COASTAL STRIP FROM WILBINGA TO MINDARIE

Boundary Definition: protected area boundary (Boundary adjusted from that in draft *Perth's Bushplan.*)

SECTION 1: LOCATION INFORMATION

Bush Forever Site no. 397 **Area (ha):** bushland 404.7 (Site includes open water.)
Map no. 6, 7, 12, 13, 19
Map sheet series ref. no. 2034–IV NE, 2034–IV NW, 2034–IV SE, 2035–III SW
Other Names: Submission Area 238, Karli Spring
Local Authorities (Suburb): Shire of Wanneroo (Alkimos, Yanchep, Eglinton, Jindalee, Quinns Rocks, Two Rocks, Mindarie)
System 6 (1983): Part M1, M2 area of bushland goes beyond System area boundaries, all bushland described

SECTION 2: REGIONAL INFORMATION

LANDFORMS AND SOILS

Spearwood Dunes
Sands derived from Tamala Limestone (Qts: S7)
Tamala Limestone (Qtl: LS1, LS3)
Quindalup Dunes (Holocene dunes)
Safety Bay Sands (Qhs: S1, S2, S3)

VEGETATION AND FLORA

Vegetation Complexes
Spearwood Dunes
Cottesloe Complex — Central and South
Quindalup Dunes
Quindalup Complex

Floristic Community Types: *not sampled, types inferred
Supergroup 2: Seasonal Wetlands (additional wetland, Karli Spring, type not inferred)
*16 Highly saline seasonal wetlands (*Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs)
Supergroup 4: Uplands centred on Spearwood and Quindalup Dunes
*29a Coastal shrublands on shallow sands
*29b *Acacia* shrublands on taller dunes
*S11 Northern *Acacia rostellifera — Melaleuca systena* shrublands
*S13 Northern *Olearia axillaris — Scaevola crassifolia* shrublands
*S14 *Spinifex longifolius* grasslands and low shrublands

WETLANDS

Wetland Types: sumpland (not previously described (DEP 1999, Robinson 1997)) (wetland identified under floristic community types is the *Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs)
Natural Wetland Groups
Quindalup (not further allocated)
Wetland Management Objectives: Conservation (<1ha) (DEP 1999)
Swan Coastal Plain Lakes EPP: none identified

THREATENED ECOLOGICAL COMMUNITIES

Not assessed, Not determined

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: ocean — limestone cliff, tall dune
Vegetation and Flora: detailed survey (part Site — Robinson 1995, Trudgen and Keighery 1990a&b); limited survey (DEP 1999, Hames Sharley Australia 1992, Robinson 1997; part Site — LeProvost *et al.* 1984, Semeniuk, V&C Research Group 1991b)
Structural Units: mapping (Hames Sharley Australia 1992; part Site — Robinson 1995, Trudgen and Keighery 1990a&b, LeProvost *et al.* 1984)
Spearwood Dunes
Uplands — Tamala Limestone: Closed to Open Low Heaths and Closed to Open Heaths dominated by *Melaleuca cardiophylla* (uncommon), *M. huegelii* (uncommon), *Dryandra sessilis* var. *cygnorum* or *Acacia truncata*; *Frankenia pauciflora* Low Shrubland (uncommon)
Quindalup Dunes
Uplands — Older dunes and plains (limited area, atypical so close to coast): Open Low Heaths to Shrublands dominated by *Melaleuca systena*, *Acacia rostellifera* or *Olearia axillaris* often over *Lomandra maritima* Herbland; *Melaleuca systena* and *Acacia lasiocarpa*

Uplands — Younger dunes: Open Low Heaths to Shrubland dominated by *Myoporum insulare*, *Scaevola crassifolia*, *Spyridium globulosum*, *Acacia truncata*, *A. rostellifera* and *Olearia axillaris*
Uplands — Strand: *Spinifex longifolius* and *S. hirsutus* Grasslands
Wetlands — *Lepidosperma gladiatum* Closed Sedgeland
Scattered Native Plants: not assessed
Vegetation Condition: ranges from near-Pristine to Degraded, with areas of severe localised disturbance; see comments in Other Special Attributes (below)
Total Flora: 83 native taxa, 27 weed taxa (part Site — Robinson 1995) (estimated >60% expected flora)
Significant Flora: *Conostylis pauciflora* subsp. *euryrhipis* (3), *Stylidium maritimum* (3); *Melaleuca cardiophylla*, *Lechenaultia linarioides*; typical of Tamala Limestone taxa — *Grevillea preissii*, *Diplopeltis huegelii* subsp. *huegelii*, *Trymalium ledifolium* subsp. *ledifolium*

Fauna: limited survey for birds (30 species), native mammals (1 species) and reptiles (8 species) (LeProvost Environmental Consultants 1990). Significant bird species: category 1 (1), category 3 (6) and category 4 (9)
Linkage: adjacent bushland to the north (Site 406) and east (Site 289); part of Greenways 1, 35, 37 (Tingay, Alan & Associates 1998a); part of a regionally significant fragmented bushland/wetland linkage (Part A, Map 7)
Other Special Attributes
Site constrained in meeting the specific coastal reserve criteria; four met to a limited extent —

(i) Quindalup Dune types: predominantly younger dunes
(ii) Continuing natural processes: 406.6ha (302.3ha of bushland) Quindalup Dunes extending to maximum of 0.8km inland but generally less, dunes truncated
(iii) Shoreline: soft (sandy) and hard (vegetated rocky areas south of Quinns and south of Burns Beach)
(iv) Linkage: part of semi-contiguous north–south vegetated coastal strip;

Large proportion recommended for protection in study of City of Wanneroo bushland (Trudgen 1996). Only wetland in the Quindalup Dunes north of Perth in the Perth Metropolitan Region.

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Not listed

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

Criteria: Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, General criteria for the protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation, Criteria not relevant to determination of regional significance, but which may be applied when evaluating areas having similar values
Recommendation: Part A: Site with Some Existing Protection; Existing Parks and Recreation Reserve — subject to review. Part B: Rural Complementary Mechanism (see Table 3, Volume 1).

397
See Eglinton -
Atkins working
File for current
Information

COASTAL STRIP FROM WILBINGA TO MINDARIE

Boundary Definition: protected area boundary

SECTION 1: CADASTRAL INFORMATION

(Lots, locations and derived information to be updated in the public submission period)

Bushplan Site no. 397 **Map no.** 6, 7, 12, 13, 17, 24, 25, 31 **Map sheet series ref. no.** 2034–IV NE, 2034–IV NW, 2034–IV SE, 2035–III SW

System 6 (1983): Part M1, M2 area of bushland goes beyond System area boundaries, all bushland described

Other Names
Submission Area 238

Area (ha): total 549.4; bushland 402.2

Local Authorities (Suburb)
Shire of Wanneroo (Alkimos, Yanchep, Eglinton, Jindalee, Quinns Rocks, Two Rocks, Mindarie)

Zoning
MRS: Parks and Recreation, Urban, Urban Deferred, Waterways, Rural
TPS: Rural, Urban Development, Residential Development, Ocean, Marina Development Zone, Landscape

Ownership Categories
State Government, Local Government, Private (including commercial organisation)

Lot/Location/Reserve numbers (Purpose), Street name
7019, 11170 Ocean Dr; 211 Quinns Rd; 211, 11186 Kinsale Dr; 77, 280, 9917, 12037 Rosslare Prom; 2, 133, 135, 8313, 8613, 8999, 9306, 9918 Two Rocks Rd; 134 Yanchep Beach Rd; 101 Romeo Rd; 11 Pipidinny Rd; 612 Hornpipe Ct; 8289, 9740, 10603 Wilkie Ave; 12222 Jordan St; 12835 Foreshore Vsta; 503 Toreopango Ave; 304 Two Rocks Rd; 220 Shearwater Ave; 504 Sovereign Dr; 1, 9, 12 Marmion Ave; 1000 Lisford Ave; 9131 Brazier Rd; 108, 312, 8508, 8984, 8989, 9307, 9321, 9917, 10538, 12489 street not identified
Crown Reserve

SECTION 2: REGIONAL INFORMATION

LANDFORMS AND SOILS

Spearwood Dunes
Sands derived from Tamala Limestone (Qts: S7)
Tamala Limestone (Qtl: LS1, LS3)

Quindalup Dunes (Holocene dunes)
Safety Bay Sands (Qhs: S1, S2, S3)

VEGETATION AND FLORA

Vegetation Complexes

Spearwood Dunes
Cottesloe Complex — Central and South

Quindalup Dunes
Quindalup Complex

Floristic Community Types: *not sampled, types inferred

Supergroup 2: Seasonal Wetlands
*16 Highly saline seasonal wetlands

Supergroup 4: Uplands centred on Spearwood and Quindalup Dunes
*29a Coastal shrublands on shallow sands
*29b *Acacia* shrublands on taller dunes
*S11 Northern *Acacia rostellifera* — *Melaleuca acerosa* shrublands
*S13 Northern *Olearia axillaris* — *Scaevola crassifolia* shrublands
*S14 *Spinifex longifolius* grasslands and low shrublands

WETLANDS

No wetlands mapped (wetland identified above is the *Frankenia pauciflora* Low Shrubland)

THREATENED ECOLOGICAL COMMUNITIES

Not assessed, Not determined

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: ocean — limestone cliff, tall dune

Vegetation and Flora: detailed survey (part Bushplan Site — Robinson 1995, Trudgen and Keighery 1990a&b); limited survey (Hames Sharley Australia 1992; part Bushplan Site — Le Provost *et al.* 1984, Semeniuk, V&C Research Group 1991b)

Structural Units: mapping (Hames Sharley Australia 1992; part Bushplan site — Robinson 1995, Trudgen and Keighery 1990a&b, Le Provost *et al.* 1984)
Spearwood Dunes
Uplands - Tamala Limestone: Closed to Open Low Heaths and Closed to Open Heaths dominated by *Melaleuca cardiophylla* (uncommon), *M. huegelii* (uncommon), *Dryandra sessilis* var. *cygnorum* or *Acacia truncata*; *Frankenia pauciflora* Low Shrubland (uncommon)
Quindalup Dunes
Older dunes and plains (limited area, atypical so close to coast): Open Low Heaths to Shrublands dominated by *Melaleuca acerosa, Acacia rostellifera* or *Olearia axillaris*
Younger dunes: Open Low Heaths to Shrubland dominated by *Myoporum insulare, Scaevola crassifolia, Spyridium globulosum, Acacia truncata, A. rostellifera* and *Olearia axillaris*
Strand: *Spinifex longifolius* and *S. hirsutus* Grasslands
Scattered Native Plants: not assessed

Vegetation Condition: ranges from near Pristine to Degraded, with areas of severe localised disturbance; see comments in Other Special Attributes (below)
Total Flora: 83 native taxa, 27 weeds (part Bushplan Site — Robinson 1995) (estimated >60% expected flora)
Significant Flora: *Conostylis pauciflora* subsp. *euryrhipis* (3), *Stylidium maritimum* (3); *Melaleuca cardiophylla, Lechenaultia linarioides*; typical of Tamala Limestone taxa — *Grevillea preissii, Diplopeltis huegelii, Trymalium ledifolium* subsp. *ledifolium*

Fauna: limited survey by LeProvost Environmental Consultants (1990) for birds (30), native mammals (1) and reptiles (8). Significant bird species: category 1 (1), category 3 (6) and category 4 (9)
Linkage: adjacent bushland to the north (BS406) and east (BS289); part of proposed Greenways 1, 38, 36, 4 (Tingay, Alan, & Associates 1997a); part of a regionally significant fragmented bushland/wetland linkage (Volume 2A, Map 8)

Other Special Attributes
Bushplan Site constrained in meeting the specific coastal reserve criteria; four met to a limited extent —
(i) Quindalup Dune types: predominantly younger dunes
(ii) Continuing natural processes: 406.6ha (302.3ha of bushland) Quindalup Dunes extending to maximum of 0.8km inland but generally less, dunes truncated
(iii) Shoreline: soft and hard (vegetated areas south of Quinns and south of Burns Beach)
(iv) Linkage: part of semi-contiguous North—South vegetated coastal strip;

Large proportion recommended for protection in the study of City of Wanneroo bushland (Trudgen 1996)

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

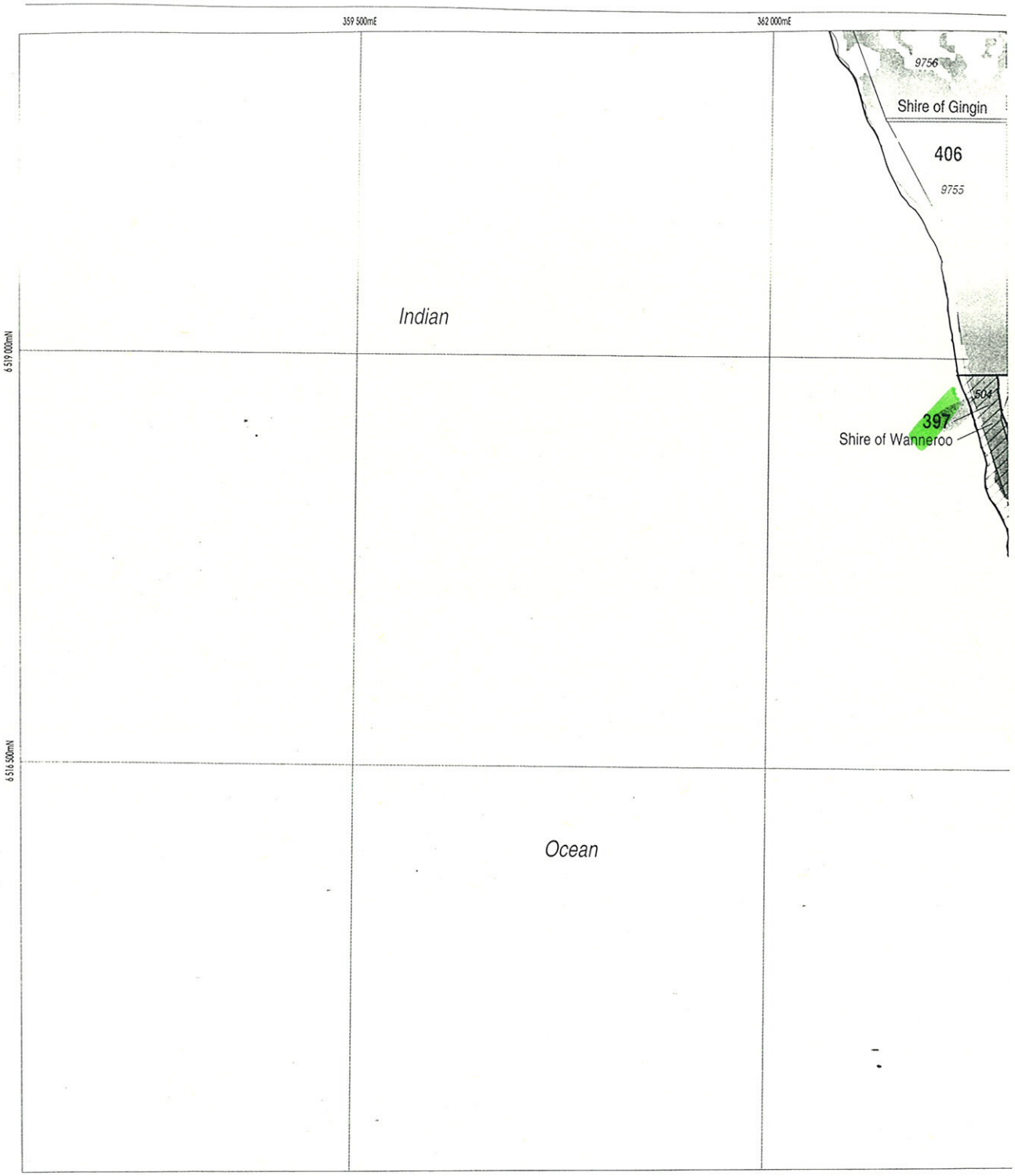
Not listed

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

Criteria: Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation, Criteria not relevant to determination of conservation value, but which may be applied when evaluating areas having similar values

Opportunities and/or Constraints
Opportunities: Bushplan Site/part Bushplan Site location of Scheduled Fauna; under MRS Parks and Recreation Reservation and TPS Landscape Zoning, Crown Reserve
Constraints: private land; under MRS Urban Zoning and Urban Deferred Zoning

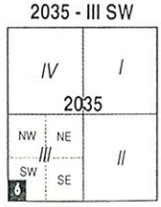
Recommendation: The existing care, control and management intent of the reserve is endorsed. Long-term security and support for conservation management of the Bushplan Site to be enhanced by: amending the purpose of the reserve to include conservation; and applying appropriate mechanisms in consultation with the reserve management body.



LEGEND

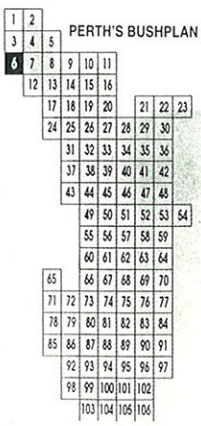
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2035 - III SW



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



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SCALE

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Metres

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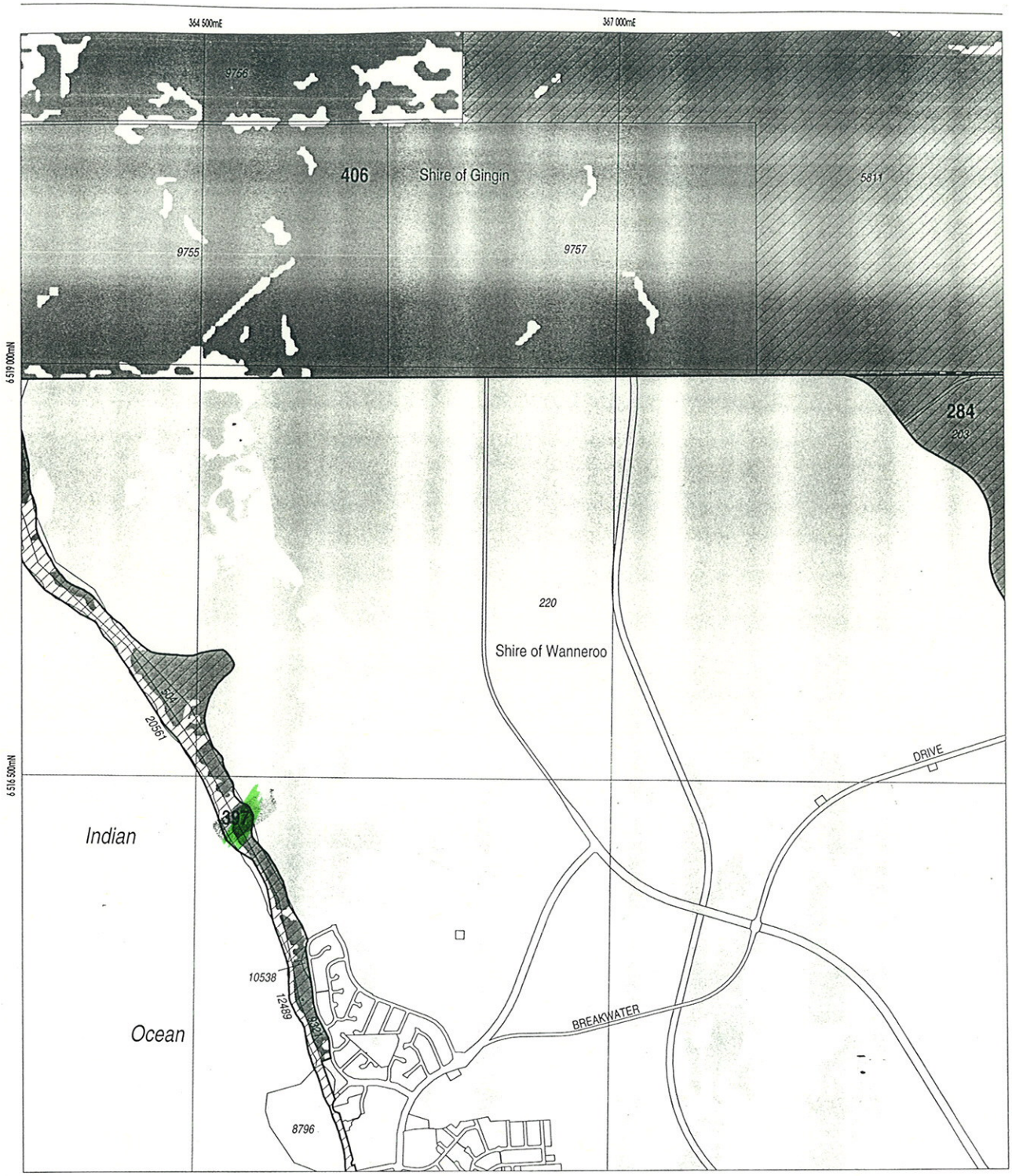
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Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

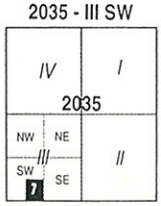
Bushplan Site Map



LEGEND

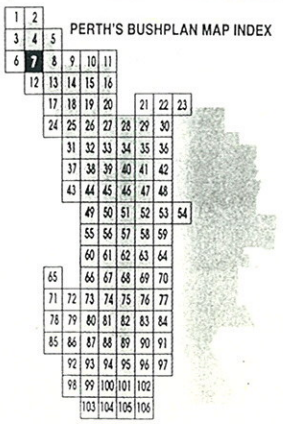
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2035 - III SW



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



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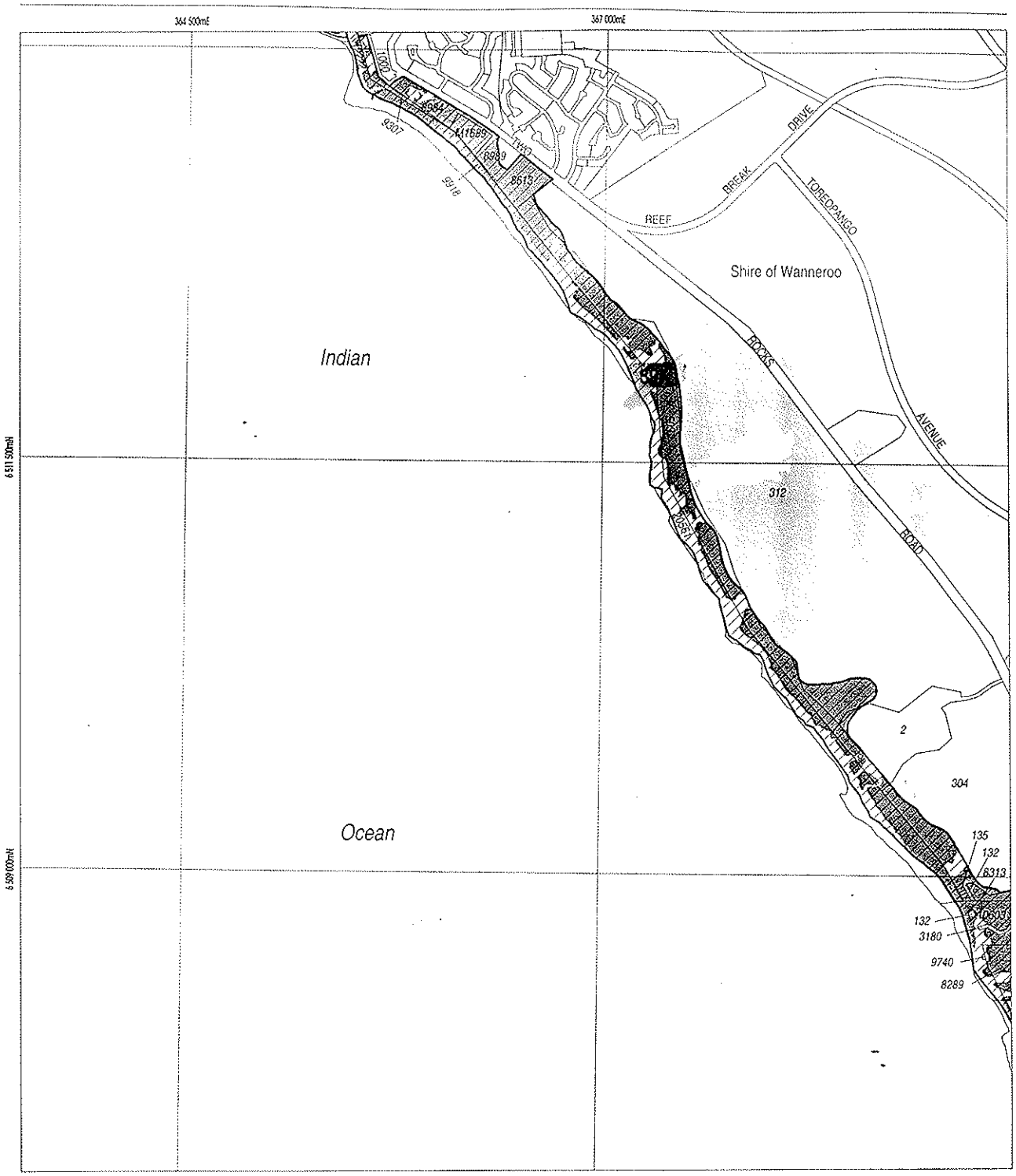
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Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map



LEGEND

- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV NW

1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX

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Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map

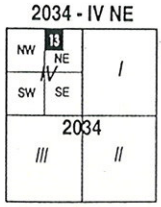
Map 12



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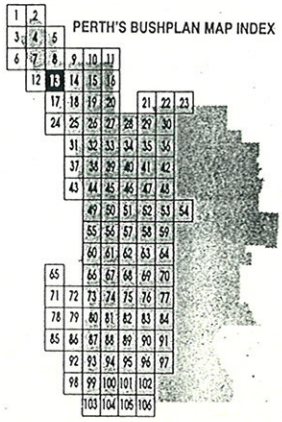
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV NE



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



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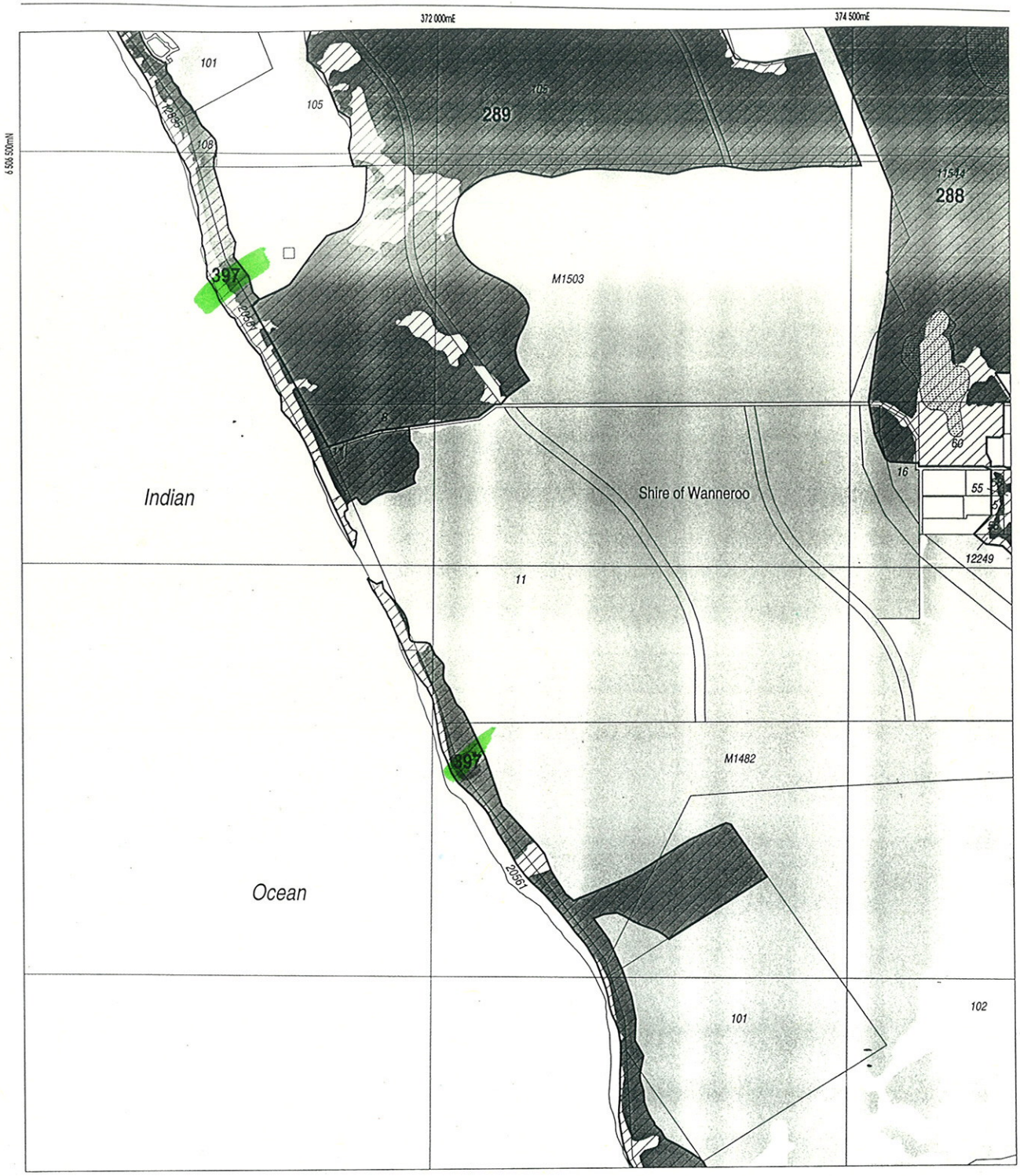
Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map

Map 13



LEGEND

- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV NE

NW | NE 17 | I
SW | IV | SE
III | 2034 | II

1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX

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Metres

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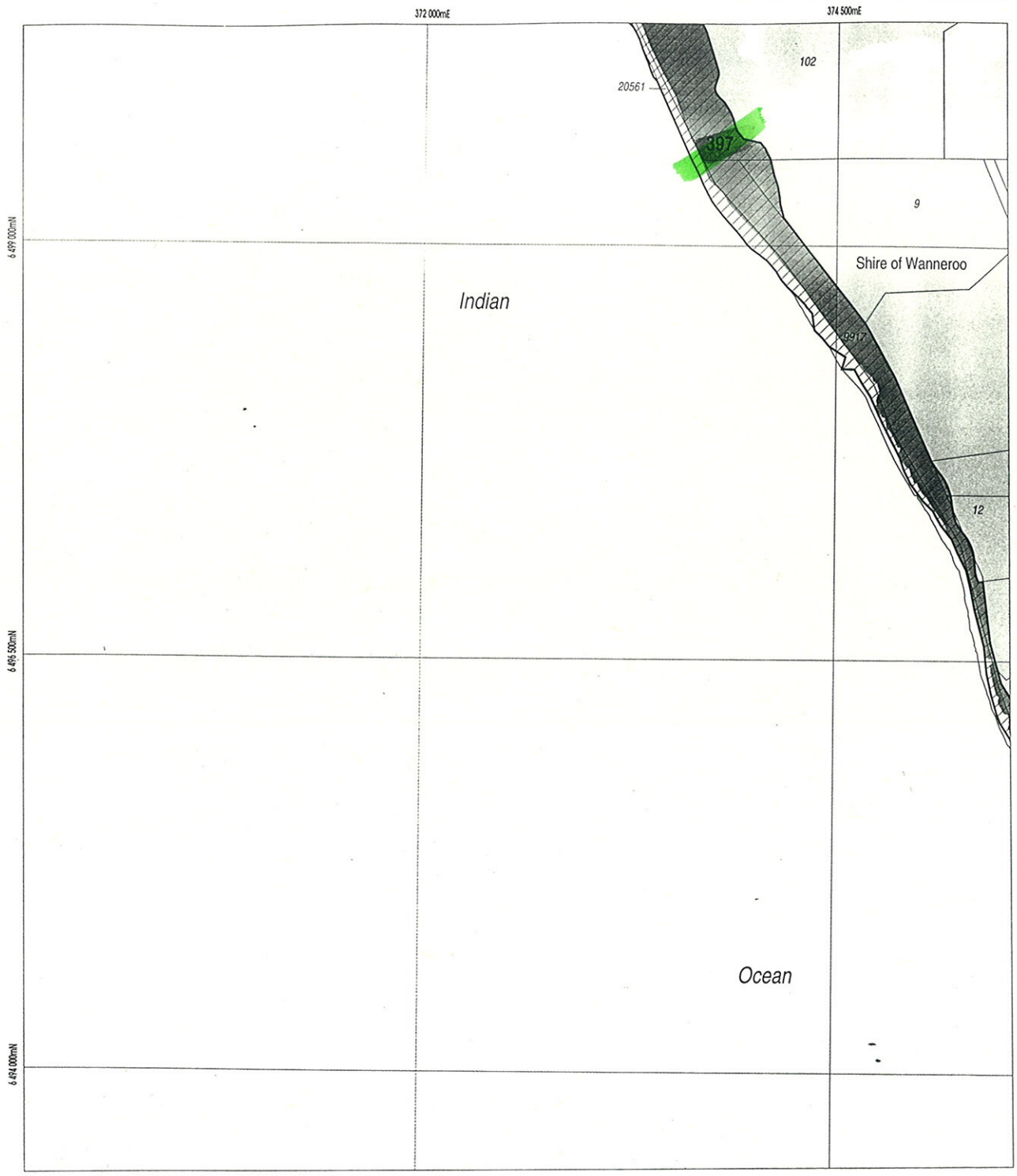
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Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

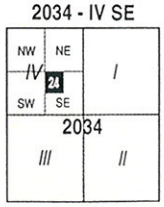
Bushplan Site Map



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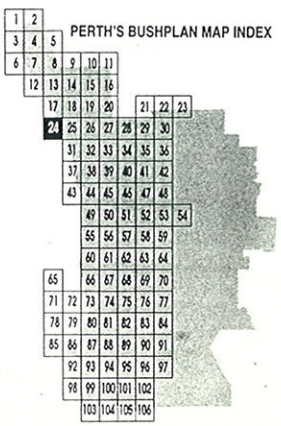
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV SE



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



N

SCALE

0 500 1000

Metres

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Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

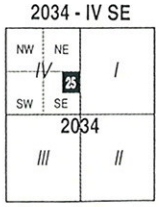
Bushplan Site Map



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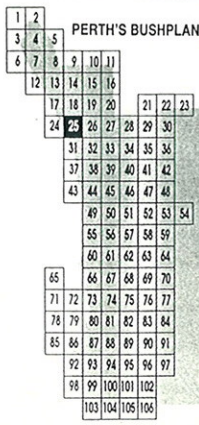
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV SE



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



N

SCALE

0 500 1000

Metres

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ntw-map11//environ/bushplan//bushv2_25.dgn

Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map



LEGEND

- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2034 - IV SE

NW | NE | I
SW | SE (31) | II
III

1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX

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		103	104	105	106				

N

SCALE

0 — 500 — 1000
Metres

Produced by Project Mapping Section
Land Information Branch, Ministry for Planning, Perth W.A. November 1998

ntw-map11//environ/bushplan//bushv2_31.dgn

Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map



L Lomandra maritma Low Herb Sedgeland
D Dryandra sessilis Shrubland to Tall Closed Scrub

N

Scale 1:11 400

FIGURE 5

PROPOSED ROS CHANGES TO VEGETATION COMPLEX AND ASSEMBLAGE RESERVATION

(Assemblage Survey by Dr Arthur Weston, 1998)

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

SECTOR 7

SECTOR 8

MINDARIE KEYS

Gradual accretion is expected at abutment of the Mindarie Keys breakwater.

Shore has been stable since 1941.

Wide, sandy beach backed by a very high, steep frontal dune.

Protect foredune and maintain 30m minimum buffer against sea level rise. (See Section 2.2.4 Technical Report)

Large blowout is cut off from its sand supply but the sand sheet is still active.

Wide, sandy beach is perched above a consistent line of outcropping beach rock. The beach is backed by a very steep, high frontal dune.

Extensive rock outcrops has resulted in a stable shoreline.

Protect foredune and maintain 30m minimum buffer against sea level rise. (See section 2.2.4 Technical Report)

LOT 1004

LOT 17

LOT 2

MARMION AVENUE

BURNS BEACH

KEY

Geomorphic Units

- Rocky shore
- Sandy beach shore
- Modern to recent beach ridges and foredune (Quindalup dunes)
- Mobile transgressive dune terrain (Quindalup dunes)
- Stabilised transgressive terrain (Quindalup-Spearwood dunes)
- Stabilised and degraded dune terrain (Spearwood dunes)
- Anticipated position of pleistocene tamala limestone ridge flank beneath young (< 6000 years old) Safety Bay sand and Becher sand sequences

Vegetation Units

1. STRAND VEGETATION ON FOREDUNE
2. Carpobrotus HERBFIELD, spinifex GRASSLAND and Scaevola/Myoporum Low open HEATH on relatively unstable foredune
3. Low Acacia SHRUBLAND and Low HEATH on stabilised beach ridges
4. HERBFIELD/GRASSLAND on sparsely vegetated beach ridges
5. Low open HEATH on rocky shore on shallow soils
6. SAND HEATH ON TRANSGRESSIVE DUNE
7. Acacia SHRUBLAND (A. rostellifera, A. cochlearis, A. cyclops) on sheltered sites
8. LOW OPEN HEATH (Olearia axillaris)
9. LOW CLOSED HEATH (Associated with Acacia shrubland)
10. CLOSED HEATH WITH BUCKBOOMS
11. Low HEATH (Olearia axillaris)
12. LOW HEATH / GRASSLAND
13. UNSTABLE DUNES (eg)
14. BLOWOUTS
15. Isolated specimens of Eucalyptus gomphocephala
16. LIMESTONE HEATH/SPEARWOOD DUNES
17. TALL OPEN SHRUBLAND (Melaleuca cardiophylla)
18. LOW OPEN HEATH (Eucalyptus scoparia, Melaleuca huegelii)
19. EUC. CLOSED MALLEE HEATH (E. foecunda, E. petraea)
20. Low open heath
21. LOW OPEN BANKSIA WOODLAND (B. attenuata, B. menziesii)
22. LOW BANKSIA WOODLAND
23. LOW EUCALYPT WOODLAND

COASTAL PLANNING STUDY

Burns Beach to Jindalee

3

Hames Sharley Australia

Hames Sharley WA Pty Ltd
300 Rokeby Road
Subiaco WA 6008

Planning, Architecture, Interior Design and Landscape Architecture

0 100 200M

NORTH

SECTOR 5

SECTOR 6

Maximum reserve width has been determined by the subdivision of land making an extra buffer zone against erosion impossible - therefore trapping of wind blown sand and foredune preservation should be implemented.

Sandy coast

Seasonally fluctuating shoreline - Northern side of cusp is in recession in Winter and accretion in Summer

Groyne

Southern side of cusp is in accretion in Winter and recession in Summer

Limestone rock cliffs, narrow sand pocket beaches and limestone reef platforms.

Stable coastline

QUINNS ROCKS

MINDARIE KEYS

LOT 1064

LOT 1

LOT 2

MARMION AVENUE

KEY

Geomorphic Units

- Rocky shore
- Sandy beach shore
- Modern to recent beach ridges and foredune (Quindalup dunes)
- Mobile transgressive dune terrain (Quindalup dunes)
- Stabilised transgressive dune terrain (Quindalup - Spearwood dunes)
- Stabilised and degraded dune terrain (Spearwood dunes)
- Anticipated position of pleistocene tamala limestone ridge flank beneath young (< 6000 years old) Safety Bay Sand and Becher Sand sequences

Vegetation Units

1. STRAND VEGETATION ON FOREDUNE
2. Cakile maritima HERBFIELD, spinifex GRASSLAND and Scaevola/Myoporum LOW OPEN HEATH on relatively unstable foredune
3. Low Acacia SHRUBLAND and Low HEATH on stabilised beach ridges
4. HERBFIELD/GRASSLAND on sparsely vegetated beach ridges
5. Low OPEN HEATH on rocky shore on shallow soils
5. SAND HEATH ON TRANSGRESSIVE DUNE
6. Acacia SHRUBLAND (A. rostellifera; A. cochlearis, A. cyclops) on sheltered sites
7. LOW OPEN HEATH (Olearia axillaris)
8. LOW CLOSED HEATH (Associated with Acacia shrubland)
9. CLOSED HEATH WITH BLACKBOYS
10. Low HEATH (Olearia axillaris)
11. LOW HEATH / GRASSLAND
12. UNSTABLE DUNES (qa)
13. BLOWOUTS
14. Isolated Specimens of Eucalyptus gomphocephala
15. LIMESTONE HEATH/SPEARWOOD DUNES
16. TALL OPEN SHRUBLAND (Melaleuca cardiophylla)
17. LOW OPEN HEATH (Eucalyptus sessilis, Melaleuca hnaeifolia)
18. Esc. CLOSED MALLEE HEATH (E. foecunda, E. petraea)
19. Low open heath
20. LOW OPEN BANKSIA WOODLAND (B. attenuata, B. menziesii)
21. LOW BANKSIA WOODLAND
22. LOW EUCALYPT WOODLAND

COASTAL PLANNING STUDY

Burns Beach to Jindalee

ENVIRONMENT

NOVEMBER 1992

Hames Sharley Australia

Hames Sharley WA Pty Ltd

2 OF SEVEN

0 100 200M

NORTH

SECTOR 1

SECTOR 2

SECTOR 3

SECTOR 4

KEY

Geomorphic Units

Rocky shore
Sandy beach shore
Modern to recent beach ridges and foredune (Quindalup dunes)
Mobile transgressive dune terrain (Quindalup dunes)
Stabilised transgressive dune terrain (Quindalup - Spearwood dunes)
Stabilised and degraded dune terrain (Spearwood dunes) (anticipated position of Becher formation limestone ridge, think beneath young (< 6000 years old) Safety Bay Sand and Becher sand sequences)

Vegetation Units

1 STRAND VEGETATION ON FOREDUNE
Cakile maritima HERBFIELD, spinifex GRASSLAND and scaevola / Myoporum low open HEATH on relatively unstable foredune
2 Low Acacia SHRUBLAND and low HEATH on stabilised beach ridges
3 HERBFIELD / GRASSLAND on sparsely vegetated beach ridges
4 Low open HEATH on rocky shore on shallow soils
5 SAND HEATH ON TRANSGRESSIVE DUNE
Acacia SHRUBLAND (A. rostellifera, A. cochlearis, A. cyclops) on sheltered sites
6 Low open HEATH (Olearia axillaris)
7 Low closed HEATH (Associated with Acacia shrubland)
8 CLOSED HEATH WITH BLACKBOOS
9 Low HEATH (Olearia axillaris)
10 Low HEATH / GRASSLAND
11 UNSTABLE DUNES (Qa)
12 BLOWOUTS
13 Isolated specimens of Eucalyptus gomphocephala
13 LIMESTONE HEATH / SPEARWOOD DUNE
14 TALL OPEN SHRUBLAND (Melaleuca cardiophylla)
15 Low open HEATH (Banksia sessilis, Melaleuca huegelii)
16 EUC. CLOSED MALLEE HEATH (E. foecunda, E. petraea)
17 Low open heath
18 Low open BANKSIA WOODLAND (B. attenuata, B. menziesii)
19 Low BANKSIA WOODLAND
Low EUCALYPT WOODLAND

2

LOT 9

17

17

16

16

16

3

Eroding sandy beach backed by relatively low beach ridges and dunes

The beach has had a recession rate of 1.1m per annum, between 1941 and 1987. An erosion buffer zone of 110m, for the next 100 period should be provided. (See section 2.2.4 Technical Report).

6

LOT 10

17

16

17

12

MARMION AVENUE

Groyne constructed since 1941

4

Predominantly rockshore with limestone cliffs, narrow sand pocket beaches and limestone reef platforms

1

Rocky shoreline is stable, minimum width of 30m from clifftops should be maintained for landscape preservation. (See section 2.2.4 Technical Report)

Outcrops of beach rock allows a wider beach to be maintained above normal high tide levels

LOT 12

14

5

7

5

5

19

19

Relatively wide, sandy beach is backed by very high, steep frontal dunes, across which, access is difficult.

5

8

The shoreline is stable. Preservation of the foredune and a minimum width of 50m, as an erosion buffer, is recommended. (See section 2.2.4 Technical Report).

LOT 5

19

19

Full - Net area in accretion

6

QUINNS ROCKS

COASTAL PLANNING STUDY

Burns Beach to Jindalee

ENVIRONMENT

1 OF SEVEN

Hames Sharley Australia

Hames Sharley WA Pty Ltd

0 100 200M

NORTH

NOVEMBER 1992

System 6 Update - Floristic Community Type Mapping Information **DRAFT ONLY**

AREA INFORMATION

System 6 Area (C or M) or Update Area (Update) M2.

Conservation Area
Nature Reserve
Reserve No
National Park
Reserve No
Local Government
Reserve No
Other
Proposed Conservation Areas
Local Government
Reserve No
Other

Conservation Area

Nature Reserve
Reserve No
National Park
Reserve No
Local Government
Reserve No
Other

AREA

Total Area	hectares
Completely Degraded	hectares
comments:	

AREA MAPPED FLORISTIC UNITS Boundaries: System6 CALM

Units	Site (Condition) Code	Bound	Area (ha)	Area(ha)

Boundaries determined by use of Metro Regional Area

aerial photograph Run 2 5007-8 Run 3 5016-17 Run 4 5020
orthophoto 20cm N NT; 20SK NE
vegetation map
soil map

4/12/92

BS 397 QUIN

Subm 321

(1906)

SYSTEM 6 BUSHLAND SUBMISSION FORM
FOR CONSIDERATION IN THE UPDATE PROGRAMME

COASTAL BUSHLAND: QUINNS ROCKS TO ALKIMOS

LOCATION, OWNERSHIP AND ZONING OF THE AREA

1. **Location**

a) Bordering Roads: east and west of proposed Marmion Ave extension
b) Nearest Corner: as above
c) Lot Number: Lot 5 Quinns Rocks, Lots 9, 10 and 12 Jindalee, Lots pt 7 and 8 Butler, Lot 102 Alkimos
d) Suburb/Location: Quinns Rocks, Jindalee, Alkimos and Butler
e) Local Council: City of Wanneroo
f) Site Name: Quindalup dunes north of Quinns Rocks to Alkimos
g) Approximate size of area (ha): estimated area size 700 ha
h) Location on map: please see attached copy of aerial photo
i) Map: Streetsmart Street Directory, 1996
j) Map no.: 10 and 11
k) Grid Ref.: Map 10: 1C (top left) to Map 11: 1A (top right)
Map 10: 7E (bottom left) to Map 11: 7A (bottom right)
l) Other information to find location: please see attached copy of aerial photo.
m) Aware of any development proposals that are likely to affect the area?
Yes, proposed urban development

2. **Who owns the area?** Private land

3. **If you own the land?** not applicable

4. **What is the area zoned?** Urban under MRS

PHYSICAL CHARACTERISTICS

5. **Why do you consider this area important?** The area is a large, intact remnant of remnant vegetation and landforms of the Quindalup and Spearwood dune systems, the series of parabolic dunes north of Quinns Rocks are characteristic of this sector of coastline but are poorly reserved (Semeniuk, Cresswell and Wurm, 1989). The significance of the area was recognised in the environmental audit for the North West Corridor (V & C Semeniuk Research Group, 1992). The area

includes mixed heathlands on Quindalup dunes, *Dryandra sessilis* heathland, *Melaleuca cardiophylla* heathland, Banksia woodlands including areas with rich and intact understorey vegetation, stand of *Eucalyptus foecunda* and stand of *Allocasuarina lehmanniana*, includes small wetland close to coast with surrounding *Lepidosperma gladiatum* sedgeland.

6. What are the soil type/s and colours? White/Grey and Yellow sands of the Quindalup and Cottesloe soil types.

7. Any special features such as unusual landforms/landscapes? Yes. The area includes a series of parabolic Quindalup dunes - a characteristic but poorly conserved geomorphic feature of this part of the coast. The vegetation on these coastal landforms is intact. The significance of the landforms and vegetation is noted by V & C Semeniuk (1992).

8. Is the area a wetland or does it include a wetland? Yes, Karli Spring occurs in Quindalup dunes a few hundred metres from the beach and is mostly surrounded by Coastal sword Sedge (*Lepidosperma gladiatum*).S
d) Swamp

9. What percentage of the wetland is open water in summer? thought to hold water all year round.

VEGETATION / FAUNA

10. What percentage of the area is indigenous vegetation? ~100%

11. If the area includes regions of cleared native bushland please indicate reasons for the inclusion. No.

12. Has any previous flora or fauna work been done on the area? The Alkimos area has been surveyed by Trudgen and Keighery (1990a).

13. The condition of the native bushland?
b) Excellent. Some of the land east of Karli Spring is very good - degraded from excellent due to grazing.

14. Disturbances affecting the area?
m) Grazing; some grazing east of Karli Spring
o) Off-road vehicle use; tracks mainly along coast.

15. Plant species of interest in the area? *Melaleuca cardiophylla* occurs north of Quinns Rocks on limestone ridges. *Allocasuarina lehmanniana* has been seen in the area, this species is not common in the metropolitan region. Species of special interest were recorded by Trudgen and Keighery (1990). Fremantle mallee (*Eucalyptus foecunda*) occurs in the area.

16. Do you know of any animals that use the area? Yes, Echidnas, Emus, Western Grey Kangaroos and many other animals. As this area is a large remnant that is intact, we feel that many animals would live here. See below for further information.

17. Is the area used by any native animals of special interest? Our group has recorded the occurrence of the Brush-tail Wallaby in Banksia woodland in Butler, this species is on the CALM Reserve List. Southern Brown Bandicoots are also thought to live in the area, they have been reported at Mindarie and Quinns Rocks - this species is gazetted rare. Our group has also recorded the Scale-foot lizard (*Pygopus lepidopodus*) in the area, this species is uncommon (John Dell, WA Museum, pers. comm.).

SURROUNDING AREA
18. Are there any bushland areas (including wetlands) near this area? The submitted area is part of a large bushland remnant on the urban fringe. Neerabup National Park is nearby but represents different ecosystems.

19. Does the submitted area link other bushland areas? Yes, the submitted area adjoins the coastal reserve.


5030 WA3490 (C) METRO REGIONAL AREA RUN 4N (5026-5041) 1:20000 06.01.95 940900
N

Coastal Bushland:
Quinns Rocks to Alkimos

This area continues on to attached photo.



BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

DOCUMENT TRANSMITTAL

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TO: DEPARTMENT of ENVIRONMENTAL PROTECTION

ADDRESS: WESTMALIA SQUARE

ADDRESS: 141 ST GEORGES TCE, PERTH, 6000

ATTENTION: MR GARY WILLSON DATE: 4pm

FROM: STEVE ROLLS TIME: 7/10/99

SUBJECT: JINDALEE OUR REF: M99155

☐ For Approval ☑ For Your Information ☐ Please Check & Return

☐ For Submission ☑ As Requested ☐ Other

DEPARTMENT OF ENVIRONMENTAL PROTECTION
- 8 OCT 1999
File No 1 _____ Name [redacted]
File No 2 _____ Name _____
File No 3 _____ Name _____

Gary Willsson

DESCRIPTION

Dear Garry,

further to our meeting, please find attached colour aerial photograph, marked up by Arthur Weston together with his flora notes, and a clear reserve boundary overlay.

REMARKS Best Wishes,

Steve Rolls

Delivered by: ☐ Our Courier ☐ Your Courier ☑ Post ☐ Hand

It is the responsibility of the recipient to either destroy or mark as superceded any superceded versions of the accompanying documents.

Distribution: WHITE - With Documents YELLOW - File

Department of Environmental Protection

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Chief Executive Officer
Ministry for Planning
Albert Facey House
469 Wellington Street
Perth WA 6000

Att: Ms Marion Thompson

Your Ref
Our Ref PB196 V1
Enquiries Mr Gary Whisson

PRELIMINARY ENVIRONMENTAL COMMENTS - JINDALEE CONCEPT PLAN

The following comments represent preliminary advice from the Department of Environmental Protection on the conservation implications of the proposed Jindalee Concept Plan. In particular, comment is provided on the proposal to develop a portion of the existing coastal reserve, in exchange for the protection of an east-west strip following the crest of a prominent ridge linking the coast to the crest of Eglington Hill, the highest point in the vicinity.

Coastal Reserve

The coastal reserve has been identified as part of the regional system of conservation areas for Perth since the early 1980's as part of System 6 recommendation M2. More recently the area has been recognised for conservation in Perth's Bushplan (part recommendation 397). As an existing coastal reserve that is also reserved for Parks and Recreation under the MRS, the reserve is identified in Perth's Bushplan as an area with some existing level of protection.

The coastal reserve adjacent to the Jindalee land development is one of the widest sections of coastal reserve in the NW corridor of Perth. The northern half of the reserve is located on a retreating sand coast. In this area the proposal retains a boundary that approximates the current reserve boundary. The proposal is likely to be acceptable, provided the road and parking areas and associated facilities for coastal access are not sited in the foreshore reserve. The design should also ensure the protection of the limestone cliffs and associated vegetation in this area.

The southern half of Jindalee is located on a more stable limestone coast backed by land rising in several generally north-east to south-west aligned limestone (and sand over limestone) ridges to high points approximately 1 km inland in the alignment of Eglington Hill. Though mapped as Quindalup dunes the vegetation on these dunes is more typically that of the Spearwood Dune System, reflecting the influence of the underlying Tamala limestone. A prominent ridge on the southern edge of Jindalee visually separates this development from the existing Quins Rocks development to the south.

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The coastal reserve is of regional conservation significance, (as well as having important recreation and landscape values), for its representation of the foreshore and near coastal vegetation and landforms, and because it protects a near contiguous corridor of native bushland that provides a linkage for fauna moving along the coast and between other more substantial existing and proposed coastal conservation reserves.

In places this reserve is quite narrow to the extent that its conservation values and functions in these sections are threatened. These areas in particular require careful management to maintain and help restore the native vegetation. In this context the wider reserve at Jindalee is significant for the greater habitat value it provides and its better representation of coastal vegetation and landform types.

Environmental issues
From an environmental perspective a proposal to excise a significant area from the coastal reserve at Jindalee for urban development would need to clearly demonstrate that the loss of this area would be compensated for by other additions of at least equal conservation value.

The concept plan seeks to relate the development more closely to the coast as the major focus, including a regional beach and local beaches. It is understood that Jindalee is seen as a demonstration of the community code concept. DEP recognises the planning benefits of the coastal node development approach proposed for this area and is supportive of the principle of community code concept of urban development. However the current community code does not integrate requirements for enhancing protection of the natural urban bushland environment as part of the approach to improving the quality of the urban environment. This is the main deficiency in the code at present and reflects the contentious issues associated with this development proposal.

The community/planning benefits arising from the proposed development should not be gained at the expense of the natural environment. As this site is seen as a demonstration of the community code concept, it is even more important that it is not seen as setting an undesirable precedent in terms of trading regionally significant bushland for other planning benefits.

Proposed exchange of coastal reserve for east west ridge
On this site the issue is the relative benefits of trading portions of the coastal reserve for the proposed east west link to the top of Eglington Hill. As has been indicated on visits to the area, the coastal reserve is of regional significance while the link to Eglington Hill as currently proposed in the plans is likely to be of local significance.

On further inspection of the site it is clear that portions of the coastal reserve are degraded through serious weed invasion, as well as the obvious impacts of vehicle tracks. This may allow the development to be revised to approach closer to the coast in these areas, while retaining and thickening the reserve in other areas of intact vegetation to provide habitat conservation and landscape nodes. The narrowness of the east-west link has previously been recognised as a concern. It is recommended that this link should be significantly widened. A substantial intact area of bushland at the junction between this link and the coastal reserve should be the main point at which the coastal reserve is widened to form a consolidated bushland node. Other bushland nodes should also be retained. The small reserve protecting the tall ridge on the southern boundary should be retained even though the vegetation is substantially disturbed by vehicle tracks at this point. These disturbed areas should be rehabilitated by controlling weeds and brushing with material recovered from the same type of vegetation cleared form other sites during the development process.

Where the coastal reserve is narrowed to allow closer coastal development the vegetation should be retained at least as far inland as the existing vehicle tracks, which are located on relatively flatter land above and behind the slope leading down to the coastal limestone cliffs. As with the sandy northern section, the car parks and roads should be located behind the modified coastal reserve.

Under the Community Code concept the standard 10% allocation of POS can be reduced to 8%, if the POS is developed and managed by the developers for the first two years of its establishment. Retention of bushland areas is not normally considered a part of this 8%, but scope exists in the code for a proportion of this POS to be retained in the form of Bushland if there is considered to be a reasonable provision for recreation facilities in the area. In this case it could be argued that the coastline and beaches provide a very significant recreational resource such that there is scope for a proportion of the normal developed POS to be retained for bushland conservation to augment the areas to be retained in exchange for the coastal reserve.

Retention of landscape, vegetation and sense of place
The concept of Special Landscape Design Precincts is supported. This concept could be considered for wider application within the development. It is understood that as far as possible the natural landform of the property will be retained in the development, the proposal to retain the main dune ridge as bushland is part of this concept. This objective is strongly supported. It should enable the existing bushland to be retained on as many blocks as possible when they are sold, so that the purchasers have the opportunity to retain areas of native vegetation on their property. This will significantly enhance the sense of place which is lost when the vegetation is cleared and landforms are reshaped in most developments. The contrast to the development to the south of Jindalee is a case in point.

Information requirements
Additional information is required to adequately present the proposed adjustment to the Public Open Space conservation areas. At present the information on the vegetation and plan of the site is too limited to substantiate the design proposed.

As part of the development a comprehensive flora and vegetation survey should be undertaken. This should include a search for declared rare, priority and other significant flora species; mapping of the vegetation units and vegetation condition as well as an assessment of the regional values of the current reserve and the proposed reserves. In order to provide a consistent framework for describing vegetation types and values this should address the information categories used in Perth's Bushplan Site descriptions, as identified in the attached information sheet.

Yours sincerely

R A D Sippe
DIRECTOR
POLICY COORDINATION DIVISION

1 November 1999

enc.

MEDIA MONITORS
THE WEST AUSTRALIAN
Wednesday, 23 September 1998
Page: 45

I Policy



Bush blockade: John Hollywood, left, and fellow protesters signal their opposition to development of bush at Burns Beach. PICTURE: NIC ELLIS

Minister backs EPA to clear bush project

By Geraldine Capp

ENVIRONMENT Minister Cheryl Edwardes has backed an Environmental Protection Authority decision to refuse development of 205ha of coastal bush at Burns Beach.

But Mrs Edwardes has supported the EPA's view that a further 55ha of bush on the corner of Marmion Avenue and Burns Beach Road could be cleared for housing.

Conservationists and local residents appealed to Mrs Edwardes that all the bush should be saved because it was of high conservation value and was the last of its kind on the Perth coast.

The Burns Beach Property Trust put forward the plan to build up to 2500 houses on the 260ha lot in 1995.

The land is zoned rural and the EPA is conducting a separate assessment on the environmental impact of rezoning the land for urban use.

Wanneroo resident Audrey Hine said yesterday she was extremely disappointed that Mrs Edwardes dismissed all her grounds of appeal.

"The whole area should be protected because it is a rare piece of bushland and one of the only pieces left in the northern corridor," Mrs Hine said.

She said emus lived in the bush and many native Christmas trees would be destroyed.

But Mrs Edwardes said the emus and Christmas trees were not listed as an endangered species under the Wildlife Conservation Act. The emus would survive in the bush that was not cleared.

Burns Beach resident John Hollywood said Mrs Edwardes' decision was a half-win for conservationists because most of the bush would be saved.

"I am a happy that four-fifths of the block will be saved and there is still a chance to stop the development through the rezoning process," he said.

"But I do not expect the EPA will refuse the urban zoning now that the Minister has supported the EPA's assessment of the project."

Mr Hollywood objected on the grounds that shareholders in the Burns Beach Property Trust did not live in the area and did not see the continuing urban sprawl.

But he said the developer would still have to preserve 10 per cent of the 55ha as public open space.

Mrs Edwardes said the residential location of the several hundred investors in the trust was not relevant to the environmental assessment.

Not Canyon follows up Mrs Condition with Hocey I understand it may allow for further TPRS amendment over the remaining area. true Minister has allowed for development in designated area of bulletin and remainder is protected until review in mrs amendment NTH 2/10.

Graham

DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT
PERTH ENVIRONMENT PROJECT : BIBLIOGRAPHY OF ENVIRONMENTAL TOPICS

PIC:
EPARED FOR: M 1&2 - Burns Beach

Date prepared:
04/14/94

COASTAL PLANNING STUDY : BURNS BEACH TO JINDALEE, SUMMARY REPORT [FOR DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT AND THE CITY OF WANNEROO] / Hames Sharley Australia -- Subiaco, W.A. Hames Sharley, 1992.

1. COASTAL PLANNING. 2. BURNS BEACH. 3. JINDALEE.
PEP TOPIC: 1. GEOMORPHOLOGICAL UNIT.

ISBN: 0 7309 5297 5 Accesn. No. 920860

Location(s) : EPA

COASTAL PLANNING STUDY : BURNS BEACH TO JINDALEE, TECHNICAL REPORT [FOR DEPARTMENT OF PLANNING AND URBAN DEVELOPMENT AND THE CITY OF WANNEROO] / Hames Sharley Australia -- [Subiaco, W.A. Hames Sharley]] 1992.

1. COASTAL PLANNING. 2. BURNS BEACH. 3. JINDALEE.
PEP TOPIC: 1. GEOMORPHOLOGICAL UNIT.

ISBN: 0 7309 3292 3 Accesn No. 920859

Location(s) : EPA

CONSERVATION AREA : OCEAN REEF/BURN'S BEACH SOUTH. / Foulds, W. (William). English. 1983.

1. NATURAL AREAS. 2. BURNS BEACH. 3. OCEAN REEF. 4. COASTAL FLORA.
PEP TOPIC: 1. COASTLINE. 2. FLORA SPECIES.

Location(s) : WCX =JOONDALUP...Q333.7209941 FOU copies:1 <562884>

FLORA OF BURNS BEACH COASTAL RESERVE / Keighery, G.J.: Keighery, B.J.

(Unpublished Report.) BJK

1. BURNS BEACH. 2. DARLING. 3. FLORA. 4. PERTH REGION. 5. SWAN.
6. VEGETATION. 7. COASTAL RESERVES.
PEP TOPIC: 1. COASTLINE. 2. FLORA SPECIES.

Location(s) : CALM

M1 Two Rocks Open Space
Other Names: Yanchep
Specific Study/studies Miscellaneous studies

Flora
Vegetation Map 1 2 3
Flora list 1 2 3
Rare Taxa done / suitable / doubtful

Fauna
Mammals 1 2
Birds 1 2 RAOU
Reptiles and Amphibia 1 2
Invertebrates 1 2

Vegetation Condition Map Comment

Disturbance Factors Comment Management

Swan Coastal Plain Floristic Survey

AHC: National Estate- Listed / Interim / Notified National Trust: Heritage Classification

M2 Coastal strip from Two Rocks to Burns Beach
Bulletins 200 (Mindarie Keys, alt boundaries), 500 (Eglington Beach Reseort, alt. boundaries), 485 (Burns Beach, alt boundaries)

Other Names:
Specific Study/studies Miscellaneous studies refer to areas (individual) within the greater area

Flora
Vegetation Map 1 2 3
Flora list 1 2 3
Rare Taxa done / suitable / doubtful

Fauna
Mammals 1 2
Birds 1 2 RAOU
Reptiles and Amphibia 1 2
Invertebrates 1 2

Vegetation Condition Map Sites Comment

Disturbance Factors Comment Management

Swan Coastal Plain Floristic Survey compatible sites also

AHC: National Estate- Listed / Interim / Notified National Trust: Heritage Classification

Note: M1&2 and the extension of M6 to the coast should be considered as a unit as these recommendations are continually being 'modified' and the original proposals may not be tenable with changed land use. Keighery 1990, Griffin 1993, Keighery and Keighery 1992, Trudgen and Keighery 1990, Alkimos, Eglington, Mindarrie, Ningana and SCPFS 1994 can be used to gain information on the area.
This general statement also applies to other coastal M areas M35, M46, M90, M91, M106 & M 107 and the miscellaneous studies can be used to gain information on the area.

M1 Two Rocks Open Space		
M1.1 Regional park recommendations be applied to this area.	Unresolved Issues	At this stage there is no regional park proposal for this area.
M1.2 Proposal under Metropolitan Region Scheme to reserve M1 is endorsed.	Implemented	Recommendation is an endorsement. DPUD are reconsidering the boundaries of the reserve area through the Yanchep-Sun City development. Quinns Rock Environmental Research Group has an interest in this area.
M2 Coastal strip from Two Rocks to Burns Beach Bulletins 200 (Mindarie Keys, alt boundaries), 500 (Eglington Beach Reseort, alt. boundaries), 485 (Burns Beach, alt boundaries)		
M2.1 Regional park recommendations be applied to this area.	Unresolved Issues	A regional park is not being considered for this area. DPUD is preparing management plan for southern portion of M2. Quinns Rock Environmental Research Group has an interest in this area.

System 6 - REPORT Information Search Date 5/94

Please circle the appropriate response or respond in the space provided.

Area M 2 Name
Title
Published/Unpublished Date
Author/s

Author: Keighery G.J. Keighery B.J.
Date: 1992
Title: Flora of Burns Beach coastal reserve
Source: Unpublished Report

Community Group
Management Plan

Soils			
Units	mapped	described	referenced

Landscape		
Features	described	referenced

Flora					
Vegetation Map	describes a typical transect				
Units				Site based (no)	
Mapped					
Veg Units	Comparable Heddle *et al*		Compared Heddle *et al.*	Unit not mapped by Heddle *et al.*	
Flora list					
Timing	%completion			Significant Taxa	
	Trees	Shrubs Herbs	Sedges	Weeds	DRF CALM Prority Other

Fauna			
Timing	%completion		Significant Taxa
	Mammals	Birds	Sched1 Sched2 Other
	Reptiles	Invertebrates	

Vegatation Condition		
Site based	Mapped	Units
Disturbance Factors		
Phytophthora	observed	Other incidental
	tested	itemised

Notes

SHEET 1: System 6 - REPORT Information Search Date 13/5/94

Please circle the appropriate response or respond in the space provided

Area M 2 Name Burns Beach (part)

Title Flora and Vegetation of the Burns Beach Coastal Reserve

Published (Unpublished) Date 1992

Author/s G.J. Keighery and B.J. Keighery

Location of Publication CALM (Woodvale)

Purpose (why was the report prepared?) Flora Survey - student study

Government

Corporate

Community Group

Management Plan

Soils

Units mapped described referenced

Landscape

Features (described) referenced

Flora

Vegetation Map general description, sites along transect

Units Muir Site based (no) 5 or 6

Mapped

Veg Units (Comparable Heddle *et al*) Compared Heddle *et al*. Unit not mapped by Heddle *et al*.

Flora list not surveyed in detail, search significant flora

Timing %completion 60%. (Significant Taxa)

3 yrs (Trees) (Shrubs) (Herbs) (Sedges) (Weeds) DRF CALM Priority Other

Spring

Fauna

Timing %completion Significant Taxa

Mammals Birds Sched1 Sched2 Other

Reptiles Invertebrates

Vegatation Condition

Site based Mapped Units

Disturbance Factors general comments

Phytophthora observed NA Other (incidental)

tested itemised

Notes

- 2 permanent sites for floristic survey SCP

SHEET 1: System 6 - REPORT Information Search Date 3/5/94 Wan

Please circle the appropriate response or respond in the space provided.

Area M 2 Name (part)	
Title	Eglington / Atkinson Structure Plan.
Published/Unpublished	Date
Author/s	Allan Tingay and Assocs
Location of Publication	
Purpose (why was the report prepared?)	
Government	
Corporate	
Community Group	
Management Plan	

Soils			
Units	mapped	described	referenced

Landscape		
Features	described	referenced

Flora						
Vegetation Map						
Units				Site based (no)		
Mapped						
Veg Units	Comparable Heddle *et al*			Compared Heddle *et al.*	Unit not mapped by Heddle *et al.*	
Flora list						
Timing	%completion				Significant Taxa	
	Trees	Shrubs	Herbs	Sedges	Weeds	DRF CALM Priority Other

Fauna			
Timing	%completion		Significant Taxa
	Mammals	Birds	Sched1 Sched2 Other
	Reptiles	Invertebrates	

Vegatation Condition		
Site based	Mapped	Units
Disturbance Factors		
Phytophthora	observed	Other Incidental
	tested	itemised

Notes

SHEET 1: System 6 - REPORT Information Search Date 13/5/94

Please circle the appropriate response or respond in the space provided

Area M 2 Name Mindarrie (part)

Title Flora of the Mindarrie Casp Area

Published (Unpublished) Date 1991 (Lyons & Gibson Database)

Author/s G.J. Keighery

Location of Publication CALM (Woodvale)

Purpose (why was the report prepared?)

(Government) CALM – DPUD

Corporate

Community Group

Management Plan

Soils			
Units	mapped	described	referenced

Landscape		
Features	described	referenced

Flora						
Vegetation Map						
Units				Site based (no)		
Mapped						
Veg Units	Comparable Heddle *et al*		Compared Heddle *et al.*		Unit not mapped by Heddle *et al.*	
Flora list						
Timing	%completion				Significant Taxa	
	Trees	Shrubs Herbs	Sedges	Weeds	DRF	CALM Priority Other

Fauna			
Timing	%completion		Significant Taxa
	Mammals	Birds	Sched1 Sched2 Other
	Reptiles	Invertebrates	

Vegatation Condition		
Site based	Mapped	Units
Disturbance Factors		
Phytophthora	observed	Other incidental
	tested	itemised

Notes

System 6 - VERBAL Information Search Date 12/5/94

Area M 2 Name BURNS BEACH (part)				
Source N. GIBSON, G.J. KEIGHERY, G.J. KEIGHERY etc Swan Coastal Plain Floristic Survey (see general)				
Purpose (why was the study done?)				
Government				
Corporate				
Community Group				
Management Plan				
Publication Planned	Yes	No	Date	
Planned Location				

Soils		
Units	described	referenced

Landscape		
Features	described	referenced

Flora						
Vegetation Map						
Units MUIR / Floristic				Site based (no) 2		
Mapped						
Veg Units	Comparable Heddle *et al*		Compared Heddle *et al.*		Unit not mapped by Heddle *et al.*	
Flora list						
Timing	%completion				Significant Taxa	
	Trees	Shrubs Herbs	Sedges	Weeds	DRF	CALM Prority Other

Fauna			
Timing	%completion		Significant Taxa
	Mammals	Birds	Sched1 Sched2 Other
	Reptiles	Invertebrates	

Vegetation Condition				
Site based	Mapped	Units		
Disturbance Factors				
Phytophthora	observed		Other	incidental
	tested			itemised

Notes

L

Lomandra maritima, a sedge-like herb (L)

Lomandra maritima Low Herb Sedgeland, often with Melaleuca acerosa (>0.5m) shrubs from <2% cover to, occasionally, open low heath (mainly Spearwood Dunes).

The southern and central part of the survey area. In the survey area it is mainly restricted to ridges and upper slopes away from the coast

Sites: ① L.m., M.a., Loxocarya aspera, Hemiandra ?glabra, Romulea rosea, Hybanthus calycinus, Eremophila glabra ssp. West Coast, Rhagodia baccata ssp. baccata, Conostylis ?aculeata ssp. cygnorum, Austrostipa ?macalpinei, Hardenbergia comptoniana, Lechenaultia linarioides occasional Acacia saligna, Spyridium globulosum, Olearia axillaris (grey), Scaevola ? thesioides ssp. thesioides

⑦ like ① but with more shrubs

61.75 ±, 62.0, (11), (12)

D D Dryandra sessilis (Parrotbush)

(D)

Dryandra sessilis Shrubland to Tall Closed Scrub

often with only one, dominant shrub, but sometimes with other species and intergrading with M, B, S

Generally on shallow sand over limestone on ridges and upper slopes.

Sites: (3), (4), (61.7) (62.2), (19)

C

Scaevola crassifolia (Thick Leaved Fan Flower) (C)

Scaevola crassifolia Open to Closed Low Heath with Carpobrotus virescens, Lepidosperma gladiatum, Isolepis nodosa, Spyridium globulosum, spinifex sp. , Olearia axillaris, ~~(Foredunes) and Inner~~ Pelargonium Capitatum,

(Foredunes)

Sites: (10), (11B)

RS Acacia nodt. / Spy. glob (RS)

Mixture of the two,
which intergrade with each other
and with Melaleuca cardiophylla
(62.3)

Sites: (62.2) southward up hill, (62.3)

MS MS Mel. card / spy- 9100.

MS

Mixture and mosaic of Melaleuca cardiophylla and Spyridium globulosum vegetation.

R

Acacia rostellifera (R)

Acacia rostellifera ~~Shrubland~~ Open Heath to Closed Tall Scrub often with Acacia cochlearis

Sites: (6), (18) Acan cochlearis

MD

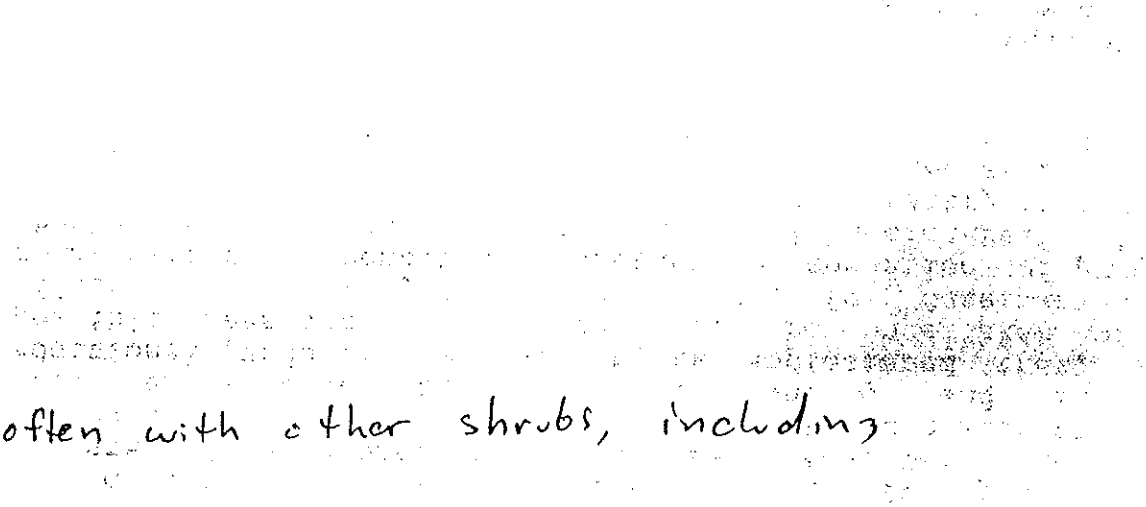
Mel. card. / Dry: sess. (MD)

Mosaic and mixture of Melaleuca cardiophylla, Mel. huegelii & Dryandra sessilis

Sites: (8)

Eyridium globulosum

(5)



often with other shrubs, including

There are also a few, scattered Tuart trees (or mallees) on lower slopes and in valleys in the southern part of the strip, probably outside the survey area.

Sites: (3A), (11B)

MM

M. cord, M. hues., Myoporum insulare

(MM)

Mixed Closed ~~Heath~~ Heath to Closed Tall Scrub on sand over limestone, with (Melaleuca cardiophylla) M. hueseli, Myoporum insulare, Scaevola nitida, ~~and~~ Acacia cyclops, ~~and other shrubs~~ Spyridium globulosum, ?Acacia ~~truncata~~ ?truncata ~~linifolia~~, Leucopogon parviflorus

This variation of the Melaleuca cardiophylla community runs eastward from a limestone cliff.

Site: (13)

LS

L. maritima / Spyridium glob.

(LS)

Spyridium globulosum Tall Open to Open Shrubland and scattered ~~Mata~~ shrubs and groups of shrubs over Lomandra maritima, Low Herb Sedgeland

Mainly on middle to upper slopes.

Sites:

M

Melaleuca cardiophylla (& M. huegelii)

M

Melaleuca cardiophylla Closed Tall Scrub, often with M. huegelii (Chenille Honey-myrtle)

on sand, often shallow over limestone, usually on middle slopes, and intergrading with Dryandra sessilis and Spyridium globulosum communities.

Sites: (3B), (8), (11D), (64.8), (65.05), (65.2)

CT

Scaevola crassifolia / Tetragonia decumbens

(CT)

Mosaic or mixture of Scaevola Heath and mats of Tetragonia decumbens and Very Low Heath of Frankenia ?pauciflora on coastal limestone and shallow soil over limestone.

(on cliffs above beach) - 1 location

Sites: (12) (65.55)

X x Xanthorrhoea preissii (Balga) (X)

Xanthorrhoea preissii Open Shrubland to Tall Open Scrub, generally over Lomandra maritima Low Herb Sedgeland

Sites: (2) 1-2m, 30-70%, (5), (62.0 N)

XS XS Xanth. preiss / spy. glob (XS)

Mosaic and mixture of Xanthorrhoea preissii unit and Spyridium globulosum unit (over L)

Site:

W

Weeds

(W)

Pelargonium capitatum and various annual grasses are the most widespread conspicuous weeds in the survey area, but *Trachyandra divaricata*, *Euphorbia terracina*? and *Carpobrotus edulis* are also conspicuous, especially near the coast.

They are commonest in cleared areas, and open areas along tracks, especially in [illegible] vegetation.

Sites: (62.2), (62.5), (9), (11), (11c), (14)

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M2

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAM FOR MINDARIE KEYS PROJECT

VOLUME I - REPORT

CONSTR. SURP.

BS 397

See attached Vdume II for flora lists

March 1985

Scott & Furphy Engineers Pty. Ltd.
Consulting Engineers
Le Provost Semeniuk & Chalmer
Environmental Consultants

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C6.2.3 FAUNA

Several studies have been carried out on the fauna of the northern Swan Coastal Plain, the most relevant being those conducted by the Western Australian Museum (1978), Butler (1981) and Kinhill Stearns (1983). The latter two studies took place in a proposed refuse disposal facility at Mindarie. This site is south of, and contiguous with, the Mindarie Keys proposal and it can therefore be assumed that their fauna is very similar, if not identical. The Western Australian Museum study was used to prepare a provisional list of those species which could be expected if further seasonal field studies were conducted.

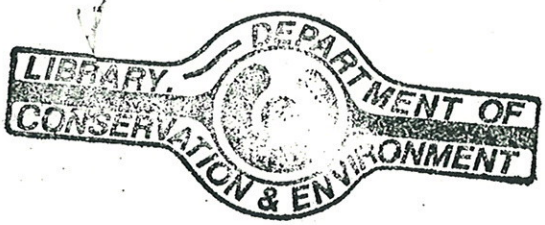
Authors such as Kitchener et al. (1978) and Storr et al. (1978) consider many of the northern Swan Coastal Plain fauna listed for the Mindarie area as scarce or rare. This is correct in a local, but not in a regional sense, since all the known and predicted species have geographic ranges extending well beyond the area under review. Many, if not most, of the animals recorded are present in surrounding uncleared land, and national parks such as Neerabup and Yanchep. Further detail is provided in Appendix 6.

1. Olearia/Spinifex/Tetragonium

627.2:1
Sco
vol.2
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See attached Volume II for flora lists

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAM FOR MINDARIE KEYS PROJECT

VOLUME II - TECHNICAL APPENDICES

March 1985

Scott & Furphy Engineers Pty. Ltd.
Consulting Engineers
Le Provost Semeniuk & Chalmer
Environmental Consultants

TABLE 2

THE COMPOSITION OF THE ELEVEN ASSEMBLAGES DESCRIBED FROM THE QUINNS ROCK STUDY AREA

* Indicates introduced species

1. Olearia/Spinifex/Tetragonium Low Shrubland

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Asteraceae		
* Artotheca populifolia	.	+
Olearia axillaris	+	.
Senecio lautus	.	+
Aizoaceae		
* Carpobrotus edulis	.	+
Tetragonia decumbens	+	.
Brassicaceae		
Cakile maritima	.	+
Chenopodiaceae		
Atriplex isatidea	.	+
Rhagodia baccata	.	+
Rhagodia sp.	.	+
Cyperaceae		
Lepidospermum gladiatum	+	.
Scirpus nodosus	.	+
Euphorbiaceae		
Phyllanthus calycinus	.	+
Geraniaceae		
* Pelargonium capitatum	+	.
Goodeniaceae		
Scaevola crassifolia	+	.
Onagraceae		
* Oenthera drummondii	.	+

.....cont'd

TABLE 2 (continued)

1. Olearia/Spinifex/Tetragonium Low Shrubland (continued)

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Papilonaceae		
Hardenbergia comptoniana	.	+
Poaceae		
* Avena fatua	.	+
Spinifex hirsutus	+	.
S. longifolius	+	.
Liliaceae		
Acanthocarpus preisii	+	.
* Trachyandra divaricata	.	+
Myoporaceae		
Myoporum insulare	+	.
Rhamnaceae		
Spyridium globulosum	.	+
Santalaceae		
Santalum acuminatum	.	+

.....cont'd

TABLE 2 (continued)

2. Olearia/Melaleuca/Acacia/Santalum Open Heath

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Asteraceae		
Olearria axillaris	+	.
* Senecio elegans	.	+
Cyperaceae		
Lepidosperмum gladiatum	+	.
Epacridaceae		
Leucopogon propinquus	.	+
Dilleniaceae		
Hibbertia racemosa	.	+
Euphorbiaceae		
Phyllanthus calycinus	.	+
Goodeniaceae		
Scaevola crassifolia	.	+
Geraniaceae		
* Geranium molle	+	.
* Pelargonium capitatum	+	.
Haemodoraceae		
Conostylis candicans	+	.
Liliaceae		
Acanthocarpus preissii	+	.
Mimosaeceae		
Acacia cochliaris	+	.
A. cyanophylla	.	+
A. pulchella	.	+
Myrtaceae		
Melaleuca acerosa	+	.
M. heugelii	.	+
M. cardiofolia	.	+

.....cont'd

TABLE 2 (continued)

2. Olearia/Melaleuca/Acacia/Santalum Open Heath (continued)

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Papilonaceae		
Hardenbergia comptoniana	.	+
* Medicago polymorpha	+	.
Poaceae		
* Avena fatua	+	.
Primulaceae		
* Anagallis sp.	+	.
Restionaceae		
Loxocarya sp.	.	+
Rhamnaceae		
Spyridium globulosum	+	.
Santalaceae		
Anthobolus sp.	.	+
Santalum acuminatum	.	+
Thymeliaceae		
Pimelia ferruginea	.	+

TABLE 2 (continued)

3. Olearia/Melaleuca Low Open Shrubland

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Aizoaceae		
* Carpobrotus edulis	.	+
Asteraceae		
Olearia axillaris	+	.
* Senecio elegans	.	+
Senecio lautus	.	+
Chenopodiaceae		
Rhagodia baccata	+	.
Cyperaceae		
Lepidosperma gladiatum	.	+
Dilleniaceae		
Hibbertia hypericoides	.	+
Epacridaceae		
Leucopogon propinquus	.	+
Euphorbiaceae		
Phyllanthus calycinus	.	+
Geraniaceae		
* Geranium molle	+	.
* Pelargonium capitatum	.	+
Goodeniaceae		
Scaevola crassifolia	.	+
Haemodoraceae		
Conostylis candicans	+	.
Liliaceae		
Acanthocarpus preissii	+	.
* Trachyandra divaricata	.	+

.....cont'd

TABLE 2 (continued)

3. **Olearia/Melaleuca Low Open Shrubland** (continued)

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Mimosaceae		
Acacia cuneata	.	+
Myoporaceae		
Eremophila glabra	.	+
Myoporum insulare	.	+
Myrtaceae		
Calothamus quadrifidus	.	+
Melaleuca acerosa	+	.
M. heugelii	.	+
Papilonaceae		
Gompholobium tomentosum	.	+
Hardenbergia comptoniana	.	+
Kennedia prostrata	.	+
* Medicago polymorpha	+	.
Templetonia retusa	.	+
Poaceae		
* Avena fatua	.	+
Proteaceae		
Dryandra nivea	.	+
Grevillea thelmaniana	.	+
Petrophile serruriae	.	+
Rhamnaceae		
Spyridium globulosum	+	.
Sterculiaceae		
Thomasia triphylla	.	+

.....cont'd

TABLE 2 (continued)

4. Eucalyptus gomphocephala/Lepidospermum Open Forest

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Cyperaceae		
Lepidospermum gladiatum	+	.
Myrtaceae		
Eucalyptus gomphocephala	+	.
Papilonaceae		
* Medicago polymorpha	+	.
Poaceae		
* Avena fatua	+	.
and mixed introduced species	+	.
Rhamnaceae		
Spyridium globulosum	+	.

.....cont'd

TABLE 2 (continued)

5. **Melaleuca/Thomasia/Grevillea Low Shrubland**

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Asteraceae		
Olearia axillaris	.	+
Helichrysum sp.	.	+
Epacridaceae		
Leucopogon propinquus	.	+
Euphorbiaceae		
Phyllanthus calycinus	.	+
Geraniaceae		
* Geranium molle	+	.
Goodeniaceae		
Scaevola crassifolia	+	.
Haemodoraceae		
Conostylis candicans	+	.
Liliacea		
Acanthocarpus preissii	.	+
Mimosaceae		
Acacia cuneata	+	.
A. rostellifera	.	+
Myoporaceae		
Eremophila glabra	.	+
Myrtaceae		
Calothamnus quadrifidus	.	+
Melaleuca acerosa	+	.
M. cardiophylla	.	+
M. heugelii	.	+

.....cont'd

TABLE 2 (continued)

5. **Melaleuca/Thomasia/Grevillea Low Shrubland** (continued)

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Papilonaceae		
Gompholobium tomentosum	.	+
Hardenbergia comptoniana	+	.
* Medicago polymorpha	+	.
Templetonia retusa	.	+
Poaceae		
* Briza maxima	.	+
Primulaceae		
* Anagallis sp.	+	.
Proteaceae		
Dryandra sessilis	+	.
D. nivea	+	.
Grevillea thelmaniana	+	.
Petrophile serruriae	.	+
Restionaceae		
Loxocarya sp.	+	.
Sterculiaceae		
Thomasia triphylla	+	.
Stylidiaceae		
Stylidium spp	.	+
Violaceae		
Hybanthus calycinus	.	+

....cont'd

TABLE 2 (continued)

6. **Acacia/Melaleuca Closed Scrub**

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Chenopodiaceae		
Rhagodia sp.	.	+
Euphorbiacea		
Phyllanthus calycinus	.	+
Haemodoraceae		
Conostylis candicans	.	+
Mimosaceae		
Acacia cyanophylla	+	.
A. rostellifera	+	.
Myrtaceae		
Calothamnus quadrifidus	.	+
Eucalyptus rudis	.	+
Melaleuca acerosa	.	+
M. cardiofolia	+	.
M. heugelii	+	.
Orchidaceae		
Caladenia latifolia	+	.
Rhamnaceae		
Spyridium globulosum	.	+
Santalaceae		
Anthobolus sp.	.	+

.....cont'd

TABLE 2 (continued)

7. Acacia/Dryandra Tall Shrubland

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Asteraceae		
* Senecio elegans	.	+
Chenopodiaceae		
Rhagodia sp.	.	+
Geraniaceae		
* Geranium molle	+	.
* Pelargonium capitatum	.	+
Mimosaceae		
Acacia cyanophylla	+	.
A. cyclops	.	+
Myrtaceae		
Calothamnus quadrifidus	.	+
Melaleuca acerosa	+	.
M. cardiofolia	.	+
M. heugelii	+	.
Papilonaceae		
* Medicago polymorpha	+	.
Poaceae		
* Avena fatua	+	.
Primulaceae		
* Anagallis sp.	+	.
Proteaceae		
Dryandra sessilis	+	.
Hakea glabella	.	+
Petrophile serruriae	.	+
Rhamnaceae		
Spyridium globulosum	.	+

.....cont'd

TABLE 2 (continued)

8. Dryandra/Melaleuca Closed Heath

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Dilleniaceae		
Hibbertia hypericoides	+	.
Haemodoraceae		
Conostylis candicans	+	.
Myrtaceae		
Melaleuca acerosa	+	-
M. cardiofolia	.	+
M. heugelii	.	+
Proteaceae		
Dryandra nivea	+	.
D. sessilis	+	.
Petrophile serruriae	+	.
Restionaceae		
Loxoncarya sp.	+	.

9. Acacia cuneata Closed Heath

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Mimosaceae		
Acacia cuneata	+	.
A. cyanophylla	.	+
Proteaceae		
Dryandra sessilis	.	+
Petrophile serruriae	.	+

.....cont'd

TABLE 2 (continued)

10. Banksia/Xanthorrea Low Open Woodland

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Dilleniaceae		
Hibbertia hypericoides	+	.
Haemodoraceae		
Conostylis candicans	.	+
Xanthorrea preissii	+	.
Proteaceae		
Banksia attenuata	+	.

11. Threlkeldia/Frankenia Herbland

SPECIES	DOMINANT TO COMMON WITHIN A STRUCTURAL COMPONENT	PRESENT WITHIN A STRUCTURAL COMPONENT
Chenopodiaceae		
Threlkeldia diffusa	+	.
Frankeniaceae		
Frankenia paucifolia	+	.
Myoporaceae		
Tetragonia decurrens	+	.

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See File 105

TOKYU CORPORATION

RESPONSE TO
DRAFT NORTH-WEST CORRIDOR STRUCTURE PLAN
DEPARTMENT OF PLANNING & URBAN DEVELOPMENT
(February 1991)

YANCHEP STRUCTURE PLAN

VERTEBRATE FAUNA SURVEY

ALAN TINGAY & ASSOCIATES

OCTOBER 1991

BFS 393

DRAFT TWO ROCKS YANCHEP FORESHORE MANAGEMENT PLAN

Comments due
02/8/05
Now Sent
BR 8/9/05

June 2005

City of Wanneroo

City of Wanneroo, 23 Dundebar Road, WANNEROO WA 6065
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1.0 INTRODUCTION

1.1 Background

In 1997, Council adopted two Foreshore Management Plans for the Two Rocks Yanchep foreshore area, these being:

1. The Two Rocks - Yanchep Foreshore Management Plan for the foreshore areas adjacent to the two townsites. This plan was prepared by Bill James Landscape Architects on behalf of the City.

2. The Lot 614 Yanchep Foreshore Management Plan relating to the foreshore area abutting the Ocean Lagoon Estate, Yanchep. This plan was prepared by O'Brien Planning Consultants on behalf of Peet and Company as part of its land development obligations.

Council considered a consolidation and review of these plans at its meeting on 17 December 2002 and resolved to endorse a series of management strategies and plans for the purposes of advertising. The review was generally an update of the strategies contained in the 1997 plans and related to various rehabilitation, fencing and other works that were still to occur in the subject area. In addition, the review sought to investigate an alternative site for the Yanchep Surf Life Saving Club and a pathway/boardwalk connection between Compass Circle and Foreshore Vista.

The review was advertised for an eight-week period concluding on 21 March 2003. Twelve submissions and a 158-signature petition were received. Many of these submissions identified the need for a more detailed assessment of the environmental issues affecting this foreshore area. Flora and vegetation surveys, together with associated management recommendations have since been undertaken by an environmental consultant in order to verify the suitability to the plan recommendations. Appropriate adjustments have been made to the plan recommendations, where necessary, to reflect the environmental assessment.

Council adopted the Capricorn Coastal Village Structure Plan at its meeting on 14 October 2003. This structure plan area is located to the immediate north of the existing Yanchep Townsite and abuts the foreshore reserve that exists between the Yanchep Lagoon and the existing Club Capricorn Holiday Village. A draft independent Foreshore Management Plan was prepared for the foreshore area abutting this estate by the developer, however to provide for a higher level of integration, the developer agreed to assist in preparing a single consolidated plan for the overall area. This was also agreed by Council at its meeting on 16 March 2004.

The current plan represents a consolidation and review of the previous Foreshore Management Plans for the Two Rocks Yanchep area.

1.2 Purpose

The purpose of the Foreshore Management Plan is to provide a framework for protecting and enhancing the environmental, landscape, heritage and recreation values of the study

area, whilst providing for a level of infrastructure necessary to cater for the significant planned future growth of the Two Rocks and Yanchep areas.

Whilst the Foreshore Management Plan is intended to be a strategic document, which will guide development, use and management of land within the study area over the long term, the plan will require periodic review in order to ensure that it remains relevant and that its objectives are being met.

1.3 Objectives

The objectives of the Foreshore Management Plan are to:

1. Identify the natural resources and processes as well as the necessary management measures for preserving and enhancing the environmental values of the study area;
2. Identify and provide for sustainable levels of leisure, recreation, tourism, commercial and general public infrastructure necessary for the planned population growth in the surrounding area;
3. Identify and provide opportunities for interpretational facilities consistent with the environmental and heritage values of the area;
4. Develop an implementation plan for future development and management within the study area, which outlines priorities, responsibilities and an indication of the likely costs of each action.

1.4 Study Area

The study area is located approximately 50 kilometres north of the Perth Central Business District, within the north western part of the City of Wanneroo. It extends a distance of around seven kilometres and an area of 1,350 hectares.

The study area comprises two separate sections, being the areas of foreshore located:

1. Between the Club Capricorn Resort and the southern extent of Trumpeter Way in the 'Ocean Lagoon' Estate, Yanchep;
2. Adjacent to the existing Two Rocks residential area.

Figure 1 indicates the regional location and extent of the study area.

1.5 Land Tenure

The study area consists of numerous land parcels in both Crown and freehold ownership, as detailed in **Tables 1** and **2** and **Figure 2.**

TABLE 1 - LAND TENURE – TWO ROCKS

Reserve(R)/Lot No.	Owner/ Vesting Agency	Purpose	Power to Lease (years)
R20561	Crown/ City of Wanneroo	Recreation and purposes incidental thereto	21
R45379	Crown/Department of Land Information	Foreshore Management	N/A
R33444	Crown/City of Wanneroo	Public Recreation	No
R44322	Department for Planning and Infrastructure	Navigation Beacon	N/A
Lot 34601	Crown Land/DLI	Government Purposes	N/A
Lot 8796	Crown land leased to Yanchep Sun City P/L	Marina	
R34379	Crown vested City of Wanneroo	Public recreation	No
Lot 8506	Crown/DLI		
Lot 8508	Crown/DLI		
R33431	Crown/City of Wanneroo	Public Recreation	No
Lot 10	Tokyu Corporation	Parks and Recreation	N/A
Lot 8989	Pyrford Court Pty Ltd	Parks and Recreation and Urban Development	N/A
R30959	Crown/City of Wanneroo	Public Recreation	No

TABLE 2 - LAND TENURE - YANCHEP

Reserve (R)/Lot No.	Owner/ Vesting Agency	Purpose	Power to Lease
R20561	Crown/City of Wanneroo	Recreation and purposes incidental thereto	21
R32510	Crown/City of Wanneroo	Public Recreation	No
Lot 304	Capricorn Investment Group Pty Ltd	Public Recreation and Urban Development	N/A
R29352	Crown/City of Wanneroo	Public Recreation	No
R39022	Crown/City of Wanneroo	Clubrooms	Up to 21
R12439	Crown/City of Wanneroo	Recreation (A Class Reserve)	No
R43792	Crown/City of Wanneroo	Purposes ancillary to beachfront recreation	Up to 21
R29694	Crown/City of Wanneroo	Recreation	Up to 21
R29354	Crown/City of Wanneroo	Public Recreation	No
R32978	Crown vested City of Wanneroo	Public Recreation	No
Lot 612	Crown/City of Wanneroo	Public Recreation	No
R45385	Crown/City of Wanneroo	Public Recreation	No
Lot 132	Freehold	House	N/A
Lot 133	Freehold	House	N/A
Lot 134	Freehold	House	N/A
Lot 135	Freehold	House	N/A

1.6 Zoning

The study area is predominantly reserved for Parks and Recreation under both the Metropolitan Region Scheme and City of Wanneroo District Planning Scheme No. 2, with some small areas zoned Urban and Urban Development under the respective schemes. Detailed zonings of the study area and surrounding land are shown on **Figures 3** and **4**.

2.0 Natural Environment

2.1 Climate

The Two Rocks Yanchep area experiences a warm Mediterranean climate with hot dry summers and cool wet winters. Air temperatures are similar to those experienced in Perth, where mean daily maximum temperatures vary from 30°C in summer to 17.5°C in winter, and mean daily minimum temperatures vary from 18.5°C in summer to 9.1°C in winter.

Rainfall in the area occurs mostly during the winter months, with monthly totals during this period occasionally in excess of 100mm. Monthly rainfall of up to 50mm may occur in the remaining months. Previous records indicate that the average annual rainfall is around 670mm.

Winds are an important climatic factor in the Two Rocks, Yanchep area as much of the landscape in the study area has been constructed by aeolian (wind driven) deposition and is particularly susceptible to the erosive powers of the wind if the natural vegetation is removed.

During the summer months winds blow from the east to south-east in the morning (4am to midday) and from the south-west in the afternoon (1pm to 6pm). Alternatively, winter is characterised by north-westerly storm winds that back to the west and south-west, interspersed with calmer periods.

Major storms during winter, involving 70 km/h winds for periods of 6 to 24 hours, occur two to ten times per year. Occasionally, in the period of summer to autumn, tropical cyclones migrate further southwards than normal and may bring gale force winds to the Two Rocks, Yanchep coastline. During these events winds up to 130km/h are often experienced.

2.2 Geology

The geological formations present in the study area consist of Holocene Safety Bay Sand and the Pleistocene Tamala Limestone.

Safety Bay Sand occurs within the Quindalup Dune System, which is the most recent of the dune systems represented on the Swan Coastal Plain. It comprises white, fine to medium grained, sub-rounded sand composed of small marine organism skeletal fragments with small amounts of quartz and feldspar. The calcium carbonate content is generally greater than 50%.

The coastal dunes adjacent to the beach have been formed from the action of the ocean and wind on the Safety Bay Sand. The Safety Bay Sand is generally unconsolidated but may be weakly cemented in places. The sand is stabilised temporarily by vegetation but where disturbance has occurred and this vegetation cover is lost the sand becomes highly mobile.

Tamala Limestone occurs within the Spearwood Dune System, which is the intermediate aged (late Pleistocene) dune system of the Swan Coastal Plain. It is made up of light to yellowish brown fine to coarse grained, sub angular to well rounded aeolian calcarenite (sand grains cemented together by calcium carbonate to form rock.) Tamala limestone occurs within the study area as exposed beach cliffs, wave cut platforms and rock shelves where the overlying Safety Bay Sand has been removed through wind and wave action.

2.3 Geomorphology

The geomorphic unit of the study area is the Quindalup Dune System. This system is a Holocene aeolian (wind-formed) landform of the Safety Bay Sand. It contains a variety of dune forms with those present within the study area consisting fretted parabolic dune field and discontinuous shore parallel ridges including fore dunes.

Parabolic dunes are sand dunes that are u-shaped to spatulate in plan, and are convex in the downwind direction. Fretted describes a condition where the arms of the dunes have developed subsidiary smaller blowouts and parabolic dunes. These dunes predominate at both Two Rocks and Yanchep.

Shore parallel ridges are a system of linear parallel sand ridges developed transverse to the shore. These dunes occur in areas of accretion, that is where sand is being deposited by wave and wind action. These dunes form narrow strips at the back of the beach north of Yanchep and south of Two Rocks.

Where the dunes have been cut back by the sea to expose limestone, the underlying Spearwood Dune System outcrops as Tamala Limestone.

2.4 Tides

The study area has one tide per day. The normal tide is 0.5 metre with a range over the year in the order of 1 metre. A 100-year storm surge will produce a tidal surge of 1.9 metre above chart datum. This compares to a mean high water level of 0.9 metre and the highest astronomical (storm independent) tide level of 1.3 metres.

2.5 Wave Climate

Wave conditions are influenced by a variety of factors including wind, tides, atmospheric conditions and bathymetry.

The Two Rocks Yanchep area experiences a prevailing refracted long period (7-15 seconds) south-west swell. Local wind conditions may generate short period (2-7 second) waves which are superimposed on the swell.

Sea breezes reinforce south-west waves in summer and may cause seas of up to 1.5 metres. North-west and westerly gales may produce high energy waves. Summer sea breezes and winter storms will cause seasonal variation in the prevailing wave conditions.

Wave attenuation occurs by wave refraction, shoaling, breaking, atmospheric inputs, bottom friction, wave interaction and wave diffraction. The extent of attenuation will depend on nearshore bathymetry, seagrass cover and the presence/absence of offshore reef.

2.6 Ongoing Coastal Processes

Coastal processes are dominated by wind and tidal action, which distribute sediment by seasonal onshore and offshore migration and longshore transport. The magnitude of these processes is dependant on climatic conditions.

A primary factor influencing these processes in the Two Rocks Yanchep area is the prevailing south westerly swell. This has eroded the outer reefs, caused onshore sediment transport, and continues to produce longshore currents that mobilise sand in the surf zone.

Diffraction of the swell waves as they pass through the inner chain of reefs produces local longshore currents in the surf zone that flow in various directions, depending on the complex patterns of divergence and convergence produced during diffraction. Wind generated waves have a significant effect in this near shore environment because they overprint local currents to produce a sustained unidirectional longshore current. Such sustained currents generally move sediment northward during summer and southward during winter in response to prevailing seasonal winds. As the summer wind, swell, and wave regime is dominant, there is a slight northerly bias to net sediment transport.

The banks of offshore reefs and seagrass meadows that generally are adjacent to the coast, significantly attenuate the offshore wave climate and reduce wave heights, resulting in a considerably milder sediment transport regime along much of this coast than might be expected on an open coast.

During winter, steep wind generated waves contribute to coastal processes by combining with surges during storm events, to attack high parts of the beach normally isolated from wave action. This type of wave attack erodes the beach and foredunes and produces an offshore bar. During summer, sediment from the bar and sediment generated by erosion of pre-existing geomorphic features, such as reefs and the sea floor, is returned to the beach by the prevailing south-west swell and wind waves.

2.7 Shoreline Movement

An analysis of aerial photographs between 1941 and 1996 indicates that the vegetation line to the south of the Yanchep Lagoon has been fairly constant. The waterline in this area has however experienced large fluctuations over time with an overall erosion of around 30 to 40 metres. In the Lagoon area itself, the vegetation line has moved offshore in the northern sector and remained constant in the southern sector. The waterline in the lagoon area has however fluctuated significantly over time, with the northern section showing an offshore movement, or accretion, whilst the southern section closest to the reef showing erosion.

To the north of the Lagoon, the construction of the Club Capricorn groyne appears to have inflenced sediment movement and shoreline stability, interrupting the longshore movement of sand causing erosion on the northern side and accretion on the southern side of the groyne. From 1971, when the groyne was constructed, to 1982, the vegetation line in the area between the groyne and the Lagoon has moved offshore by around 50 metres. The shoreline in this area has also accreted significantly with the groyne now being saturated to its end with sand. Since 1982, the waterline has remained fairly constant, fluctuating within a 20 metre band. The accreting influence of the groyne appears to extend between 700 and 1,000 metres south of the groyne. There was no evidence that the groyne has affected the Lagoon. North of the groyne the vegetation has exhibited continual offshore movement. In contrast, the waterline moved continually onshore, narrowing the gap between the water and vegetation, until 1987 when slight accretion has occurred, indicating that the sand bypassing the groyne had become more significant. Immediately north of the groyne, there has been continual accretion, particularly between 1971 and 1982, following the construction of the groyne.

The construction of the Two Rocks marina also appears to have influenced sediment movement and shoreline stability for the Two Rocks portion of the study area. An analysis of aerial photographs showing the coastal vegetation line in the vicinity of the Two Rocks marina from 1941 to 1973 indicates that the position of the coastal vegetation during this time generally varied less that ten metres. These plans also show that from 1973, when the marina was constructed, to 1983, there was significant accretion of the coast immediately south of the marina. In 1997, a more detailed shoreline movement study was undertaken which indicates that the vegetation line moved in a seaward direction by about 21 metres between 1985 and 1996. The steep sandy cliff face along the beach to the north of the marina indicates that this section of coastline is experiencing erosion. Given the present configuration of the breakwaters and the net longshore transport from south to north, it is anticipated that this pattern will continue for decades to come.

2.8 Sea Level Change

There is strong evidence and international consensus that the global climate is changing and that increasing concentrations of greenhouse gases in the atmosphere is playing a significant contributing role in this. The potential impacts of global climate change includes a rise in sea level, with the resultant implications for coastal stability.

Predictions for sea level rise vary, with recent estimates ranging from a rise of 9 to 88 centimetres to 2100AD. A one centimetre rise in sea level is likely to cause a one metre shoreline retreat on a sandy beach. The State Coastal Planning Policy has accepted a sea level rise figure of 38 centimetres for inclusion in its coastal setback development guidelines.

The issue of potential climate change and any resultant effects on coastal processes is quite complex and would be site specific. For example, the future potential erosion from climate induced sea level change could be offset by the shoreline accretion to the south of the Two Rocks marina.

2.9 Flora and Vegetation

A flora and vegetation survey for the majority of the study area was carried out by Bowman, Bishaw, Gorham Environmental Management Consultants in 2002. The Survey methodology, flora, vegetation types and condition are detailed in **Appendices 1 – 3** respectively. The remaining portion of the study area, being that area north of the Yanchep Lagoon, was surveyed by ATA Environmental in 1992 and 2004.

2.9.1 Flora

The plant taxa recorded from survey work are estimated to constitute more than 80 per cent of the expected flora present within the study area, both native and alien. Ten taxa which, according to Bush Forever are significant, were recorded during survey work. They are *Acacia xanthina, Actites megalocarpa, Agonis flexuosa, Allocasuarina lehmanniana, Callitris preissii, Eucalyptus foecunda, Grevillea obtusifolia, Melaleuca cardiophylla, Melaleuca lanceolata* and *Stylidium maritimum*. However, four of these taxa - *Agonis flexuosa, Callitris preissii, Grevillea obtusifolia* and *Melaleuca lanceolata* - are suspected of having been planted or otherwise introduced into the study area.

No Declared Rare or Priority 1 or 2 Flora plants were found in the study areas, nor are any likely to be there.

2.9.2 Vegetation

Bush Forever

The majority of the study area lies within Bush Forever Site 397, which relates to the coastal strip from Wilbinga to Mindarie. The boundary of Bush Forever Site 397 in relation to the study area is shown in **Figure 5**.

Bush Forever lists vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region, along with their areas and other information. Forty eight percent of the original 24,381 ha of Quindalup Complex remains. This percentage is more than the 30% "threshold level" specified by the Environmental Protection Authority to remain uncleared. However, it should be noted that this information was based on 1997 aerial photos and much clearing has happened since then. Fourteen percent (3,527 ha) of the original Quindalup vegetation has some existing protection. Bush Forever specifies that at least 10 per cent of each vegetation complex needs effective protection.

Vegetation Types and Condition

The vegetation types and condition recorded during the survey work has been mapped and included in **Figures 6** and **7**. **Figure 6e** provides a list of the vegetation types mapped in the study area and **Table 3** contains the six-point condition scale used, which is consistent with the scale used in Bush Forever.

TABLE 3
Vegetation Condition Scale

Symbol	Condition	Description
P	Pristine	No obvious signs of disturbance
E	Excellent	Vegetation structure intact, disturbance affecting individual species, weeds are non-aggressive species
V	Very Good	Vegetation structure altered, obvious signs of disturbance
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained
D	Degraded	Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good condition without intensive management
CD	Completely Degraded	Vegetation structure not intact; the area completely or almost completely without native species ('parkland cleared')

Floristic Community Types

Seven Floristic Community Types (FCTs) were inferred from the survey data. From the species recorded during the survey and reference to Gibson *et al.* (1994) and Bush Forever FCTs 16, 27, 29a, 29b, S11, S13 and S14 are those most likely to be represented in most of the study area.

The names given to the seven floristic community types in Bush Forever are:

- FCT 16 Highly saline seasonal wetlands (*Frankenia pauciflora - Sarcocornia quinqueflora*)
- FCT 27 Species-poor mallees and shrublands on limestone
- FCT 29a Coastal shrublands on shallow sands
- FCT 29b *Acacia* shrublands on taller dunes
- FCT S11 Northern *Acacia rostellifera – Melaleuca acerosa* (*M. systena*) shrublands
- FCT S13 Northern *Olearia axillaris – Scaevola crassifolia* shrublands
- FCT S14 *Spinifex longifolius* grasslands and low shrublands.

The Reservation and Conservation Status given by Gibson *et al.* (1994) for four of the seven floristic community types (FCTs) which may be represented in the study area are as follows:

FCT	Extent of Reservation	Risk
FCT 16	Poorly reserved	Vulnerable
FCT 27	Well reserved	Low risk
FCT 29a	Poorly reserved	Susceptible
FCT29b	Poorly reserved	Susceptible

Bush Forever lists Floristic Community Types 16, S11 and S14 as being confined to the Perth Metropolitan Region. Type 29b is sampled and inferred in most of the coastal Bush Forever sites, but the only coastal Bush Forever Site listing Type 27 is Site 325 (Ocean Reef).

None of these seven floristic community types is listed as a threatened ecological community in Bush Forever. However, Floristic Community Types 29a and 29b have been proposed for listing as ranks 100 and 101 respectively (English and Blyth 1997).

Vegetation Significance

Griffin (1993) and Griffin and Trudgen (1994, 1991) have concluded from detailed studies of Quindalup Dunes flora and vegetation north of the Swan River and south of Mandurah that there is significant variation in vegetation along the coast. Even within the relatively short distance covered in this Foreshore Management Plan, there appears to be significant variation between areas, even if allowance is made for variation in defining vegetation types. The survey work implies variation in both flora and especially vegetation. Consequently, and at least provisionally, any vegetation type in the study area assigned a condition rating of Very Good or Excellent probably warrants consideration as significant for conservation.

Larger stands of *Melaleuca cardiophylla* are considered significant also because such stands are at the southern end of their range and are poorly reserved in the Perth Metropolitan Region. Griffin and Trudgen (1994) list the range of *Melaleuca cardiophylla* as Exmouth to Mullaloo. Forms of the *Melaleuca cardiophylla* association were found throughout the study area, but the largest stands and the ones assessed to be in the best condition adjoin study area, in particular south-east of the Two Rocks South portion of the study area. *Melaleuca cardiophylla* Closed Scrub is widespread to the south and east of the residential area of Two Rocks. It also occurs in one isolated patch near 'The Spot', located between the Two Rocks and Yanchep.

Melaleuca systena – Acacia lasiocarpa Low Shrubland over *Lomandra maritima* graminoid Herbland (MAL) vegetation within a few metres of the coast in the Two Rocks North and Yanchep foreshore areas is considered significant because it is atypically close to the coast.

The *Scaevola nitida* vegetation in the south-eastern corner of the Yanchep foreshore area is considered significant not only because it is in Very Good to Excellent condition, but also because it may be rare in the Perth Metropolitan Region. At least neither it, nor its dominant species, is referred to in the Bush Forever descriptions of coastal Bush Forever sites more than once or twice.

Weeds and other Alien Species

37 of the taxa recorded in the study area are established aliens or environmental weeds. (Refer to **Appendix 2**). The aliens include some south-western native trees and large shrubs which, in the context of the study area are aliens. They are not native to the study area and were probably, at least originally, planted and have spread since then. These species include *Eucalyptus utilis* and *Melaleuca nesophylla* and probably *Callitris preissii*,

Agonis flexuosa and *Melaleuca lanceolata*. The Victorian Tea Tree *Leptospermum laevigatum* was also planted and is now spreading.

The beach and foredune vegetation is now largely alien, mainly due to the perennial rhizomatous grasses *Thinopyrum distichum* and *Ammophila arenaria*, that have been planted to stabilise the sand, and the herbaceous plants *Cakile maritima, Euphorbia paralias* and *Tetragonia decumbens*. These species are largely restricted to loose sandy disturbed areas near the coast but some, especially the *Tetragonia*, impact upon native species there.

Another grass planted to stabilise sand, *Ehrharta villosa*, which is established in the Two Rocks South and Yanchep sections of the study area, is spreading and has the potential to become a major environmental weed. In the southern strip of the Yanchep section of the study area, it is already smothering native vegetation on one dune between Brazier Road and the beach. Several other annual grasses are serious weeds, but they are long established and do not smother mature shrubby vegetation.

The most widespread conspicuous weeds in the study area are *Pelargonium capitatum* and *Trachyandra divaricata*. These introductions from South Africa are probably the most serious widely distributed non-grass weeds of the coastal dunes.

Several garden daisies, including *Arctotis stoechadifolia*, *Gazania linearis* and *Osteospermum ecklonis* are now well established in some of the foreshore study area, especially disturbed sites in the northern Two Rocks area. Some of these species may have potential to spread more widely and to invade bushland areas after fires.

2.10 Fauna

Alan Tingay and Associates carried out a vertebrate survey for the broader Two Rocks Yanchep area in 1993. As part of this survey, the coastal heath habitat unit (which includes the study area) was sampled for the presence of frogs, reptiles, birds and mammals. The species observed during the survey included one frog species, 10 reptile species, 26 bird species and one mammal species. The fauna identified is generally typical of the region.

In 2003, Alan K Jones and Cheryl Gole carried out a survey and review of Birds and Reserves of the City of Wanneroo, a project initiated by Birds Australia Western Australia (Inc), which was jointly funded by the City of Wanneroo and the Perth Biodiversity Project. This survey incorporated the coastal area, which includes the study area. This survey also identified 26 bird species including some now extinct at most metropolitan coastal areas. Significant species recorded in the coastal area of Wanneroo include the Variegated Fairy-wren, White-winged Fairy-wren, White-browed Scrubwren, White-breasted Robin and Tawny-crowned Honeyeater.

2.11 Landscape

The landscape within the study area is generally of low to moderate relief. The coastline comprises a series of long gentle crescent shaped beaches contained by sandy points. The major visual element is the shoreline. This line, where the ocean meets the land, leads the eye along the beach into the distance terminating where a sandy point meets the sea. The

dunes to the east of the shoreline form the limit of view from the beach, while to the west the panorama extends to the level horizon over open water. In places the view from the beach includes nearshore and offshore rock formations. For example, the view from Leeman's Boat Landing includes the "two rocks" from which the locality gets its name. The Yanchep Lagoon is a major landscape feature as is the high dune crest behind the kiosk.

The study area provides panoramic views of open ocean and long, one sided, vistas along the shore. Attention is drawn to visual detail in the foreground and middle ground. This detail becomes very important as it can easily detract from an otherwise very attractive view. Within more extensive backdune areas there are contained vistas of undulating landform, coastal vegetation and introduced planting and buildings.

The landscape within the coastal reserve is generally of high visual quality. The minor bare sand areas do not detract significantly from the overall quality. The major bare sand dune slope encroaching onto Two Rocks Road at the entrance to Two Rocks and the north western slope of this same dune do have a significant visual impact.

Major Viewing Locations

The major viewing locations at Yanchep and Two Rocks foreshores are as follows:

1. The Kiosk at Yanchep - provides views over the Lagoon and north up the coast to groyne at Club Capricorn;

2. The hill directly behind the Kiosk is potentially a major viewing location providing 360 degree panoramic views;

3. The informal track at the south end of Compass Circle provides long views south along the shoreline and over dunes to a distant sandy point and north over dunes and along the beach to a small salient south of the Lagoon;

4. Leeman's Boat Landing memorial provides panoramic ocean views with interest created by rock formations emerging from the sea in the foreground. Also provides a long vista south along the coast terminating at "the Spot"; and

5. The proposed beacon site provides long views over sand dunes and ocean to the north terminating at a sandy point, and over dunes and the Marina to the south.

The Built Form

The following are the built forms at Yanchep and Two Rocks foreshores:

1. The Tavern at Two Rocks has a very strong affinity with its site in form, texture and colour. It is distinctly Mediterranean in style with no visible roofline. This building is a fine example of built form respecting its environment;

2. The orange and white burr shaped building at Two Rocks is totally alien to the landscape. It is highly visible and very intrusive. It may be "fun" but it is also hideous;

3. The Marina and its buildings are functional and appropriate to their location and use;

4. The Marina car park is without a sense of human scale. The horizontal plane is unrelieved by any vertical elements and the ground plane is very harsh. The edges to the north, south and west of the car park are abrupt, harsh and untidy;

5. The Leeman's Boat Landing memorial is isolated and unattractively fenced;

6. The Yanchep Kiosk building is well sited and is pleasing in form, scale and colour. The associated car park, road, retaining walls, steps, barriers and bins are, however, of poor visual quality. The road and the car park visually cut the kiosk off from the beach. Power lines to the north of the kiosk intrude into the view from the Kiosk to the north;

7. The toilet at Fisherman's Hollow is partially hidden from the view of the passing traffic. The colours could be changed to match the Kiosk;

8. The car park at Fisherman's Hollow visually dominates the entrance to the open space. The space is poorly defined and the edge details of post and rail barriers and large limestone boulders are poor;

9. The car parks on Compass Circle visually extend the bitumen road surface into the dune landscape to the point where they become dominant;

10. Signs are of varying quality. The large "Dog exercise area" signs on the beaches at Yanchep and Two Rocks are very intrusive;

11. The beach end of some path fences at Yanchep are broken down and unattractive; and

12. The sump on Brazier Road is visually intrusive and unscreened from the road.

3.0 Social Environment

3.1 Cultural Heritage

3.1.1 Aboriginal Heritage

Under the Aboriginal Heritage Act, 1972 it is an offence to damage, alter or destroy any aboriginal site, unless the consent of the Minister for Aboriginal Affairs has been obtained. This includes sites that are both registered and not registered.

A search of the Department's Register of Aboriginal Sites in January 2005, revealed that two mythological sites had been registered within the Yanchep portion of the study area. These sites are "The Limestone Reef" and "The Yanchep Beach" whose ID numbers are 17596 and 17599 respectively.

The Final Report prepared by Lily Bhavna Kauler for Elder Harry Nannup of Aboriginal Community College, Gnangara (1997-1998) included the following story:

> *"The Story has been told about the shark and the whale and the crocodile and the fight that they had and the formation of Rottnest and Garden Island and as the crocodile was walking back he laid down exhausted at what is now known as Yanchep beach and here you can see the outline of his whole skeletal frame work and it was here that he shed his skeletal frame work and then moved on."*

It will be necessary to seek appropriate clearances under the Aboriginal Heritage Act prior to undertaking works within this part of the study area.

3.1.2 European Heritage

Yanchep Lagoon and Fisherman's Hollow

Although understood to have been used prior to European occupation by Aboriginal people as a swimming and fishing hole, Fisherman's Hollow together with the Yanchep Lagoon have been frequented by holidaymakers since the early 1900s. The Lagoon became an anchorage for the Cray fishing fleet in the late 1950s and 1960s before the Two Rocks Marina was built.

Lindsay Homestead

In 1926 Mary Lindsay purchased approximately 23,000 acres of land along the coast to the approximate location of Two Rocks, which became known as Yanchep Estate. Prior to this, the land was owned by the Midland Railway Company, which was granted the land following the construction of the railway to Geraldton, completed in 1894. The Lindsay family lived in tents while a timber-framed homestead was constructed by the Bunning Brothers in the area north of Brazier Road and west of Two Rocks Road. This homestead still remains today. The stables and men's quarters are believed to have been built nearby

from some of the materials from the wreck of the Alex T Brown, although it is not known if any fabric remain.

In 1927 Mary Lindsay built a hostel and a store for campers in the area. Although meals were not provided, camping accommodation and essential supplies including water, food and fishing tackle were available. Mary Lindsay was well known for her work protecting the natural dune landscape and vegetation. During World War II, the army took over the premises. The homestead during World War II was used for entertaining VIP guests including military service personnel.

Leeman's Boat Landing

In March 1658, Abraham Leeman van Santwits, first officer and navigator of the Waeckende Boey and thirteen sailors came ashore in the vicinity of Wanneroo Beach where they found wreckage from the Vergulde Draeck but no sign of survivors. Unable to return to their ship because of bad weather, and abandoned by Samuel Volkersen the skipper of the Waeckende Boey, Leeman set sail for Batavia in a overloaded open boat. He and three sailors survived the journey.

In 1982 a limestone obelisk was erected at the end of Marcon Street in Two Rocks in recognition of Leeman's Landing. A plaque at the Leeman's Boat Landing site, signifies the area where Leeman and his men came ashore. Twenty years before the arrival of the British settlers, whalers visited this region as they followed pods of whales along the Western Australian Coast.

3.1.3 Shipwrecks

There is one identified wreck site off the study area, the "Emily", which was wrecked in 1868, just south of the Two Rocks town site. Although the current position of the wreck is not known, this wreck, if it still exists, is considered to be important in terms of early industrial development in Western Australia.

A second wreck, that of the "Alex T Brown" which ran aground in 1917, still lies 100 metres south of the "Spot". This wreck is the only example of a wooden schooner of its class to be wrecked along the Western Australian coastline. While this wreck is located outside the study area, it will have significance as a destination from both Yanchep and Two Rocks.

3.2 Population Growth

A population of approximately 4,000 people currently reside within the Two Rocks Yanchep area. The townsites at Two Rocks and Yanchep are surrounded by approximately 4,000 hectares of vacant urban zoned land, which is currently being planned for a community of around 150,000 people. A District Concept Plan has recently been lodged with the City by the predominant landowner, Yanchep Sun City Pty Ltd. Once adopted this plan is intended to form the basis of a District Structure Plan which will be used to guide the future planning and development of Two Rocks and Yanchep.

Whilst more detailed planning for a number of development fronts within the Two Rocks Yanchep area is underway, the most relevant to the study area is the Capricorn Coastal

Village Structure Plan, which relates to the coastal area immediately north of the Yanchep townsite. This structure plan provides the planning framework for a future population of over 7,500 people and depicts a coastal road along its interface with the foreshore and a coastal centre in the vicinity of the Club Capricorn Resort. Subdivision approval for the southern portion of this structure plan area has now been approved by the Western Australian Planning Commission, with the first stages of subdivision planned to be undertaken in the near future.

Recent population projections undertaken for the City of Wanneroo indicate that the Two Rocks Yanchep area will grow to an approximately population of 5,100 by 2006, 8,800 by 2011 and 21,300 by 2021. This growth will have implications for the study area, both in terms of management and infrastructure provision. Existing levels of facilities and infrastructure need to be reviewed and a greater potential for conflict between different recreational user groups will become evident. Increased population will also place greater pressure on natural areas. This will necessitate formalising access tracks to focus pedestrian access to the beach and other focal points. Indirectly, the natural environment may also be compromised through increased littering, possible disease, introduction of weeds and pollution. The planned population growth will also provide opportunities for the study area. It will create the opportunity to provide a greater range of facilities and infrastructure, including commercial and tourist facilities to the area. The greater population and increased use of the study area will also increase surveillance of the area, which could potentially reduce antisocial activities such as graffiti and vandalism.

3.3 Recreation Use

The main focus in the Two Rocks portion of the study area is the marina. Facilities here include a small boat launching ramp, tavern, shops, car parking and mooring facilities for both commercial and pleasure craft.

The main focus of activity in the Yanchep portion of the study area is the Lagoon. The Lagoon is a popular coastal destination for both Yanchep and Two Rocks residents as well as visitors and tourists. The main attraction of the area is its suitability for family swimming due to the protection afforded by the offshore reef, which attenuates wave energy to produce calm onshore conditions on most occasions. The area also has high scenic value and is popular for snorkelling, recreational fishing and windsurfing. Existing facilities at the Lagoon include car parking, picnic areas, a kiosk, toilet facilities and a surf club.

The foreshore area adjacent to the Club Capricorn Resort is generally utilised by guests and visitors of the chalets, hotel and caravan park. Facilities in the foreshore area currently consist of two car parking areas accommodating approximately 20 bays each and informal beach access tracks through the dunes. The beach area is used for walking, sunbathing, recreational fishing, surfing (experienced and beginners) and swimming. The beach is mostly suitable for experienced swimmers due to the in-shore wave breaking pattern and cross-shore currents.

The Lindsay Homestead is located within privately owned portion of the study area to the north of the Lagoon. The homestead has historic significance as the first building in the Two Rocks Yanchep area. The homestead is currently occupied as a private residence and contains some modern additions to the original building. A large shed is located close to

the house. A large Melaleuca tree, possibly planted by the Lindsay family is located close to the south-western corner of the house. A sandy track situated in a natural valley provides pedestrian access between the homestead and the beach.

Four private lots are located north of the existing surf club. There is currently no gazetted road access to these lots. The location of these private residences, surrounded by public reserves appears incongruent and land ownership, use and management issues require resolution between the landowners, the Western Australian Planning Commission and the City of Wanneroo. The houses directly abut the foreshore reserve. A system of sandy tracks provides access between each house and the beach.

Outside the Lagoon and marina areas a series of small car parks and beach access tracks link the coastal road with the beach. Two dog exercise beaches also exists to the south of the Lagoon and marina.

A beach user survey carried out by Coastwise Coastal Planning and Management in February 1999 indicates low to medium use of beach facilities within the study area. At the time of survey, the Lagoon was the most popular beach in the study area with 141 people present. None of the beach car parks were filled to capacity at the time of survey. Results of the survey are outlined in **Table 4**.

TABLE 4
RESULTS OF BEACH USER SURVEY ON 7 FEBRUARY 1999

Location	People on Beach	People in Water	Total people	No of Cars
Beach Access Path North of Marina	-	7	7	3
Marina Southern Carpark	10	-	10	49
Marcon Street Car Park	1	1	2	4
Informal Car Park Southern Two Rocks	8	6	14	5
Club Capricorn	15	21	36	14
Yanchep Lagoon	123	18	141	106
Yanchep lagoon South	20	14	34	11
Brazier Road Car Park	7	-	7	2
Ocean Lagoon	3	17	20	10

3.4 Anticipated Future Beach Use

In order to plan for the future demands likely to be placed on the foreshore reserve, it is necessary to determine which activities are likely to occur, and what associated facilities will be needed to support these activities. Recreational pursuits will be determined primarily by the physical characteristics of the coast and secondly by the types of services or facilities that will be provided in the area. For example, while most people are attracted to the beach to use the natural features of the environment such as the water, beach and dunes, the provision of cafes and grassed recreation areas may also attract people.

The types of activities expected to occur in the study area in the future are listed in **Table 5.**

TABLE 5
TYPICAL ACTIVITIES EXPECTED TO OCCUR IN THE STUDY AREA

Water-related	Reef-related	Beach-related	Foreshore Area
Windsurfing Kite surfing Surfing Swimming Wading Boogie Boarding Surf-lifesaving	Scuba Diving Snorkelling	Fishing Walking Jogging Dog Exercising Sunbathing Sports Relaxing Surf-lifesaving	Picnicking Walking Jogging Cycling Viewing Scenery Environment and heritage education

Many of these activities do not require provision of support facilities, beyond amenities for human comfort. Activities that will require facilities are:

- Cycling and walking - Dual use path, bike racks, watering facilities at stopping points, and toilets at regular intervals.
- Fishing – Possible fish cleaning area.
- Picnicking - Tables, seats, shelters, kiosks, toilets, barbeques, water supply, and bins.
- Surf lifesaving - Storage area for equipment, meeting rooms, exercise and social areas.

All of these activities require access roads and pedestrian beach access paths in the foreshore area. Associated facilities include car parking space, dual use paths, and bicycle racks. Beaches expected to attract large numbers of people will also require toilets, showers, change rooms, a kiosk, and possibly hire facilities. Rubbish bins are also necessary on the beach itself, and shade shelters on the beach also may be considered.

District beaches have a physical environment suitable for a relatively wide range of activities and therefore require facilities to cater for the likely number of beach users. They also require appropriate levels of road access connecting to the district distributor road network. Development adjacent to district beaches should be commensurate with the area's significance.

Local beaches have fewer uses and therefore require limited amenities. Such areas may be suited to more specific activities such as dog exercising or fishing. They will require a lower order of road access connecting from the district distributor road network but should still be easily accessible to those from outside of the local area. Development adjacent to local beaches is usually suitable for low to medium density housing with some potential for kiosk facilities. The provision of passive recreational areas such as grassed play or picnic areas are appropriate within the foreshore reserve of local beaches.

It is essential to ensure that the physical environment can meet the recreational demands and also support the infrastructure likely to be imposed by these demands.

4.0 Tourism Development

The Two Rocks Yanchep area has long been associated with tourists and visitors. Historically both areas have attracted a significant injection of capital funds from Bond Corporation and others which has seen the development of wild life parks, a marina and other built facilities which all contribute to tourist potential. Yanchep National Park has a vital role in influencing the tourism interest for the area as a whole. This park has an iconic status in Perth. Recent studies have illustrated the economic value of National Parks for the region in which they are situated to be significant. The contribution to the local economy generated by the Yanchep National Park is estimated at $16,594.500 based on 2004 visitor figures of 185,000. This contribution will be strengthened with the expansion of associated facilities in the area to entice visitors to linger and spend time and money locally.

The foreshore area itself has an abundance of natural resources, including high quality beaches, scenery, surfing, fishing, diving and boating opportunities, heritage and environmental interpretive opportunities that combine to provide a valuable basis for expanding the areas tourist potential. Capturing the tourism potential of these facilities will begin to create demand for a range of ancillary services including dining and accommodation facilities and the planned population growth for the surrounding area will act to reinforce demand for these facilities.

The Foreshore Management Plan seeks to facilitate the tourism potential of the area by providing for the development of several activity nodes along the Two Rocks Yanchep foreshore. The Two Rocks marina is planned to be subjected to future structure planning. The area in the vicinity of Leeman's Boat Landing is proposed to be developed with a broad range of picnic and recreational facilities. The Club Capricorn area is planned to be redeveloped as a coastal village centre as part of the development of the adjoining land estate and the concept plan for the Yanchep Lagoon included in this management plan not only provides for the redevelopment of the entire area to ultimately include a full range of picnic and recreational facilities, but also provides for several future building sites that could potentially attract the development of tourist/recreation based retail, cafes/dining/tavern facilities or short stay accommodation.

5.0 THE PLANNING CONTEXT

The following planning policies are considered relevant in the formulation of the Management Proposals for the Two Rocks and Yanchep study area.

Statement of Planning Policy No.2.6: State Coastal Planning Policy

In recognition of the demands and pressures on the coast and the need for coordinated decision-making, the Western Australian Planning Commission developed this policy under section 5AA of the Town Planning and Development Act. The policy seeks to ensure that coastal issues are appropriately considered in planning decisions and actions.

The objectives of the policy are to:

- Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance;
- Provide for public foreshore areas and access to these on the coast;
- Ensure the identification of appropriate areas for the sustainable use of the coast for tourism, recreation ocean access, commercial and other activities; and
- Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides wave conditions, sea level change and biophysical criteria.

Some of the key measures of this policy are to:

- Ensure that when selecting a development location, regard is given to infrastructure capacity, and where possible existing infrastructure be upgraded and improved;
- Ensure that new buildings and foreshore infrastructure on the coast are positioned to avoid risk of damage from coastal processes and, where possible, avoid the need for physical structures to protect development form potential damage caused by physical processes on the coast. The policy includes setback guidelines, which should be applied to determine appropriate setbacks to accommodate coastal processes.

Bush Forever (Government of Western Australia, 2000)

Bush Forever applies specifically to bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. It identifies 51,200 hectares of regionally significant bushland for protection, covering 26 vegetation complexes. This amounts to about 18% of the original extent of vegetation on the Swan Coastal Plain portion of the Metropolitan Region. Areas selected as Bush Forever Sites, which are representative of regional ecosystems and habitats, play a central role in the conservation of Perth's biodiversity.

As part of the Bush Forever process, specific criteria were developed to select coastal areas in the metropolitan area suitable for conservation areas. The six criteria relate to:

- Inclusion of a succession of different Quindalup dune types;
- The requirement for the site to be of sufficient size that natural processes such as dune formation can continue;
- Inclusion of sandy and/or rocky shorelines;
- Linkage to other bushland or coastal areas;
- Possession of a variety of vegetation types; and
- Possession of a variety of adjacent habitats to provide for the diverse reptilian and bird fauna of the coastal dunes.

The majority of the study area lies within Bush Forever Site 397, which relates to the coastal strip from Wilbinga to Mindarie. The boundary of Bush Forever Site 397 in relation to the study area is shown in **Figure 5**.

The Bush Forever designation has implications for planning and management within the study area. The natural vegetation in the area has been identified as regionally significant. Development in this area must have conservation as a high priority with minimal clearing. Possible environmental impacts of proposals on the surrounding bushland must also be minimised. The Bush Forever Practice Note 14 does however recognise that Parks and Recreation Reserves perform a variety of functions other than just conservation and provides for a case-by-case review involving consideration of planning and environmental issues beyond bushland protection.

Draft Bushland Policy for the Perth Metropolitan Region Statement of Planning Policy 2.8 (2004)

The aim of this draft policy is to provide a statutory policy and implementation framework that will ensure bushland protection and management issues in the Perth Metropolitan area are appropriately addressed and integrated with broader land use planning and decision making to secure long-term protection of biodiversity and associated environmental values.

Some of the specific measures of this policy relating to the Bush Forever Protection Areas are that proposals or decision making should support a general presumption against the clearing of regionally significant bushland, except where a proposal or decision:

- Is consistent with the overall purpose and intent of an existing reserve, existing approved uses and/or existing planning or environmental commitments or approvals; or
- Is in accordance with an existing endorsed master plan, management plan or similar, which has appropriately considered bushland protection requirements; or it is considered through a whole-of-site, formal master plan or management plan process, or similar, which effectively coordinates bushland protection and future development requirements within an overall strategic framework and seeks to maximise the protection of conservation values; or
- Can be reasonably justified with regard to wider environmental, social, economic or recreational needs and all feasible alternatives have been considered in order to avoid or minimise any direct loss of regionally significant bushland; and reasonable

mitigation strategies are secured to offset any loss of regionally significant bushland where appropriate and practical.

Previous Coastal Planning Studies

A Coastal Planning Strategy for the Yanchep area was prepared on behalf of Tokyu Corporation, as supporting documentation for the amendments to the Metropolitan Region Scheme in the Yanchep-Two Rocks area in 1996.

The Strategy defined the Foreshore Reserve boundary for the Two Rocks Yanchep area, taking into account the physical environment and the potential for coastal recreational demand. Potential locations for supporting facilities and amenities were also identified.

The strategy classified beaches along the Two Rocks Yanchep coastline as either regional, district or local, based on their potential to attract people. Those beaches classified as regional in nature being those which were likely to be the focus of use by residents of the surrounding region as well as local residents; local beaches were classified as those which were likely to be used more by people within walking or cycling distance of the beach; and district beaches were classified as those which displayed a combination of both regional and local beach characteristics. The following table outlines how the various beaches within the study area were classified under this hierarchy.

Beach Location	Classification
North of the Two Rocks Marina	Local/District
South of the Two Rocks Marina	District
Between Club Capricorn Groyne and the Yanchep Lagoon	Local
Yanchep Lagoon	District
South of the Yanchep Lagoon	Local

Bill James Landscape Architects prepared a Foreshore Management Plan, for the foreshore areas adjacent to the Yanchep and Two Rocks townsites in 1995. Council adopted this plan on 22 October 1997. The plan provided proposals for appropriate infrastructure and management of the foreshore area. Key issues arising from the plan included pedestrian/vehicular conflict at the Yanchep Lagoon, the lack of beach facilities at Two Rocks and the unstable nature of the foreshore to the north of the Two Rocks marina.

O'Brien Planning Consultants prepared a Foreshore Management Plan for the foreshore area adjacent to Lot 614 (the Ocean Lagoon Estate) in 1997. The plan provided proposals for coastal car parks, access paths and lookouts as well as proposals for the ongoing management of the foreshore area.

6.0 PROPOSALS

The study area has been divided into five sectors, namely Two Rocks North, Two Rocks South, Yanchep North, Yanchep South and the Yanchep Lagoon. The following sections describe the proposals relevant to each sector.

6.1 Two Rocks North

This sector extends between the northern boundary of the study area and Leeman's Landing. It includes the marina, associated facilities and the car park.

The area to the north of the marina is experiencing gradual erosion. Given the configuration of the marina breakwaters and the net south to north longshore sediment transport, this erosion is likely to continue for many years. In June 2004, Council resolved to fund, in conjunction with the Department for Planning and Infrastructure, the appointment of a coastal engineering consultant to investigate the likely extent of erosion and propose potential management strategies to address the issue. This is a separate detailed engineering study for this part of the coastline, which will require separate consultation and consideration by Council. The Foreshore Management Plan should therefore refer to the study as an action to be completed.

In 2002, the City replaced the boardwalk adjacent to Sceptre Court with a concrete beach access way, including a viewing platform, a wooden stairs to the beach and a 10-bay parking area at the entrance of the beach access way. Given the erosion being experienced in this part of the foreshore, this access way remains the only one north of the marina. Depending on the outcome of the erosion study referred to above however and the likely impact that the chosen strategy will have on erosion, it may be necessary to revisit the appropriateness of additional beach access ways through this part of the foreshore.

Seagrass currently accumulates on the beach to the immediate south of the marina's southern breakwater. The City, in conjunction with the Department for Planning and Infrastructure and key landowners in the area prepared a Sea Grass Strategy to investigate possible solutions to this issue. As an outcome of this strategy in December 2004, Council provided in principle support to the expansion of the Two Rocks Marina in order to assist in accommodating the future demand for marina facilities in the region. It also resolved to seek similar support from the State Government, before progressing further planning for this option. In view of this, the foreshore management plan identifies the marina area as being subject to future structure planning and does not contain any specific proposals for this area at this time.

A gazetted dog exercise area is located between the marina and the Leeman's Boat Landing site. Sign posting to the area is unsightly and could be replaced with more visually sympathetic signage.

Opportunities:

- The beach north of the Marina is a suitable beach for swimming and fishing and provides walking access to popular surfing area to the north of the study area;

- A concrete surface beach access way provides connection to the beach;
- The coastal vegetation is in a healthy and relatively undisturbed condition; and
- A gazetted dog exercise area is located between the marina and the Leeman's Boat Landing site.

Constraints:

- The steep sand cliff is gradually eroding;
- Accumulation of seaweed to the south of the marina; and
- No dual use pathway along Sovereign Drive.

Specific Recommendations:

1. Complete the existing investigation into the likely extent of erosion north of the marina and the potential management strategies to address this.
2. Following the outcome of the above study review the appropriateness of additional beach access ways through this part of the foreshore
3. Provision of a 2.5 metre wide dual use path along the western side of Sovereign Drive;
4. Provide a shower at the Sceptre Court beach access way; and
5. Replace signage at the dog exercise area with more visually sympathetic signage.

Figure 8a depict the proposals of this Sector.

6.2 Two Rocks South

This sector extends from the Leeman's Boat Landing to the southern boundary of the Two Rocks study area. The foreshore reserve ranges in width between 200 and 400 metres. Two Rocks Road form the eastern boundary.

The area comprises extensive dunes with vegetation in a relatively undisturbed state. The condition of the vegetation between Two Rocks Road and the secondary dunes is stated to be 'Very Good to Excellent'. Between the beach and the secondary dunes the condition is 'Good'. There are numerous tracks linking Two Rocks Road to the beach through the dunes.

The Leeman's Boat Landing area is located at the northern end of an outstanding regional beach. Some basic facilities currently exist at this location, including a toilet block, car park, memorial and pathways, although much of this infrastructure is in a dilapidated condition. In order to recognise the significant attributes of this location and provide a beach node for the Two Rocks community, the Foreshore Management Plan proposes the preparation and implementation of a concept plan making provision for a broad range of picnic and recreational facilities.

Opportunities

- The extensive and relatively undisturbed dunes between Two Rocks Road and the beach are an important coastal landscape feature which will become increasingly valuable as urbanization proceeds; and

- The beach is wide and stable providing suitable conditions for a wide variety of beach activities.
- The presence of high dunes provide an opportunity to locate look-outs to enjoy the panoramic views of the ocean.
- An existing bituminised car park at the Leeman's Landing.
- An existing concrete surfaced beach access way connecting Leeman's Landing with the beach.
- The beach to the south of Leeman's Boat Landing is an ideal swimming beach;
- The accretion terrace to the north and south of Leeman's Boat Landing is evidence of a stable shoreline;
- The cleared and degraded land around Leeman's Boat Landing is suitable for development of a grassed parkland;
- Leeman's Boat Landing site provides panoramic views to the south and the north west; and
- The heritage significance of Leeman's Boat Landing site can be used to give identity to the area.

Constraints:

- An area zoned Urban intrudes into the foreshore to the west of Two Rocks Road;
- The numerous tracks between Two Rocks Road and the beach degrade the dune landscape;
- The area is presently accessible to off road vehicles.
- Leeman's Boat Landing site and other infrastructure in the vicinity are poorly presented and inadequate in the longer term.

Specific Recommendations:

1. Prepare and implement landscape concept plans for a Leemans Boat Landing picnic/recreation area, including provision for an expansion of the existing car park, upgrade of the existing toilet facility and memorial, the conversion of the existing drainage sump into a landscaped swale, pathways and a range of recreation/picnic facilities.
2. Provide two beach access ways, including associated car parking, lookouts, signage, bins and bike racks, as shown on the concept plans.
3. Provide a 2.5m wide dual use path along the foreshore between the fore and secondary dunes, linking Leeman's Boat Landing to the southern boundary of the study area and indicating a possible link toward the Yanchep Lagoon;
4. Close and rehabilitate the remaining tracks;

Figure 8b shows the Foreshore Management proposals for this sector.

6.3 Yanchep North

This sector is approximately 1.3 km long and extends from the northern boundary of the Yanchep portion of the Study Area to the immediate north of the Yanchep Lagoon. The proposed coastal road within the Capricorn Village Structure Plan area would form the eastern boundary of this sector. When the Capricorn Village is developed the foreshore at

this sector would be about 250 metres in width. The foreshore undulates and contains several significant high dunes. A ridge runs parallel to the beach.

A groyne is located at the northern end of this sector and provides a safe swimming beach to the immediate north of the groyne. The beach to the south of the groyne has been accreting since the construction of the groyne in the early 1970s resulting in a wide sandy beach. When the Capricorn Village Structure Plan area is developed, this beach could become a very popular beach attracting beach goers from various localities. Currently, it is also a popular surfing beach.

The Club Capricorn Resort gains access off Two Rocks Road via a private road, which terminates at the groyne. There are two car parking areas at the groyne, which all together makes provision for about 30 bays. Due to its relative isolation and the private status of the access road to the Capricorn Village beach, not many beach goers use this beach. This situation would undoubtedly change once the Capricorn Village is developed with a network of public roads that leads to this beach.

The Lindsay Homestead, a heritage building, is located within this sector and gains access off Two Rocks Road. This building is currently under the ownership of the Capricorn Village Joint Venture.

Four freehold lots each containing a house is located within this sector. These houses gain access via a limestone track off Two Rocks Road. The southernmost house also gains access off Brazier Road via a limestone track, which is also used by the Yanchep Surf Life Saving Club. Private landscaping and other works have been informally extended into the foreshore area. The plan includes recommended actions to address these encroachments and better define the boundary between public and private land.

The vegetation condition of this foreshore from the northern boundary up to the Lindsay Homestead and to the east of the proposed coastal road is classified as 'Very Good to Excellent'. Between the Lindsay Homestead and the southern boundary of the sector the condition ranges from "Degraded to Very Good'. At the beach the condition ranges from 'Degraded to Good'.

The coastal road is proposed intersect with Brazier Road within the Yanchep Lagoon area. The road would generally take an alignment through the crest of the dunes, not only to minimise the extent of the road batters, but also to provide magnificent views to the road users. The batters of the coastal road would be stabilised and vegetated to suit the landscaping treatment or native vegatation of the adjacent areas.

Yanchep Surf Life Saving Club

The existing Yanchep Surf Life Saving Club is located at the northern end of the Yanchep Lagoon. Whilst minor renovations were undertaken in 2003, it is generally accepted that the existing facility does not adequately cater for existing or future needs. With considerable population (and therefore beach patronage) increases forecast in the area, the City engaged consultants to investigate, amongst other things, the most appropriate future location for the surf club facility. This study was undertaken in conjunction with a Project Reference Group comprising Elected Members, City Officers and representatives from the Yanchep Two Rocks Recreation Association, Two Rocks Yanchep Residents Association,

Yanchep Surf Life Saving Club, Yanchep Sun City Pty Ltd, and Surf Life Saving Western Australia. The study identified three possible sites for the future Yanchep Surf Life Saving Club, including the Yanchep Lagoon, the existing surf life saving club and the beach adjoining Club Capricorn. The preferred option recommended by the study and supported by the Project Reference Group was for the fore dune area adjacent to the Club Capricorn groyne. This site offered good swimming and carnival beaches, was well located to serve the growing community, allowed sufficient space for ancillary amenities, provided good presence and effective surveillance of popular swimming areas.

The consultant's report noted however that access and service provision to the preferred site would be problematic in the short term and therefore provided an interim development option for the existing facility at the Lagoon. This interim option included additional storage, access, car parking and amenities. Concern was however raised by the Project Reference Group regarding the cost of this interim solution ($520,020) and the fact that it would not effectively deal with existing beach access issues. It was noted that further discussions would be required between the relevant stakeholders to develop an alternate interim solution.

Council considered the study at its meeting on 14 December 2004 and resolved to note the outcomes of the study and refer the report and recommendations for consideration in the preparation of this foreshore management plan.

In the context of the future growth planned for the Yanchep area, the Club Capricorn site provides the best long term location for the club facility, subject to the detailed location and design of the facility integrating with the planning currently occurring for the Capricorn Coastal Village centre. Given the current access and servicing difficulties to the new site and the fact that it is removed from the present development front, an acceptable and cost effective interim solution is required to meet the short to medium term needs of the club and beach going community. Key issues with the existing facility that need to be addressed if this facility is to be maintained include the dilapidated condition of the existing building, the surface and gradient of the beach access ramp, inadequate car parking and vehicle/emergency access, visual isolation of the club building and the provision for growth (storage and meeting facilities etc).

The foreshore management plan deals with a number of these issues (under the Yanchep Lagoon section) and discussions are continuing with relevant stakeholders with a view to proposing an acceptable and cost effective interim solution for the facility for Council to consider in adopting the final plan.

Lindsay Homestead.

As regards the usage of the Lindsay Homestead, in the short-term, the residential use of the house will be maintained. However, as the land within the Structure Plan is progressively developed, a number of alternative uses for the homestead are being considered. These could include:

- Community Purposes - heritage/environment centre; day care; community centre.
- Sales Office/Information Centre.
- Commercial - kiosk, bed and breakfast, or café.

A combination of these public and commercial uses will ensure that the general public will have access to this unique heritage building. It is envisaged that the Homestead will become a focal point of this southern area. Strong pedestrian links will be provided between the adjoining residential areas and the beach.

The longer-term options for the homestead lot will also involve developing the surrounding valley for recreational use as a grassed picnic area. The vegetation condition within the valley is found to be "Completely Degraded to Degraded' due to many years of associated uses with the residence. The valley is sufficiently protected from the sea breeze that any proposals would function very well.

Public Open Space areas

In the draft Capricorn Village Structure Plan, two public open space areas have been proposed at the interface of the Structure Plan area and the foreshore, which form part of the open space requirement for the Capricorn Village Structure Plan area. These open space areas have been proposed to be extended into the foreshore to create functional areas to provide foreshore recreational facilities.

The northern open space area (1.65 hectares) is located in a valley near the groyne. Considering the possible demand for recreational facilities within this foreshore from the future residents of Capricorn Village Structure Plan area, it is proposed to use this open space area for community gathering and to include a possible amphitheatre in a natural hollow as a public venue. The dunes surrounding this site will shelter it from south-westerly winds. This open space would also contain other recreation and picnic facilities. Along the northern boundary of this open space a car park is proposed, in addition to the parking embayments proposed along the coastal road.

The vegetation condition of this portion of the foreshore, including the open space area is stated to be "Very Good to Excellent". The open space proposals would result in only minimal area of vegetation within this sector. However, in view of the likely demand for recreational facilities on the foreshore to cater to the needs of the future population, this proposal is considered to be appropriate.

The other open space area (1.05 hectare) is proposed adjoining the Lindsay Homestead. As the majority of the vegetation at this location is stated to be in "Good to Completely Degraded" condition, this proposal is not likely to have a significant environmental impact.

A concept plan will be developed for each of these recreation areas prior to development taking place.

Dual use paths and beach access ways

A 2.5 metre wide sealed dual use path is proposed to run just behind the low fore dunes. It would provide good views of the ocean to the users. The vegetation condition along the alignment of this dual use path is 'Degraded to Good' and therefore this proposal would not impact on high quality vegetation.

As the vegetation condition to the east of the proposed dual use path is 'Very Good to Excellent', in order achieve minimum vegetation disturbance, 1.5 metre wide boardwalks are proposed at an interval of about 100 to 150 metres to connect the Coastal Road and the beach. These access ways would be approximately 150 to 250 metres in length. Most of the boardwalks are proposed at a minimum gradient of 1:14 to allow access to the physically challenged.

The existing approach road to the beach at the groyne is proposed to be retained as a Emergency Vehicular Access.

Opportunities:

- A coastal road, positioned to provide magnificent views to the road users;
- Accreting stable beach due to the groyne;
- Beaches suitable for both swimming as well as surfing;
- The high dunes which could provide opportunities for sheltered recreational areas and lookouts;
- The vegetation condition of this sector is stated to be 'Very Good to Excellent'.

Constraints:

- Currently no accessible public road and lack of a road link to the Lagoon;
- Development of the foreshore depends on the development of the Capricorn Village Structure Plan area; and

Specific Recommendations:

1. Prepare and implement landscape concept plans for the two picnic/recreation areas;
2. Establishment of a new Surf Life Saving Club adjacent to the Club Capricorn Groyne;
3. Provide a 2.5 metre wide dual use path along the foreshore as shown on the concept plans;
4. Provide beach access ways, including associated car parking, lookouts, signage, bins and bike racks, as shown on the concept plans
5. Provision of new car parking areas and upgrading the existing car parking areas at the groyne;
6. Provide clear interface between private housing lots and the foreshore reserve and rehabilitate adjacent foreshore
7. Investigate potential future uses for the Lindsay Homestead

Figure 8c shows the Foreshore Management Proposals of the Yanchep North sector.

6.3.2 Yanchep Lagoon Area Precinct

This precinct extends generally between the existing Yanchep Surf Life Saving Club in the north and the intersection of Brazier Road and Wilkie Avenue in the south. The natural setting of the Yanchep Lagoon area provides an opportunity for the development of an exceptional coastal node. The Lagoon is already the most popular swimming beach in the district, and with major population growth planned in the short to medium term, its

popularity is set to increase. The run down state of much of the infrastructure at the Lagoon provides an opportunity to replan the area to provide for this growth and also address a number of existing design and operational issues.

Brazier Road runs north-south through the locality of Yanchep, traverses through the Lagoon area and joins Two Rocks Road. As Brazier Road approaches the Lagoon area from the south, it forms a T-junction with Wilkie Avenue before entering the Lagoon area. Within the Lagoon area, the road provides panoramic views to the passers-by and therefore it attracts through traffic. The road is too narrow with a pavement width of about 5.5 metres. It makes a sharp 'S' bend before joining Two Rocks Road. The high dunes on either side of the 'S' bend restrict visibility to the motorists.

A kiosk is strategically located about 4 metres above the road level to the east of Brazier Road overlooking the ocean and providing panoramic views of the ocean. This kiosk, constructed by the City in the 1980s, is situated within a Crown Reserve vested in the City. The kiosk has been leased till 2009 with an option to extend the lease to 2016. There are parking areas at the kiosk between the road and the kiosk making provision for about 90 carparking bays.

The Yanchep Surf Life Saving Club is located off Brazier Road via a limestone driveway. Being located behind a dune, the club building is not visible from the road. This building does not have parking facilities.

There are two picnic areas within the precinct, which are maintained by the City of Wanneroo. The northern picnic area (referred as Picnic Cove) is located to the immediate south of the SLSC on the western side of Brazier Road. It has a grassed area with a few gazebos and a barbeque. A beach access way runs through the picnic area connecting it to the SLSC and the beach. This picnic area is subject to seasonal strong summer south-westerly winds.

The southern picnic area is at Fisherman's Hollow. This picnic area is sheltered behind dunes. It has a large grassed area with a few gazebos and a barbeque. There are parking and toilet facilities attached to this picnic area. At the Fisherman's Hollow, Brazier Road runs over a limestone cliff overhang. The overhang was designated as dangerous because of slabbing roof. The 'Review of Coastal Limestone Hazards' conducted by Gordon Geological Consultants in 1998 recommended that this overhang should be filled in.

There are a number of access ways leading to the beach.

Vision

A beachfront node with exceptional landscape qualities providing a diverse range of facilities and experiences for people to gather, recreate and socialise.

Key Drivers for Change

- Existing popular beach node
- Lack of quality facilities – those that are available are rundown
- Huge planned population growth

Opportunities

- Existing popular beach location for both residents and visitors
- Offshore reef which provides a sheltered basin for safe swimming
- Undulating dunal topography providing for panoramic views and vistas from several locations, including major viewing locations at the kiosk – to Club Capricorn and the prominent dune behind the kiosk – 360 degree views
- Sheltered areas at Fisherman's Hollow and Picnic Cove
- Indigenous and European heritage providing opportunities for interpretative facilities and public art theme
- Existing buildings (Kiosk, surf club and toilet block)
- Relatively low ultimate traffic volumes due to district roads bypassing area
- Stable coastline
- Enormous planned population growth
- Imminent development of Capricorn Coastal Village bringing access to public utility services in particular reticulated water and sewer
- Rundown existing infrastructure providing imperative for early development and reducing design constraints
- Popularity and developing population provides economic opportunities for range of tourist, recreation and convenience uses
- Holiday zoning of adjacent site
- Expansive are of natural dunal vegetation still in good condition

Constraints

- Strong summer south westerly winds
- Fragile coastal vegetation etc
- Existing A-Class reserve (for recreation) designation over northern portion of Lagoon precinct.
- Bush forever designation constraining extent of possible works.
- Extent of existing services especially reticulated sewer and water.
- Location and level of the kiosk constrains design options.
- Cliff overhangs.
- Safety of northern approach road.
- Location of the prominent dune constrains design options.
- Poor visual quality of existing roads, car parks, retaining walls, steps, barriers, bins, signage, landscaping, etc

Urban Design principles

- Built on existing assets – natural setting and environment including topography and site features, climate (sun, shade, wind) and protection of viable stands of coastal vegetation), indigenous and European heritage, key landmarks and existing facilities
- Provide a unifying theme to overall Lagoon area and strategies to reinforce this to create image and ensure all elements blend together as a coherent whole rather than assembled piecemeal as for impact on overall character of the area - for signs,

paving materials and design, public art, trees, furniture bins, seats, lighting, bike racks other furniture etc - architectural detail, colours, materials etc
- Clearly identifiable focus for overall area
- High level of pedestrian amenity and accessibility both into and around the Lagoon area
- Legibility to create a sense of place and a distinctive identity – precincts, paths, nodes, edges and landmarks
- Quality design and materials (esp. fundamental elements such as pavement, tress seats, lighting)
- Continuous edge to buildings
- Diverse range of facilities and experiences to provide a vibrant atmosphere, appropriate for a wide range of people which will extend the use of eth area and overall popularity of the area
- Crime Prevention Through Environmental Design principles

Summary of Key Considerations

Movement Considerations

- Existing movement systems require total overhaul.
- New movement systems should focus on providing pedestrian priority (retain traffic flow, minimal speed and visually integrated car parking. The are should be considered firstly a public space and secondary focus as a traffic route for vehicles
- Lagoon should be the focus of movement systems throughout the Yanchep area (pedestrian/cycle, vehicle and bus)
- Through movement for vehicles provides opportunity for viewing, scenic drop off etc opportunities and therefore should be maintained.
- Coastal road should be relocated eastwards to provide better separation to cliff/banks.
- Vehicular and pedestrian link from the proposed Capricorn Village should be provided.
- Northern approach road should be redesigned to improve safety.
- Approach roads should be located to take advantage of scenic vistas
- Strong links to neighbourhood pedestrian/cycle paths (existing and proposed) should be provided as a popular recreation/exercise facility.
- Wide clearly defined paths should be provided along both sides of coastal road to provide high quality pedestrian access between nodes, furniture, opportunity for stopping to view, bikes, side by side walking etc.
- Pedestrian safety and amenity should be improved in particular, design of coastal road to be low speed emphasising pedestrian orientation through narrow lanes, street parking, street trees, lighting, pavement material and design, separation of paths and vehicle lanes, median, crossings etc to maximise pedestrian safety.
- Entry statements should be provided at both north and south entry roads, perhaps roundabouts with central art feature to provide sense of arrival and mark definite change in road character.
- Around 200 car bays should be provided at the Lagoon, predominantly as street side parking to minimise visual impact.

- Tourist bus access should be provided particularly bus embayments and road design to facilitate access.
- Easy access should be provided for all user groups including disabled, elderly, young.

Public Space Considerations

- Emphasise gateway to Lagoon precinct from north and south approaches.
- Well defined edges to precincts to encourage more intensive use and greater potential for pedestrian use and social interaction
- Provide venue for outdoor performances, fairs, markets and other community activities
- Provide interpretive facilities to through public art etc to emphasise and promote cultural heritage of area.
- Strong pathway link between Picnic Cove and Fisherman's Hollow
- Provide for opportunities activities, festivals eg amphitheatre, pavement square
- Provide picnic and playground facilities
- Streetscape and public areas should be provided with consistent theme for trees, signs, furniture (bins, seats), lighting, public art required to hang development together
- Well serviced (eg plenty of seating in/out of sun) and well lit for night time use
- Protect natural areas that area planned to be retained – fencing and management

Built Form Considerations

- Provide increased opportunity for compatible commercial businesses such as cafes, restaurants, hotel etc to improve range of facilities and diversity and vibrancy of area, employment opportunities,
- Provide opportunity for short stay accommodation to increase activity level in terms of intensity and duration, facilitate tourism and provide presence at night for safety and security reasons.
- Improve relationship of surf club with Picnic Cove area by part removal of dune.
- Reuse of surf club building
- Built form to be designed with active edges to streets and other public spaces, landmark elements, interest, safety, views, vistas, shade etc.
- Heritage and landscape qualities of area to be reinforced in built form.
- Focal points at each end of picnic cove (surf club and kiosk) to stimulate activity.

Key Actions

A detailed concept plan has been prepared for the Lagoon area as shown on **Figure 9**. Key features of this concept plan are as follows:

- The exclusion of a future road, planned under the 1997 Foreshore management plan to extend through the dune to the east of the kiosk. The exclusion of this proposal under the new plan will lead to the retention of a sizable, intact, high quality conservation area and ensure that the Lagoon area remains on a through

traffic route, which will assist in maintaining the vitality of the area and a high level of passive surveillance.

- The realignment of Brazier Road to remove the 'S' bend on its northern approach and provide a greater buffer to the coastal cliffs. This will also provide for a significant recreation area at the northern end of the lagoon in the vicinity of Picnic Cove. The chosen alignment will enable a magnificent coastal vista from both the northern and southern approaches. To maximise safety, the road design is planned to be low speed and pedestrian oriented. Car parking areas are planned to be visually integrated into the design by use of street side bays. A roundabout/entry statement feature at both the northern and southern entrances to the precinct are planned to provide a sense of arrival and assist in lowering traffic speeds. Design levels of the road will require steps and ramping structure to the kiosk and adjoining planned development sites.
- A road connection from the Capricorn Coastal Village to the Lagoon area as required by the developer's subdivision approval and formalised vehicle access to the existing surf club facility with additional car parking in this vicinity.
- Generous pathways along both sides of Brazier Road with links to the adjoining neighbourhood path system in order to provide an interconnected system of recreational circuit paths.
- A viewing area for use by both pedestrians and motorists opposite Fisherman's Hollow, with expansive north and south beach vistas.
- Improvements in the picnic, recreation and landscape facilities at both the 'Picnic Cove' and 'Fisherman's Hollow', including the removal of the small dune to the immediate south east of the existing surf club facility in order to increase the useable recreation area, visually integrate the building into the recreation area and improve passive surveillance to the building.
- Provision for additional beach commercial/tourist buildings such as cafes, a hotel, short stay accommodation, tourist shops etc adjacent to the kiosk and provision for the redevelopment of the existing surf club building for commercial/community use.
- Provision of a lookout and associated access to the significant dune crest to the east of the kiosk.
- Fencing and rehabilitation of conservation areas and improvements to controlled beach access ways, including surf club access and the provision of disabled access.
- Themed building guidelines, landscaping, signage, street furniture, lighting, public art and interpretive facilities etc.

This plan would require a staged implementation program to ensure minimum disruption to the operation of the area and cost effective construction. The construction of the Brazier Road realignment and the link road to the Capricorn Coastal Village, together with general earthworks of the new Picnic Cove recreation area would need to be undertaken in the first instance. Much of the land affected by this is however located within an A Class reservation and it is therefore likely that the approval process for these works could take up to 12 months. Once these works have been completed, the staging of the remaining works could be undertaken as discrete projects based on priority and the extent of available funding.

Specific Recommendations:

1. Realign and upgrade Brazier Road including associated paths, parking bays, entry statements, barrier wall and earthworks for expanded Picnic Cove.
2. Construct the link road to the Capricorn Coastal Village
3. Development of expanded Picnic Cove
4. Upgrading of Fisherman's Hollow
5. Construct new access way/car park to existing Surf Life Saving Club
6. Construction of a beach access way meeting disabled access standards
7. Investigate opportunities for the establishment of additional commercial/tourist facilities adjacent to the kiosk and the redevelopment of the existing Surf Life Saving Club site for commercial/community use
8. Extend the pathway system within the Lagoon area to link with pathways in the adjacent residential area sufficient to provide a network of recreational circuits.
9. Construction of a viewing deck opposite Fisherman's Hollow
10. Construct a lookout and associated paths on the dune crest east of the kiosk
11. Undertake an ongoing monitoring program of the water depth within the Yanchep Lagoon.

Figure 9 depicts the Yanchep Lagoon area proposals.

6.4 Yanchep South

This sector covers the area to the south of the lagoon area up to the southern boundary of the Yanchep Study Area. Brazier Road, Compass Circle, Foreshore Vista and Trumpeter Way provide the eastern boundary.

The width of the foreshore reserve in this sector generally varies between 100 and 200 metres. At the south-western corner of Brazier Road and Wilkie Avenue there are houses which back directly onto the reserve. Consequently the foreshore reserve behind these houses is about 50 metres wide. These houses are about 10 metres above the beach level. Some of the residents have encroached upon the foreshore reserve by way of extending their backyard.

A gazetted dog exercise area is located in this sector covering a length of 400 metres. This area is serviced with a bituminised beach accessway and a carpark. An unsightly fenced drainage sump is located adjacent to the carpark as well as large unsightly signage.

An extensive rock shelf extending off the "Lagoon" rock shelf runs parallel to the beach. Beach sand extends out to this shelf during the summer and is removed in winter, leaving a shallow lagoon of calm water.

The condition of the dune vegetation is classified as 'Very Good to Degraded'. There are small limestone cliffs offering shelter from south-west winds. A low pine post and rail barrier on portion of the boundary controls indiscriminate access.

This is a local beach with two small carparks on Compass Circle and Brazier Road, which make provision for about 10 bays each. These parking areas are not line marked. There are

numerous access paths to the beach. The beach is used for swimming, sunbathing, fishing, relaxing and walking.

As per the recommendations of the previous adopted FMP, the City constructed two beach accessways off Compass Circle. Peet and Company, which developed Ocean Lagoon Estate constructed a part of the dual use path and the beach accessway off Foreshore Vista.

Opportunities:

- Pleasant local beach with adequate existing facilities for local users.
- High dunes provide lookouts over the coast; and
- A dual use path exists at the southern section of the sector abutting Ocean Lagoon Estate and connected to the beach by a beach accessway.

Constraints:

- Absence of a dual use paths running north-south; The relative narrowness and steepness of the landform constrain the location of a dual use path within the foreshore reserve;
- 'Dog Exercise Area' sign large and unsightly;
- Sump adjacent to Brazier Road unsightly;
- The dunes are susceptible to wind erosion and bare sandy areas will need to be repaired;
- Sand accretion at the foot of the constructed beach accessways; and
- The beach at the Ocean Lagoon Estate is subject to rip currents, which are hazardous to bathers.

Specific Recommendations:

1. Provide beach access ways, including provision/upgrading of associated car parking, lookouts, signage, bins and bike racks, as shown on the concept plans
2. Provide 2.5-metre wide dual use path along the western side of Brazier Road and Compass Circle.
3. Provide a dual use path connecting Foreshore Vista and Compass Circle with a combination of concrete surface and boardwalk including a lookout at the Compass Circle end
4. Provide clear interface between private housing lots and the foreshore reserve and rehabilitate adjacent foreshore
5. Replace the drainage sump at the entrance of the beach access way leading to the Dog Exercise Area with a swale incorporating a recreation area.
6. Convert the existing southern beach access way off Compass Circle into a 'Controlled Emergency Vehicular Access way'
7. Replace the two 'Dog Exercise Area' signs with more visually sympathetic signage

Figure 8d depict the proposal for this Sector.

7.0 Foreshore Management

7.1 Dune rehabilitation

Figures 11a to c depicting the Rehabilitation Plans outline the areas for rehabilitation as follows;

- Areas requiring minimal rehabilitation and weed removal,
- Areas requiring significant rehabilitation and weed removal, and
- Beach areas/dune faces requiring native species replanting.

These plans do not include the Capricorn Village foreshore since the adjacent area is generally in good condition as there are no residential developments except for the Club Capricorn Resort. Consequently, the foreshore vegetation is not disturbed. Any rehabilitation works required would be undertaken only after the foreshore proposals are built.

Most of the dune surfaces facing the beach require at least low levels of rehabilitation to ensure longer-term sand stability. These seaward margins are areas of lower stability, because of their generally steep slopes, lesser degree of stabilisation by vegetation, and their high exposure to coastal winds.

The following are some of the rehabilitation methods.

Stabilisation

Brushing of areas outlined in **Figures 11a to c** as requiring significant rehabilitation should be undertaken, and replanting of native species is recommended at rates of one plant per square metre.

Brushing is considered the most effective and economical method of surface stabilisation for coastal environments. Brushing provides wind protection and discourages people from walking across the dunes. Brush should be laid with the stems facing to the prevailing wind, starting at the top of the dune or area to be protected. Successive layers of brush are to overlap the stems of the preceding rows. Areas to be cleared in the vicinity would be the preferred source as seeds would contain local genetic diversity.

Species Selection

Native species that were observed regularly along the dune faces and beach areas are shown in **Appendix 4**. It is recommended that these native species be planted along beach lines and on dune faces, as they are currently able to maintain the dune face and exhibit resilience to conditions faced.

A preliminary list of species for use in general rehabilitation of the degraded areas, based on those species observed or expected to occur in the foreshore reserve, is presented in **Appendix 4**.

Weed Control

Out-competing introduced species by planting native species is recommended, particularly in areas of lower stability such as dune and beach areas, rather than removing existing weeds with soil holding capacity. Areas that require minimal weed removal are outlined in **Figures 11a to c.**

The removal of weeds should be staged and replanting of these areas should be undertaken concurrently to maintain the soil holding capacity of these introduced species.

Introduced species that require gradual removal are; *Ehrharta villosa*, *Pelargonium capitatum, Euphorbia paralias* and *Trachyandra divaricata.*

Before a dune can be revegetated there may first be a need to provide some protection to the sand surface to prevent excessive sand movement and to provide a suitable microclimate for plant germination and development. Stabilization may consist of laying brush on the ground, or erecting sand trapping fences, or a combination of both. Prior to this it will often be necessary to regrade the dunes to provide a suitable landform. Steep slopes, particularly those facing the west and southwest, may be impossible to stabilize without first reducing the slope. An ideal maximum slope is about 1 in 6.

7.2 Dune Building Fences

Fences, which trap sand can be used to build up a dune. These are particularly useful for re-establishing breached or eroded foredunes.

7.3 Fire Control

The exclusion of wild fires from dune areas is essential for successful rehabilitation. If a fire should begin it is more easily controlled if there are established fire breaks running across the direction of the fire advance. Paths to the beach will act as fire breaks but being quite narrow they will be only effective in stopping a fire of low intensity. They will, however, provide firefighters with a line to defend and to work from. In extensive dune areas wider paths of 3.0m should be provided. Dual use paths, roads and wider than normal beach access paths will serve this purpose.

7.4 Plan Disease Management

Dieback

Phytophthora is unlikely to express as dieback disease in the study area due to its well drained and alkaline soils. However hygiene measures used to control Phytophthora can also be useful in restricting the introduction of weeds and disease in general. Care is taken to prevent dieback being transported in soil or plant root material to other bushland areas. Dieback can be spread by the introduction of plants and soil for bushland restoration, and vectors such as vehicles, earth-moving equipment, humans, bikes and horses through movement of infested soil and plant matter on tyres, boots and hoofs.

CALM has specified factors that indicate the degree of risk of spreading dieback (CALM, 1992). The risk of spreading dieback is related to the nature of the proposed operation or development, and the nature of the site. The sort of operations and activities that could

occur with the City of Wanneroo that relate to dieback include track and firebreak construction and maintenance, weed control, bushland restoration, building construction (for example, the construction of the new Surf Life Saving Club), general maintenance, vehicle movement and pedestrian movement.

Honey Fungus

A plant pathogen, which may be found in the City of Wanneroo foreshore region is *Armillaria luteobalbina* (also known as honey fungus), which is a mushroom-producing fungus that is native to Western Australia and commonly occurs in the south-west of the state. *A. luteobalbina* poses a greater threat to vegetation communities than *Phytophthora*, as it is not restricted to certain soil types and can occur anywhere along the foreshore. There is no known cure for the disease.

As *A. luteobalbina* is not purely a soil-borne pathogen, it is difficult to contain the pathogen by utilising current hygiene practices. The best strategy for minimising the impact of the fungus is by reducing plant stress which will enable plants to resist and combat fungal attack. Spreading infected plant material during any dune stabilisation operations and other earthmoving activities should also be avoided.

Aerial Canker

At present there are no mechanisms to control this fungus other than removing infected material, so the best mitigating action would be to minimise factors that cause plant stress which will allow infected plants to combat infection.

Restricting Spread

As there is no practical large-scale cure for *Phytophthora* or *Armillaria* dieback, prevention of infection is the primary means of defence. This involves preventing movement of infected soil, plant matter and water into uninfected areas, and careful placement of tracks so that they do not cross between infected and uninfected areas. Any soil or plant material used for bushland restoration or landscaping should be certified as *Phytophthora*-free. Hygiene procedures should be implemented when conducting works within the study area including:

- disinfecting all machinery equipment and boots before entering bushland areas; and
- imported soil and fill should be certified dieback-free.

Reducing Plant Stress

Management strategies for reducing plant stress involve the ready availability of the plants' needs and prevention of adverse external factors. The use of appropriate revegetation techniques and minimisation of disturbance is of high importance particularly in the initial stages of plant development. Following is a list of techniques that can act to minimise plant stress and increase survival rates of seedlings.

- Tree guards help maintain a moist microenvironment and shelter from wind stress

- and sandblasting;
- Mulch primarily discourages weed growth but also helps trap nutrients and water
- and stabilises sand;
- Weed control is necessary to prevent competition;
- Limited reticulation may be required in some areas to alleviate water stress;
- Soil preparation – fertiliser may sometimes be required; and
- Brushing stabilises sand and deters disturbance by people.

The level of care required depends on the species. When planting hardy dune binding grasses such as *Spinifex* species, techniques to stabilise the sand and combat wind stress and water loss will be more important than maintaining nutrient levels. In these areas placement of brush or tritter is all that will be necessary. When planting heath species in more sheltered and stable areas, additional methods such as tree guards and reticulation may be used depending on the situation and the budget.

Education

Perhaps the most important aspect of plant disease management is education in hygiene procedures for people undertaking rehabilitation or other conservation works in natural areas. Short day-courses can be an invaluable way to raise awareness amongst rehabilitation practitioners and can also provide an opportunity for conservation workers from friends groups and local government to meet and interact.

7.5 Fauna Management

Fox control using 1080 poison (sodium monofluoroacetate) is not appropriate within the area due to the proximity of the bushland to urban areas. Native animals tolerate low levels of 1080 poison, but the poison is highly toxic to humans and domestic animals as well as feral animals. If foxes become a problem, a program of trapping should be initiated in consultation with the Department of Conservation and Land Management.

Control of feral cats is very difficult; however selective trapping and removal of individuals could be implemented if cats became a significant problem in the area. Domestic cats that roam at night also pose a significant threat to wildlife and a strategy of education should be implemented.

Rabbit control should be undertaken in areas of rehabilitation and revegetation. The use of Pindone baits may not be appropriate, particularly considering non-target native fauna may also be affected. Instead, rabbit-proof fencing should be erected around rehabilitation areas. If rabbit infestation is high, mesh or wire tree-guards may be necessary.

Dogs are not permitted on most of the study area except within the gazetted 'dog exercise areas' located at Two Rocks and Yanchep foreshores. Unrestrained dogs can have an impact on the natural environment as well as posing danger or distress to other recreational users. Dog faeces pose a hazard to health and must be removed by the dog owners. There is little scope for additional dog-exercising areas within the study area due to potential conflicts between other users and threats to natural areas. Signs are already erected at most beach access points. Signs should also be erected at access points to the Dual Use Pathway.

7.6 Signs

Appropriate signs should be erected at strategic locations. This should be based on an Aquatic Safety Assessment, which would provide recommendations for eliminating or mitigating risks. The Royal Life Saving Society Australia in its submission has indicated its intentions to assist the City of Wanneroo to prepare this assessment during the time of the implementation of the FMP proposals. It is important that signage throughout the study area is designed with a consistent theme and the design coordinates with other infrastructure. The preparation of a sign plan for the study area is therefore recommended to guide the location and design of new or replacement signs.

8.0 Implementation

It is anticipated that the recommended actions will be undertaken over a period of time in a staged manner **Table 6** below summarises the recommended Foreshore Management Plan actions.

TABLE 6

RECOMMENDED FORESHORE MANAGEMENT PLAN ACTIONS

Each of the recommended actions have been assigned a priority and responsibility for implementation. The priority rating system applicable is as follows:

- High [H] primary importance/implement immediately (within 2 years)
- Medium [M] secondary importance/implement within 2 – 5 years
- Low [L] longer term consideration/implement within 5 years plus

The primary responsibility for implementing or overseeing implementation of each recommended action is also nominated. The key for symbols used in the table is as follows:

- PD Planning and Development
- TS Technical Services
- CD Community Development
- CS Corporate Services
- CVJV Capricorn Coastal Village Joint Venture

General Recommendations (Applicable to the entire Study Area)

No	Proposal	Priority	Responsibility
1	Establish a coordinating group to oversee implementation of this Management Plan.	H	PD
2	Apply to the relevant state government agencies to rationalise the existing reservations, purposes and vestings to reflect the management plan proposals and enable consistent management.	H	PD
3	Carry out assisted natural regeneration following the principles of the Bradley method in good to excellent condition areas progressing to fair to good areas.	H-M	TS
4	Carry out reconstruction/revegetation of in areas of degraded and completely degraded.	H	TS
5	Close and rehabilitate all tracks not required for access, walking trails or fire breaks.	H-M	TS
6	Implement a comprehensive weed control program	H-M	TS

No	Proposal	Priority	Responsibility
	within the study area in conjunction with regeneration and rehabilitation works.		
7	Develop a fire management plan that details specific strategies to minimise the risk of fire within the study area and enable effective response and rehabilitation in the event of an outbreak.	H	CD/TS/PD
8	Keep accurate records of fire history of the study area including details of date and extent of fires.	H	CD
9	Use appropriate hygiene procedures to prevent the spread of dieback and other plant diseases into infected areas.	Ongoing	TS
10	Upgrade and install fencing to conservation areas.	H	TS
11	Monitor and record feral cat and fox sightings and these become a significant problem in the study then implement selective trapping and removal of individuals	L	TS
12	Initiate an education campaign to raise awareness of the environmental problems of cats roaming at night targeting local residents.	M	PD
13	Formalise beach access ways as indicated on the concept plans.	H-M	TS
14	Construct a continuous coastal dual use path within the foreshore and adjoining coastal road as specified in the concept plans.	H-M	TS/CVJV
15	Construct lookouts in locations specified on the concept plans.	M-L	TS
16	Restrict access to limestone cliffs, install cliff hazard warning signage and stabilise cliffs where appropriate for safety reasons by way of filling, collapsing etc.	H	TS
17	Install bin housings throughout the study area.	M	TS
18	Install recycle bin facilities at all key recreation areas within the study area.	M	TS
19	Prepare consistent theme for buildings, signage, furniture, landscaping, lighting bins, bike racks throughout study area.	H	PD/TS
20	Prepare and implement a signage plan to direct the placement and replacement of signs within the study area. Signage types to include directional, information, interpretative, educational, safety etc.	H	PD/TS
21	Ensure appropriate clearances are received under the Aboriginal Heritage Act prior to undertaking works.	H	PD
22	Incorporate information on Aboriginal and non-aboriginal history into interpretive material where appropriate.	M	TS

Specific Recommendations

Two Rock North

No	Proposal	Priority	Responsibility
23	Complete the existing investigation into the likely extent of erosion north of the marina and the potential management strategies to address this.	H	TS
24	Following the outcome of the above study review the appropriateness of additional beach access ways through this part of the foreshore.	M	PD
25	Provide a 2.5 metre wide dual use path on the western side of Sovereign Drive.	H	TS
26	Provide a shower at the northern beach access way	H	TS
27	Replace the 'Dog Exercise Area' signs with more visually sympathetic signage	H	TS

Two Rocks South

No	Proposal	Priority	Responsibility
28	Prepare and implement landscape concept plans for a Leemans Boat Landing picnic/recreation area including provision for an expansion of the existing car park, upgrade of the existing toilet facility and memorial, the conversion of the existing drainage sump into a landscaped swale, pathways and a range of recreation/picnic facilities.	M	
29	Provide a 2.5 metre wide dual use path along the foreshore as shown on the concept plans	M	TS
30	Provide two beach access ways, including associated car parking, lookouts, signage, bins and bike racks, as shown on the concept plans	H	TS

Yanchep North

No	Proposal	Priority	Responsibility
31	Prepare and implement landscape concept plans for the two picnic/recreation areas	M	CVJV
32	Establishment of a new Surf Life Saving Club adjacent to the Club Capricorn Groyne.	L	CD
33	Provide a 2.5 metre wide dual use path along the foreshore as shown on The concept plans	L	CVJV
34	Provide beach access ways, including associated car parking, lookouts, signage, bins and bike racks, as shown on The concept plans	M	CVJV
35	Provide clear interface between private housing lots and the foreshore reserve and rehabilitate adjacent foreshore	M	TS

36	Investigate potential future uses for the Lindsay Homestead	L	CD/CVJV

Yanchep South

No	Proposal	Priority	Responsibility
37	Provide beach access ways, including provision/upgrading of associated car parking, lookouts, signage, bins and bike racks, as shown on the concept plans	H	TS
38	Provide 2.5-metre wide dual use path along the western side of Brazier Road and Compass Circle.	M	TS
39	Provide a dual use path connecting Foreshore Vista and Compass Circle with a combination of concrete surface and boardwalk including a lookout at the Compass Circle end.	H	TS
40	Provide clear interface between private housing lots and the foreshore reserve and rehabilitate adjacent foreshore	H	TS
41	Replace the drainage sump at the entrance of the beach access way leading to the Dog Exercise Area with a swale incorporating a recreation area.	L	TS
42	Convert the existing southern beach access way off Compass Circle into a 'Controlled Emergency Vehicular Access way'	H	TS
43	Replace the two 'Dog Exercise Area' signs with more visually sympathetic signage	H	TS

Yanchep Lagoon Area Precinct

44	Realign and upgrade Brazier Road including associated paths, parking bays, entry statements, barrier wall and earthworks for expanded Picnic Cove.	H	TS
45	Construct the link road to the Capricorn Coastal Village	H	CVJV
46	Development of expanded Picnic Cove	H	TS
47	Upgrading of Fisherman's Hollow	M	TS
48	Construct new access way/car park to existing Surf Life Saving Club	H	TS
49	Construction of a beach access way meeting disabled access standards	H	TS
50	Investigate opportunities for the establishment of additional commercial/tourist facilities adjacent to the kiosk and the redevelopment of the existing Surf Life Saving Club site for commercial/community use.	M-L	CS

51	Extend the pathway system within the Lagoon area to link with pathways in the adjacent residential area sufficient to provide a network of recreational circuits.	H	TS
52	Construction of a viewing deck opposite Fisherman's Hollow	H	TS
53	Construct a lookout and associated paths on the dune crest east of the kiosk	M	TS
54	Undertake an ongoing monitoring program of the water depth within the Yanchep Lagoon.	M	TS

9.0 Monitoring And Review

It is recommended that this management plan be reviewed in five years time since. A review will provide a formal opportunity to review the effectiveness of the plan in meeting present and changing needs and pressures. It is likely that some amendments may be required before this five-year review due to changed circumstances and public demand. These amendments can very likely be accommodated in the detailed designs of the specific proposals contained in this report.

10. REFERENCES

1. Bowman Bishaw Gorham (2003) - *Foreshore Vegetation Survey and Management Recommendations Mindarie, Yanchep and Two Rocks*

2. ATA Environmental (2004) – *Draft Capricorn Coastal Village Structure Plan*

3. Bill James Landscape Architects (1997)- *Two Rocks – Yanchep Foreshore Management Plans*

4. O'Brien Planning Consultants (1997) – *Foreshore Management Plan for Lot 614 Yanchep*

5. Gordon Geological Consultants (1998) – *Review of Coastal Limestone Hazards.*

Appendix 1.- Survey Methodology and Limitations

METHODS

The vegetation survey, condition assessment and rare flora search comprised the following three, overlapping stages:

- preparation for fieldwork, including familiarization with the appearance of the significant flora to be searched for and examination of relevant reports, maps and other information;
- fieldwork to determine types, distribution and condition of vegetation units and significant flora habitats, and presence or absence of any rare flora and other significant flora, and
- office and herbarium work done following the periods of fieldwork (1) to check identifications of plant specimens collected and photographed during fieldwork and (2) to prepare this report.

Prior To Field Work

Prior to field work, potentially relevant maps, publications and reports were searched for and those that were located were reviewed, and aerial photography was examined.

The aerial photography examined includes stereoscopic pairs of 1:20,000 scale contact prints from Metro Regional Area aerial photography, mostly flown in 1998 and earlier, stereoscopic pairs of photocopies of that aerial photography enlarged to 300% and 400%, and digital printouts of aerial photography. This aerial photography was used for inferring extent and boundaries of vegetation units before, during, between and after field work.

Lists of Declared Rare and Priority Flora taxa recorded in the vicinity of the study areas were compiled from results of two sets of searches of three databases carried out in November 2002 by the Wildlife Branch of Department of Conservation and Land Management. These three Department of Conservation and Land Management databases are *Threatened Flora, Priority Species List* and *WA Herbarium Specimen*, and the search area parameters used are:

- Yanchep – Two Rocks coastal area
  Coordinates: 115^33' – 115^39' and 31^29' – 31^36'
  Names: Alkimos, Eglington, Two Rocks, Yanchep
- Mindarie coastal area
  Coordinates: 115^40' – 115^44' and 31^39' – 31^44'
  Names: Burns Beach, Hillarys, Iluka, Jindalee, Mindarie, Ocean Reef, Quinns Rock, Tamala Park

Eight taxa were listed in results of these searches. These eight taxa and their Conservation Codes are:

• *Astroloma microcalyx*	Priority 2	P2
• *Conostylis bracteata*	Priority 3	P3
• *Eucalyptus argutifolia*	Declared Rare Flora	DRF
• *Hibbertia spicata* subsp. *leptotheca,*	Priority 3	P3
• *Lasiopetalum membranaceum*	Priority 3	P3
• *Sarcozona bicarinata*	Priority 3	P3
• *Tetratheca pilifera*	Priority 3	P3
• *Thomasia triloba*	Priority 3	P3

The cover letter with the results from the database searches emphasizes that "the information supplied should be regarded as an indication only of rare flora that may be present". There may well be Priority Flora in the area other than those listed in the Department of Conservation and Land Management results, but probably none other than those listed in the *Bush Forever* Table 13 list of significant flora (Government of Western Australia 2000, Vol. 2, pp. 51-55). However, this list predates the current master list of Declared Rare and Priority Flora (Atkins 2001, 2002).

Herbarium specimens of the eight taxa in the printouts, and of other taxa listed in *Bush Forever, Volume 2* Table 13 and pages 380 and 383, and their labels in the Western Australian Herbarium were examined, and other botanists and various publications were consulted, including Atkins (2001), Paczkowska and Chapman (2000), Hoffman and Brown (1998) and Hopper *et al.* (1987).

Field Work

Dr. Arthur Weston, sometimes with Carolyn Harding or other assistants, walked transects through the study area in November and December 2002, looking for significant flora and describing and photographing vegetation at representative, releve sites. The principal taxa of significant flora searched for are the eight listed above, in Section 2.1, but other coastal significant flora listed Table 13 of *Bush Forever, Volume 2*, both Priority flora and non-Priority taxa, were also searched for. Further checking was done in February 2003.

Observations on vegetation structure and floristic composition of vegetation were recorded and condition of the vegetation was assessed. Most stands of vegetation, especially on the older dunes, were in various stages of secondary succession, and no attempt was made to infer what climax vegetation would be.

The system used for describing vegetation and the six-point scale used for assessing vegetation condition are, basically, from Keighery (1994), Muir (1977) and Government of Western Australia (2000, Vol. 2, p. 493), and from Keighery (1994), Trudgen (1991) and Government of Western Australia (2000, Vol. 2, p. 493-494), respectively.

The part of the system for descriptions of vegetation used in this report, and with the additions of two occasionally used height categories, Very Tall and Very Low, is:

Canopy cover / Form, height	100% - 70%	70% - 30%	30% - 10%	10% - 2%
Trees 10-30m Trees < 10m	Closed Forest Low Closed Forest	Open Forest Low Open Forest	Woodland Low Woodland	Open Woodland Low Open Woodland
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs > 4m Shrubs > 2m Shrubs 1-2m Shrubs < 1m Shrubs < 0.5m	Closed Very Tall Scrub Closed Tall Scrub Closed Heath Closed Low Heath Closed Very Low Heath	VeryTall Open Scrub Tall Open Scrub Open Heath Open Low Heath Open Very Low Heath	Very Tall Shrubland Tall Shrubland Shrubland Low Shrubland Very Low Shrubland	VeryTall Open Shrubland Tall Open Shrubland Open Shrubland Low Open Shrubland Very Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

The six-point condition scale is, basically:

P Pristine — No obvious signs of disturbance,

E Excellent — Vegetation structure intact, disturbance affecting individual species (plants?), weeds are non-aggressive species,

V Very Good — Vegetation structure altered, obvious signs of disturbance,

G Good — Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained,

D Degraded — Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good (sic) condition without intensive management, and

C Completely Degraded — Vegetation structure not intact; the area completely or almost completely without native species ('parkland cleared').

Hussey *et al.* (1997), Marchant *et al.* (1987) and other floras and field guides were used for tentative plant identifications in the field.

After Field Work

Plant specimens collected during the field work were pressed, dried and identified by checking them against a variety of keys and descriptions in floras and taxonomic works, only some of which are referred to in the report, by consulting other botanists, and by comparing them with specimens in Western Australian Herbarium collections.

During the process of identification and following it, the names of the plants identified were checked against the Table A list in Appendix A and other lists of significant flora, including those listed in the *Bush Forever* (2000, Volume 2, Table 13) list of significant flora.

The provisional vegetation descriptions and boundaries were revised, refined and finalised, and the significance of plant associations, vegetation complexes and floristic community types in the study area was assessed in terms of conservation and reservation status.

Report preparation including drafting a vegetation map to show boundaries and condition of vegetation units in the study areas.

LIMITATIONS

Vegetation

Although several days were spent in the field sampling vegetation and ground-truthing vegetation mapping, it was impossible to describe every stand of vegetation in detail. As is standard practice in vegetation mapping, it was necessary to infer vegetation similarities from texture, colour and patterns on aerial photography viewed stereoscopically.

Delimiting stands of vegetation and assigning names to them is, perforce, much more arbitrary than identifying plants, because they usually do not have clear boundaries or consistent features and because vegetation is not static; it is continually changing, and at various rates. It changes rapidly during and immediately after fire or other major disturbance, more slowly as it approaches a climax state, and its appearance changes during the year. Consequently, it may be difficult, or impossible, to match what is seen on aerial photography with what is observed on the ground, especially if the aerial photography is, as in the case of the stereoscopic aerial photography used in this study, several years old.

Setting out and sampling sets of quadrats according to methods described by Keighery (1994) and subsequent analysis of the samples using the appropriate PATN programs would be useful in validating the inferences made in this report about representation of floristic community types in the study area.

Flora

Many species of plants were not in flower at the time of the survey, and no attempt was made to compile a comprehensive list of species. Many species could be added to the list if more field work were undertaken during peak periods of flowering, and at other times, and, as was done, e.g., by Keighery *et al.* (1997), during three flowering seasons in consecutive years. The resulting list might, possibly, include Priority Flora and other significant species, but probably not any Declared Rare Flora or high Priority species.

Identification of species that are very similar when they are vegetative, e.g. several species of Iridaceae, can be confirmed only when they are in flower, generally in early spring.

Appendix 2- Flora of the Foreshore Study Areas

Flora of the Wanneroo Foreshore Study Areas (by taxon name)

	Taxon Name	Form	BS397	Notes
	Acacia cochlearis	Sh	TY	
	Acacia cyclops	Sh	TY	
	Acacia lasiocarpa var. lasiocarpa	Sh	TY	
	Acacia rostellifera	Sh	TY	
	Acacia saligna	Sh	TY	
	Acacia truncata	Sh	TY	
	Acacia xanthina	Sh	TY	
	Acanthocarpus preissii	Sh/He	TY	
	Acrotriche cordata	Sh	TY	
*	Agave ?americana	He	TY	
	Agonis flexuosa	Tr/Sh	-Y	alien?; r, s
	Allocasuarina lehmanniana	Sh	-Y(19)	s
*	Anagallis arvensis	He	TY	
*	Arctotheca calendula	He	TY	
*	Arctotis stoechadifolia	He	TY	
	Austrodanthonia sp.	Gr	TY	
	Austrostipa ?flavescens	Gr	TY	
*	Avena barbata	Gr	TY	
*	Bartsia trixago	He	T-	=Bellardia t.
	Beyeria cinerea	Sh	TY	
*	Brassica tournefortii	He	TY	
*	Bromus diandrus	Gr	TY	
*	Cakile maritima	He	TY	
	Callitris preissii	Tr/Sh	-Y	natural?; s, E
	Calothamnus Quadrifidus	Sh	??	
	Carpobrotus virescens	He/Sh	TY	
	Cassytha ?aurea	Vi	TY	
	Cassytha glabella	Vi	TY	
	Cassytha racemosa	Vi	TY	
	Cassytha sp.	Vi	??	
	Clematis linearifolia ('C. microphylla')	Vi	TY	
	Comesperma integerrimum	Vi	-Y	
	Conostylis aculeata subsp. aculeata	He	TY	
	Conostylis candicans (narrow-leaf form)	He	TY	
	Conostylis pauciflora subsp. euryrhipis (P3)	He	X	P3, p, s
*	Conyza bonariensis	He	??	
*	Crassula glomerata	He	TY	
	Cryptandra mutila	Sh	T-	
*	Cuscuta epithymum	Bi	TY	
	Cynodon dactylon	Gr	??	
	Desmocladus flexuosus	Se	TY	
	Dianella revoluta	He	TY	
	Diplopeltis huegelii subsp. huegelii	Sh	X	
*	?Diplotaxis tenuifolia	He	T-	
*	Dischisma arenarium	He	TY	
	Dodonaea aptera	Sh	TY	
	Dryandra lindleyana	Sh	??	
	Dryandra sessilis var. cygnorum	Sh	X	few
*	Ehrharta longiflora	Gr	TY	

*	Ehrharta villosa	Gr	TY	
	Eremophila glabra	Sh	TY	
	Eucalyptus gomphocephala	Tr	-Y	
*	Euphorbia paralias	He	TY	few?
*	Euphorbia terracina	He	TY	major weed
	Exocarpos sparteus	Sh	TY	
*	Foeniculum vulgare	He	TY	
	Frankenia pauciflora	Sh	-Y	few
*	Galenia pubescens	He	-Y	few
*	Gazania linearis	He	TY	
	Gompholobium tomentosum	Sh	TY	
	Grevillea obtusifolia (planted?)	Sh	T-	?;s,e, EN
	Grevillea preissii subsp. preissii	Sh	X	
	Guichenotia ledifolia	Sh	T-	
	Hardenbergia comptoniana	Vi	TY	
*	Hedypnois rhagadioloides	He	TY	
*	?Helminthotheca echioides	He	-Y(17)	
	Hemiandra pungens	Sh	TY	
	Hibbertia huegelii	Sh	??	
	Hypochaeris glabra	Sh	??	
	Iridaceae spp.	He	??	
	Isolepis nodosa	Se	TY	
	Kennedia prostrata	Vi	TY	
*	Lagurus ovatus	Gr	TY	
	Lechenaultia linarioides	Sh	X	p
	Lepidosperma gladiatum	Se	TY	
	Lepidosperma squamatum	Se	TY	
	Leptomeria preissiana	Sh	TY	
*	Leptospermum laevigatum	Sh	TY	
	Leucophyta brownii (=Calocephalus brownii)	Sh	TY	
	Leucopogon insularis	Sh	TY	
	Leucopogon parviflorus	Sh	TY	
*	Lolium rigidum	Gr	?TY	
	Lomandra maritima	He	TY	
	Lysinema ciliatum	Sh	T-	
*	Matthiola incana	He/Sh	-Y	
	Melaleuca cardiophylla	Sh	TY	r, s
	Melaleuca huegelii	Sh	TY	
	Melaleuca lanceolata	Sh	T-	planted?; d, s
	Melaleuca nesophila	Sh	TY	alien
	Melaleuca systena	Sh	TY	=M. acerosa
*	Melilotus indicus	He	TY	
	Myoporum insulare	Sh	TY	
	Nemcia reticulata	Sh	T? Y	
*	Nerium oleander	Sh	TY	few
*	Oenothera drummondii	Sh/He	TY	
	Olearia axillaris	Sh	TY	
	Opercularia vaginata	He	-Y	
*	Orobanche minor	He	?Y	
*	Osteospermum ecklonis	He	T-	
*	Oxalis pes-caprae	He	??	
	Ozothamnus cordatus	He/Sh	TY	
*	Parapholis incurva	Gr	-Y(17)	few
*	Pelargonium capitatum	He	TY	

	Phyllanthus calycinus	Sh	TY	
	Pimelea ferruginea	Sh	TY	fls wh
*	Plantago lanceolata	He	T-	
	Poa sp.	Gr	TY	> 1 sp.?
*	Reichardia tingitana	He	T-	
	Rhagodia baccata	Sh	TY	
*	Romulea rosea	He	TY	
	Salsola tragus	He	T-	
	Santalum acuminatum	Tr/Sh	TY	
	Sarcocornia blackiana	Sh	-Y	
*	Scabiosa atropurpurea	He	T-	
	Scaevola crassifolia	Sh	TY	
	Scaevola globulifera	Sh	T-	
	Scaevola nitida	Sh	-Y	
	Scaevola thesioides subsp. thesioides	Sh	TY	
*	Schinus terebinthifolia	Sh/Tr	TY	few
	Senecio lautus subsp. maritimus	He	TY	
*	Solanum nigrum	He	-Y	
*	Sonchus oleraceus	He	TY	
	Spinifex hirsutus	Gr	TY	
	Spinifex longifolius	Gr	TY	
	Spyridium globulosum	Sh	TY	
*	Stenotaphrum secundatum	Gr	TY	few?
	Stylidium maritimum	He	X	P3, p, s
*	Tamarix aphylla	Sh?	-Y	very few
	Templetonia retusa	Sh	TY	
*	Tetragonia decumbens	Sh/He	TY	
*	Thinopyrum distichum	Gr	TY	=Elymus d.
	Thomasia triphylla	Sh	-Y	
	Threlkeldia diffusa	Sh	TY	
	Thysanotus arenarius	He	T-	few
*	Trachyandra divaricata	He	TY	
	Tricoryne elatior	Sh/He	-Y(1)	
	Trifolium sp.	He	??	
	Trymalium ledifolium	Sh	X	
	Wahlenbergia sp.	He	-Y	
	Westringia dampieri	Sh	T-	

* = Alien specie

Legend

Column 1 Taxon Name

An asterisk (*) preceding the taxon name indicates that the species is a weed.
A question mark (?) indicates that the identification to the name following it is tentative.

Column 2	**Form**	growth form of plants
Gr		(grass),
He		(herbaceous plant),
M		(mallee),
Se		(sedge),
Sh		(shrub),
Tr		(tree),
Vi		(vine).

Column 3	**BS397**	recorded in Bush Forever Site 397
T		in Two Rocks North and/or Two Rocks South study areas
Y		in Yanchep study area
( )		site in which recorded
?		probably in T / Y but not confirmed
X		listed in *Bush Forever* for Bush Forever Site 397

Column 4 Notes

Significance codes (from *Bush Forever* Table 13)

P3	(Priority 3: poorly known taxa),
d	(disjunct populations),
e	(endemic to the Swan Coastal Plain),
p	(poorly reserved),
r	(northern or southern limit of known range),
s	(significant populations)
E	(endemic to the swan coastal plain in the perth metro region

Appendix 3 - Vegetation Types and Condition

Two Rocks North

Quindalup Dunes Uplands – Older dunes and plains

(1) Open Low Heaths and Low Shrublands dominated by few to all of the generally very low shrubs *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* over *Lomandra maritima* graminoid Open to Closed Herbland with *Acanthocarpus preissii* and *Desmocladus flexuosus* common; extensive in northern half.	Condition generally Very Good, often Excellent, sometimes Good	MAL, MAL+, Mi/MAL, O/MAL, SMiAc/MAL
(2) Open to Closed Heaths and Shrublands dominated by *Melaleuca cardiophylla,* sometimes with, or sparately, *Acacia cyclops, Acacia xanthina, Melaleuca huegelii, Myoporum insulare* or *Spyridium globulosum* generally over very weedy understories; several small stands on the eastern side; *M. cardiophylla* and *M. huegelii* are more commonly associated with Spearwood Dunes Uplands – Tamala Limestone	Condition generally Good, seldom Very Good, more often Degraded	McAc, McAx, Mch, MchAc, McMi, MiMc, MiMh, Mi, Ac, McMiAx, Ac/Pc, AcMi, Acx/Pc

Quindalup Dunes Uplands – Younger dunes

(1) Heaths and Low Heaths to Shrublands dominated by *Scaevola crassifolia, Myoporum insulare* or, less commonly and taller, *Spyridium globulosum* or *Olearia axillaris*, often over *Rhagodia baccata* Open Low Heath or *Lepidosperma gladiatum* Sedgeland to Open Sedgeland and *Acanthocarpus preissii* or *Tetragonia decumbens* Herbland to Closed Herbland	Condition generally Good to Very Good, with large areas Degraded to Completely Degraded	Mi/ApLg, MiS, MiSc, MiScS, MiScT, MiSSc, OMi/Lg, Mi, OMiSc/ApLg, O/Sc/ApLgT, ScMiO, SMi
(2) Shrubland of *Olearia axillaris* over *Rhagodia baccata* Open Low Heath to Low Shrubland, with *Threlkeldia diffusa*; one small stand above the northern end of *Lepidosperma gladiatum* due south of the tower, in the central western part of the study area	Condition Very Good to Excellent	O/Rb

Quindalup Dunes Uplands - Beach and fore-dunes to loose sand face of mobile dunes

(1) Open to Closed Grasslands of *Thinopyrum distichum, Spinifex longifolius* and *Spinifex hirsutus* with/and Herblands to Closed Herblands of *Tetragonia decumbens* or *Cakile maritima*; patchy on the strand and open sand of fore-dunes and blowouts	Condition of *Spinifex* generally Very Good to Excellent; the other species are aliens	SlT, Sl/T, Sh, Sl+, SlTdT, Cm, Td, T, B
(2) Low Open Shrubland to Low Open Heath of *Leucophyta brownii*; few small stands on loose sand on blowouts on coast due south of tower	Condition Very Good to Degraded	Lb

Quindalup Dunes Wetlands

Sedgelands to Closed Sedgelands of *Lepidosperma gladiatum*, with *Rhagodia baccata,* depressions (mainly) south of the tower, mainly in the central strip of the study area	Condition of stand nearest the tower Excellent; others Very Good to Degraded	Lg

Weeds and other aliens

Herblands, Grasslands and smaller areas of other vegetation structural classes (formations) dominated by aliens	Condition Completely Degraded (to Degraded)	W, C, Cm, Ac/Pc, Acx/Pc, As', Ml, Mn, Mn/Pc, Pc, PcEtAs', St

Two Rocks South

Spearwood Dunes Uplands – Tamala Limestone

(1) Open to Closed Heaths and Shrublands and Tall Scrubs dominated by *Melaleuca cardiophylla* and *Dodonaea aptera*, often with *Melaleuca huegelii* and *Spyridium globulosum*, sometimes with *Acacia xanthina* or *Acacia cyclops*, generally over *Melaleuca systena, Rhagodia baccata* Low Shrubland to Open Low Heath and Open Grassland of *Poa* sp., often with many annual weeds, sometimes over *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* Open Low Heaths and Low Shrublands over *Lomandra maritima* graminoid Open to Closed Herbland; mainly in the southeastern part of the study area	Condition generally Very Good, with some Excellent and some Degraded to Completely Degraded	McD, AxMcD, AxMcD/MAL, McD/MAL, Ac, McD/W
(2) Open Heath to Shrubland and Tall Shrubland dominated by *Melaleuca cardiophylla*, mostly over and with *Westringia dampieri* Low Shrubland to Open Low Heath over *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* Open Low Heaths and Low Shrublands over *Lomandra maritima* graminoid Open to Closed Herbland; limited area in southeastern corner and southeast of it	Condition Very Good to Degraded	McWd, Mc/W, Wd/MAL

Quindalup Dunes Uplands – Older dunes and plains

(1) Open Low Heaths and Low Shrublands dominated by few to all of the generally very low shrubs *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* over *Lomandra maritima* graminoid Open to Closed Herbland with *Acanthocarpus preissii* and *Desmocladus flexuosus* common, sometimes with overstorey of *Spyridium globulosum, Myoporum insulare* or *Dodonaea aptera*; extensive in central and central eastern parts.	Condition generally Excellent to Very Good, sometimes Good or Degraded	MAL, MAL2, MiD/MAL, S/MAL, Pc/MAL
(2) Open to Closed Heaths and Shrublands to Tall Shrublands dominated by *Melaleuca cardiophylla*, sometimes with, or sparately, *Acacia cyclops, Acacia xanthina, Melaleuca huegelii, Myoporum insulare* or *Spyridium globulosum* generally over very weedy understories; several small stands on the eastern side.	Condition generally Good to Degraded; some Completely Degraded and some Very Good	Ac, Mc, AcS, Ax, Mi, AcMh
(3) Open Heath to Open Shrubland of *Olearia axillaris* over *Acacia truncata, Melaleuca systena* Low Shrubland to Open Low Heath	Condition Very Good to Excellent	O/AtMs

Quindalup Dunes Uplands – Younger dunes

(1) Heaths and Low Heaths to Shrublands dominated by *Scaevola crassifolia, Myoporum insulare* or, less commonly and taller,	Condition generally Good to Very	OSc/Lg, MiO, SOAc

Spyridium globulosum or *Olearia axillaris*, often over *Rhagodia baccata* Open Low Heath or *Lepidosperma gladiatum* Sedgeland to Open Sedgeland and *Acanthocarpus preissii* or *Tetragonia decumbens* Herbland to Closed Herbland	Good, with large areas Degraded to Completely Degraded	
(2) Open Heath of *Olearia axillaris* over *Scaevola crassifolia* Open Low Heath over *Lepidosperma gladiatum* Sedgeland to Open Sedgeland; on western slopes of two largest central dunes	Condition Excellent to Very Good	O, OSc
(3) Open Heath dominated by *Acacia rostellifera, Acacia saligna* (possibly planted for rehabilitation) over and with *Pelargonium capitatum* and/or other weeds, mainly *Euphorbia terracina, Trachyandra divaricata* and *Bromus* spp. and other grasses; plateau of truncated central dune	Condition Degraded to Completely Degraded	Ars/Pc

Quindalup Dunes Uplands - Beach and fore-dunes to loose sand face of mobile dunes

(1) Closed Grassland of *Thinopyrum distichum*, with areas of *Cakile maritima* Herbland, especially in the north, and *Spinifex longifolius* Grasslands; edge of strand and fore-dunes along most of coast	Condition of *Spinifex* generally Very Good to Excellent; the other species are aliens	SlT, Sl/T, Sl, Cm, Td, B
(2) Open Heath of *Olearia axillaris* over *Spinifex longifolius* Grassland to Closed Grassland and weeds; on low, long parallel dunes bordering *Thinopyrum distichum* Closed Grassland in central and south-western part of study area	Condition Good	O/Sl

Weeds and other aliens

Herblands, Grasslands and smaller areas of other vegetation structural classes (formations) dominated by aliens	Condition Completely Degraded (to Degraded) or worse	W, C, Cm, Pc, Ev, Fv, G, Pc/MAL (in part), PcW

Yanchep

Spearwood Dunes Uplands – Tamala Limestone

(1) Open to Closed Heaths and Shrublands dominated by *Melaleuca cardiophylla* and *Melaleuca huegelii*, sometimes with *Santalum acuminatum*, generally over *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* Open Low Heaths and Low Shrublands over *Lomandra maritima* graminoid Open to Closed Herbland; on limestone and shallow soils on the eastern side of the northern part of the study area, west of Newman Road	Condition generally Very Good, with some Good to Degraded	Mh, Mc(h), MhSa/MAL, Mh/MAL
(2) Very Low to Very Low Open Shrubland of *Frankenia pauciflora*, (cliff-edge community), with *Sarcocornia blackiana*; also with *Scaevola crassifolia* on adjacent sandy slope; few small areas on beach-edge limestone platforms west of Fisherman's Hollow	Condition Very Good	Fp

Quindalup Dunes Uplands – Older dunes and plains

(1) Open Low Heaths and Low Shrublands dominated by few to all of the generally very low shrubs *Melaleuca systena, Leucopogon parviflorus, Leucopogon insulare, Acrotriche cordata* over *Lomandra maritima* graminoid Open to Closed Herbland with *Acanthocarpus preissii* and *Desmocladus flexuosus* common, sometimes with overstorey of combinations of *Spyridium globulosum, Acacia cyclops, Olearia axillaris, Santalum acuminatum* and *Acacia cochlearis*; a large proportion of the northern part of the study area, north of Wilkie Avenue	Condition generally Very Good to Excellent	MAL, AcS/MAL, SaAc'/MAL, OS/MAL
(2) Heaths to Scrubs (to Shrubland) of *Spyridium globulosum,* in the northeastern corner of the study area and, in a small area bordering Wilkie Avenue, with *Acacia cyclops* and *Schinus terebinthifolia*	Condition generally Excellent to Good, small areas Degraded	S, AcSSt
(3) Low Closed Forest of *Eucalyptus gomphocephala* over *Spyridium globulosum, Rhagodia baccata* Open to Closed Heath and Low Woodland with shrubs of *Spyridium globulosum* and *Acacia cyclops*; in centre of northern part of study area	Condition Good to Degraded	Eg, EgSAc
(4) Shrubland to Open Shrubland of *Scaevola crassifolia, Olearia axillaris* over *Hemiandra pungens, Melaleuca systena* Open Low Heath over *Acanthocarpus preissii* Herbland and *Desmocladus flexuosus* Sedgeland; small stand in southeast corner of study area and another, smaller, unmapped stand 300-400m northwest of it	Condition Very Good to Excellent	SnO
(5) Tall Open Scrub of *Melaleuca cardiophylla,* (*Olearia axillaris*); very small stand in southeast corner of study area	Condition Very Good	Mc

Quindalup Dunes Uplands – Younger dunes

(1) Heaths and Low Heaths to Shrublands dominated by *Scaevola crassifolia, Myoporum insulare* or, less commonly and taller, *Spyridium globulosum* or *Olearia axillaris*, often over *Lepidosperma gladiatum* Sedgeland to Open Sedgeland and *Acanthocarpus preissii* or *Tetragonia decumbens* Herbland to Closed Herbland; almost all of southern part of study area and western edge of northern part	Condition generally Very Good, with some areas Good to Degraded and others Excellent	MiScO, ScO, MiScO/Lg, MiSAc/Lg, MiSc/Lg, ScMi
(2) Open to Closed Very Low Heath of *Scaevola crassifolia, Frankenia pauciflora*; lower sand slopes adjacent to beach-edge limestone platforms west of Fisherman's Hollow and southwest of junction of Kaiber Avenue with Brazier Road	Condition Very Good to Excellent	ScFp

Quindalup Dunes Uplands - Beach and fore-dunes to loose sand face of mobile dunes

(1) Closed Grassland of *Thinopyrum distichum,* with areas of *Spinifex hirsutus* and *Spinifex longifolius* Grasslands; edge of strand and fore-dunes along most of coast, with *Olearia axillaris* Shrubland to Open Shrubland overstorey southwest of junction of Wilkie Avenue with Brazier Road	Condition of *Spinifex* generally Very Good to Excellent; the other species are aliens	TdShl, B, O/TdShl

(2) Low Open Shrubland to Low Open Heath of *Leucophyta brownii*; small area with ScFp southwest of junction of Kaiber Avenue with Brazier Road	Condition Very Good	Lb
(3) Shrubland to Open Shrubland of Olearia axillaris over Pelargonium capitatum shrub-like Herbland, with few Spinifex longifolius, Scaevola crassifolia, Acanthocarpus preissii and Senecio lautus and weeds, especially Trachyandra divaricata; fore-dune swales in northwestern part of study area	Condition Degraded to Completely Degraded	O/Pc

Quindalup Dunes Wetlands

Closed Sedgeland of *Lepidosperma gladiatum*, with *Rhagodia baccata* ; depression near invagination of northern boundary of study area	Condition Excellent	Lg

Weeds and other aliens

Herblands, Grasslands and smaller areas of other vegetation structural classes (formations) dominated by aliens	Condition Completely Degraded (to Degraded) or worse	W, C, Ev, Fv, G, Ll, LlW, Ll/MAL

Appendix 4 – Rehabilitation Species List

Native Species For Replanting Beach Areas/Dune Faces

Olearia axillaris
Scaevola crassifolia
Spinifex longifolius

General Native Replanting Species List

Acacia rostellifera
Acanthocarpus preissii
Desmocladus flexuosus
Hardenbergia comptoniana
Lepidosperma gladiatum
Leucophyta brownii
Lomandra maritima
Melaleuca huegelii
Olearia axillaris
Pimelea ferruginea
Rhagodia baccata subsp. *baccata*
Scaevola crassifolia
Spinifex hirsutus
Spinifex longifolius
Spyridium globulosum
Templetonia retusa

Ac	*Acacia cyclops* Shrubland to Heaths
AcMi	*Acacia cyclops, Myoporum insulare* Open to Closed Heath
Ac/Pc	*Acacia cyclops* Shrubland to Heaths over an herbaceous ground layer of aliens, usually with *Pelargonium capitatum* conspicuous
AcS	*Acacia cyclops, Spyridium globulosum* Open Heath
AcSSt	*Acacia cyclops, Spyridium globulosum* Open Heath with a few plants of *Schinus terebinthifolia*
AcS/MAL	*Acacia cyclops, Spyridium globulosum* Open Shrubland over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
Acx/Oc	*Acacia cyclops, Acacia xanthina* Open Shrubland over *Pelargonium capitatum* Open to Very Open Heath
Ac'/MAL	*Acacia cochlearis* Open Low Heath to Low Open Shrubland over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
AcoOaSgAc	*Acacia cochlearis, Olearia axillaris, Spyridium globulosum* and *Acacia cyclops* Low Closed Heath
Ar	*Acacia rostellifera* Open Heath to Tall Open Scrub
Arc	*Acacia rostellifera, Acacia cyclops* Closed Tall Scrub to Shrubland
Arc/Pc	*Acacia rostellifera, Acacia cyclops* Open Heath over/with *Pelargonium capitatum* and/or other weeds, mainly *Euphorbia terracina,* and *Bromus* spp. and other grasses
ArS	*Acacia rostellifera, Spyridium globulosum* Open Heath to Closed Tall Scrub
ArS/MAL	*Acacia rostellifera, Spyridium globulosum* Shrubland to Closed Tall Scrub over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
Ax	*Acacia xanthina* Open Heath, in small to very small stands
AxMcD	*Acacia xanthina, Melaleuca cardiophylla, Dodonaea aptera* Open Heath to Tall Shrubland
AxMcD/MAL	*Acacia xanthina, Melaleuca cardiophylla, Dodonaea aptera* Open Heath to Tall Shrubland over Very Low Shrublands, Heaths and Herblands or *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
B	Baech, adjoining loose sand and cliff or steep slope, largely bare of vegetation
C	Cleared and/or very weedy (condition of C - Completely Degraded - or worse)
Cm	*Cakile maritima* Very Open to Open Herbland (often in B)
C-W	See C and W
Eg	*Eucalyptus gomphocephala* Open to Closed Forest (or Low Forest) over weeds and patches of *Rhagodia baccata* shrubs
EgSAc	*Eucalyptus gomphocephala* Low Woodland and *Spyridium globulosum, Acacia cyclops* Open Heath to Tall Shrubland
Ev	*Ehrharta villosa* Closed Perennial Grassland
Fp	*Frankenia pauciflora* Very Low Shrubland to Very Low Open Shrubland, on limestone
Fv	*Foeniculum vulgare* Tall Herbland to Tall Closed Herbland
Lb	*Leucophyta brownii* Low Open Shrubland to Open Low Heath, in very small stands
Lg	*Lepidosperma gladiatum* Open to Closed Sedgeland
Ll/MAL	*Leptospermum laevigatum* Tall Shrubland to Closed Tall Scrub over Very Shrublands, Heath and Herblands *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
MAL	Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species (the other species include *Acrotriche cordata, Leucopogon parviflorus, Leucopogon insulare, Acanthocarpus preissii* and *Desmocladus flexuosus*)
MAL2	Very Low Shrublands, Heaths and Herblands of *Leucopogon insulare, Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
Mc	*Melaleuca cardiophylla* Open to Closed Heath (to Shrubland)
McAc	*Melaleuca cardiophylla, Acacia cyclops* Open to Closed Heath (to Shrubland)
McD	*Melaleuca cardiophylla, Dodonaea aptera* Open to Closed Heath
McD/MAL	*Melaleuca cardiophylla, Dodonaea aptera* Open to Closed Heath (to Scrubs) over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
Mch	*Melaleuca cardiophylla, Melaleuca huegelii* Open to Closed Heath (to Scrubs)
Mc/W	*Melaleuca cardiophylla* Open Shrubland to Shrubland over/with various species of aliens (weeds)
Mh	*Melaleuca huegelii* Open to Closed Heath (to Scrubs)
Mi	*Myoporum insulare* Open to Closed Heath
MiD/MAL	*Mypoporum insulare, Dodonaea aptera* Shrubs to Heaths (to Shrublands) over and with Very Low Shrublands, Heaths and Herblands to *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
Mi/MAL	*Myoporum insulare* Low Open Shrubland to Open Heath over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
MiMc	*Myoporum insulare, Melaleuca cardiophylla* Open Heath (Shrubland to Closed Heath)
MiO	*Myoporum insulare, Olearia axillaris* Open to Closed Heath
MiSc	*Myoporum insulare, Scaevola crassifolia* Open to Closed Heath (to Low Heaths)
MiSc/Lg	*Myoporum insulare, Scaevola crassifolia* Shrublands to Heaths (to Low Shrublands to Low Heaths) over *Lepidosperma gladiatum* Sedgeland
MiScO	*Myporum insulare, Scaevola crassifolia, Olearia axillaris* Low Shrubland to Closed Heath
MiScO/Lg	*Myoporum insulare, Scaevola crassifolia, Olearia axillaris* Open Heath to Open Low Heath over *Lepidosperma gladiatum* Sedgelands
MiSSc	*Myoporum insulare, Spyridium globulosum, Scaevola crassifolia* Open (to Closed) Heath
Ml	*Melaleuca lanceolata* large shrubs; probably planted and not native here
Mn	*Melaleuca nesophylla* Tall Open Scrub to Closed Tall Scrub
O	*Olearia axillaris* Open Heath
O/MAL	*Olearia axillaris* Open Heath to Low Open Shrubland, often with *Myoporum insulare,* over Low to Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
O/Pc	*Olearia axillaris* Shrubland to Open Shrubland over *Pelargonium capitatum* shrub-like Herbland, with few *Spinifex longifolius, Scaevola crassifolia, Acanthocarpus preissii* and *Senecio lautus* and weeds, especially *Trachyandra divaricata*
O/Rb	*Olearia axillaris* Shrubland to Open Heath over *Rhagodia baccata* Low Shrubland, with *Enchylaena tomentosa* common
OSc	*Olearia axillaris, Scaevola crassifolia* Open Heath to Low Heaths
OS/MR	*Olearia axillaris, Spyridium globulosum* Open Heath to Closed Tall Scrub over *Melaleuca systena, Rhagodia baccata* Ls to Open Low Heath
Pc	*Pelargonium caitatum* Herbland to Very Open Herbland with other weeds, mainly *Euphorbia terracina, Bromus* spp., and other grasses
PcEtAs'	*Pelargonium capitatum, Euphorbia terracina, Arctotis stoechadifolia* Closed Herbland to Herbland
Pc/MAL	*Pelargonium capitatum* shrub-like Herbland over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
S	*Spyridium globulosum* Heaths to Scrub
SaAc'/MAL	*Santalum acuminatum, Acacia cochlearis* Open Shrubland to Open Heath over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
SAr/MAL	*Spyridium globulosum, Acacia rostellifera* Open Heath to Shrubland over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
ScFp	*Scaevola crassifolia, Frankenia pauciflora* Open to Closed Very Low Heath
Sc/Lg	*Scaevola crassifolia* Heath to Low Heath over *Lepidosperma gladiatum* Sedgeland
ScMi	*Scaevola crassifolia, Myoporum insulare* Open Low to Closed Heath, also with *Enchylaena tomentosa, Tetragonia decumbens* and *Lepidosperma gladiatum*
ScMiO	*Scaevola crassifolia, Myoporum insulare, (Olearia axillaris)* Open Heath over *Acanthocarpus preissii, (Threlkeldia diffusa, Rhagodia baccata)*
ScO	*Scaevola crassifolia, Olearia axillaris* Open Heath to Low Heaths
Sh	*Spinifex hirsutus* Grasslands
Sl	*Spinifex longifolius* Closed Grassland to Open Grassland
SlT	*Spinifex longifolius* Closed Grassland to Open Grassland over *Tetragonia decumbens* Herblands to Closed Herbland
SlTdT	*Spinifex longifolius, Thinopyrum distichum* Closed Grassland to Open Grassland over *Tetragonia decumbens* Herbland to Closed Herbland
S/MAL	*Syridium globulosum* Open Shrubland to Closed Tall Scrub over and with Very Low Shrublands, Heaths and Herblands of *Melaleauca systena, Acacia lasiocarpa, Lomandra maritima* and other species
SMi	*Spyridium globulosum, Myoporum insulare* Heath
SMiAc/MAL	*Spyridium globulosum, Myoporum insulare, Acacia cyclops* Shrubland to Heaths over and with Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species
SnO	*Scaevola nitida, Olearia axillaris* Open Shrubland to Shrubland
SOAc	*Spyridium globulosum, Olearia axillaris, Acacia cyclops, Myoporum insulare* Open (to Closed) Heath (and Tall Scrubs)
St	*Schinus terebinthifolia* large shrubs; some probably planted; others self-seeded and spreading
Td	*Thinopyrum distichum* Very Open to Closed Grassland
TdShl	*Thinopyrum distichum, Spinifex hirsutus, Spinifex longifolius* Closed Grassland to Grassland
W	Various species of alien plants (weeds and, in some cases, potential weeds)
Wd/MAL	*Westringia dampieri* Low Shrubland to Open Low Heath over Very Low Shrublands, Heaths and Herblands of *Melaleuca systena, Acacia lasiocarpa, Lomandra maritima* and other species

City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN

VEGETATION TYPES LEGEND

FIGURE 6e

YSC-2003-001FMP-f06a.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION TYPES
Two Rocks (North)
FIGURE 6a

YSC-2003-001FMP-f06b.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION TYPES
Two Rocks (South)
FIGURE 6b

YSC-2003-001FMP-f06c.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION TYPES
Yanchep (North)
FIGURE 6c

YSC-2003-001FMP-f06d.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION TYPES
Yanchep (South)
FIGURE 6d

YSC-2003-001FMP-f07a.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION CONDITION
Two Rocks (North)
FIGURE 7a

YSC-2003-001FMP-f07b.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



VEGETATION CONDITION LEGEND

P **Pristine**
Pristine or nearly so, no obvious signs of disturbance

E **Excellent**
Vegetation structure intact, disturbance affecting individual species and weeds are non aggressive

V **Very Good**
Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

G **Good**
Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

D **Degraded**
Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

C **Completely Degraded**
The structure of the vegetation is no longer intact and the areas is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

SOURCE: BUSH FOREVER, Govt. of W.A., 2000

City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION CONDITION
Two Rocks (South)
FIGURE 7b

YSC-2003-001FMP-f07c.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION CONDITION
Yanchep (North)
FIGURE 7c

YSC-2003-001FMP-f07d.dgn DATUM: MGA DRAWN BY: EDS 07-02-05 CHECKED BY: AD 07-02-05 PRINTED: Thu 24 Mar



City of Wanneroo

TWO ROCKS, YANCHEP
FORESHORE MANAGEMENT PLAN
VEGETATION CONDITION
Yanchep (South)
FIGURE 7d

REMNANT VEGETATION

IN THE QUINNS ROCKS AREA:

DESCRIPTION OF VEGETATION AND FLORA

AND

ITS CONSERVATION SIGNIFICANCE

by

Nicky Robinson

cartography by Keith Breheny

report for Quinns Rocks Environmental Group Inc.
August 1997

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1. SUMMARY

Remnant vegetation and flora of the Quinns Rocks area, bounded by Pipidinny Road, Burns Beach Road and Wanneroo Road, are described, major vegetation communities are mapped, and their conservation significance is assessed.

Aerial photography was used to identify major vegetation communities, and ground truthing together with information from previous studies in small sections of the study area, were synthesised to formulate vegetation descriptions and maps. Vegetation communities include two Strand communities, six Quindalup communities, six Spearwood communities, and one Herdsman community .

A total of 473 species representing 255 genera and 77 families of vascular plants are recorded. At least one species of Declared Rare Flora, five priority species, and 23 other significant taxa occur in the study. Introduced species total 89. The flora list was compiled from previous studies in most representative sections of the study area, but as these studies do not cover the entire study area, the list is likely to be incomplete.

Large areas of remnant vegetation exist in the study area, which are representative of communities within the Quindalup and Cottesloe – Central and South vegetation complexes of Heddle (1980). The remnants have high conservation value due to the high level of clearing of these vegetation complexes and their lack of reservation for conservation throughout their original range, particularly in the Perth Metropolitan Area. Remnants in the study area represent an opportunity to add substantial areas to the conservation estate that have the potential to maintain sustainable ecosystems. They are generally in good to very good condition and are relatively large with low border to area ratios. They also provide linkages to other conservation areas adjacent to the study area.

Much is still unknown about the Swan Coastal Plain vegetation and flora. Integration of conservation with planning for urban development in the area is vital in order to preserve the natural values of the area for future generations.

the Indian Ocean in the west, Wanneroo Road in the east, Pipidinny Road in the north and Burns Beach Road in the south (see Figure 1).

Substantial areas of the remaining bush are planned for urban development (Department of Planning and Urban Development, 1992). Areas reserved for parks and recreation include Neerabup National Park, which runs north-south, west of Wanneroo Road, and the coastal strip, from the beach to up to 1km inland. The other major land use is urban. There are also several small holdings under market gardening along the eastern edge of the study area.

Apart from land reserved for public use, the tenure of the remainder is freehold with most areas of remnant vegetation owned by private developers, Landcorp or Homeswest.

The study area includes parts of the System 6 areas M2, M3 and M6, recommended for reservation for conservation and public amenity (Environmental Protection Authority, 1983). Approximately half of M2 (the coastal strip from Two Rocks to Burns Beach) is within the study area. Beonaddy Swamp in the north-east corner of the study area forms part of M3 (Yanchep National Park). M6 (Neerabup National Park) and proposed additions, lie almost entirely within the study area.

The condition of remnant bushland varies from poor to very good, although much is in good to very good condition (see Appendix 1 for Condition Rating Scale). Condition depends largely on the level of disturbance. Disturbances include grazing, use of four-wheel drive and off-road vehicles, rubbish dumping, fire, feral animals (particularly rabbits), clearing for urban development, agriculture and road building. Surrounding land uses also influence condition.

3. PHYSICAL ENVIRONMENT

Vegetation communities present at any site are greatly influenced by a range and combination of characteristics of the physical environment.

3.1 Geology, Geomorphology, Soils and Topography

The dominant geological/geomorphological features of the study area are the Quindalup Dune (Holocene Safety Bay Sand) system of the western side which overlies the older Spearwood Dune (Pleistocene Tamala Limestone) system exposed on the eastern side. Both systems are derived from aeolian deposits (Churchward & McArthur, 1980).

The Quindalup system forms a discontinuous strip of beach ridges and parabolic dunes along the south-west coast of Western Australia. In the study area its width varies. It extends inland up to 3.8km at one point in the north, but for 1.5km south of Quinns Rocks and at Burns Beach it discontinues, and here the Tamala limestone is exposed at the coast (Churchward & McArthur, 1980).

The dunes of the Quindalup system can be classified according to age: Q1 dunes are the oldest and generally occur furthest inland, followed by Q2 and Q3 dunes, with the youngest Q4 dunes occurring along the immediate coastline. The soils of the Quindalup dunes comprise white calcareous sands, and each age is differentiated by steepness, relief, organic matter accumulation in the upper layer, cementation in the lower layers, and vegetation associations. The Q1 dunes are the least steep with the lowest relief, have the greatest accumulation of organic matter, and greatest cementation. There is little differentiation of the coastal heath vegetation associations between Q1, Q2 and Q3 dunes, but Q4 dune vegetation is distinct and typified by pioneer species able to tolerate the harsh conditions closest to the coast (McArthur & Bartle, 1980).

The more extensive Spearwood system is found generally to the east of the Quindalup system. It is characterised by grey-brown surface sand over yellow sand over Tamala

limestone. Sand depth varies, with a maximum of 2m, and the limestone is often exposed at the surface. Where this system extends to the coast, exposed limestone forms low cliffs (McArthur & Bartle, 1980). The deeper soils of the Spearwood system support *Eucalyptus* and *Banksia* open forests and woodlands, and the shallower soils support heath communities.

The system is sub-divided into Karrakatta and Cottesloe soils with the former having deep yellow sands, and the latter shallower sands with much exposed limestone (Churchward & McArthur, 1980). In the study area Cottesloe soils dominate, and only a small area in the south-east corner is covered by the Karrakatta soil.

Other important features of the study area are three small wetlands. Beonaddy Swamp in the north-eastern corner of the study area, and the un-named wetland in the south-eastern corner (an extension of the Lake Joondalup wetland chain, identified as "Joondalup, North" by Arnold, 1990), are part of the Herdsman unit which are described by Churchward & McArthur (1980) as "peaty swamps". Hill et al. (1996) describes them as "sumplands" (seasonally inundated basins). Beonaddy Swamp is 45% undisturbed or vegetated, and the Joondalup North wetland is 86% undisturbed or vegetated (Hill et al., 1996). Karli Spring is a small wetland in the Quindalup Dune system approximately 100m from the beach in the northern section of the study area.

Topographically the study area ranges in height from sea level at the beach, to 75m in the south-eastern corner. Typically, the parallel dunes rise steeply from the beach to 10 or 20m, with the parabolic dune crests reaching up to 50m. Beyond the dunes the landscape is gently undulating, rising gradually from 15 to 20 m in the central-west to 45 to 55m in the east (Department of Land Administration, 1987).

3.2 Climate

The study area has a Mediterranean climate with hot dry summers and reliable winter rainfall. Annual rainfall is approximately 625 – 750mm. Strong south-westerly winds in

summer have the potential to cause blowouts of sparsely vegetated dunes (Trudgen & Keighery, 1990).

4. LITERATURE REVIEW

Heddle et al. (1980) mapped vegetation complexes in relation to landforms, soils and climatic conditions. Each complex is described in terms of projected foliage cover and height of dominant life-forms and species, and understorey species composition. The main vegetation complexes represented in the study area are Quindalup and Cottesloe – Central and South. Karrakatta – Central and South and Herdsman complexes are represented to a minor extent.

The Quindalup system extends from Dongara in the north to Geographe Bay in the south (Semeniuk et al., 1989). The original extent of the Cottesloe – Central and South complex was a discontinuous strip from 13km north of Lake Pinjar (west of the study area) to Lake Preston (south of Mandurah) (Trudgen, 1996).

The Quindalup system is by no means uniform in terms of geomorphology and vegetation throughout its range. Semeniuk et al. (1989) recognised variation from north to south, and divided the system into 5 sectors based on distinct associations of geomorphic units and vegetation habitats (due to different sedimentological, geomorphic, climatic and other edaphic factors). The sector within which our study area lies is Whitfords to Lancelin.

Griffin (1993), in a floristic study of the Quindalup dunes between the Swan and Irwin Rivers, recognised floristic variation north-south attributable to variation in Pleistocene deposits and on this basis he divided the system into sectors. The sector, within which our study area lies, coincides with that of Semeniuk et al. (1989). Within sectors, vegetation composition also varied which he related primarily to variation in landforms with other factors being proximity to the coast, time since colonisation, geology and soils.
In a later study, Griffin & Trudgen (1994) divided this sector into sub-sectors based on this within sector variation. Our study area lies within two of these sub-sectors, Moore River to Quinns Rocks, and Quinns Rocks to Whitfords.

Trudgen (1996) assessed the conservation values of remnant vegetation within the context of Heddle's classification for the whole of the City of Wanneroo. The City has extensive and significant remnants which are important for conservation in a regional context. Recommendations were based on vegetation condition, the conservation status of complexes (including extent of clearing and adequacy of representation in reserves), and potential to connect remnants and existing conservation areas.

Recommendations were made to reserve much of the remnant vegetation in our study area as representative examples of vegetation complexes and transitions between complexes. Linkages between the coast, Neerabup National Park and Yanchep National Park were also recommended for reservation.

Gibson et al. (1994) took a different approach in studying the vegetation of the Swan Coastal Plain. Their concept of floristic community types was highly correlated to seasonal moisture regimes and geomorphology, but poorly correlated to Heddle's vegetation complexes. It is difficult to determine precisely which floristic community types occur in our study area because of differences in methodology between the Swan Coastal Plain study and this study. Their descriptions are based on very detailed and site specific data, whereas this study, which takes a broader, generalised approach in describing the vegetation communities.

Information on sites in the area could have been accessed and still could be - Trudgen 1996 does consider those in the City of Wanneroo.

The sites are approximately as listed the next column.

√ Gibson et al sites are in
- Neerabup
- Yanchep
- Burns Beach (south)
- State Forest 65 E

Heddle/Bystem 6 Sites
- Wilbinga/191
- Guttin 1993 sites

While I would not suggest this be added at this late stage it would be useful to have the groups

The flora and vegetation of various sections of the study area have been mapped and/or described by several authors. Surveys by Keighery et al. (1996) and Mattiske (1990) covered Neerabup National Park and an adjacent Water Reserve in the eastern section. Other surveys were in the western section. Between Burns Beach and Mindarie surveys were conducted by Keighery (1991), Halpern Glick Maunsell (1995), and Kinhill Stearns (1983). Sections north of Quinns Rocks were surveyed by Robinson (1995), Trudgen & Keighery (1990), and LeProvost Environmental Consultants (1990). The coastal communities between Burns Beach and Jindalee were mapped by Hames Sharley Australia (1992). Flora of remnants in and near Quinns Rocks townsite have been surveyed by the Quinns Rocks Environmental Group (David Wake, QREG, pers. comm.)

Vegetation classifications used in these surveys differ in the level of detail of descriptions. They provide useful information on the flora and vegetation but are incomplete in their coverage of the study area.

5. MAPPING AND DESCRIPTION OF THE VEGETATION AND FLORA

5.1 Methods

5.1.1 Vegetation mapping and description

The vegetation maps were compiled from interpretation of aerial photography augmented with ground truthing and synthesis of information on vegetation maps from previous studies.

The aerial photographs used were 1 : 20,000 colour photographs taken for the Department of Land Administration on 6 January 1995 (WA3490 Metro Regional Area). A photo mosaic was compiled and the major vegetation communities were traced. Ground truthing was concentrated on easily accessible public land, and consequently assessment of the vegetation in large sections of the map relied on photo interpretation based on this ground truthing. The final maps produced here are reduced to approximately 1 : 22,500.

Some parts of the study area had been previously mapped by Halpern Glick Maunsell (1995); Hames Sharley Australia (1992); Keighery, Keighery and Gibson (1996); Kinhill Stearns (1983); LeProvost Environmental Consultants (1990); and Robinson (1995). These were used to aid photo interpretation.

The vegetation descriptions are based on observations made when ground truthing and synthesis of information from the above mentioned studies. The vegetation structural classification system used follows Keighery (1994) which was developed during floristic surveys on the Swan Coastal Plain (see Appendix 2).

5.1.2 Flora description

The flora list was compiled from previous flora surveys in various sections of the study area. These surveys were Keighery et al. (1996), Mattiske (1990), Keighery (1991), Robinson (1995), and Trudgen & Keighery (1990). No detailed surveys were found for the wetlands, but dominant species were given by Arnold (1990) for the two Herdsman complex wetlands.

5.2 Limitations of the study

5.2.1 Vegetation mapping and description

Due to limited resources and the large area covered by the project, some degree of generalisation is unavoidable in the vegetation maps and vegetation descriptions.

The scale of the maps (approximately 1 : 22,500) inevitably results in some loss of detail and precision in identifying communities. One consequence of scale limitations is that the narrow belt of coastal communities from the strand to the first stabilised dune, cannot be mapped, although the vegetation has been described in section 5.2. These communities are *Cakile maritima* Very Open Herbland, *Spinifex hirsutus/S. longifolius* Grassland, and *Scaevola crassifolia* Low Heath.

Small remnants (usually under 1 hectare) occur on some residential lots and public land, particularly in the Quinns Rocks townsite. These also were not mapped.

The use of aerial photography in composing a photo mosaic also results in some distortion. The vegetation maps should therefore be used with a degree of caution in this regard.

The aerial photographs were taken in 1995, two years before this study (in early 1997), and changes in land use and to remnant vegetation have since occurred. Some remnants

have been cleared for urban development and known changes have been incorporated into the vegetation maps. Other changes may have occurred due to the natural dynamic processes in remnants, or due to disturbances such as fire and grazing. These may affect the structure, floristics and condition of remnants. The maps have incorporated these changes where known.

5.2.2 Flora description

Previous studies from which the flora list is derived, do not cover the entire study area and therefore the list is likely to be incomplete. In particular, species occurring in the Herdsman Complex are likely to be under-represented as no previous detailed studies were found for these wetlands.

6. VEGETATION DESCRIPTION

6.1 General description of the study area

The coastal foredunes are very steep along the much of the study area. Outcrops of limestone, forming low cliffs, also occur at a few locations along the coast.

Beyond the foredunes the Quindalup communities occur on dunes of various ages with the older Q1, Q2 and Q3 dunes landward of the youngest Q4 dunes. There are some large blowouts and several smaller ones close to the coast.

The mosaic of Spearwood communities generally occur east of the Quindalup communities. These comprise mainly of Cottesloe - Central and South Vegetation Complexes. There is also a small area of Karrakatta - Central and South Complex in the south-eastern corner of the study area (Trudgen, 1996).

Two small areas of the Herdsman Vegetation Complex occur in the north-eastern corner, and the south-eastern corner (Trudgen, 1996).

6.2 Detailed description

Most of the following vegetation communities are mapped on Figures 3, 4 and 5 (a legend for these maps is given in Figure 2). Those communities not mapped (due to limitations of scale) are notated in the text.

Areas on the maps marked urban (U), pasture (P) or cleared (C) are generally devoid of any native vegetation. (Some small patches occur in places but because of scale limitations, these could not be mapped.) Those marked as highly disturbed (S7) are all within the Spearwood system and generally have some remnant native overstorey species.

6.2.1 Strand vegetation communities

Cakile maritima Very Open Herbland (not mapped)

This narrow belt of strand vegetation occurs on low foredunes or beachridges seaward of the first stabilised (or partly stabilised) dune. *Spinifex* spp. are also be found here.

Spinifex hirsutus/S. longifolius Grassland (not mapped)

Occurs on the beach side of the first stabilised dune. The introduced *Ammophila arenaria* is also found on the dunes.

6.2.2 Quindalup vegetation communities

Blowouts (Q1)

There are two large blowouts south of Mindarie and several other smaller ones. They are very sparsely vegetated by *Spinifex* sp. or *Lepidosperma gladiatum* with *Scaevola crassifolia, Isolepis nodosa, Carpobrotus* sp. and the introduced *Trachyandra divaricata* on the blowout ridges. In places *Olearia axillaris* and *Spyridium globulosum* occur.

Scaevola crassifolia Low Heath (Q2) (not mapped)

This community is found on the white sand of the youngest dunes (the foredunes and primary dunes, classified as Q4 dunes by McArthur & Bartle (1980)), and merges with *Spinifex* sp. Grassland at the top of the first dune system.

Apart from *O. axillaris*, other common species are *Lepidosperma gladiatum, Isolepis nodosa, Acrotriche cordata, Hemiandra pungens, Rhagodia baccata, Conostylis candicans, Leucophyta brownii, Acanthocarpus preissii, Leucopogon parviflorus,* and the introduced species *Tetragonia decumbens, Pelargonium capitatum, Trachyandra divaricata* and *Lagarus ovatus*. Larger shrubs (but usually less than 1m) are scattered in the swales: these include *Olearia axillaris, Exocarpus sparteus, Acacia lasiocarpa, Acacia cyclops,* and *Spyridium globulosum.*

Olearia axillaris Open Heath (Q3)

Occurs on the white to grey, calcareous sand of the older, steep to undulating Q1, Q2 and Q3 dunes.

There are significant amounts of other shrubs, particularly *Spyridium globulosum* which dominates in some areas. Other common shrub species are *Acacia saligna, A. rostellifera, A. cochlearis, A. cyclops, Santalum acuminatum, Calothamnus quadrifidus,* and *Myoporum insulare*. Many of the larger shrubs, particularly *Acacia* spp. are found on the deeper soils of sheltered swales. The lower layer is often dominated by *Lomandra maritima,* with other common species *Rhagodia baccata, Melaleuca acerosa, Acanthocarpus preissii, Desmocladus flexuosus,* and many others. Single trees of *Eucalyptus gomphocephala* (tuart) are found occasionally in the swales with several trees forming a small woodland very rarely.

Density of the vegetation is highly variable with total cover varying from 50% in exposed sites on dune ridges, and up to 100% in the sheltered sites.

Melaleuca acerosa/Acacia lasiocarpa Closed Low Heath over *Lomandra maritima* Herbland (Q4)

Occurs on the white to grey, calcareous sand of the older, steep to undulating Q1, Q2 and Q3 dunes.

This community varies in the mix of dominants present. *L. maritima* and *M. acerosa* are single dominants in some areas such as north of Burns Beach and north of Quinns Rocks, while *M. acerosa* and *A. lasiocarpa* are co-dominants south of Pipidinny Road.

Other common species are *Acanthocarpus preissii, Rhagodia baccata, Phyllanthus calycinus, Conostylis candicans, Hemiandra pungens, Desmocladus flexuosus, Lepidosperma squamatum* and the introduced *Pelargonium capitatum. Acacia saligna* is

also common in small stands or single shrubs. *Eucalyptus gomphocephala* is found occasionally on the lower dune slopes and in the swales.

The density of the vegetation is variable, often covering only 50% of the ground. There is much evidence of fire immediately south of Mindarie Keys. Indicators of this include the burnt remains of many shrubs, the fairly common occurrence of *Anthoceris littorea* ('fireweeds'), and low *Acacia saligna* shrubs (less than 0.5m). A high level of weed invasion in some areas may also be indicative of frequent fires.

Acacia rostellifera Heath and Scrub (Q5)

Occurs commonly in the shelter and deeper soils between dune ridges.

The structure of this community varies from Closed Heath and Tall Scrub to Open Heath. Where it occurs as Closed Heath and Tall Scrub there is little understorey in the dense thickets. Some stands show evidence of fire with the dead stems protruding above the shrubs that have apparently resprouted from suckers. It is expected that Low Heath would mature into Heath in the absence of fire.

Closed Sedgeland (Q6)

This community refers to Karli Spring, a small wetland behind the parallel dunes between Quinns Rocks and Pipidinny Road. The dominant species is *Lepidosperma gladiatum* (David Wake, QREG, pers. comm.). No other studies were found for the spring.

6.2.3 Spearwood vegetation communities

Banksia attenuata B. menziesii Low Woodland (S1)

Occurs in flat to undulating areas on grey over yellow sand.

B. attenuata is the dominant species with *B. menziesii* less common. *Nuytsia floribunda, Eucalyptus gomphocephala, E. todtiana* and *Allocasuarina fraseriana* are also found occasionally. The taller understorey dominants are *Xanthorrhoea preissii* and *Macrozamia riedlei*. The lower layer is very variable in species present, and in density of

cover. In some locations the layer is very dense, and in others, bare ground is dotted with rabbit burrows.

Eucalyptus marginata Open Forest and Woodland over *Banksia attenuata* Low Woodland (S2)

Occurs generally east of the Connolly Drive alignment on grey over yellow sand.

The presence and density of *E. marginata* and *B. attenuata* varies in this community. Other important overstorey species include *Corymbia calophylla* (previously *E. calophylla*), *E. todtiana* and *B. menziesii*. On higher ground, particularly along the western side of the Wanneroo Road alignment, *E. marginata/C. calophylla* Open Forest merges into *E. gomphocephala* Woodland.

Common species in the *Banksia* layer include *Allocasuarina fraseriana* and *B. grandis*, and *B. ilicifolia* and *B. littoralis* occur occasionally. The next layer is dominated by *Xanthorrhoea preissii* and *Macrozamia riedlei*. Common understorey species are *Hibbertia hypericoides, Petrophile* sp., *Hakea* spp., and *Mesomelaena stygia*.

Eucalyptus gomphocephala Woodland (S3)

Occurs on grey over yellow sand over limestone, usually on rises where the sand is shallow.

Between the Tamala Park Landfill Site and the Connolly Drive alignment, in the south of the study area, this community has an understorey of *Banksia attenuata, Xanthorrhoea preissii* and introduced grasses. This area has obviously been subject to grazing.

In the eastern portion of the study area *E. gomphocephala* Woodland is associated with *Dryandra sessilis* Heath on the higher ground, and merges with *E. marginata/Corymbia calophylla* Forest/Woodland down the slopes. It is generally in much better condition although there are some degraded areas outside the boundary of Neerabup National Park, which have few native understorey species.

Limestone Heath (S4)

Occurs on limestone ridges on shallow grey over yellow sand, commonly with exposed rock.

This vegetation community is very variable. The most common dominant species is *Dryandra sessilis* which often occurs in dense monotypic stands, but other commonly occurring co-dominant species are *Xanthorrhoea preissii, Melaleuca huegelii, Acacia truncata* and *M. cardiophylla*. The latter two species also form dense stands with little or no *D. sessilis* present.

Known locations of substantial areas of *Melaleuca cardiophylla* Heath are: adjacent to the large blowout north of Burns Beach; in the large remnant near Mindarie Keys; and close to the coast approximately 1.5km north of Quinns Rocks.

In the eastern section of the study area, *D. sessilis* Heath is found in association with *Eucalyptus gomphocephala* which forms a woodland around the perimeter, and sometimes trees are scattered through the heath.

Other common species of this community are *Acacia saligna, A. pulchella, Calothamnus quadrifidus, Hakea trifurcata, H. prostrata, Hibbertia hypericoides* and *M. acerosa*.

A. pulchella occurs where *D. sessilis* is less than 1m. These areas have obviously been subject to a fairly recent fire. The structural classification of this association varies according to the time since the last fire. In some areas *D. sessilis* is less than 0.5m (Low Heath), and in others it is over 2m (Closed Tall Scrub). The latter is presumably the climax community. Height may also be determined by degree of exposure to winds from the ocean.

Xanthorrhoea preissii Shrubland (S5)

Occurs in the central eastern section of the study area on grey over yellow sand.

Common understorey shrubs include *Hibbertia hypericoides*. Keighery et al. (1996) recorded *Hakea trifurcata, Calothamnus quadrifidus, Melaleuca acerosa, Dryandra sessilis, Conostylis aculeata, Mesomelaena pseudostygia* and *Desmocladus flexuosus* for this vegetation association.

Eucalyptus foecunda/E. petrensis Closed Mallee (S6)

The only known area of this community large enough to be mapped occurs west of Marmion Avenue in the southern section of the study area. It is associated with a Limestone Heath community. There are other areas of this community, but due to the limitations of this study, their locations could not be confirmed.

Highly Disturbed Areas (S7)

These areas generally occur in the central section of the study area. They have been subject to grazing to the extent that the understorey consists almost entirely of introduced grasses, with very few or no native species. The trees and shrubs of the overstorey occur as either isolated or scattered individuals, or small to large stands. Species include *Eucalyptus marginata, E. todtiana, E. gomphocephala, Corymbia calophylla, Banksia* spp. and *Xanthorrhoea preissii*.

6.2.4 Herdsman vegetation communities

Melaleuca rhaphiophylla Low Open to Closed Forest (H1)

This is the dominant fringing community of Beonaddy Swamp in the north-east, and the Joondalup North wetland in the south-east. Other important species at both wetlands are *Eucalyptus rudis* with *Typha* sp. occurring in dense stands in disturbed areas. Some *Melaleuca lateritia* occurs at the Joondalup North wetland, and *M. preissiana*, a species

uncharacteristic of the Spearwood system, occurs to the south of the wetland (Arnold, 1990).

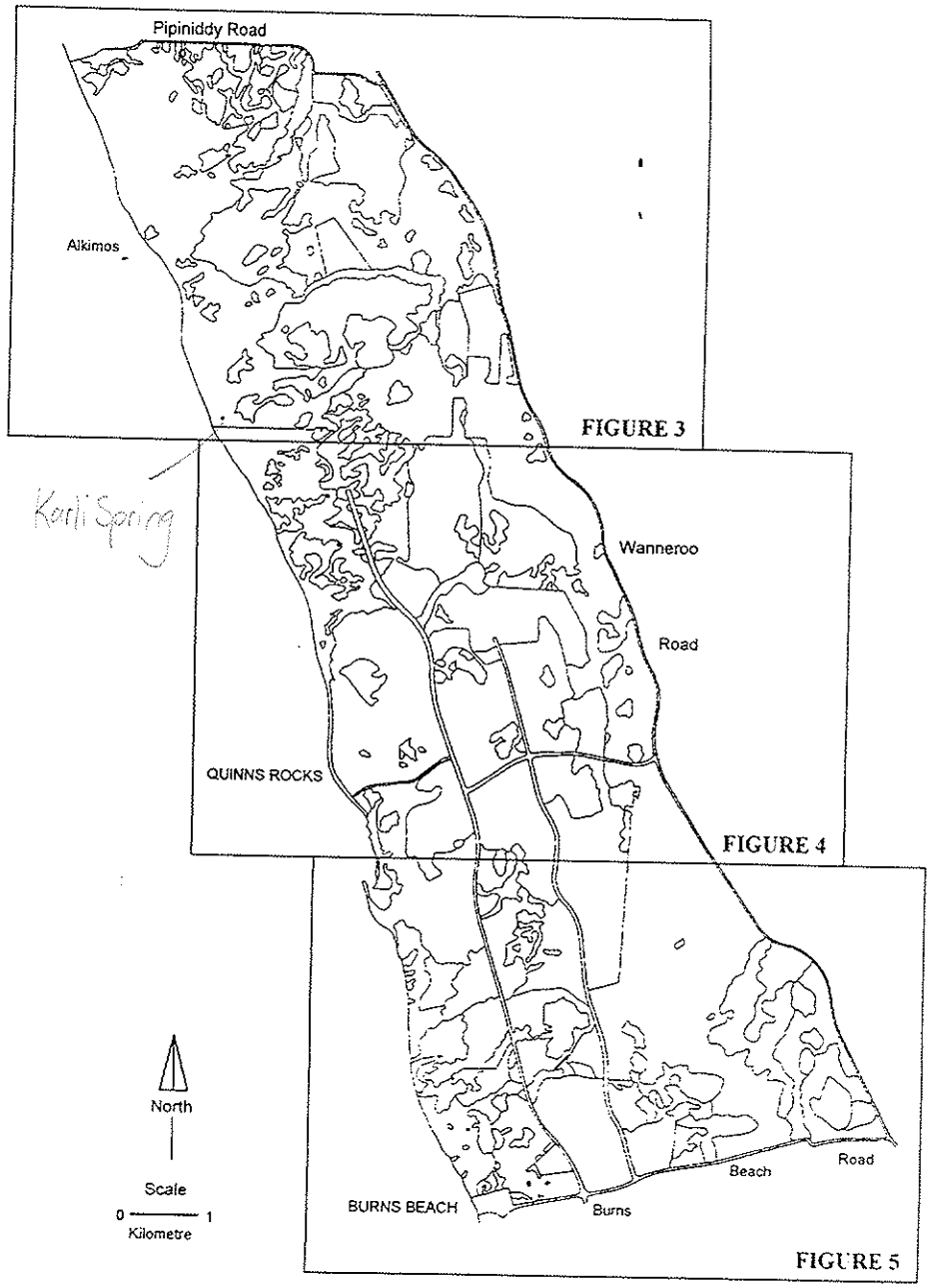


Figure 2. Legend showing layout of vegetation map coverage

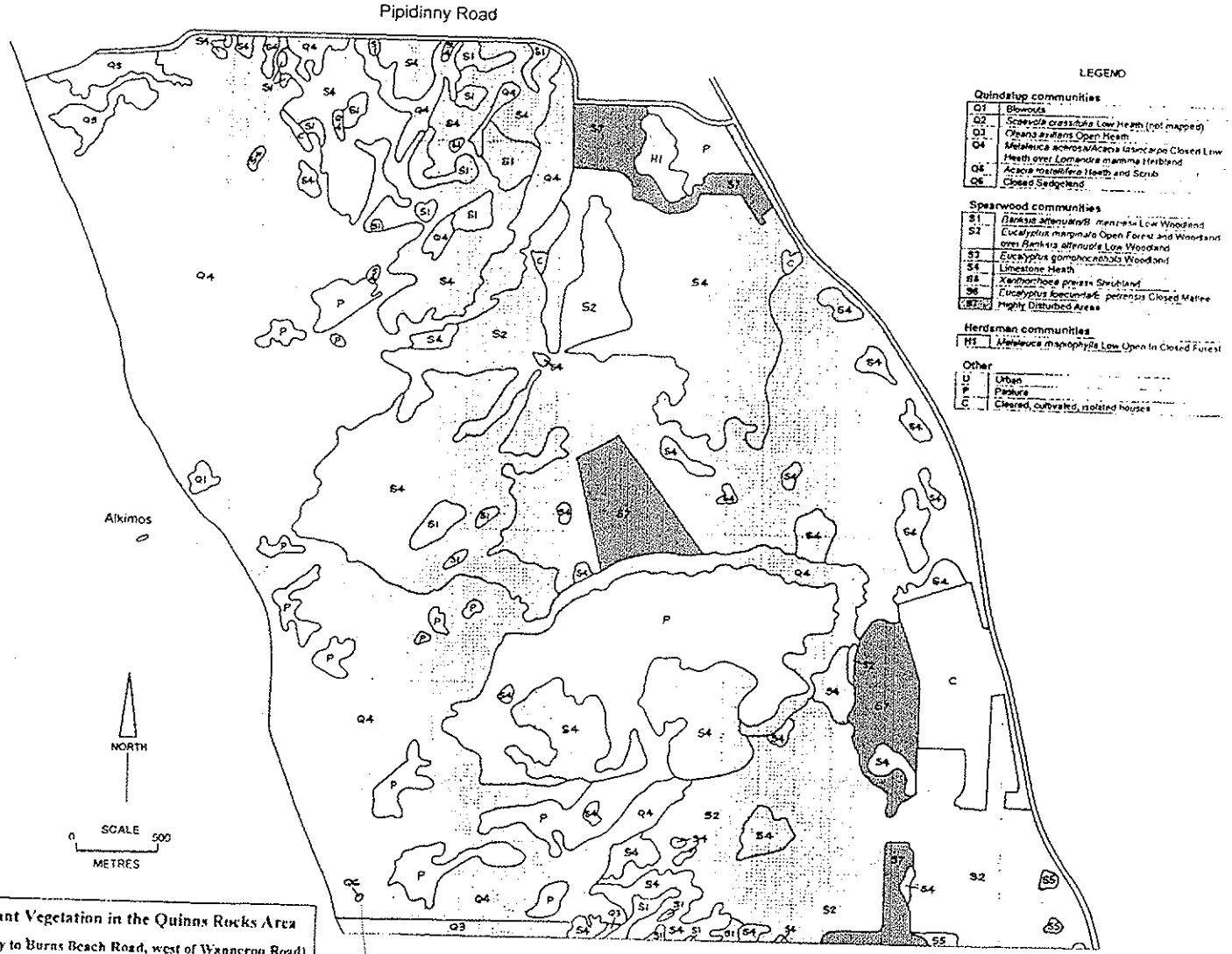


Figure 3. Remnant Vegetation in the Quinns Rocks Area
(Pipidinny to Burns Beach Road, west of Wanneroo Road)
- Northern Section

Karli spring

~ 160m inland

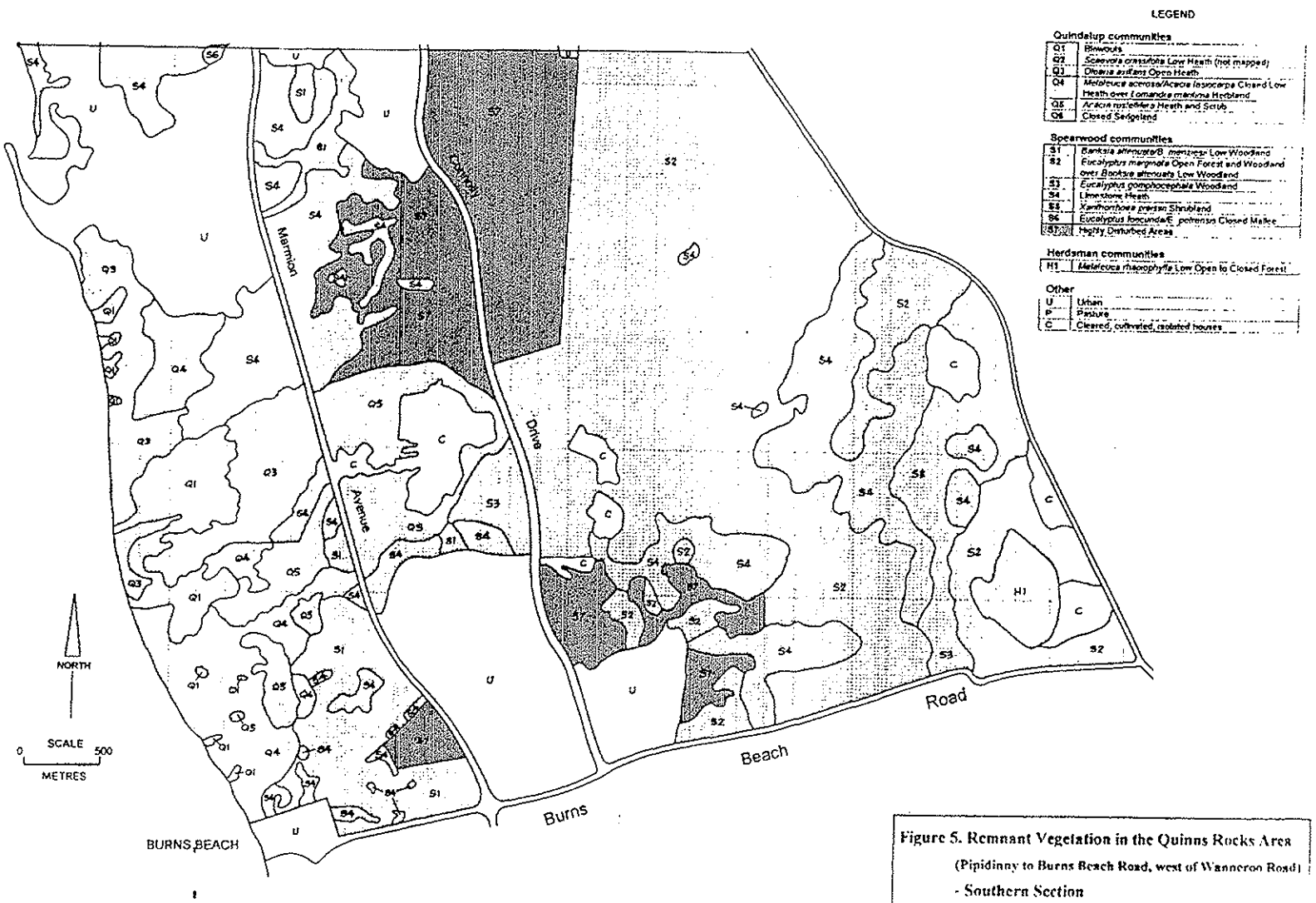


Figure 5. Remnant Vegetation in the Quinns Rocks Area
(Pipidinny to Burns Beach Road, west of Wanneroo Road)
- Southern Section

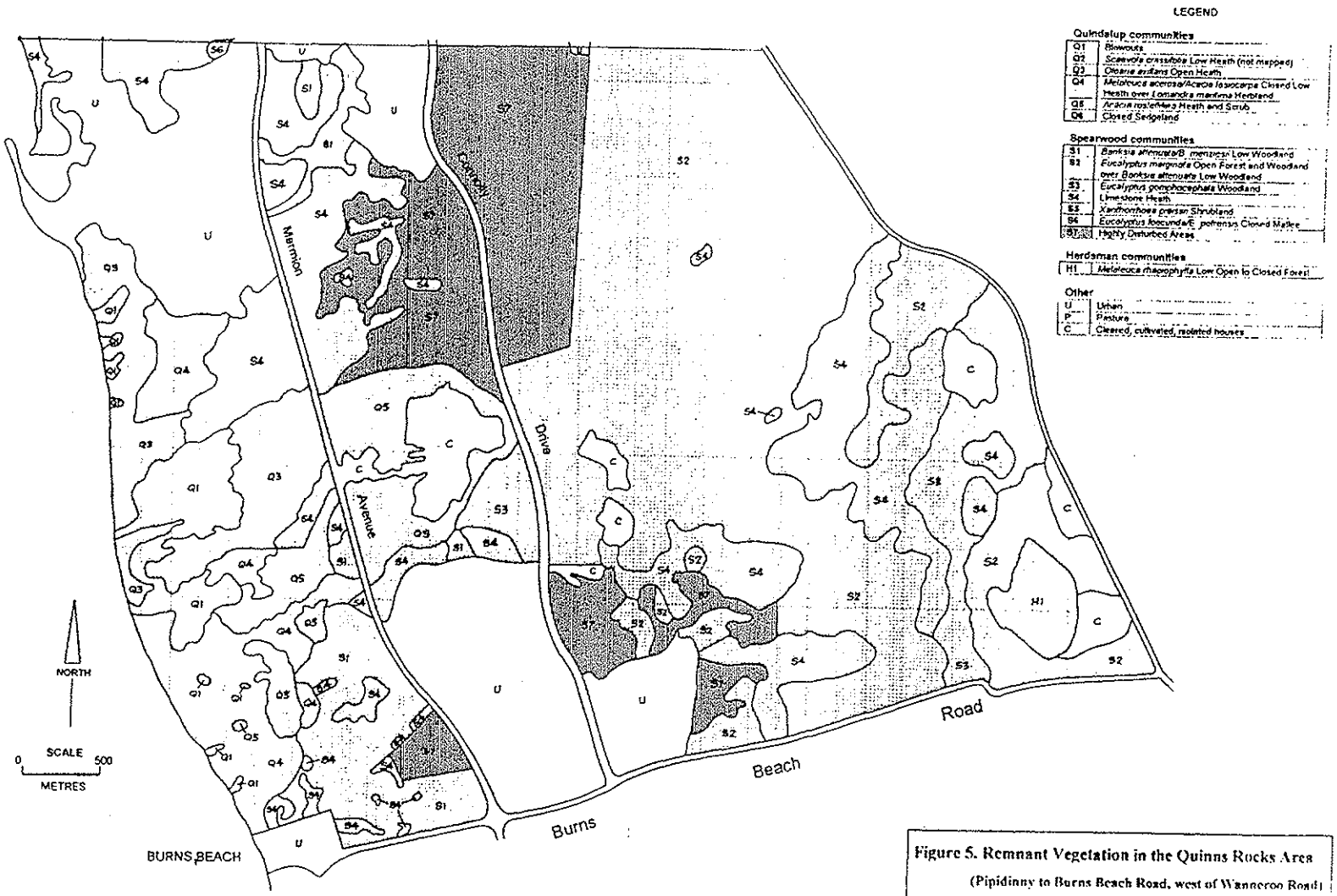


Figure 5. Remnant Vegetation in the Quinns Rocks Area
(Pipidinny to Burns Beach Road, west of Wanneroo Road)
- Southern Section

7. FLORA DESCRIPTION

7.1 General description

A total of 473 species representing 255 genera and 77 families of vascular plants were recorded. Introduced (weed) species total 89. A flora list is given in Appendix 3.

The most species rich families are Proteaceae (29 natives), Myrtaceae (27 natives), Asteraceae (27 native and 12 weed species), Cyperaceae (25 natives), Orchidaceae (25 natives), Papilionaceae (23 natives, 12 weeds), Epacridaceae (16 natives), and Poaceae (15 natives, 22 weeds).

Families with the most weed species are Poaceae (22 species), Asteraceae (12), and Papilionaceae (12).

7.2 Significant Taxa

7.2.1 Declared Rare and Priority Taxa

At least one species of Declared Rare Flora (DRF) and five priority (poorly known) species listed by Atkins (1996), occur in the study area. DRF have special protection under the *Wildlife Conservation Act 1950* and cannot be harvested, injured in any way, or destroyed without written permission from the Minister for CALM. Priority (P) species are taxa that are poorly known and require further survey to determine their conservation status, or are rare but not threatened and require monitoring.

Eucalyptus argutifolia (Myrtaceae) - DRF
Small stands of this rare mallee species occur at the southern end of its range in the study area. It extends north only as far as Seabird (Keighery, 1992).

Lepidium pseudohyssopifolium (Brassicaceae) - P1

This herb occurs on limestone surfaces and has only been found in Western Australia on the Nullabor and the Swan Coastal Plain (Keighery et al., 1996).

Hibbertia spicata subsp. *leptotheca* (Dillenaceae) - P3

This is endemic to Tamala Limestone ridges between Yalgorup and Wedge Island (Keighery et al., 1996).

Conostylis pauciflora subsp. *euryhipis* (Haemodoraceae) - P3

This is found only on the Quindalup dunes between the northern part of the study area and Cervantes (Trudgen & Keighery, 1990).

Jacksonia sericea (Papilionaceae) - P3

This species is at the northern end of its range in the study area, in Neerabup National Park (Keighery et al., 1996).

Stylidium maritima ms (Stylidiaceae) - P3

Although locally common, there of few populations of this species and much of its habitat has been cleared or degraded (Keighery et al., 1996).

7.2.2 Other significant taxa

Other significant taxa include species that: are at the end of their range or close to it in the study area; occur as disjunct populations in the study area; are poorly known or uncommon species but not listed by CALM as rare; are undescribed; or are endemic to the Swan Coastal Plain.

Laxmannia sessiliflora subsp. *australis* (Anthericaceae)

This is a widespread species but the southern end of its range on the Swan Coastal Plain is in the north of the study area (Trudgen & Keighery, 1990).

Leptorhynchos scabrus (Asteraceae)

This is locally common on the Quindalup Q2 and Q3 dunes in the north of the study area, and although it is widespread it is poorly collected and may be uncommon (Trudgen & Keighery, 1990).

Sonchus megalocarpa (Asteraceae)

The northern most population of this species is on blowout ridges in the south of the study area. It is the only known mainland population north of Bunbury. It also occurs on Garden Island (Keighery, 1991).

Allocasuarina lehmanniana (Casuarinaceae)

This once common Quindalup dune species is not well known in reserves (Keighery, 1991).

Cyatochaeta avenacea (Cyperaceae) – unlikely north to here

This sedge occurs along the coast to Fitzgerald River National Park but the northern end of its range is close to the study area (Gibson et al., 1994).

Schoenus latitans (Cyperaceae)

A sedge at the southern end of its range close to the study area (Gibson et al., 1994).

limestone endemic

Astroloma microcalyx (Epacridaceae)

This is a limestone endemic species only occurring on the Swan Coastal Plain (Keighery et al., 1996).

Lechenaultia linarioides (Goodenaceae)

This shrub extends to Dirk Hartog Island and inland to Mingenew but the southern end of its range is near Perth (Marchant et al., 1987).

Gyrostemon ramulosus (Gyrostemonaceae)

This small tree is widespread in drier parts of Australia but it is uncommon in the Metropolitan Region and Perth is the southern end of its range on the Swan Coastal Plain (Powell, 1990).

Conostylis teretifolia subsp. *planescens* (Haemodoraceae)

This uncommon *Banksia* Woodland species is at the southern end of its range in the study area (Trudgen & Keighery, 1990).

Hemiandra pungens (Lamiaceae)

A dune form of this widespread species found in the study area, only occurs from Wanneroo to Seabird (Keighery et al., 1996).

Baeckea robusta (Myrtaceae)

The southern end of this species' range is close to the study area (Gibson et al., 1994).

Leptospermum spinescens (Myrtaceae)

This shrub is at the southern end of its coastal range at Perth. Outside the Perth Region its leaves are often shorter and broader (Marchant et al., 1987).

Melaleuca cardiophylla (Myrtaceae)

Low dense shrublands of this species are not well conserved on the Swan Coastal Plain (Keighery, 1992), and the southern end of its range is at Bold Park (Gibson et al., 1994).

Jacksonia stricta (Papilionaceae)

This near coastal shrub it at the southern end of its range in or close to the study area. It extends north to Eneabba (Marchant et al., 1987).

Nemcia reticulata (Papilionaceae)

The coastal form of this species extends from the study area (Burns Beach) to Northampton and is not known in any conservation reserves south of Nambung (Gibson et al., 1994).

Billardiera variifolia (Pittosporaceae)

This twining shrub occurs only occasionally on the Swan Coastal Plain and the northern end of its range is close to the study area (Marchant et al., 1987).

Persoonia comata (Proteaceae)

This is at the southern end of its range in the north of the study area (Trudgen & Keighery, 1990).

Petrophile aff. *brevifolia* (Proteaceae)

This undescribed species occurs only on the Swan Coastal Plain (Trudgen & Keighery, 1990).

Petrophile aff. *serruriae* (Proteaceae)

An undescribed species of the Swan Coastal Plain between Perth and Geraldton (Trudgen & Keighery, 1990).

Veronica aff. *calycina* (Scrophulariaceae)

This Quindalup dune species is known only from Alkimos and Yalgorup. Its favoured habitat type has mostly been degraded by grazing or cleared, and consequently it is uncommon and may be rare. It is probably *V. stolonifera* described from Fremantle (Gibson et al., 1994).

Stylidium aff. *repens* (Stylidiaceae)

The southern most locality of this undescribed species occurs near the coast in the north of the study area (Trudgen & Keighery, 1990).

Pimelea rosea (Thymelaeaceae)

This shrub occurs near the coast (Marchant et al., 1987), and is at the northern end of its range close to the study area at Lake Pinjar (Gibson et al., 1994).

confusing

8. CONSERVATION SIGNIFICANCE

8.1 The values of remnant vegetation

The values attached to remnant vegetation, or bushland, are many.

The conservation value of bushland lies in the need to conserve representative samples of all species and communities both common and rare, and to preserve natural processes that maintain the biosphere in which we live. Such processes are outline in the State Planning Strategy Discussion Paper on Environmental Issues (in Keighery & Gray, 1993). These include maintaining water cycles, regulating climate, protecting soil, nutrient cycling, regulating insect populations, providing renewable resources, protecting species and genetic diversity, and providing habitat for pollinators of agricultural crops.

All bushland has an intrinsic value. Whether species are common or rare, they are part of the unique and diverse flora of Western Australia which is part of our heritage. The aesthetic values of bushland provide us with a source of artistic inspiration and a sense of place and of well-being. Bushland also provides places for active and passive recreation.

Bushland is an educational resource enabling students to observe and understand how organisms function and how natural processes work and contribute to our own survival. There is still many aspects of our natural environment to be studied and documented. Remnant bushland provides an opportunity to increase our scientific knowledge at all levels of study and gain a greater understanding of how to manage our natural resources for the benefit of present and future generations.

The economic value of bushland includes its' potential to attract tourists who come to see Western Australia's famous wildflowers. Other economic benefits are protection from land and water supply degradation associated with clearing native vegetation, and as a potential genetic resource for agricultural crops, the cut flower and nursery industries, or chemical compounds with medicinal or other industrial uses.

By conserving remnant bush, we are not only preserving biodiversity and natural processes (which also implies conserving fauna and their habitats, and geomorphological features and processes), but by default are also preserving all other values. Assessment of conservation value or significance will therefore will focus on the biological values of the vegetation.

8.2 Criteria for assessing conservation value

Criteria adopted here for assessing conservation value are similar to those used by other authors, such as Trudgen (1996). They are as follows:

1. The value of vegetation in a regional context.

This refers to where the remnant occurs in the overall distribution of the vegetation type, how it varies throughout its range and how well this variation is represented in reserves.

2. The potential for maintaining sustainable ecosystems.

This refers to the conditions required to allow ecosystem processes to continue functioning in the long-term in order to retain the integrity of the remnant. Factors to be considered include the size and shape of reserves, external influences, connectivity, duplication of reserves, and the condition of the vegetation.

3. The significance of flora present.

This refers to the diversity of flora, and the presence of Declared Rare Flora (DRF), Priority species (poorly known and geographically restricted taxa), species at their range ends, and isolated populations of species.

8.3 Assessment of conservation value

The map of remnant vegetation in the study area (Figure 6) shows relatively large areas on both the Quindalup and Spearwood systems remaining.

8.3.1 Value of vegetation in a regional context

8.3.1.1 Extent, variation and reservation of the Quindalup system

The Quindalup system extends from Dongara to Geographe Bay. Semeniuk et al. (1989), Griffin (1993), and Griffin & Trudgen (1994) discuss the reservation status of the Quindalup system and draw the same conclusion: that the variation within the system is inadequately represented in reserves between Lancelin and Whitfords. The narrow coastal reserves of the sector in the Perth Metropolitan Area, only preserves the seaward parts of the system.

Given that very little of the Quindalup system is reserved in this sector, and that the entire width of the system is still largely intact in the study area, the remnant vegetation has a very significant conservation value.

Karli Spring is currently under review by CALM as a possible "Critically Endangered Ecological Community" (Val English, CALM, pers. comm.).

8.3.1.2 Extent, variation and reservation of the Spearwood system

The variation found within the Quindalup system is also likely to occur in the Spearwood system (Trudgen, 1996). The diverse flora of this system was once extensive and escaped clearing because the poor sandy soils were little use for agriculture. However as urbanisation expands plant communities, such as *Banksia* Woodlands, are fast disappearing (Keighery & Gray, 1993).

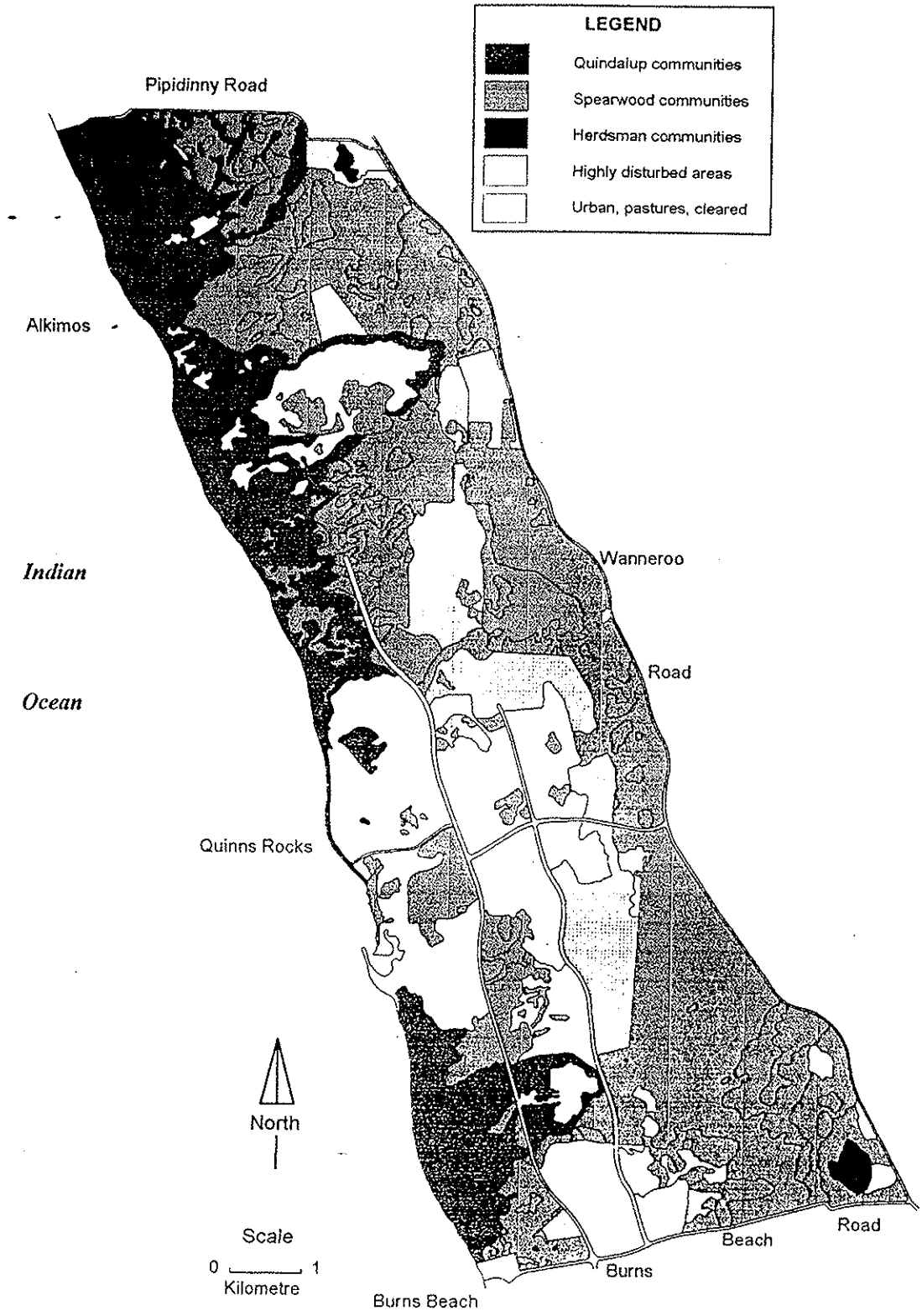


Figure 6. Remnant vegetation in the Quinns Rocks Area
(Pipidinny to Burns Beach Road, west of Wanneroo Road)

With only 20-30% of the original area of Cottesloe – Central and South remaining (the largest portion being north of the Swan River), and only 8% represented in reserves (Trudgen, 1996), the section found in the study area has a very significant conservation value.

This view is supported by Keighery et al. (1996, p.81) in a study of the floristics of Neerabup National Park. They conclude that the Park is a "... very significant regional conservation area" due in part to its "... relatively large areas of the regional floristic community types typical of the Spearwood Dunes."

8.3.1.3 Extent and reservation of the Herdsman unit

Trudgen (1996) estimates that only 20-30% of this unit is extant in the Perth Metropolitan Area, and of the original distribution only 5-10% is represented in reserves. Both wetlands in the study area therefore have significant conservation value because of the high level of clearing of this unit despite being in only poor to good condition. The Joondalup North wetland in the south-east has particularly significant value because it occurs in a transition zone between Cottesloe – Central and South and Karrakatta – Central and South vegetation complexes. It is subject to the Environmental Protection (Swan Coastal Plain Lakes) Policy (Hill et al., 1996).

8.3.1.4 Vegetation transitions and combination of vegetation complexes

The ecotones or transition areas between the Quindalup and Spearwood communities are also important for conservation, and in the study area they are well represented. Ecotones are often areas of greater diversity than within discrete communities. At the boundary, suites of species from each habitat may be found together with those that utilise both habitats, and those that thrive under conditions provided by the boundary (Smith, 1990).

Trudgen (1996) states that these transitions have significant conservation value, and the combined area increases the total value. Conserving interfaces also conserves the sequence of these systems (Griffin & Trudgen, 1994).

8.3.2 Potential for maintaining sustainable ecosystems

In assessing conservation value of an area, the potential for maintaining viable and sustainable ecosystems is an important factor. A review of the principles of reserve design for preserving long-term conservation values is useful in this assessment.

In an ideal situation reserves should be as large as possible with a minimum border length (Lunney & Recher, 1986). If reserves are compact in shape then the border/area ratio, and consequently external influences, are minimised. External influences include different physical conditions at the edge, such as levels of solar radiation, wind, water and nutrients, all of which can have a profound effect on the biota (Saunders et al., 1991). Other impacts on reserves with large borders, or on small reserves, particularly in urban areas, are vulnerability to weed infestation, frequent fires, invasion by feral animals, and increased accessibility and disturbance by human activity (Lunney & Recher, 1986). These factors lead to a cycle of disturbance, which in turn leads to degradation of the natural values of the reserve.

Other design principles include providing connections or corridors of natural habitat between reserves to facilitate the movement of flora propagules and fauna. The capacity for movement aids in preservation of species and genetic diversity. If connection is not possible, movement is more likely between closely clustered reserves than between those that are isolated by large tracts of land devoid of native vegetation (Lunney & Recher, 1986).

Reserves should also be duplicated so that outbreaks of disease or natural catastrophes in one reserve do not lead to extinction of species which are dependent on specific habitats (Lunney & Recher, 1986).

The condition of reserves is also important. If they are in good condition initially they are more likely to retain integrity in the long-term.

While it is unlikely that an ideal situation will ever exist (particularly in areas close to urban centres which historically have been subject to some form of disturbance, such as is the case in the study area), these principles are still useful in assessing conservation value and in reserve design.

Substantial areas of remnant vegetation with minimum border length/area ratios, and which are in very good condition (according to Trudgen, 1996), exist in the study area. The largest area is in the northern section, north of Quinns Rocks (see Figure 6). Although there are sections of highly disturbed, pasture, and cleared land, the remnant vegetation is interconnected in this area. It also links to Neerabup National Park in the south and east of the study area.

Other substantial, well-shaped areas in very good condition (Trudgen, 1996) are the Quindalup and Spearwood communities west of Marmion Avenue in the southern section, and the southern part of Neerabup National Park and proposed additions (see Figures 5 and 6). These two areas are linked by the land surrounding the Tamala Park landfill site which is in poor to good condition (Trudgen, 1996), and which was recommended for reservation in the System 6 report (EPA, 1983). The value of this connection is reduced to some degree by Marmion Avenue and Connolly Drive (two fairly major roads which dissect it north-south).

The smaller remnants in the central, urban areas of Quinns Rocks, Mindarie and Merriwa are in good to very good condition (Trudgen, 1996). The clustered nature of these remnants and their close proximity to larger remnants helps facilitate some exchange of biota, which consequently helps protect their long-term viability.

The Herdsman unit wetlands and Karli Spring are also relatively small but they adjoin larger remnants, and the former act as links to remnants outside the study area.

The highly disturbed sections of the study area are concentrated along the western boundary of Neerabup National Park. These areas can have a negative impact on adjoining bush by providing a source of weeds. However the scattered native trees and shrubs, while they cannot be described as remnant vegetation, still have some value as a part of the natural landscape (Keighery & Gray, 1993) and can provide important habitats. Tuart (*Eucalyptus gomphocephala*), the largest tree of the coastal plain, is particularly important as "one of the most biologically valuable trees of Perth" (Powell, 1990). Hollows are used by nesting birds and other fauna, virtually every part of the tree is utilised by insects which are also a food source for larger fauna, the bark shelters lizards, and large fungi growing on the trunk are in turn inhabited by thousands of insects.

The study area is also linked to adjoining bushland. In the north it is linked or closely connected, to bushland at Eglinton and to Yanchep National Park. In the east it has some linkage to a north-south chain of wetlands and remnant bushland east of Wanneroo Road. In the south-east Neerabup National Park and surrounding bushland (proposed for addition to the Park), is connected to Yellagonga Regional Park by the Joondalup North wetland. In the south-west bushland forms a continuum with that at Iluka and with the coastal reserve. These linkages, despite some dissection by roads of various widths, may well contribute to the long-term preservation of conservation values of the study area and it's surrounding bushland and wetlands.

This assessment has not considered proposed land uses. Development is planned for much of the study area, including large parts of what is remnant vegetation (DPUD, 1992). The conservation values described here would be affected by such development and should be considered in land use planning for the area.

8.3.3 Significance of flora

No definitive assessment can be made of flora diversity in the study area due to the limitations of this study in compiling the flora list. However some general comments can

be made based on previous studies. Trudgen (1996, p.46) described the flora of the City of Wanneroo as "diverse". Keighery et al. (1996, p.81) recognised that the Spearwood dunes have a "diverse flora". Griffin (1993) found species richness in the Quindalup dunes relatively low but this was in comparison to the particularly rich kwongan flora.

The presence of one species of Declared Rare Flora, six Priority species, and at least twenty-three other significant taxa, attests to the area's conservation significance. It is not only these taxa that add to the conservation significance of the area, but also locally common species that do not occur, or are not common elsewhere. Trudgen & Keighery (1990) give the examples of *Lomandra maritima* and *Pimelea ferruginea* which only occur on the Quindalup dunes: if communities found on this inadequately reserved complex are not protected, common species such as these may also become rare.

Gibson et al. can be used to consider species richness ie diversity associated with part of floristic groupings

9. DISCUSSION AND CONCLUSION

The study area has large remnants of native vegetation on the Quindalup and Spearwood systems, and many of these are in good to very good condition. The vegetation communities and flora found in the study area are inadequately represented in reserves, as outlined in the previous section. An opportunity exists here to preserve conservation values in the long-term by the addition of significant areas to the conservation estate.

The area has high conservation value, and this view is supported by other authors:

- "the Alkimos area and adjoining uncleared areas have considerable conservation value for flora, vegetation and geomorphological types" (Trudgen & Keighery, 1990, p.45);
- The area between Burns Beach and Mindarie has "... a mixture of very important and important areas for conservation of vegetation with lesser, but still significant value for flora" (Griffin & Trudgen, 1994, p.1-2);
- "Neerabup National Park is a very significant regional conservation area ..." (Keighery et al., 1996, p.81);
- The entire area has "significant", "high" or "very high" conservation value (Trudgen, 1996).

Many remnants in the study area clearly fulfills the Western Australian Government's Urban Bushland Strategy definition of regionally significant bushland (see Appendix 4), and others have high local significance.

The presence of many poorly known species highlights the fact that, despite the study area being readily accessible in terms of distance from our main urban centre, there is still much we don't know about its flora. Gibson et al. (1994, p.1) found "... significant gaps in our knowledge of the distribution of flora and floristic communities ..." of the Swan Coastal Plain. With the gradual encroachment of urban development in the study area, "Availability of such knowledge is vital if conservation of our unique flora and plant

communities is to be integrated with urban and industrial growth" (Gibson et al., 1994, p.1). Scarce complex plant communities cannot be restored once land is cleared for development – they are gone forever (Keighery & Gray, 1993).

Fragmentation of bushland into small reserves does not ensure long-term preservation of conservation values. A comparative study between a section of the coastal reserve in the study area surrounded by large tracts of relatively undisturbed bushland, and a section of coastal reserve surrounded by long established urban development at City Beach, showed dramatic differences. The undisturbed reserve had a statistically significant higher diversity and significantly lower weed cover that the urban reserve (Robinson, 1995).

Only by conserving large areas of remnant vegetation can we hope to gain a better knowledge of our vegetation and flora, and preserve them for future generations.

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APPENDIX 1 - VEGETATION CONDITION SCALE

The scale follows that of the Ministry for Planning's Perth Environment Project, as used by Trudgen (1996).

Description	Very Poor	Poor	Good	Very Good
High level disturbance	> 50%	25-50%	< 25%	0
Low level disturbance	> 75%	50-75%	25-50%	< 25%
Species recruitment	absent	local	general	general
Population structure	senescent	senescent	good	good
Vertical strata	> 75% lost	25-75% lost	< 25% lost	intact
Community diversity	> 75% lost	25-75% lost	< 25% lost	intact

APPENDIX 2 - VEGETATION STRUCTURAL CLASSIFICATION

The vegetation structural classification system in the table below follows Keighery (1994).

	Canopy Cover (percentage)			
Life form /Height class	100 - 70	70 - 30	30 - 10	10 - 2
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10-30m	Closed Forest	Open Forest	Woodland	Open Woodland
Trees under 10m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs over 2m	Closed Tall Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland
Shrubs 1-2m	Closed Heath	Open Heath	Shrubland	Open Shrubland
Shrubs under 1m	Closed Low Heath	Open Low Heath	Low Shrubland	Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

APPENDIX 3 - FLORA LIST

The following list is compiled from previous flora surveys in various parts of the study area. These surveys are Keighery (1991) and species recorded are denoted by 'K', Trudgen & Keighery (1990) denoted by 'TK', Robinson (1995) denoted by 'R', Mattiske (1990) denoted by 'M', Keighery, Keighery & Gibson (1996) denoted by 'KG', and Arnold (1990) denoted by 'A'.

'K', 'TK' and 'R' are surveys from the western section of the study area, while 'M', 'KG' and 'A' are from the eastern section.

Common names are taken from Powel & Emberson (199), Marchant et al. (1987), Bennett (1988), and Rippey & Rowland (1995).

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
AIZOACEAE							
* Carpobrotus edulis	Pigface; Hottentot Fig	+	+	+	+	+	
Carpobrotus virescens	Native Pigface	+	+	+			
Carpobrotus modestus						+	
* Tetragonia decumbens		+	+	+			
AMARANTHACEAE							
Ptilotus drumondii	Narrow Leaf Mulla Mulla					+	
Ptilotus manglesii	Pom-Poms	+			+	+	
Ptilotus polystachyus	Prince Of Wales Feathers	+	+			+	
Ptilotus stirlingii	Stirling's Mulla Mulla		+			+	
ANTHERICACEAE							
Caesia micrantha	Pale Grass Lily	+				+	
Chamaescilla corymbosa	Blue Squill					+	
Corynotheca micrantha	Sand Lily	+	+			+	
Dichopogon capillipes		+			+	+	
Laxmannia sessiliflora ssp. australis	Nodding Lily		+				
Sowerbaea laxiflora	Purple Tassels		+		+	+	
Thysanotus arenarius		+	+			+	
Thysanotus manglesianus	Fringed Lily					+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Thysanotus multiflorus	Many-Flowered Fringe Lily					+	
Thysanotus patersonii	Twining Fringe Lily	+	+	+	+	+	
Thysanotus sparteus						+	
Thysanotus triandrus			+				
Tricoryne elatior	Yellow Autumn Lily	+	+	+		+	
APIACEAE							
Daucus glochidiatus	Native Carrot	+	+	+		+	
Eryngium pinnatifidum	Blue Devils				+	+	
Homalosciadum homalocarpum			+			+	
Hydrocotyle blepharocarpa						+	
Hydrocotyle callicarpa	Small Pennywort					+	
Hydrocotyle diantha				+		+	
Hydrocotyle hispidula						+	
Trachymene coerulea	Blue Lace Flower	+				+	
Trachymene pilosa	Small Lace Flower	+	+	+	+	+	
Xanthosia huegelii		+	+			+	
ASPARAGACEAE							
* Myrsiphyllum asparagoides						+	
ASPHODELACEAE							
* Asphodelus fistulosus	Wild Onion; Onion Weed			+			
* Trachyandra divaricata		+	+	+			
ASTERACEAE							
Actites megalocarpa		+					
* Arctotheca calendula	Capeweed			+	+	+	
* Arctotheca populifolia	Dune Arctotheca; Dune Cabbage	+					
Asteridea pulverulenta	Common Bristle Daisy					+	
Brachyscome iberidifolia	Swan River Daisy				+	+	
* Carduus pycnocephalus						+	
* Centaurea melitensis	Maltese Cockspur					+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
* Cirsium vulgare						+	
* Conyza albida	Tall Fleabane	+				+	
Euchiton sphaericus			+			+	
* Hedypnois rhagadioloides	Cretan Weed					+	
Hyalosperma cotula					+	+	
* Hypochaeris glabra	Flat Weed	+	+	+	+	+	
Lagenifera huegelii	Coarse Lagenifera	+	+			+	
Lagenifera sp. Should not be listed, unless to genus					+		
Leptorhyncuos scabrus			+				
Leucophyta brownii				+			
Millotia myosotidifolia					+	+	
Millotia tenuifolia	Soft Millotia	+	+				
Olearia axillaris	Coast Daisy Bush	+	+	+	+	+	
Olearia rudis	Azure Daisy Bush	+	+			+	
Ozothamnus cordatus	Tangle Daisy	+	+	+	+	+	
Podolepis canescens	Bright Podolepis		+				
Podolepis gracilis	Slender Podolepis	+	+		+	+	
Podolepis lessonii					+		
Podotheca angustifolia	Sticky Longheads	+	+			+	
Podotheca chrysantha	Yellow Podotheca					+	
Podotheca gnaphalioides	Golden Long Heads		+				
Pterochaeta paniculata						+	
Quinetia urvillei		+	+			+	
Rhodanthe citrina						+	
Senecia lautus	Coastal Groundsel	+	+	+		+	
Siloxerus humifusus	Siloxerus	+	+			+	
* Sonchus asper				+	+	+	
Sonchus hydrophilus	Native Sowthistle					+	
* Sonchus oleraceus	Common Sowthistle			+		+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
* Urospermum picroides	False Hawkbit					+	
* Ursinia anthemoides	Ursinia	+	+		+	+	
Waitzia suaveolens	Fragrant Waitzia	+	+		+	+	
BRASSICACEAE							
* Brassica barrelieri subsp. oxyrrhina	Smooth-Stem Turnip			+			
* Brassica tournefortii	Mediterranean Turnip					+	
* Cakile maritima	Sea Rocket	+	+	+			
* Heliophila pusilla		+	+	+		+	
Lepidium pseudohyssopifolium						+	
Lepidium rotundum	Veined Peppercress					+	
* Raphanus raphanistrum	Wild Radish					+	
Stenopetalum gracile						+	
CAMPANULACEAE							
* Wahlenbergia capensis	Cape Bluebell		+			+	
Wahlenbergia preissii						+	
CARYOPHYLLACEAE							
* Cerastium glomeratum	Mouse Ear Chickweed	+		+		+	
* Minuartia mediterranea						+	
* Petrorhagia velutina	Velvet Pink		+			+	
* Petrorhagia sp.					+		
* Sagina apetala	Annual Pearlwort					+	
* Silene gallica	French Catchfly	+		+		+	
CASUARINACEAE							
Allocasuarina fraseriana	Common Sheok	+	+		+	+	
Allocasuarina humilis	Dwarf Sheok	+	+		+	+	
Allocasuarina lehmanniana	Dune Sheok	+	+				
Casuarina obesa	Salt Sheok		+				
CENTROLEPIDACEAE							
Centrolepis aristata	Pointed Centrolepis			+		+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Centrolepis drummondiana							
CHENOPODIACEAE		+				+	
Atriplex cinerea	Grey Saltbush						
Halosarcia indica ssp. bidens		+					
Rhagodia baccata	Berry Saltbush			+			
Salsola kali	Prickly Saltbush	+	+	+	+	+	
Threlkeldia diffusa	Wallaby Saltbush	+					
COLCHICACEAE		+	+	+			
Burchardia congesta							
Wurmbea monantha		+	+		+	+	
CONVOLVULACEAE						+	
Dichondra repens	Kidney Weed						
CRASSULACEAE						+	
Crassula colorata	Dense Stonecrop						
Crassula exserta		+	+	+		+	
* Crassula glomerata		+	+				
Crassula pedicellosa		+	+	+			
CUSCUTACEAE						+	
* Cuscuta epithymum	Lesser Dodder						
CYPERACEAE						+	
Carex preissii							
Cyatochaeta avenacea	Not likely; should be checked prob. misid.	+				+	
Isolepis cernua	Nodding Club-Rush		+		+		
Isolepis cyperoides						+	
Isolepis marginata	Coarse Club-Rush					+	
Isolepis nodosa	Knotted Club-Rush			+		+	
Lepidosperma costale		+	+	+	+	+	
Lepidosperma gladiatum	Sword Sedge		+				
Lepidosperma leptostachyum		+	+	+			
						+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Lepidosperma longditudinale	Pithy Sword-Sedge	+					
Lepidosperma scabrum			+				
Lepidosperma squamatum		+	+	+	+	+	
Lepidosperma tenue					+		
Lepidosperma 'coastal terete' (BJK & NG 231)						+	
Mesomelaena pseudostygia					+	+	
Mesomelaena stygia	Telegraph Sedge	+	+				
Schoenus brevisetis						+	
Schoenus clandestinus		+	+			+	
Schoenus curvifolius		+	+			+	
Schoenus discifer						+	
Schoenus grandiflorus	Large Flowered Bog-Rush	+	+			+	
Schoenus lanatus	Woolly Bog-Rush					+	
Schoenus latitans					+		
Schoenus subbarbatus	Bearded Bog-Rush		+				
Tetraria octandra					+	+	
DASYPOGONACEAE							
Acanthocarpus preissii	Prickle Lily	+	+	+	+	+	
Calectasia cyanea	Blue Tinsel Lily					+	
Dasypogon bromeliifolius	Pinapple Bush					+	
Lomandra caespitosa	Tufted Mat-Rush	+	+			+	
Lomandra hermaphrodita					+	+	
Lomandra maritima	Coast Mat-Rush	+	+	+		+	
Lomandra preissii		+				+	
Lomandra sericea	Silky Mat-Rush					+	
Lomandra sonderi					+		
Lomandra suaveolens		+	+			+	
DILLENIACEAE						+	
Hibbertia aurea							

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Hibbertia hypericoides	Common Buttercups	+	+		+	+	
Hibbertia racemosa	Stalked Guinea-Flower	+	+	+	+	+	
Hibbertia spicata ssp. leptotheca		+	+			+	
Hibbertia subvaginata						+	
DROSERACEAE							
Drosera erythrorhiza	Red-Ink Sundew				+	+	
Drosera glandulifera	Pimpernel Sundew					+	
Drosera macrantha	Bridal Rainbow					+	
Drosera menziesii subsp. penicillaris	Pink Rainbow					+	
Drosera pallida	Pale Sundew		+			+	
Drosera stolonifera	Leafy Sundew					+	
Drosera sp. (climbing)					+		
EPACRIDACEAE							
Acrotriche cordata	Coast Ground-Berry	+	+	+			
Andersonia lehmanniana						+	
Astroloma ciliatum	Moss-Leaved Cranberry					+	
Astroloma microcalyx	Native Cranberry					+	
Astroloma pallidum	Kick Cranberry	+	+		+	+	
Conostephium pendulum	Pearl-Flower	+	+		+	+	
Conostephium preissii		+					
Leucopogon australis	Spiked Beard-Heath					+	
Leucopogon insularis			+				
Leucopogon aff. nutans (GJK 11159)	Nodding Beard-Heath					+	
Leucopogon parviflorus		+	+	+	+	+	
Leucopogon polymorphus			+			+	
Leucopogon aff. polymorphus			+				
Leucopogon propinquus		+	+	+	+	+	
Leucopogon sprengeloides		+				+	
Lysinema ciliatum	Curry Flower					+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
EUPHORBIACEAE							
Adriana quadripartita	Bitter Bush	+	+				
* Euphorbia peplus	Pretty Spurge					+	
* Euphorbia terracina	Geraldton Carnation Weed; False Caper	+				+	
Phyllanthus calycinus	Phyllanthus; False Boronia	+	+	+	+	+	
Poranthera microphylla	Small Microphylla					+	
Ricinocarpus glaucus	Wedding Bush		+			+	
FUMARIACEAE							
* Fumaria capreolata	Whiteflower Fumitory					+	
FRANKENIACEAE							
Frankenia pauciflora	Seaheath			+			
GENTIANACEAE							
* Centaurium erythraea	Common Centaury		+			+	
GERANIACEAE							
* Erodium cicutarium	Common Crowfoot; Common Storksbill			+		+	
* Geranium molle	Dove's Foot Cranesbill				+	+	
Geranium retrorsum				+		+	
Geranium solanderi	Native Geranium		+				
Pelargonium australe						+	
* Pelargonium capitatum	Rose Pelargonium	+	+	+	+	+	
Pelargonium littorale			+			+	
GOODENIACEAE							
Lechenaultia linarioides	Fountain Leschenaultia	+	+	+	+	+	
Scaevola canescens	Grey Flower		+			+	
Scaevola crassifolia	Thick-Leaved Fanflower	+	+	+			
Scaevola nitida	Shining Fanflower		+				
Scaevola paludosa			+				
Scaevola repens var. repens						+	
Scaevola thesioides	Rats' Tails		+			+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Verreauxia reinwardtii			+				
GYROSTEMONACEAE							
Gyrostemon ramulosus	Corkybark					+	
Tersonia cyathifolia	Button Runner	+				+	
HAEMODORACEAE							
Anigozanthos humilis	Cats Paw		+		+	+	
Anigozanthos manglesii	Kangaroo Paw		+			+	
Conostylis aculeata	Spring Cottonheads	+	+	+	+	+	
Conostylis aculeata x candicans						+	
Conostylis candicans	Grey Cottonheads	+	+	+	+	+	
Conostylis pauciflora ssp. euryhipis	Dawesville Cottonheads		+				
Conostylis setigera	Bristly Cottonheads					+	
Conostylis stylidioides		+					
Conostylis teretifolia subsp. planescens			+				
Haemodorum laxum			+			+	
Haemodorum paniculatum	Mardja	+	+		+	+	
Haemodorum spicatum	Mardja	+	+			+	
Phlebocarya ciliata						+	
HALORAGACEAE							
Glischrocaryon aureum	Common Popflower					+	
IRIDACEAE							
* Gladiolus caryophyllaceus	Wild Gladiolus	-	+		+	+	
* Homeria flaccida	One Leaf Cape Tulip	+			+	+	
Orthrosanthos laxus	Morning Iris		+			+	
Patersonia occidentalis	Purple Flag				+	+	
* Romulea rosea	Guildford Grass	+	+	+		+	
* Sparaxis bulbifera	Harlequin Flower					+	
JUNCACEAE							
Luzula meridionalis	Field Woodrush	+					

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
JUNCAGINACEAE							
Triglochin calcitrapum	Spurred Arrowgrass					+	
Triglochin centrocarpum	Dwarf Arrowgrass					+	
Triglochin trichophorum						+	
LAMIACEAE							
Hemiandra pungens	Snake Bush	+	+	+		+	
LAURACEAE							
Cassytha flava	Dodder-Laurel	+	+	+		+	
Cassytha glabella	Tangled Dodder-Laurel	+				+	
Cassytha racemosa	Dodder-Laurel	+	+			+	
LOBELIACEAE							
Isotoma hypocrateriformis	Woodbridge Poison		+			+	
Lobelia gibbosa	Tall Lobelia					+	
Lobelia tenuior	Slender Lobelia		+			+	
LOGANIACEAE							
Logania vaginalis		+				+	
LORANTHACEAE							
Amyema miquelii	Stalked Mistletoe; Broad-Leaved Mistletoe					+	
Nuytsia floribunda	Christmas Tree		+			+	
MALVACEAE							
Alyogyne huegelii	Lilac Hybiscus	+				+	
MIMOSACEAE			-	-			
Acacia cochlearis	Rigid Wattle	+	+	+	+	+	
Acacia cyclops	Red-Eyed Wattle	+	+	+		+	
Acacia huegelii		+	+			+	
Acacia lasiocarpa	Dune Moses	+	+	+		+	
Acacia pulchella	Prickly Moses	+	+		+	+	
Acacia rostellifera	Summer-Scented Wattle	+	+	+	+	+	
Acacia rostellifera x saligna			+				

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Acacia saligna	Coojong; Golden-Wreath Wattle	+	+	+	+	+	
Acacia truncata		+	+	+		+	
Acacia willdenowiana	Grass Wattle					+	
MYOPORACEAE							
Eremophila glabra	Tarbush	+		+		+	
Myoporum insulare	Boobialla	+	+	+			
MYRTACEAE							
Baeckea robusta						+	
Calothamnus quadrifidus	One-Sided Bottlebrush	+	+		+	+	
Calothamnus sanguineus	Pindak; Silky-Leaved Blood-Flower				+	+	
Calytrix angulata	Yellow Starflower		+				
Calytrix flavescens	Summer Starflower					+	
Corymbia calophylla					+	+	
Eremaea asterocarpa subsp. asterocarpa	Star-Fruited Eremaea					+	
Eremaea pauciflora	Orange-Flowered Eremaea		+			+	
Eucalyptus argutifolia	Yanchep Mallee	+					
Eucalyptus decipiens	Limestone Marlock		+			+	
Eucalyptus foecunda	Fremantle Mallee	+				+	
Eucalyptus gomphocephala	Tuart	+	+		+	+	
Eucalyptus marginata	Jarrah		+		+	+	
Eucalyptus petrensis	Rock Mallee	+					
Eucalyptus rudis	Flooded Gum						+
Eucalyptus todtiana	Pricklybark		+			+	
Hypocalymma robustum	Pink Myrtle	+			+	+	
Leptospermum spinescens		+	+			+	
Melaleuca acerosa	Coast Honey-Myrtle	+	+	+	+	+	
Melaleuca cardiophylla	Tangling Honey-Myrtle	+	+	+			
Melaleuca huegelii	Chenille Honey-Myrtle	+	+	+	+	+	
Melaleuca lateritia							+

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Melaleuca preissiana							+
Melaleuca rhaphiophylla	Freshwater Paperbark						+
Melaleuca trichophylla			+				
Scholtzia involucrata	Spiked Scholtzia					+	
Scholtzia laxiflora		+					
OLACACEAE							
Olax benthamiana	Olax	+		+		+	
ORCHIDACEAE							
Caladenia arenicola	Carousel Spider Orchid					+	
Caladenia flava	Cowslip Orchid			+		+	
Caladenia georgei	Tuart Spider Orchid					+	
Caladenia latifolia	Pink Fairy Orchid	+		+		+	
Caladenia longicauda subsp. calcigena ms	White Spider Orchid					+	
Caladenia reptans	Little Pink Fairy Orchid					+	
Cyanicula gemmata	Blue China Orchid					+	
Cyrtostylis reniformis ms						+	
Diuris corymbosa	Common Donkey Orchid					+	
Elythranthera brunonis	Purple Enamel Orchid					+	
Eriochilus dilatatus	White Bunny Orchid					+	
Leporella fimbriata	Hare Orchid					+	
Leptoceras menziesii	Rabbit Orchid					+	
Microtis media	Common Mignonette Orchid		+	+			
Prasophyllum fimbria	Fringed Leek Orchid					+	
Prasophyllum parvifolium	Autumn Leek Orchid					+	
Pterostylis aspera	Brown-Veined Shell Orchid					+	
Pterostylis brevisepala						+	
Pterostylis pyramidalis	Tall Snail Orchid					+	
Pterostylis recurva	Jug Orchid					+	
Pterostylis sanguinea	Dark Banded Greenhood					+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Pterostylis vittata	Banded Greenhood				+	+	
Pyrorchis nigricans	Red Beaks	+				+	
Thelymitra campanulata	Shirt Orchid					+	
Thelymitra sp.					+		
OROBANCHACEAE							
* Orobanche minor	Lesser Broomrape	+		+	+	+	
OXALIDACEAE							
Oxalis perennans						+	
* Oxalis pes-caprae	Soursos					+	
PAPILIONACEAE							
Bossiaea eriocarpa	Common Brown Pea	+	+		+	+	
Daviesia decurrens	Winged Bitter-Pea	+			+	+	
Daviesia divaricata	Marno	+				+	
Daviesia nudiflora		+			+	+	
Daviesia triflora		+			+	+	
Gompholobium aristatum	Yellow Pea	+				+	
Gompholobium knightianum						+	
Gompholobium marginatum						+	
Gompholobium tomentosum	Hairy Yellow Pea		+	+	+	+	
Hardenbergia comptoniana	Hardenbergia; Native Wisteria	+	+	+	+	+	
Hovea pungens	Devil's Pins					+	
Hovea trisperma	Common Hovea	+	+		+	+	
Isotropis cuneifolia	Granny's Bonned; Common Lamb-Poison	+	+			+	
Jacksonia furcellata			+			+	
Jacksonia sericea	Waldjumi	+			+	+	
Jacksonia sternbergiana			+		+	+	
Jacksonia stricta			+	+		+	
Kennedia prostrata	Running Postman	+	+	+	+	+	
* Lupinus cosentinii	Sandplain Lupin			+		+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
* Lupinus sp.					+		
* Medicago polymorpha	Burr Medic		+				
* Medicago sp.					+		
* Meliotis indica	King Island Melitot; Hexham Scent		+				
Mirbelia trichcalyx						+	
Nemcia capitata	Bacon-And-Eggs				+	+	
Nemcia reticulata		+	+	+		+	
* Ornithopus compressus	Yellow Serradella					+	
Sphaerolobium medium						+	
Templetonia retusa	Cockie's Tongue	+	+	+		+	
* Trifolium arvense	Hare's Foot Clover					+	
* Trifolium campestre	Hop Clover		+			+	
* Trifolium cernuum	Drooping Flower Clover					+	
* Trifolium glomeratum	Cluster Clover					+	
* Trifolium scabrum	Rough Clover					+	
* Vicia sativa	Common Vetch					+	
PHORMIACEAE							
Dianella revoluta	Flax Lily	+	+	+	+	+	
PHYTOLACCACEAE							
* Phytolacca octandra	Pink Ink Plant; Inkweed					+	
PITTOSPORACEAE							
Billardiera variifolia						+	
PLANTAGINACEAE							
Plantago exilis						+	
POACEAE							
* Agropyron racemosum		+	+				
* Aira caryophyllea	Silvery Hairgrass	+				+	
* Aira cupaniana			+				
* Ammophila arenaria	Marram Grass		+				

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Amphipogon turbinatus							
* Avena barbata	Bearded Oat; One-Sided Oat	+	+		+	+	
* Avena fatua	Wild Oats	+				+	
* Briza maxima	Blowfly Grass		+				
* Briza minor	Shivery Grass	+	+		+	+	
* Bromus diandrus	Great Brome		+		+	+	
* Bromus madritensis	Madrid Brome	+	+	+	+	+	
* Bromus rubens		+			+		
* Cynodon dactylon	Couch				+		
Danthonia acerosa						+	
Danthonia caespitosa	Common Wallaby-Grass		+				
Danthonia occidentalis		+	+		+		
* Desmazeria rigida			+			+	
Dichelachne crinata	Plumegrass		+			+	
* Ehrharta calycina	Perennial Veldtgrass				+	+	
* Ehrharta longiflora			+		+	+	
* Holcus setiger		+	+	+		+	
* Lagarus ovatus	Hare's Tail Grass				+	+	
* Lolium perenne	Perennial Ryegrass	+		+		+	
* Lolium rigidum	Annual Ryegrass			+			
Microlaena stipoides	Weeping Grass	+				+	
Neurachne alopecuroidea	Foxtail Mulga-Grass					+	
* Pentaschistis airoides		+				+	
Poa drummondiana	Shaking Grass					+	
Poa porphyroclados		+	+	+		+	
Spinifex hirsutus	Satin-Leaved Spinifex	+	+	+		+	
Spinifex longifolius	Long-Leaved Spinifex	+	+				
Sporobolus virginicus	Salt Couch	+	+	+			
Stipa compressa		+		+			
		+	+	+		+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Stipa elegantissima	Feather Grass					+	
Stipa flavescens	Tall Speargrass	+	+			+	
* Vulpia bromoides	Squirrel Tail Fescue					+	
* Vulpia myuros	Rat's Tail Fescue				+	+	
POLYGALACEAE							
Comesperma calymega	Blue-Spike Milkwort	+	+			+	
Comesperma confertum						+	
Comesperma integerrimum		+	+				
Comesperma volubile			+				
POLYGONACEAE							
Muehlenbeckia adpressa						+	
PORTULACCACEAE							
Calandrinia brevipedata	Short-Stalked Purslane					+	
Calandrinia corrigioloides	Strap Purslane	+				+	
Calandrinia liniflora	Parakeelya		+	+		+	
PRIMULACEAE							
* Anagallis arvensis	Pimpernel	+	+	+		+	
PROTEACEAE							
Adenanthos cygorum	Woolly Bush					+	
Banksia attenuata	Candle Banksia	+	+		+	+	
Banksia grandis	Bull Banksia		+		+	+	
Banksia ilicifolia	Holly-Leaf Banksia	+					
Banksia littoralis	Swamp Banksia						+
Banksia menziesii	Firewood Banksia	+	+		+	+	
Banksia prionotes	Saw-Tooth Banksia	+					
Conospermum triplinervum	Tree Smokebush	+	+			+	
Dryandra lindleyana		+	+	+	+	+	
Dryandra sessilis	Parrotbush	+	+	+	+	+	
Grevillea crithmifolia		+				+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
Grevillea preissii	Spider-Net Grevillea	+	+	+		+	
Grevillea vestita			+		+	+	
Hakea candolleana						+	
Hakea costata	Ribbed Hakea		+			+	
Hakea lissocarpha	Honey Bush	+	+	+	+	+	
Hakea prostrata	Harsh Hakea		+		+	+	
Hakea ruscifolia	Candle Hakea		+			+	
Hakea trifurcata	Two-Leaf Hakea	+	+		+	+	
Persoonia comata			+			+	
Persoonia saccata	Thread-Leaf Snottygobble				+	+	
Petrophile brevifolia		+	+		+	+	
Petrophile aff. brevifolia			+				
Petrophile linearis	Pixie Mops	+	+		+	+	
Petrophile macrostachya		+	+		+	+	
Petrophile serruriae		+	+		+	+	
Petrophile aff. serruiae			+				
Stirlingia latifolia	Blueboy	+	+		+	+	
Synaphea spinulosa						+	
RANUNCULACEAE							
Clematis linearifolia	Old Man's Beard; Small Leaved Clematis	+	+	+		+	
Ranunculus colonorum	Buttercup				+		
Ranunculus pumilio	Small-Flowered Buttercup					+	
RESTIONACEAE							
Alexgeorgia nitens		+	+			+	
Desmocladus flexuosus		+	+	+	+	+	
Hypolaena exsulca			+			+	
Loxocarya cinerea						+	
Loxocarya fasicularis		+		+			
Lyginia barbata		+	+		+	+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
RHAMNACEAE							
Cryptandra glabriflora						+	
Cryptandra mutila						+	
Cryptandra pungens			+			+	
Spyridium globulosum	Basket Bush	+	+	+		+	
Stenanthemum tridentatum		+	+			+	
Trymalium ledifolium		+	+	+		+	
Trymalium floribundum					+		
ROSACEAE							
* Acaena ?echinata	Sheep's Burr				+		
RUBIACEAE							
* Galium murale						+	
Opercularia vaginata	Dog Weed	+	+	+	+	+	
RUTACEAE							
Eriostemon spicatus	Pepper-And-Salt	+				+	
SANTALACEAE							
Exocarpus sparteus	Broom Ballart	+	+	+		+	
Leptomeria empetriformis		+				+	
Leptomeria priessiana				+		+	
Leptomeria spinosa	Spiny Currant Bush					+	
Santalum acuminatum	Quandong	+		+		+	
SAPINDACEAE							
Diplopeltis huegelii		+		+		+	
Dodonaea aptera			+			+	
SCROPHULARIACEAE							
* Bartsia trixago						+	
* Dischisma arenarium			+	+		+	
* Verbascum virgatum						+	
Veronica aff. calycina	Cup Speedwell		+				

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
SOLANACEAE							
Anthocercis littorea	Yellow Tailflower	+	+			+	
Anthocercis ilicifolia	Yellow Tailflower					+	
* Solanum nigrum	Black Berry Nightshade	+	+		+	+	
* Solanum linnaeanum		+	+			+	
STACKHOUSIACEAE							
Stackhousia monogyna			+			+	
Tripterococcus brunonis	Winged Stackhousia					+	
STERCULIACEAE							
Thomasia cognata		+	+			+	
Thomasia triphylla			+	+		+	
STYLIDIACEAE							
Levenhookia pusilla	Midget Stylewort					+	
Levenhookia stipitata	Common Stylewort		+			+	
Stylidium brunonianum	Pink Fountain Triggerplant		+		+	+	
Stylidium calcaratum	Book Triggerplant		+		+	+	
Stylidium diuroides	Donkey Triggerplant					+	
Stylidium junceum	Reed Triggerplant	+	+		+	+	
Stylidium maritima ms			+			+	
Stylidium macrocarpum	Flagon Triggerplant					+	
Stylidium piliferum	Common Butterfly Triggerplant		+			+	
Stylidium repens	Matted Triggerplant					+	
Stylidium aff. repens			+				
Stylidium schoenoides	Cow-Kicks				+	+	
THYMELAEACEAE							
Pimelea argentea		+			+	+	
Pimelea calcicola		+	+			+	
Pimelea ferruginea	Coast Banjine		+	+			
Pimelea rosea	Rose Banjine					+	

FAMILY/Taxon	Common Name	K	TK	R	M	KG	A
TYPHACEAE							
* Typha sp.							+
URTICACEAE							
Parietaria debilis	Native Pellitory		+	+		+	
VIOLACEAE							
Hybanthus calycinus	Native Violet		+	+	+	+	
XANTHORRHOEACEAE							
Xanthorrhoea preissii	Blackboy; Grasstree; Balga	+	+		+	+	
ZAMIACEAE							
Macrozamia riedlei	Zamia		+		+	+	

APPENDIX 4

DEFINITIONS OF REGIONALLY AND LOCALLY SIGNIFICANT

These definitions are from the Urban Bushland Strategy (Government of Western Australia, 1995.

REGIONALLY SIGNIFICANT	LOCALLY SIGNIFICANT
* Example of a regional vegetation type which is threatened or poorly reserved or a site with special value for flora or fauna conservation.	One of the better examples of a local vegetation type.
* Having considerable biodiversity or supports a population of Declared Rare Flora, priority listed flora, or threatened fauna.	Having biodiversity value but unlikely to include Declared Rare Flora. May include geographically significant species at the limit of their range.
* Vegetation in good condition or better. Threatened vegetation types may be regionally significant even if in poor condition.	Vegetation may be in poor condition but if poor, capable of regeneration.
* Usually greater than 20 hectares but may be smaller in the case of threatened or poorly reserved vegetation types, or areas with special significance for other purposes.	Ideally greater than 4 hectares but smaller areas may be of significance depending on how much remains in the locality.
Suitable for passive recreation by people from both within and beyond the locality.	Suitable for passive recreation by the local community.
Region wide use or potential for scientific or educational study.	Use or potential for use by local schools.
Having cultural heritage values of a regional or greater significance.	Having local heritage value.
Regular shape is desirable unless the area functions as a significant corridor linking other remnants.	Shape not critical but remnant should be capable of ongoing management.

* Essential criteria for bushland to be regarded as regionally significant.

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

Our Reference: M98177

1 JAN 1999

① Encl. (Plastic sleeve test pits)

18 January 1999

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Roberts Day Group
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Attention: Mr Mike Day

Dear Mr Day,

Proposed Redistribution of Regional Open Space
Lots 9, 10 and 12, Jindalee

Further to your instructions, we are pleased to provide our advice in relation to the proposed redistribution of Regional Open Space (ROS) within the Jindalee Structure Plan. In the following text we provide a background to the project, discuss the historical approaches to coastal planning and land reservation between North Fremantle and Jindalee, and draw conclusions in respect of the proposed ROS redistribution in terms of reservation of geomorphological features, and vegetation and habitat types.

1. Background

In 1996 the Jindalee Comparative Enquiry by Design Workshop was undertaken by the Western Australian Planning Commission "to consider the relative merits of conventional planning as provided for in existing Commission policies with a planning approach known as the Western Australian Community Code".

To ensure that practical comparison could be made between traditional and Community Code planning approaches, the exercise was based on a 453ha residential zoned site, located within the North West Corridor of the Perth Metropolitan Region in the path of the extending urban front.

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A large proportion (294ha or 65%) of the site examined comprises three privately owned properties (Lots 9, 10 and 12) immediately north of Quinns Rocks, known as Jindalee. The planning comparison resulting from the workshop suggested that the adoption of the Community Code planning approach would provide significant benefits.

As a logical follow on from this exercise, using the results of the workshop as a basis, a draft Structure Plan has now been prepared for Lots 9, 10 and 12 by planners Chappell and Lambert and your office on behalf of the landowners. The draft Structure Plan proposes a re-distribution of Regional Open Space (ROS) within the site including modification of the existing coastal Parks and Recreation reserve. The proposed changes to the arrangement of the reserves are summarised in Figure 1. We are advised that the ocean setbacks adopted in the plan are in accordance with the coastal stability and risk recommendations proposed by M P Rogers and Associates (1998).

The proposed modification to the ROS distribution has the following objectives:

- to adopt the planning principles and assist in realising the objectives of the Community Code planning approach;
- to recognise the requirement to maintain a functional coastal P&R reserve which incorporates a sufficient coastal hazard setback;
- to retain representative areas of the major landforms and habitats in both coastal and inland contexts; and
- to avoiding a repetition of previous urban development trends and construction methods in the NW corridor to the south, by retaining dominant ridgeline landforms and thus, offering both relief and landscape interest within the ultimate built environment.

The advice we present here examines the modified Structure Plan and the environmental implications of selectively reducing the width of the coastal reserve portion of the site, but adding areas in the form of ROS reserves aligned on three east–west orientated dune crests. Particular consideration has been given to the principles and outcomes of historical coastal reserve planning in the Perth Metropolitan Area from Jindalee south to North Fremantle, to the land chosen to be set aside as ROS in terms of geomorphology, vegetation and habitat types and the contemporary outcomes of this process.

2. Coastal Planning

Under the Metropolitan Region Scheme, reserved land near the coast is currently focused on a narrow system of foreshore reserves which follow the coastline.

Between North Fremantle and Jindalee there is a continuous strip of crown land (the foreshore reserve) between the coast and the developed urban areas (Figure 2). The width of the reserve varies from as much as 850m at Tamala Park in Wanneroo to as little as 15m at City Beach. The average width of the foreshore reserve is approximately 40m.

For the site, under consultation here, the foreshore reserve width as shown by the MRS varies between approximately 70m at Lot 12 and 220m at Lot 9 (Figure 3).

Apart from the foreshore reserve, in the north west corridor 12 coastal reserves have been established within 500m of the HWM, the spatial characteristics of which are given in Table 1 (see Figure 2 for locations). The statutory purpose of these reserves ranges from "preserving occurrences of rare and endangered flora and fauna, examples of vegetation assemblages, examples of landscape ecology, areas of scientific interest (such as geological features), areas for research and education, to providing sanctuaries and security for a range of fauna and flora" (Semeniuk *et al.*, 1989). These purposes may be considered to reflect the diversity of uses which may be encompassed in ROS reservation.

Review of Table 1 and Figure 2 demonstrates that in the Metropolitan Area south of Jindalee, emphasis has generally been placed on preserving the more seaward habitats, at the expense of inland habitats and landforms. The conclusion was also reached by Semeniuk *et al.* (1989).

Consequently, the rearrangement of reserve area distribution at Jindalee presents the opportunity to establish an ROS system which would assist in increasing the reservation of more inland landforms.

TABLE 1

Spatial Characteristics of Coastal Reserves between North Fremantle and Jindalee*

Reserve	Area (ha)	Length (m)	Minimum Width (m)	Maximum Width (m)
Leighton Beach	18	2800	30	100
Buckland Hill	6.4	500	40	200
Cottesloe Beach	12.2	3300	20	80
Swanbourne Beach	14.8	3500	20	60
City Beach	28.6	800	15	400
Trigg Bushland Reserve	83	1780	160	900
Hillary's Beach	36	1900	50	400
Whitfords Beach	9.1	1080	60	100
Burns Beach	15.3	2260	40	120
Tamala Park	107	1960	200	860
Quinns Rocks Beach	15	2200	16	540
Jindalee	41	2970	70	220

*Approximate dimensions and areas.

The largest of the coastal reserves in the study area is Tamala Park (107ha) (see Figure 2) which is jointly owned by the Cities of Wanneroo, Stirling and Perth (Hames Sharley Australia, 1992). Similar to Jindalee, the park contains good representative examples of rocky shores, sandy beaches, modern to recent beach ridges, and both mobile and stable transgressive dune terrain.

The Trigg Bushland Reserve (83ha) is an example of a coastal reserve which, rather than only extending parallel to the coast as a narrow band is also directed inland, and subsequently incorporates typical new coastal landforms, vegetation types and habitats which differ significantly from those found on the immediate seaward margin. This reserve is acknowledged to have high conservation value.

Other reserves such as Buckland Hill and Whitfords Beach are much smaller in area, and at City Beach and Quinns Rocks Beach are comparatively narrow at approximately 15m minimum width. However despite this, the reserves have displayed physical stability, and also continue the function of maintaining buffers between urban development and unstable foreshores.

Logically, in the planning of sustainable coastal reserves in the north west corridor, size and shape are relevant considerations. However, as a result of the pressure of recreational use, and indirect detrimental processes deriving from adjacent urban uses, the supply of adequate active management is probably an even more critical element. As discussed above, many reserves on the Perth coast are narrow but have been able to support and maintain a variety of functions due to civil engineering and landscaping works conducted to manage erosion, rehabilitation, revegetation, stability and public access control. It is assumed here that detailed management plans for the ROS and coastal reserves will be formulated to address these issues, consistent with other coastal developments in the locality.

If this analysis is advanced based on the position that the purpose of coastal ROS is not soley conservation, then it follows that reserve widths can be selectively reduced provided that appropriate management is implemented and applied on an on-going basis. Certainly, coastal reserve planning in the NW Corridor and at Jindalee does not reflect conservation of flora and fauna as a primary objective.

3. Geomorphology

In the context of the geomorphic aspects of the coastal reserve system Semeniuk *et al.* (1989) noted that *"where reserves are present in the Perth metropolitan area there has been a tendency for undue emphasis in preserving the more seaward assemblages at the expense of the more landward assemblages"*, and further that there is an urgent need for the "*conservation of areas of Quindalup Dunes based on their landform, scientific interest, representativeness, vegetation and relative lack of disturbance*".

Similar views have been expressed by Griffin and Trudgen (1994) and Trudgen (1996). Nonetheless, the trend of continued coastal landform preservation at the expense of more inland areas has generally continued.

Consistent with these observations the existing P&R reserve at Jindalee is located wholly at the shore and varies in width from 220m opposite the northern end of Lot 9 to 70m opposite the centre of Lot 12. The eastern P&R reserve boundaries do not correspond to the distribution of any particular geomorphic feature and as far as we can ascertain, with the coastal ROS boundary position originally determined by ruling straight lines on regional scale mapping so that an apparent adequate amount of coastal land was reserved, and a development safety setback was created.

Examination of the geomorphic elements of the reserve shows that (effectively by default) the reserve incorporates parts of five different landforms types predominantly the Q4 and Qs Quindalup Dune phases, but also small parts of the Q3 and Q2 phases, and a very small part of the Spearwood Dune system (Kls). The reserve does not and cannot capture examples of the more inland geomorphic elements which comprise the site.

Figure 4 shows how redistribution of the ROS within the site is proposed and demonstrates the narrowing of the foreshore reserve and addition of three east-west orientated areas, overlain on a map showing geomorphic units.

Analysis of Figure 4 demonstrates that the redistribution will result in:

- the retention of examples of all geomorphic units currently within the P&R reserve, with the exception of a small area of bare limestone (Kls landform);
- the retention of a significantly greater area of the Q3 dune phase in the north of the site, this being part of the Alkimos parabola – a regional scale geomorphic feature;
- the retention of a significantly greater area of the Q2 phase in the centre of the site;
- the inclusion of examples of the Ky phase of the Spearwood Dune system in two areas which were not previously in the reserve system.
- a reduction in the area of the Qs phase retained adjacent to the ocean in the centre of the site, however the addition of other examples of Qs in both the southern and more particularly the elevated central inland ROS areas.

It may be concluded from this analysis that redistribution maintains and increases the geomorphic diversity of the reserve system.

4. Vegetation and Habitats

Regional scale mapping (1:250,000) of vegetation complexes by Heddle *et al.* (1980) shows that the site's vegetation consists of Quindalup Complex and Cottesloe Complex-Central and South (Figure 5).

The Quindalup Complex is restricted to the foredunes and features spatial differences in its physiognomy and species composition due to variations in edaphic and topographical factors, and the degree of shelter from salt-laden winds (Griffin and Associates, 1993; Trudgen, 1996). This complex is represented on the western two thirds of Lots 12 and 10, and one third of Lot 9, roughly parallel to the shoreline.

The Cottesloe Complex-Central and South comprises heath on the limestone outcrops, represented on approximately the eastern third of Lots 12 and 10, and two thirds of Lot 9, adjacent to the unconstructed Marmion Avenue.

The current extent of the P&R reserve, only captures examples of vegetation from the Quindalup Complex. In contrast the redistribution of the ROS as proposed will provide reservation of examples of the more inland Cottesloe Complex-Central and South, and importantly the transition between the two.

The Quindalup Complex is currently reserved at 14% of it's original area in the Metropolitan scheme, however the Cottesloe Complex-Central and South is reserved below the Ministry for Planning's 10% target at approximately 8% of it's original area. (It is acknowledged however, that the purpose of ROS in the context of this project will not be solely for the conservation of vegetation).

On a more site specific basis, consultant botanist Arthur Weston was commissioned by Bowman Bishaw Gorham to conduct a vegetation survey of the site in November, 1998, focussing on vegetation within proposed and existing Regional Open Space reserves. Approximately 18 vegetation assemblages were identified within these areas (Figure 5). In contrast to regional vegetation complexes, assemblages may be defined on the basis of a description of the most dominant overstorey and understorey species combinations on a local scale. A full account of the botanical survey is available on request, however a summary of the findings is presented below.

Scaevola crassifolia heath was found to occur on the foredunes, with a number of other species associated with the heath such as *Lepidosperma gladiatum*, *Isolepis nodosa*,

Spyridium globulosum and others. The Quindalup Dunes, which lie behind the foredunes, contain a variety of shrubs less than 1m tall, including Acacia species (eg. *Acacia truncata, Acacia ochlearis*), *Oluric axillaris, Herdenbergia compteniana* as well as some of the foredune species. In the northern coastal dunes on Lot 9 *Acacia lasiocarpa* and *Lomandra maritima* are dominant.

Within the troughs of the Quindalup Dunes the dominant species include *Melaleuca cardiophylla, Melaleuca huegelii, Spyridium globulosum,* and *Dryandra sessilis.* Further east on the site *Acacia rostellifera* and *Acacia conchlearis* become more dominant.

Shallow sand overlying limestone occurs extensively over the site. On a number of coastal cliffs *Scaevola crassifolia* and *Tetragonia decumbens* are present. Along the slopes of the dunes *Melaleuca cardiophylla, Melaleuca huegelii, Spyridium globulosum, and Acacia cyclops* as well as a variety of other species are commonly found. Along the upper slopes and ridges of the dunes *Dryandra sessilis* is dominant. *Xanthorrhoea preissii* associations were also found in these areas as well as in similar areas closer to the coast.

The Spearwood Dunes are dominated by the *Xanthorrhoea* association as well as *Lomandra maritima* and *Melaleuca acerosa.* Weeds spread throughout the site include *Pelargonium ciptetum, Trichyandra divoricate, Corportomius edulii* and *Euphorbic terranena.*

An important, noticeable trend within the study area is the gradually increasing height of the vegetation with distance from the ocean. Low (<1m high) coastal heath occurs in the western area and changes to a higher (2-3m high) heath in eastern areas. The north facing slopes also support different assemblages of plants to the south facing slopes, reflecting changes in aspect.

One example of this is the *Dyrandra sessilis* dominant assemblage occurring on the northern facing slope while the *Lomandra maritima* dominant community occurs on the other side of the ridge on the southern facing slope. This is predominantly due to different conditions relating to distance from the ocean, and includes factors such as wind exposure, salt-spray, soil moisture and insolation that occur between these two areas.

Based on the botanical survey mapping, overlaying a map of the proposed ROS redistribution as shown in Figure 5 demonstrates the following outcomes in regard to vegetation assemblages will derive from redistribution (notations in parenthesis correspond to vegetation assemblage codes):

- the addition of the *Acacia rostellifera* (R), *Dryandra sessilis* (D), *Lomandra maritima* (L), *Acacia rostellifera/Spyridium globulosum* (RS) and *Banksia attenuata/B.menziesii* (B, small area) assemblages which would otherwise not be represented within ROS on the site;

- the addition of a large area of the *Lomandra maritima/ Acacia lasiocarpa* (LA) assemblage in the north of the site, together with *Xanthorrhoea preissii* (X) in the central ROS area;

- the retention of the *Melaleuca cardiophylla /Dryandra sessilis* (MD) assemblage in the central ROS;

- a reduction in the area of the "mixed" coastal Quindalup Dune vegetation behind the foredune (Mixed), *Xanthorrhoea preissii* (X), and *Melaleuca cardiophylla/Myoporium insulare* (MM) assemblages. However, examples of these assemblages will still remain within the P&R reserve;

- a reduction in the area of the *Melaleuca cardiophylla* (M) assemblage near the coast but addition in the central ROS area;

- a reduction of total area the *Spyridium globulosom* (S) assemblage at the coast, but the addition of another example of the assemblage in good condition in the southern ROS area;

- together with clearing for development, the loss of coastal *Melaleuca cardiophylla/Spyridium globulosum*(MS) and *anthorrhoea/L.maritima/Spyridium globulosum* (XLS) assemblages; and

- a reduction in the areas containing weeds (W).

5. Conclusions

Based on the preceding analysis, the proposed redistribution of Regional Open Space within the Jindalee site will result in the following environmental outcomes:

- the retention of the longshore continuity and total length of the existing P&R coastal reserve, but narrowing the reserve where appropriate based on existing condition and coastal stability analysis, resulting in widths similar to other reserves between Jindalee and North Fremantle;

- continued representation of each unit of the Quindalup Dunes within the coastal P&R reserve;

- the addition of examples of both the Quindalup and Spearwood Dunes landforms within ROS to provide representation of inland landforms;

- based on the current extent of the P&R reserve, only examples of vegetation from the Quindalup Complex are represented on the site, whereas the redistribution of the ROS as proposed will provide reservation of examples of an area of the more inland Cottesloe Complex-Central and South, and importantly the transition between the two;

- the Quindalup Complex is currently reserved at 14% of it's original area, however the Cottesloe Complex-Central and South is reserved below the Department of Environmental Protection's 10% target at approximately 8% of original area; and therefore there is a contribution towards the regional targets for vegetation complex reservations;

- provision of additional reserve areas on an east-west alignment to provide representation of a greater variety of vegetation types and conditions, which will assist in preserving the trend for taller vegetation, and therefore diversified habitat, with increasing distance from the ocean;

- the addition of 5 inland vegetation assemblages in ROS areas that would not otherwise be represented on the site, therefore aiding biodiversity at the site;

- the loss of two small areas of vegetation assemblages near the coast, however the remaining assemblages will retain representation in the narrowed P&R reserve, and/or additional areas of ROS; and

- maintenance of recreational values for passive coastal activities such walking, fishing and swimming.

As previously noted, it is assumed that detailed management plans for the ROS and coastal reserves will be formulated to address issues such as stability, erosion control, rehabilitation, revegetation, and public access, in common with other developments in the locality.

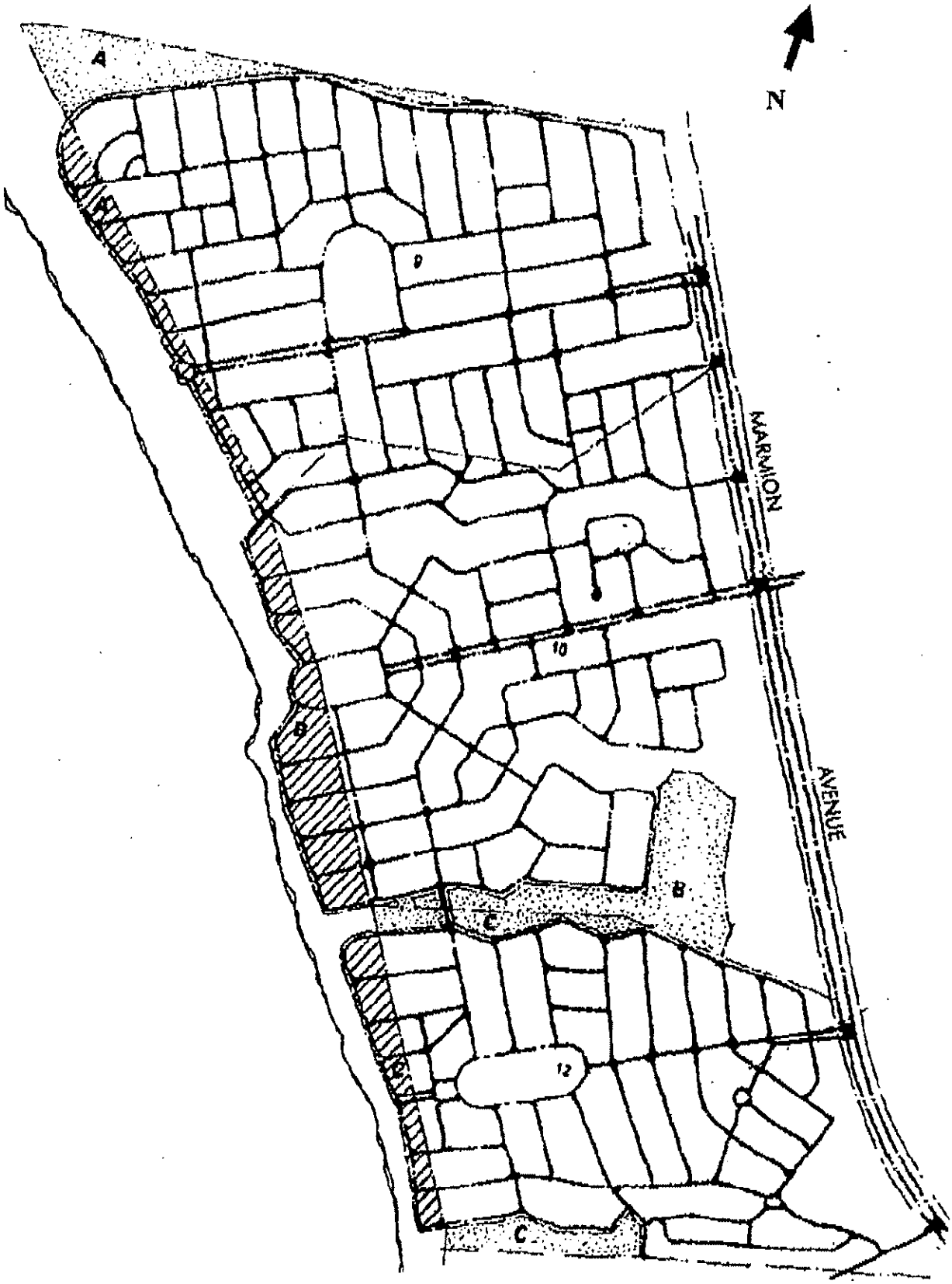
I trust the above information is to your satisfaction, however should you wish to discuss any aspect further please do not hesitate to contact me.

Yours faithfully
BOWMAN BISHAW GORHAM

MARTIN P. BOWMAN

cc Estates Development Company - Mr Michael Jones
Heath Development Company - Mr Colin Heath
Silverton Limited - Mr Gordon Howard
Chappell and Lambert - Mr Peter Chappell

- Attachments



PROPOSED LAND EXCHANGE FROM PARKS AND RECREATION TO URBAN

PROPOSED LAND EXCHANGE FROM URBAN TO PARKS AND RECREATION

FIGURE 1

PROPOSED REDISTRIBUTION OF ROS WITHIN THE JINDALEE STRUCTURE PLAN

Scale 1: 13 000 (approx.)

BOWMAN BISHAW GORHAM

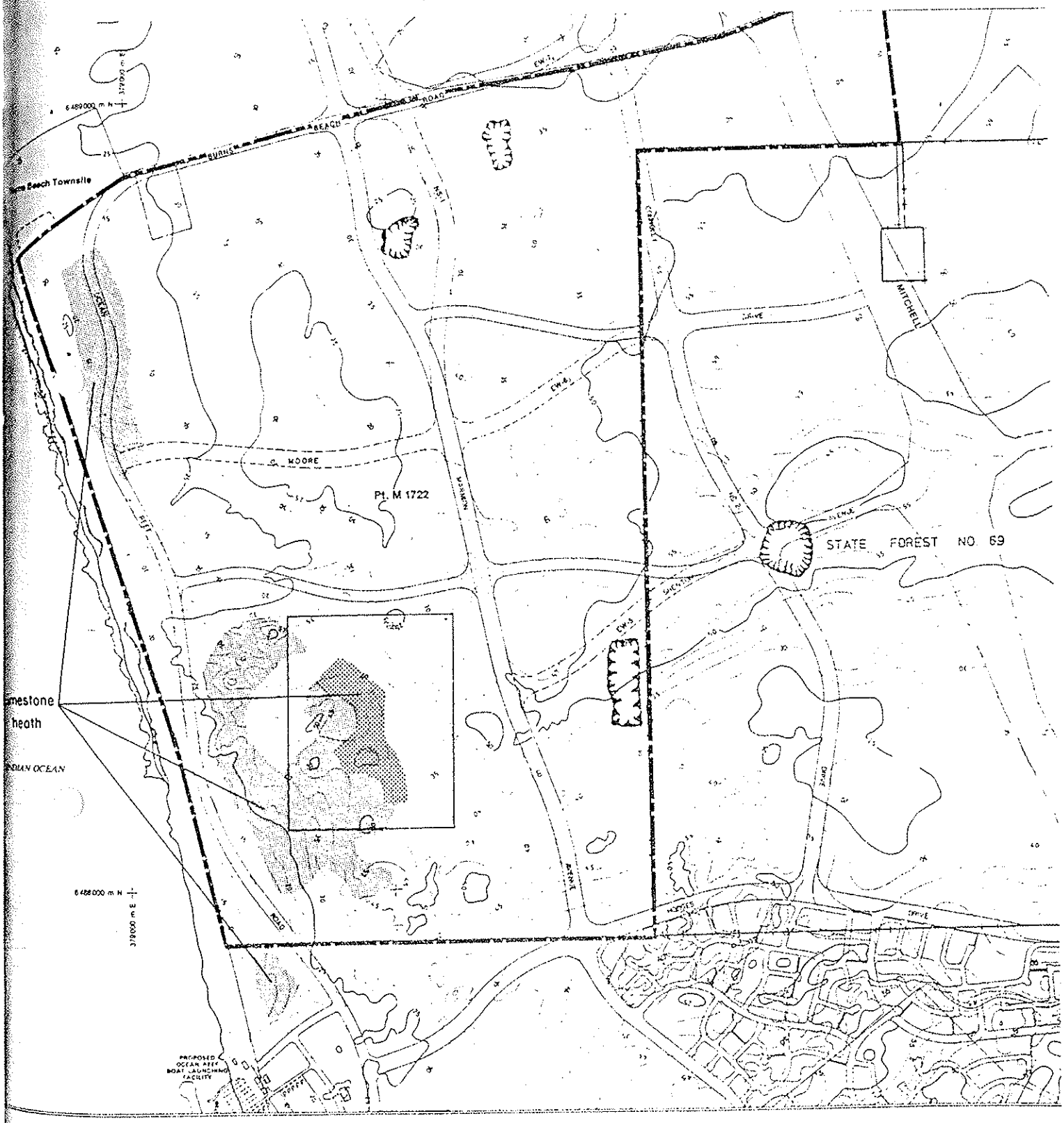
From, "Conservation Area - Ocean Reef/Burns Beach South" DR. W. FOULDS. (W.A.C.A.E), Date not known ≈ 1983.

Table 1

Identifying and differential species of associations and sub-associations of local limestone heath.

Identifying species of the Dryandra (sessilis) - Acacietum truncatae association.	Differential species of the sub-associations at Cockburn Sound.	Differential species of the sub-association at Ocean Reef/Burn's Beach.
Acacia truncata Dryandra sessilis Leucopogon parviflorus Cassytha pubescens	Templetonia retusa Grevillea thlemanniana Acacia lasiocarpa	Petrophile serrurea Bossiaea eriocarpa Casuarina humilis

Figure 1



OCATIONS OF LIMESTONE HEATH

Scale 1:20,000

Figure 2

Number of species found flowering at Ocean Reef during each month of the year. The data summarises observations from 1979 to 1981. Shrubs, cross hatched; herbs, open.

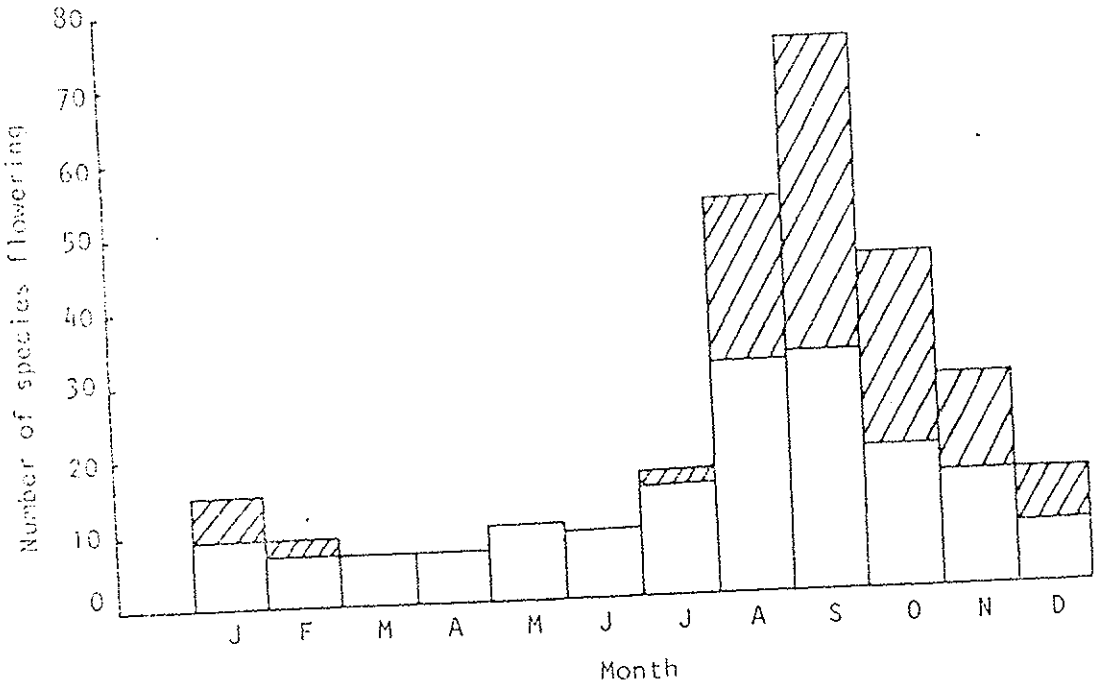
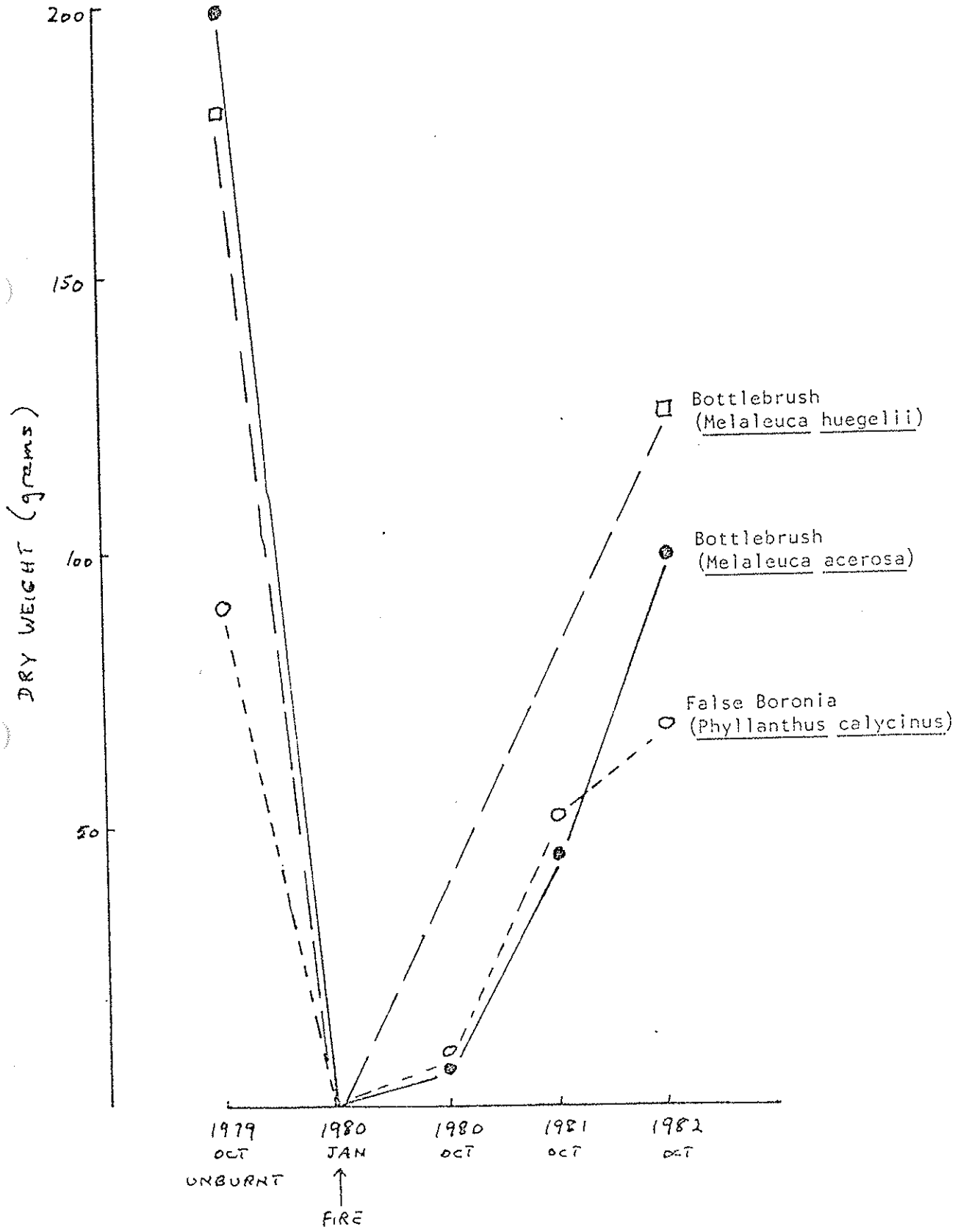


Figure 4

Growth rate of three species of shrub after burning.



APPENDIX I

Species list, type, and origin

(W = woody perennial; H = herb; n = native; i = introduced)

Species (nomenclature after Green, 1981)	Family	Type and Origin
Acacia cyclops A. Cumm ex G. Don	Leguminosae	W (n)
A. lasiocarpa Benth.	Leguminosae	W (n)
A. pulchella L.	Leguminosae	W (n)
A. truncata (N.L. Burman) Hort ex Hoffmans	Leguminosae	W (n)
Acanthocarpus preissi Lehm.	Liliaceae	W (n)
Actinanthos sp.	Proteaceae	W (n)
Anagallis arvensis L.	Primulaceae	H (i)
A. arvensis var. caerulea (L.) Gouan	Primulaceae	H (i)
Anigozanthos humilis Lindl.	Haemodoraceae	H (n)
Arctotheca calendula (L.) Levyns	Asteraceae	H (i)
Astroloma pallidum R. Br.	Epacridaceae	W (n)
Athrixia pulverulenta (Lindl.) Druce	Asteraceae	H (n)
Bellardia trixago (L.) All.	Scrophulariaceae	H (i)
Bassiaea eriocarpa Benth.	Leguminosae	W (n)
Bromus minor L.	Poaceae	H (i)
Bromus arenarius Labill.	Poaceae	H (n)
B. rubens L.	Poaceae	H (i)
Caladenia deformis R. Br.	Orchidaceae	H (n)
C. filamentosa R.Br.	Orchidaceae	H (n)
C. flava R.Br.	Orchidaceae	H (n)
C. latifolia R.Br.	Orchidaceae	H (n)
Calandrinia calyptrata Hooker	Portulacaceae	H (n)
C. Liniflora Fenzl.	Portulacaceae	H (n)
Calothamnus sanguineus Labill.	Myrtaceae	W (n)
Carpobrotus edulis (L.) L. Bolus	Aizoaceae	H (i)
Cassytha racemosa Nees.	Lauraceae	H (n)
Casuarina humilis Otto & Dietr.	Casuarinaceae	W (n)
Catapodium rigidum (L.) C.E.Hubbard ex Dony	Poaceae	H (i)
Cerastium glomeratum Thuill.	Caryophyllaceae	H (i)
Chorizema aciculare (DC.) C.A. Gardner	Leguminosae	W (n)
Clematis microphylla DC.	Ranunculaceae	W (n)
Comesperma confertum Labill.	Polygalaceae	W (n)
Conostylis aculeata sub sp. bracteata R.Br.	Haemodoraceae	H (n)

Species (nomenclature after Green, 1981)	Family	Type and Origin
Corynthecа micrantha (Lindl.) Macbride	Liliaceae	H (n)
Crassula colorata (Nees) Ostenf.	Crassulaceae	H (n)
Cryptandra leucophracta Schlecter	Rhamnaceae	W (n)
C. mutila Benth.	Rhamnaceae	W (n)
Dampiera linearis R.Br.	Goodeniaceae	H (n)
Daucus glochidiatus (Labill.) Fisch.	Apiaceae	H (n)
Daviesia divaricata Benth.	Leguminosae	W (n)
D. incrassata Sm.	Leguminosae	W (n)
Diplopeltis huegelii Endl.	Sapindaceae	W (n)
Drosera macrantha Endl.	Droseraceae	H (n)
Dryandra nivea (Labill.) R.Br.	Proteaceae	W (n)
D. sessilis (Knight) Domin	Proteaceae	W (n)
Eremophila glabra (R.Br.) Ostenf.	Myoporaceae	W (n)
Eriochilus dilatatus Lindl.	Orchidaceae	H (n)
Eriostemon spicatus A. Rich.	Rutaceae	W (n)
Erodium cicutarium (L.) L'Herit.	Geraneaceae	H (i)
Eucalyptus decipiens Endl.	Myrtaceae	W (n)
E. foecunda Schauer	Myrtaceae	W (n)
Exocarpus aphylla R.Br.	Santalaceae	W (n)
Geranium molle L.	Geraniaceae	H (i)
Gladiolus caryophyllaceus (N.L. Burman) Poir	Iridaceae	H (i)
Gompholobium tomentosum Labill.	Leguminosae	W (n)
Grevillea thelamanniana Heugel	Proteaceae	W (n)
Hakea costata Meisn.	Proteaceae	W (n)
H. prostrata R.Br.	Proteaceae	W (n)
H. trifurcata (Sm.) R.Br.	Proteaceae	W (n)
Hardenbergia comptoniana (Andr.)Benth.	Leguminosae	W (n)
Heliophila pusilla L. F.	Brassicaceae	H (i)
H. craspedioides W.V. Fitzq.	Asteraceae	H (n)
Hibbertia hypericoides (DC.) Benth.	Dilleniaceae	W (n)
H. polystachya Benth.	Dilleniaceae	W (n)
H. racemosa (Endl.) Gilg.	Dilleniaceae	W (n)
Homeria collina (Thunb.) Salisb.	Iridaceae	H (i)
Hovea stricta Meisn.	Leguminosae	W (n)
Hovea pungens Benth.	Leguminosae	W (n)
Hybanthus calycinus (DC. ex Ging.) F. Muell.	Violaceae	H (n)
Hydrocotyle diantha DC.	Apiaceae	H (n)

Species (nomenclature after Green, 1981)	Family	Type and Origin
H. pilifera Turcz. var. glabrata S. Moore	Apiaceae	H (n)
Hypochoeris glabra L.	Asteraceae	H (i)
Jacksonia furcellata (Bon pl.) DC.	Leguminosae	W (n)
Kennedia prostrata R.Br.	Legumonosae	W (n)
Lagenifera heugelii Benth.	Asteraceae	H (n)
Lechenaultia linarioides DC.	Goodeniaceae	W (n)
L. gracile R.Br.	Cyperaceae	H (n)
Leucopogon parviflorus (Andr.) Lindl.	Epacridaceae	W (n)
L. racemulosus DC.	Epacridaceae	W (n)
L. striatus R.Br.	Epacridaceae	W (n)
Loxocarya flexuosa (R.Br.) Benth.	Restionaceae	H (n)
)sinema ciliatum R.Br.	Epacridaceae	W (n)
Melaleuca acerosa Schauer	Myrtaceae	W (n)
M. cliffortioides Diels	Myrtaceae	W (n)
M. heugelii Endl.	Myrtaceae	W (n)
Melilotus indica (L.) All.	Legumonosae	H (i)
Millotia myosotidofilia (Benth.) Steetz	Asteraceae	H (n)
Olearia axillaris (DC.) F. Muell. ex Benth.	Asteraceae	W (n)
Opercularia vaginata Labill.	Rubiaceae	H (n)
Orobanche australiana F. Muell	Orobanchaceae	H (n)
Oxylobium capitatum Benth.	Legumonosae	W (n)
Parentucellia latifolia (L.) Carvel	Scrophulariaceae	H (i)
Parietaria debilis G. Forster	Moraceae	H (n)
Pelargonium capitatum (L.) L'Herit	Geraniaceae	W (i)
). Littorale Huegel	Geraniaceae	H (i)
Petrophile serruriae R.Br.	Proteaceae	W (n)
Petrorhagia pro lifera (L.) P.W. Ball and V.H. Heywood	Caryophyllaceae	H (i)
Phyllanthus calycinus Labill.	Euphorbiaceae	W (n)
Pimelea ferruginea Labill.	Thymelaeaceae	W (n)
P. sylvestris R.Br.	Thymelaeaceae	W (n)
Poa drummondiana Nees	Poaceae	H (n)
Poranthera microphylla Brongn.	Euphorbiaceae	H (n)
Rhagodia baccata (Labill.) Moq.	Chenopodiaceae	W (n)
Romulea rosea (L.) Eckl.	Iridaceae	H (i)
S. nitida R.Br.	Goodeniaceae	W (n)
S. paludosa R.Br.	Goodeniaceae	W (n)
Schoenus lanatus Labill.	Cyperaceae	H (n)

Species (nomenclature after Green, 1981)	Family	Type and Origin
Scirpus marginatus Thumb.	Cyperaceae	H (n)
Sonchus oleraceus L.	Asteraceae	H (i)
Sphaerolobium medium R.Br.	Leguminosae	W (n)
Spryidium globulosum (Labill.) Benth.	Rhamnaceae	W (n)
Stellcria media (L.) Vill.	Caryophyllaceae	H (i)
S. multiflora Hooker	Caryophyllaceae	H (i)
Stylidium brunonianum L. sub sp. brunonianum	Stylidiaceae	H (n)
S. guttatum R.Br.	Stylidiaceae	H (n)
S. junceum R.Br. sub sp. junceum	Stylidiaceae	H (n)
Templetonia retusa (Vent.) R.Br.	Leguminosae	W (n)
Thomasia cognata Steud.	Sterculiaceae	W (n)
Thysanotus patersonii R.Br.	Liliaceae	H (n)
T. pilosa Sm	Apiaceae	H (n)
Tricoryne elatior R.Br.	Liliaceae	H (n)
Trifolium campestre Schreber	Leguminosae	H (i)
Trisetaria cristata (L.) Kerguelen	Poaceae	H (i)
Trymalium ledifolium Fenzl.	Rhamnaceae	W (n)
Ursinia anthemoides (L.) Poir	Asteraceae	H (i)
Wahlenbergia gracilenta Lothian	Campanulaceae	H (n)
Wurmbea dioica R.Br.	Liliaceae	H (n)

BFL 597 (198)

ENVIRONMENTAL MANAGEMENT PROJECT
SCI 3451

A SURVEY OF THE FLORA AND VEGETATION OF COASTAL RESERVES NORTH OF QUINNS ROCKS, WESTERN AUSTRALIA

by

Nicola Robinson

NOVEMBER 1995

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The information, advice and helpful assistance provided by the following people is also gratefully acknowledged: Denis Cluning, Ian Davies and Paul Neilson at the City of Wanneroo; Ross Bowman and Alan Hilton at the Town of Cambridge; and Steve Connell at Edith Cowan University.

Last, but by no means least, many thanks to my supervisor, Dr Paul Lavery for his guidance and support.

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INTRODUCTION

Background

In 1983 the Environmental Protection Authority (EPA) System 6 study made recommendations for a coastal reserve from Two Rocks to Burns Beach (System 6 Area M2) (see Figure 1). This reserve essentially provides protection for the nearshore dune system but the EPA also considers it important for conservation of a "diverse and relatively undisturbed coastal environment", (Alan Tingay & Associates, 1991, p.3) and for recreation. Future management of the area should consider both these values (Alan Tingay, 1991).

The planning strategy for the Perth Metropolitan Region (METROPLAN) released in 1990 indicated major urban expansion would occur along the North West Corridor (see Figure 1). Much of the reserve has however been incorporated into the final North West Corridor Structure Plan (DPUD, 1992).

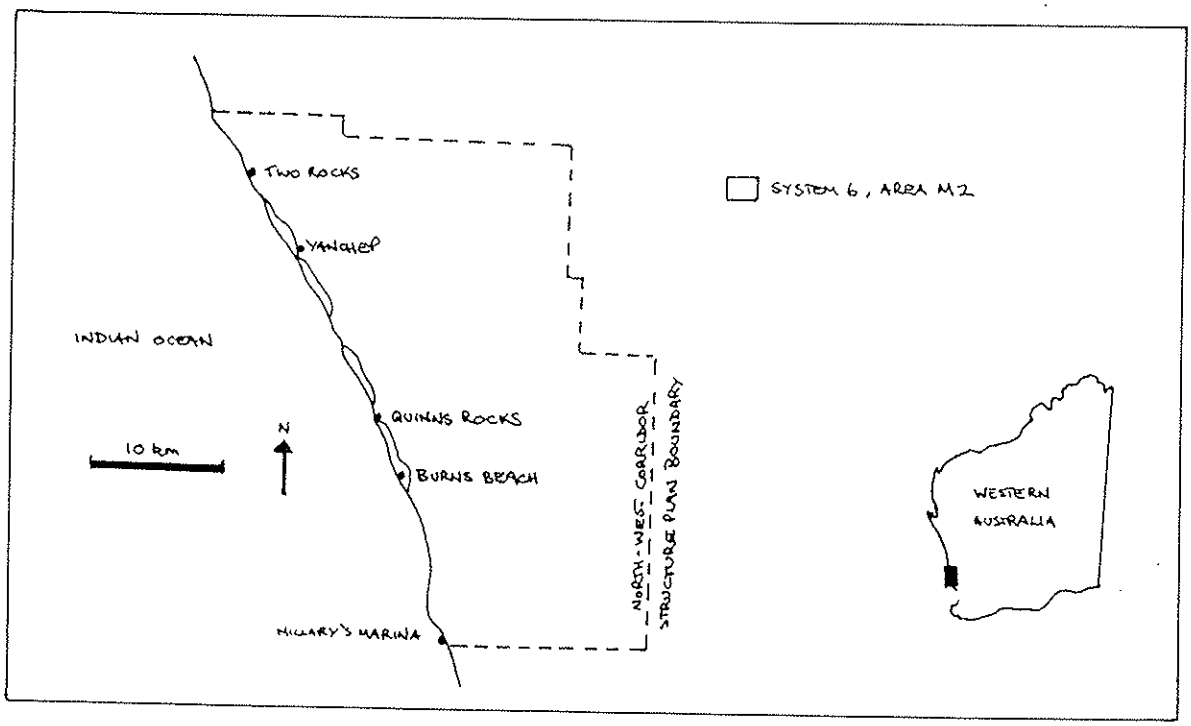


FIGURE 1 - NORTH-WEST CORRIDOR BOUNDARY AND SECTION OF SYSTEM 6 (ADAPTED FROM : EPA (1993) AND DPUD (1992))

Also in 1992 Hames Sharley Australia (for the Department of Planning and Urban Development (DPUD) and the City of Wanneroo) published their "Coastal Planning Study - Burns Beach to Jindalee". This report included recommendations concerning the coastal reserve width, specific areas to be set aside for conservation and recreation, and what access and facilities should be provided (see Figure 2).

The Study Area

The area covered by this study comprises part of the aforementioned coastal reserve (see Figure 2). It is a section of Crown foreshore reserves 20561 and 35890 (vested in the City of Wanneroo) adjacent to Lots 10 and 12 in the City of Wanneroo. The southern boundary of the area is approximately 1km north of Quinns Rocks. It is approximately 1.6km from north to south and varies in distance east-west from 200m in the north to 100m in the south (approximately 25 hectares).

Reserve 20561 is described as for "Recreation and purposes incidental thereto", and 35890 as "Reserve for Public Recreation" (City of Wanneroo, 1974). Hames Sharley (1992) include the area as Sectors 2 and 3 in their Coastal Planning Study, with the emphasis on foreshore recreation. In the North West Corridor Structure Plan it is zoned for "Conservation/Passive Recreation" while the adjacent Lots are zoned "Future Urban" (between 1997 and 2002). The City of Wanneroo has drafted plans for this development.

Currently development is occurring south of Lot 12, to the east of Marmion Avenue. At the present time no development has occurred on Lots 10 and 12 which, together with the study, area remain in their natural/semi-natural state.

Objectives of the Study

This study surveyed the flora and vegetation of the study area, in relation to its geomorphological characteristics, with the objectives of:

1. Assessing its ecological value within a regional perspective,

2. Assessing what changes may potentially occur to the vegetation once adjacent development proceeds, and

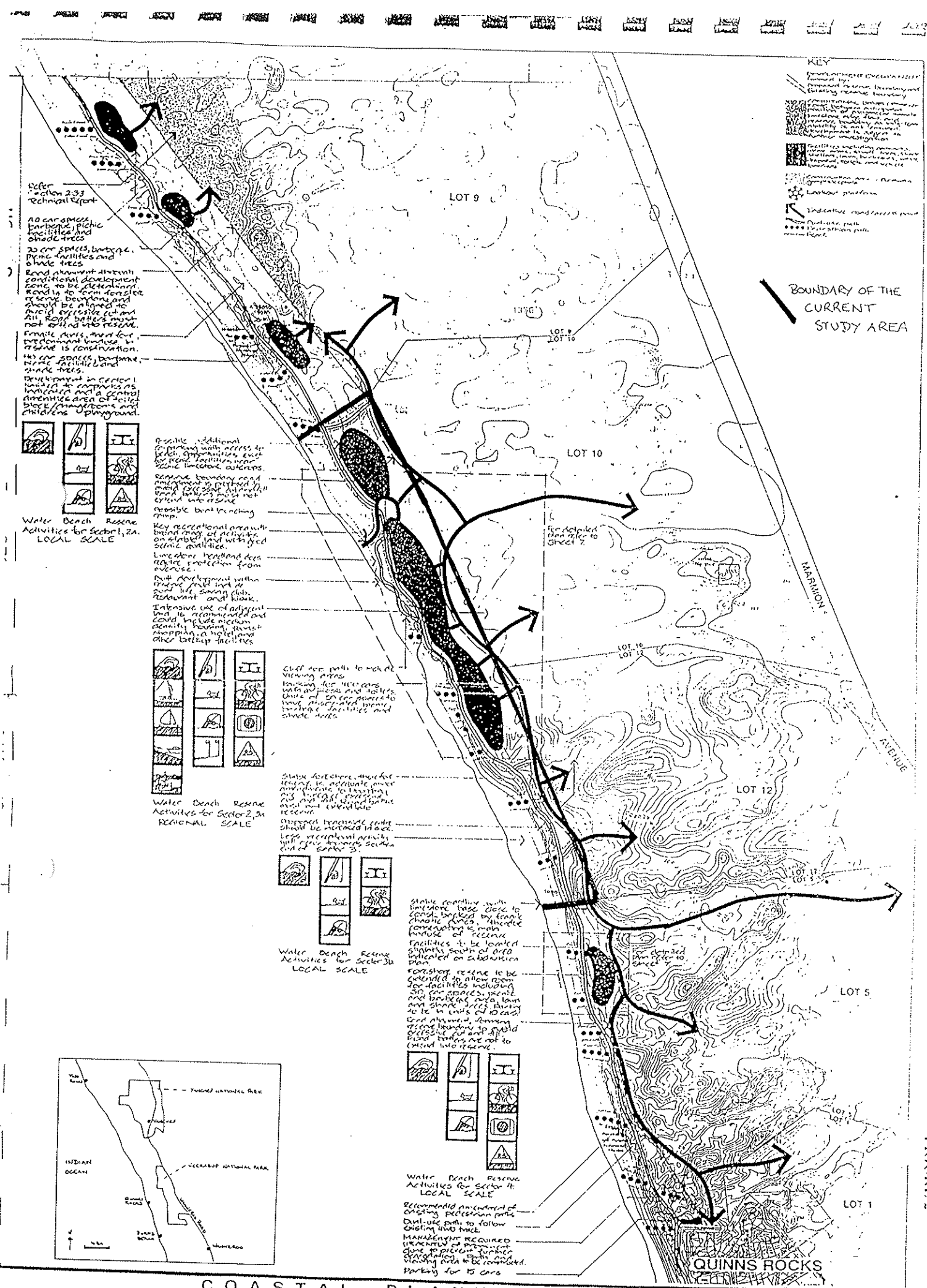


FIGURE 2

COASTAL PLANNING STUDY

Burns Beach to Jindalee

RECOMMENDATIONS

Hames Sharley Australia

3. The conclusions reached from Objective 1 and 2 are applied to determine the appropriateness of the proposed Hames Sharley recommendations for the area.

Objective 1 is achieved by comparing the outcomes of this study with regional studies that incorporated the study area. Determining a set of criteria to objectively assess the ecological value of an area would require resources and time beyond the scope of this study. It is therefore proposed to use criteria based on that by Trudgen & Keighery (1990) in a similar assessment of the Ningana area, approximately 4km to the north of the study site. These relate to the vegetation types as follows:

- Presence at the site;
- Extent at the site;
- Overall distribution;
- Where in the overall distribution they occur;
- How previous development has effected them; and
- How well reserved they are in secure conservation reserves.

Objective 2 is achieved by comparing the area to another section of coastal reserve within the Quindalup Dune System, adjacent to long-established urban development at City Beach (see Figure 3). A survey of this second area is also incorporated into this study.

The rationale behind the project is to provide some assessment of the impact of fast proceeding urban development on the vegetation.

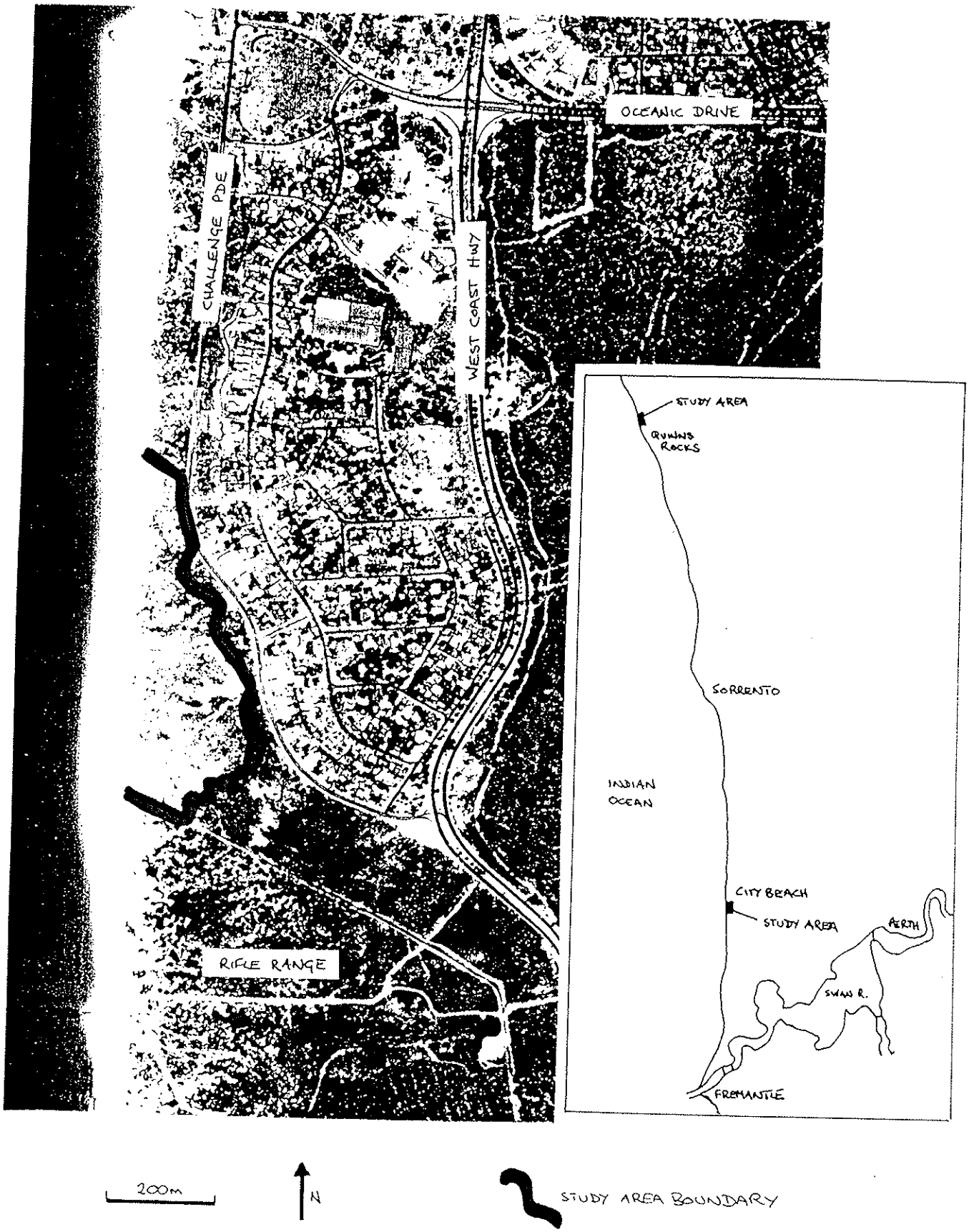


FIGURE 3 – CITY BEACH STUDY AREA

METHODS

QUINNS ROCKS STUDY AREA SITE DESCRIPTION

Location

Location details are provided in the Introduction.

Climate

The area has a Mediterranean climate with hot dry summers and reliable winter rainfall. Annual rainfall is approximately 625 - 750mm. During the summer months strong south westerly winds have the potential to cause blowouts of sparsely vegetated dunes (Trudgen & Keighery, 1990).

Geology, Geomorphology and Topography

Geological features of the study area include elements of the Quindalup Dune (Holocene Safety Bay Sand) and Spearwood Dune (Pleistocene Tamala Limestone) systems. Quindalup Dunes extend along the shoreline of the Swan Coastal Plain from Dongara in the north to Geographe Bay in the south (Semeniuk et al, 1989). They form a discontinuous strip of parabolic dunes and overlie the more continuous Spearwood Dunes (Trudgen & Keighery, 1990; McArthur & Bartle, 1980).

The western boundary of the study area is the narrow (10 - 30m) beach. There is little foredune development except for a small section (approximately 100m) just north of the southern boundary.

In the northern section the primary dune (Quindalup formation) rises steeply from the beach. In the middle section Tamala Limestone is extensively exposed as cliffs. In the southern section the primary dunes again rise steeply with locally exposed limestone.

Behind the primary dunes and cliffs much of the area comprises Quindalup parabolic dunes (Geological Survey of WA, 1985), although there are substantial areas of Tamala

Limestone outcrops especially in the north and middle sections. These form exposed cliffs behind the primary dunes in the north.

The elevation at the crest of the foredunes range from 8 to 12m, rising to a maximum of 28m on the rims of the parabolic dunes at the eastern boundary of the study area.

Disturbance History

The area is used by 4WD enthusiasts on a regular basis (personal observation). A well worn 4WD track traverses the site from north to south in the swale behind the primary dune. In some sections the track has eroded a cutting at least one metre deep. In the northern section vehicles are also driven along the beach.

Fires occur in the study area on a regular basis although it is not subjected to prescribed burning. The most recent fire (that extended from Yanchep to Burns Beach), was 3 years ago (Denis Cluning, pers. comm.).

Until 5 years ago the adjacent lots were grazed by domestic stock which were not restrained from wandering into the study area. The whole area had been a pastoral lease for over 100 years, but the study area had been progressively reserved between 5 and 10 years ago (Denis Cluning, pers. comm.).

There is still much evidence of grazing by rabbits in the area.

CITY BEACH STUDY AREA SITE DESCRIPTION

Location

The City Beach study area is a section of coastal reserve vested in the Town of Cambridge. It is bounded by the beach to the west, Challenger Parade to the east, the rifle range fence to the south and a beach access track opposite Falmouth Avenue to the north. It has a maximum distance north-south of 600m and varies east-west from 70 to 230m (see Figure 3) It is approximately 10 hectares.

Climate

The climate is essentially similar to that of the Quinns Rocks study area but annual rainfall is approximately 125mm less (Trudgen & Keighery, 1990).

Geology, Geomorphology and Topography

The study area is located on the Quindalup Dune System. The foredune is well developed along much of the beach. Behind this the primary and parabolic dunes rise steeply to a maximum elevation of 20m (Geological Survey of WA, 1986).

Disturbance History

The area is traversed east-west by five fenced access tracks to the beach (including the northern boundary track). The eastern boundary is also fenced. The fences were erected a minimum of 11 years ago (Alan Hilton, pers. comm.).

The last fire in the area occurred two years ago. This burnt the southern section from Challenger Parade to the beach. No other fires have occurred at least in the previous 9 years. The regeneration of the area has been entirely natural (Alan Hilton, pers. comm.). Although tree branches were laid over much of the ground to prevent erosion, they do not appear to have contributed seed to the regeneration.

Other disturbances includes some evidence of rabbit activity.

PRELIMINARY INVESTIGATION

Aerial photographs were used to prepare preliminary vegetation maps. These were checked by ground truthing during familiarisation trips to the study sites prior to sampling and revised iteratively throughout the project.

SAMPLING

A stratified random sampling approach was adopted. Sample sites were located randomly within each community type recognised on the preliminary map. This was done by walking on a random compass bearing for a random number of steps (Kent & Coker, 1992).

A quadrat based sampling approach was selected because this is a standard method (Kent & Coker, 1992). It is also the approach taken by Griffin (1993) and Gibson et al (1994), and so provided some compatibility of data for comparison with their studies. As in their studies, a 10 x 10m quadrat was used.

A minimum of 3 quadrats per community was selected to provide replication (and ensure sampling of natural variability). Originally 11 communities at the Quinns Rocks site, and 3 at the City Beach site were recognised. Ultimately, 42 quadrats were sampled.

Data was recorded on sheets developed and trialed by botanists and volunteers over 6 years in 3 surveys on the Swan Coastal Plain (Keighery, 1994). A copy of these are provided in Appendix 1. They were modified to reflect the coastal geomorphology, and to allow cover class percentage to be recorded for all species.

Field work was undertaken to coincide with the flowering season for a large percentage of coastal plants in early/mid September. (The survey is based on vascular plants only. It would be rendered impractical due to limited expertise and time available for identification of lower orders.)

DATA ANALYSIS

Where possible identifications were undertaken in the field. Otherwise specimens were collected and identifications made with the aid of Marchant et al (1987), Bennett (1988), Rippey & Rowland (1995), and the facilities of the Western Australian Herbarium.

Exploratory data analysis was undertaken to identify patterns in communities at the two sites. For this the Two-Way Indicator Species (TWINSPAN) computer program was utilised with species abundance data. From the output (a sorted two-way table) (see Appendix 2) a subjective decision was made about the level of subdivision of groups of quadrats into community types and final vegetation maps were produced . The vegetation structure was described using Keighery's (1994) classification (see Appendix 3).

Once the vegetation maps were drawn up and the results tabulated, four hypotheses were generated. These were as follows:

1. H_0: There is no significant difference between the mean number of species per quadrat (species richness) at the Quinns Rocks and City Beach sites.
   H_1: There is a significant difference between the mean number of species per quadrat (species richness) at the Quinns Rocks and City Beach sites.

2. H_0: There is no significant difference between the mean Shannon diversity index (as a measure of diversity) for the Quinns Rocks and City Beach sites.
   H_1: There is a significant difference between the mean Shannon diversity index (as a measure of diversity) for the Quinns Rocks and City Beach sites.

3. H_0: There is no significant difference between the mean number of weed species as a percentage of total species for the Quinns Rocks and City Beach sites.
   H_1: There is a significant difference between the mean number of weed species as a percentage of total species for the Quinns Rocks and City Beach sites.

4. H_0: There is no significant difference between the mean weed cover as a percentage of total cover for the Quinns Rocks and City Beach sites.
   H_1: There is a significant difference between the mean weed cover as a percentage of total cover for the Quinns Rocks and City Beach sites.

These hypotheses were formulated to give some comparative indication of the vegetation condition at Quinns Rocks, and to help assess how urban development will impact on their condition.

They were tested with the parametric, independent samples T test. Justification for this is that the dependent variables are 'interval' in hypotheses 1 and 2, and 'ratio' in 3 and 4, and the data were collected randomly (Fowler & Cohen, 1990). Before the tests were performed the data were determined to be 'normal' (i.e. at least 68% of the sample data fell within one standard deviation of the mean). The tests were run using the SPSS statistical computer program. This program also tests to see if the variance between samples are similar (Levene's Test).

The values of the Shannon Diversity Index usually lie between 1.5 and 3.5 although it can exceed 4.5 (Kent & Coker, 1992).

This index does not differentiate between native and weed species, and so analysis was also performed on weed cover to give a quantitative indication of the vegetation condition. The limitation of this test however is that when the data were recorded, percentage cover for each species was bracketed on a scale of 1 to 5: to give the test greater validity, actual cover for each species should have been recorded. In light of the arguably dubious nature of this test, it was conducted using two scales as follows:

Linear Scale:		Absolute Scale:
1 (<2%)	=	1%
2 (2-10%)	=	5%
3 (10-30%)	=	20%
4 (30-70%)	=	50%
5 (>70%)	=	70%

RESULTS

1. QUINNS ROCKS STUDY AREA

FLORA DESCRIPTION

Recorded Taxa

A total of 113 species representing 90 genera and 44 families of vascular plants were recorded from the study area. (A species list is provided in Appendix 4.) This number of taxa is comparable to the 122 taxa recorded by Keighery (1991) in similar habitats (i.e. "dunes", "heath" and "limestone heath") near Mindarie, 5 kilometres south of the study area.

Species native to Western Australia number 83, and introduced species 27 (24% of the total). Three taxa in the Poaceae are of unknown origin.

The most common families are Poaceae (12 species) followed by Fabaceae (9), Asteraceae (8), Mimosaceae (6) and Cyperaceae, Orchidaceae and Proteaceae each with 4 species. Introduced taxa most commonly belong to Poaceae and Asteraceae (4 species each) followed by Brassicaceae and Fabaceae (3 species each).

Of the total 113 species, 105 were recorded from the quadrats and 8 were sampled opportunistically.

Significant and Unusual Taxa

No Declared Rare Flora or Priority Flora were recorded in the study area but the following significant and unusual taxa did occur.

1. *Hemiandra pungens* "Coastal Form"
This is a glabrous and "apparently a distinct local form in this species complex [whose] distribution and status are currently unresolved" (Keighery, 1991, p.3-4). It is restricted to the Swan Coastal Plain between Wanneroo and Seabird (Keighery, 1992).

2. *Trymalium albicans*
3. *Diplopeltis huegelii*

These belong to the association of limestone endemic species which are "generally poorly known taxonomically" (Keighery, 1991, p.4). The southern range end of *Trymalium albicans* is on the Swan Coastal Plain (Gibson et al, 1994).

4. *Grevillea preissii subsp preissii*

Previously *G. thelemanniana subsp preissii* this has been re-instated by Olde & Marriott (1994) under *G. preissii*. Keighery (1992) lists it as a significant species of the Swan Coastal Plain coastal belt. Its southern range end is on the Plain (Gibson et al, 1994)

5. *Nemcia reticulata*

The coastal form which extends from Burns Beach to Northampton is not know in any conservation reserves south of Nambung (Gibson et al, 1994). (Nambung is 125km north of Quinns Rocks.)

6. *Lechenaultia linarioides*
7. *Melaleuca cardiophylla*

Both these species have their southern range ends on the Swan Coastal Plain, at Coogee and Bold Park respectively (Gibson et al, 1994).

8. *Leptomeria priessiana*
9. *Acacia cochlearis*
10. *Acacia cyclops*
11. *Acacia truncata*

These species have their northern range ends on the Swan Coastal Plain: *L. priessiana* at Bullsbrook (Gibson et al, 1994), and the *Acacia* species at Leeman. The southern range end of *A. truncata* is Bunbury (Keighery, 1992).

VEGETATION DESCRIPTION

Description of Communities

The mosaic of vegetation communities found in the coastal arena can be linked to a combination of factors which includes topography, exposure, geomorphology and soil depth (Keighery, 1991).

Communities identified in the study area are: *Spyridium globulosum/Olearia axillaris* heath over *Lomandra maritima* sedgeland (hereafter referred to as *Olearia axillaris* heath); *Scaevola crassifolia* heath; *Acacia truncata* heath; *Dryandra sessilis* heath; *Spyridium globulosum/Melaleuca huegelii* heath; *Acacia rostellifera* shrubland over *Melaleuca cardiophylla* heath (*M. cardiophylla* heath); *Scaevola crassifolia/Frankenia pauciflora* shrubland (*F. pauciflora* shrubland); and *Pelargonium capitatum*, *Medicago* sp. herbland/*Ehrharta longifolia* grassland (*P. capitatum* herbland).

The predominant communities (see Figure 4) are *Scaevola crassifolia* heath and *Olearia axillaris* heath, both associated with the sands of the Quindalup System. The limestone heaths (*A. truncata* and *D. sessilis* heaths), are also well represented.

The *S. crassifolia* heath occupies the primary dune system. Some of the species uniquely typical to this community are *Santalum acuminatum*, *Exocarpus sparteus*, *Ozothamnus cordata*, *Trachyandra divaricata* and *Tetragonia decumbens*.

Weeds account for 35% of species in this community, and the mean condition rating is 3 (see Table 1). (The condition ratings have a scale of 1 to 6: 1 is 'Pristine' and 6 is 'Completely Degraded'. Appendix 5 gives detailed descriptions of condition ratings.)

The *O. axillaris* heath is the most extensive community and also the most variable in terms of sub-communities (see Figure 5). (A more detailed study may have revealed greater subdivision associated with variations in geomorphology and/or soil.) The presence of *O. axillaris* was reasonably consistent throughout but is never more than 10 - 30% cover in any quadrat. *S. globulosum* and *L. maritima* are the other dominant species in this community. In some areas, notably in the NE corner (near the sites' maximum elevation) *L. maritima* occurs with a cover of over 70%. These areas had no shrubs over 0.5m. An area dominated by dense cover of *S. globulosum* was in the south of the study site in the location of quadrats Q31, Q32 and Q33 (see Figure 4).

Uniquely typical species associated with this community include *Acacia lasiocarpa*, *Kennedia prostrata*, *Loxocarya fasciculata*, *Nemcia reticulata*, *Gompholobium tomentosum* and *Leucopogon propinquus*.

FIGURE 4

VEGETATION MAP OF QUINNS ROCKS STUDY AREA

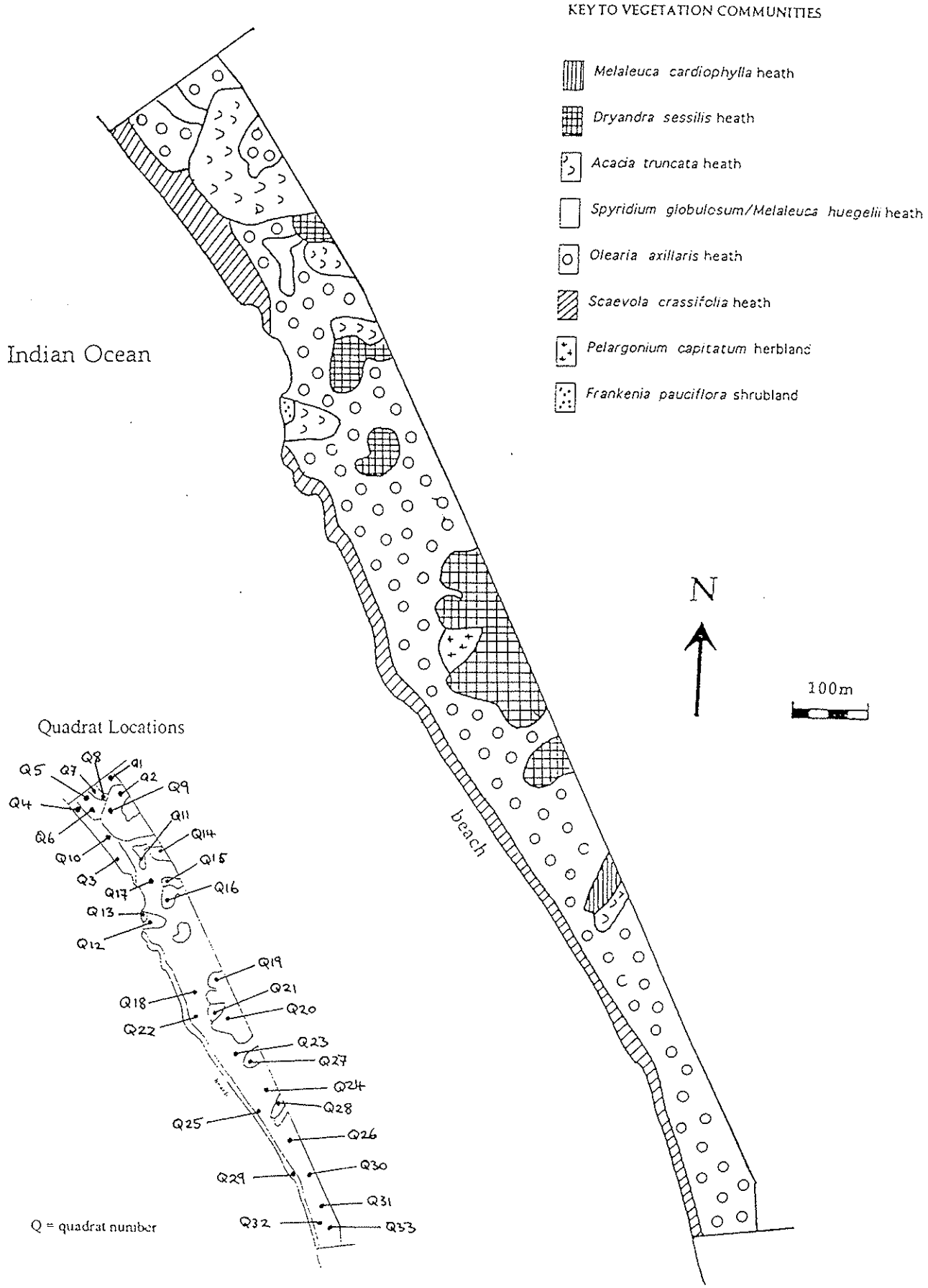


TABLE 1
SUMMARY OF RESULTS FOR VEGETATION COMMUNITIES AT QUINNS ROCKS AND CITY BEACH

VEGETATION COMMUNITY *

	Quinns Rocks Site								City Beach Site			
	1	2	3	4	5	6	7	8	1	2	3	4
Mean number of species per quadrat (species richness):												
for vegetation community	25	26	33	28	30	27	10	13	29	20	14	11
for site	28								19			
Mean Shannon diversity index:												
for vegetation community	3.07	3.09	3.35	3.18	3.25	3.16	2.17	2.45	3.23	2.85	2.54	2.31
for site	3.17								2.73			
Mean percentage weed species per quadrat:												
for vegetation community	20	34	26	28	25	35	100	23	34	45	61	57
for site	30								49			
Mean weed cover as a percentage of total cover on a linear scale: **												
for vegetation community	13	34	20	22	24	30	100	15	43	50	64	60
for site	27								54			
Mean weed cover as a percentage of total cover on an absolute scale: **												
for vegetation community	2	27	5	7	22	16	100	3	65	65	70	69
for site	19								68			
Mean condition rating: ***												
for vegetation community	2	3/4	2/3	2/3	3	3	6	2/3	4/5	5	5	5
for site	3								5			

* KEY TO:

QUINNS ROCKS SITE VEGETATION COMMUNITIES
QR1 = Melaleuca cardiophylla heath
QR2 = Dryandra sessilis heath
QR3 = Acacia truncata heath
QR4 = Spyridium globulosum/Melaleuca huegelii heath
QR5 = Olearia axillaris heath
QR6 = Scaevola crassifolia heath
QR7 = Pelargonium capitatum herbland
QR8 = Frankenia pauciflora shrubland

CITY BEACH SITE VEGETATION COMMUNITIES
CB1 = Pelargonium capitatum herbland
CB2 = Lepidosperma gladiatum sedgeland
CB3 = Trachyandra divaricata herbland
CB4 = Spinifex grassland

** COVER SCALES

LINEAR		ABSOLUTE
1 (<2%)	=	1%
2 (2-10%)	=	5%
3 (10-30%)	=	20%
4 (30-70%)	=	50%
5 (>70%)	=	70%

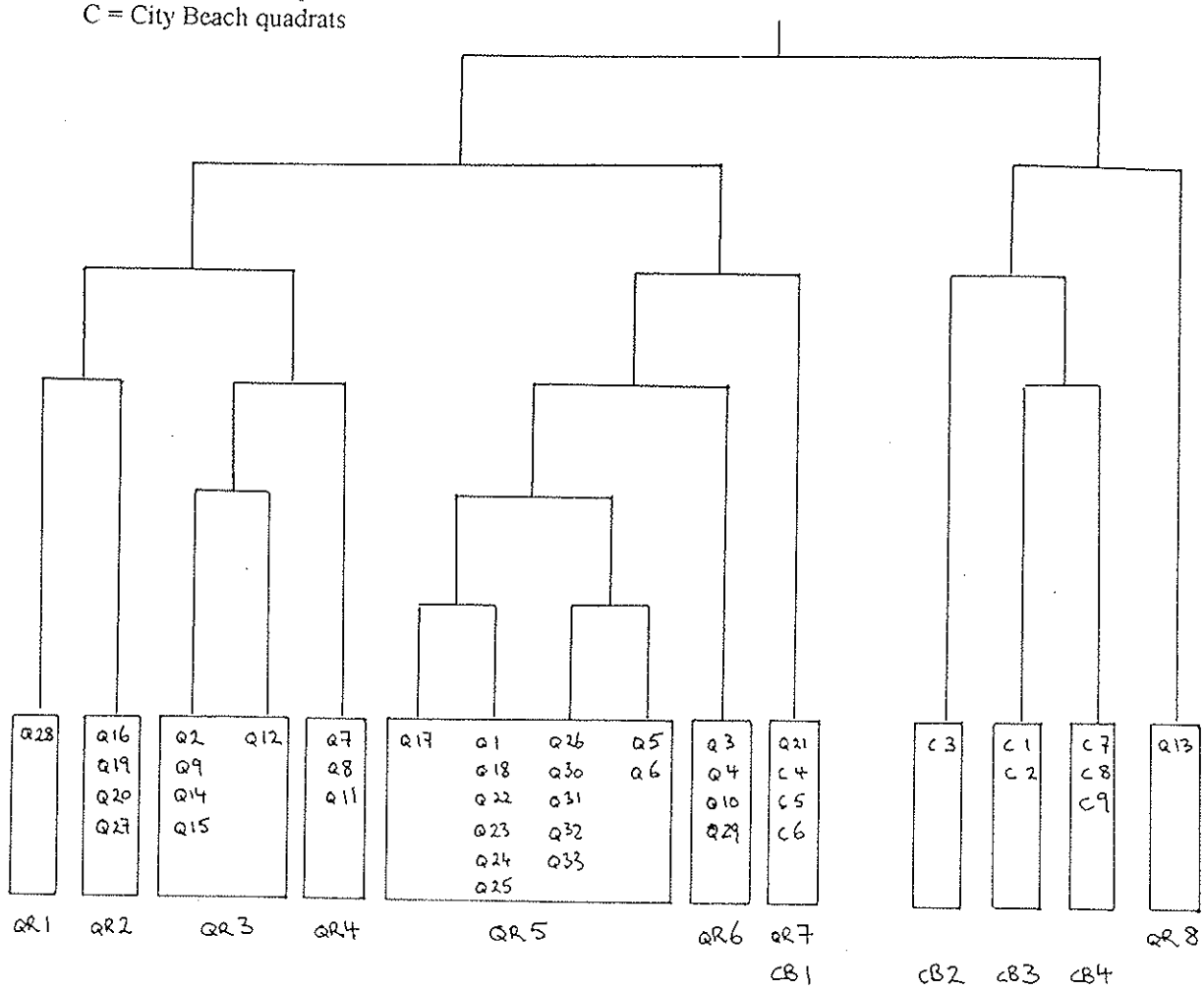
*** KEY TO VEGETATION CONDITION RATING

1 = Pristine
2 = Excellent
3 = Very Good
4 = Good
5 = Degraded
6 = Completely Degraded

FIGURE 5

TWINSPAN ANALYSIS BY QUADRAT

Q = Quinns Rocks quadrats
C = City Beach quadrats



VEGETATION COMMUNITY

Key to Vegetation Communities

QR1 = *Melaleuca cardiophylla* heath
QR2 = *Dryandra sessilis* heath
QR3 = *Acacia truncata* heath
QR4 = *Spyridium globulosum/Melaleuca huegelii* heath
QR5 = *Olearia axillaris* heath
QR6 = *Scaevola crassifolia* heath
QR7 = *Pelargonium capitatum* herbland
QR8 = *Frankenia pauciflora* shrubland

CB1 = *Pelargonium capitatum* herbland
CB2 = *Lepidosperma gladiatum* sedgeland
CB3 = *Trachyandra divaricata* herbland
CB4 = *Spinifex* grassland

The mean weed occurrence in this community is 25%, and the condition rating is highly variable (from 2 to 5/6). (It is worth noting at this point that some of these sites were in close proximity to the main 4WD track.)

In areas of Tamala Limestone, A. truncata heath is found on ridge tops and grades into *D. sessilis* heath on the lower ridge slopes and depressions. Both these communities are associated with skeletal soils (Gibson et al, 1994) which appears to be generally darker in colour than communities of the Quindalup sands (see Appendix 6). The *A. truncata* heath was the only community in which exposed limestone is recorded.

Uniquely typical species of the *A. truncata* heath were found to be *Melaleuca huegelii*, *Templetonia retusa*, *Thomasia triphylla* and *Trymalium albicans*.

Dryandra sessilis heath is in some areas badly degraded as reflected in the relatively low mean condition rating (3.5) and high mean occurrence of weed species (34%) compared to the *A. truncata* heath with a mean rating of 2.5 and only 26% mean weed occurrence. (The latter however did have quadrats of very high (42% in Q12) and very low (13% in Q2) weed occurrence) (see Appendix 6 and Figure 4 - inset).

The only records of *Grevillea preissii subsp preissii*, *Hakea lissocarpha* and *Dryandra nivea* (the former 2 commonly associated with limestone (Marchant et al, 1987)), were found in the *D. sessilis* heath.

The *Spyridium globulosum/Melaleuca huegelii* heath appears to represent a gradation between *O. axillaris* heath and *A. truncata* heath. The two areas of this heath were in quite distinct depressions.

The other 3 communities are quite unusual and are represented by one small area each.

The *Melaleuca cardiophylla* heath, occurs adjacent to a small patch of *A. truncata* heath on the eastern boundary. *M. cardiophylla* also occurs in the *D. sessilis* heath and *O. axillaris* heath, and several shrubs were noted between quadrats Q21 and Q22 in the middle section of the study area adjacent to the main track. Further studies may reveal these locations to represent additional distinct communities.

This community is also noteworthy for its relatively high condition rating (2) and low percentage weed occurrence (20%).

The *Frankenia pauciflora* shrubland, is located on the cliff top. Similarly to the *M. cardiophylla* heath this community has a relatively high condition rating (2/3) and low occurrence of weeds (23%).

The *Pelargonium capitatum* herbland is a small completely degraded area with no native species. Within this area is a WAWA bore and an old well. It is also at a 'major crossroads' of tracks. It is probable that the area was cleared of native vegetation and continues to be regularly disturbed by human impacts.

Overall Condition of the Study Area

The whole study area is generally covered in a dense vegetation with no substantial evidence of blow-outs in the dunes, or areas of sparse vegetation (apart from the main track). There are, however, two localised 'gaps' in the vegetation where the track accesses the beach. These may be potential areas of erosion.

The condition ratings range from 'Pristine/Excellent' (rating 1/2) to 'Completely Degraded' (rating 6). Areas in notably good condition include the *A. truncata* (limestone) heath communities in the north (refer to quadrats Q2, Q9 and Q14), the *O. axillaris* heath in the vicinity of quadrats Q1, Q22 and Q23, the *M. cardiophylla* heath (Q28) and *F. pauciflora* shrubland (Q13). The *A. truncata* heath also has the highest mean diversity index (3.35) followed by the *O. axillaris* heath (3.25).

The most degraded areas, with a dense cover of *P. capitatum*, were in the vicinity of quadrats Q5 and Q6 in the north, Q21 in the middle section, and Q30 in the south. All of these areas are adjacent to the main track, with the middle and southern sections being at the junction of several tracks. From observation, it is apparent that the edge of the track is also heavily infested with weeds, particularly *Arctotheca calendula* (Capeweed).

The most widespread weed is *P. capitatum*. Other commonly occurring annual weeds are *Anagallis arvensis var. caerulea, Cerastium glomeratum, Crassula glomerata, Dischisma arenarium, Ehrharta longiflora* and *Lagarus ovatus.*

2. CITY BEACH STUDY AREA

FLORA DESCRIPTION

A total of 58 species representing 31 families and 52 genera of vascular plants were recorded. (A species list is provided in Appendix 7). Species native to Western Australia number 37 and introduced species 21 (36% of the total).

The most common families are Poaceae (8 species), Cyperaceae (5), Asteraceae (4) followed by Brassicaceae, Fabaceae, Mimosaceae and Myrtaceae (3 species each). Introduced taxa mostly commonly belong to Poaceae (6), Brassicaceae (3) and Asteraceae (2).

Of the total 58 species, 55 were recorded from quadrats and 3 were sampled opportunistically.

VEGETATION DESCRIPTION

Description of Communities

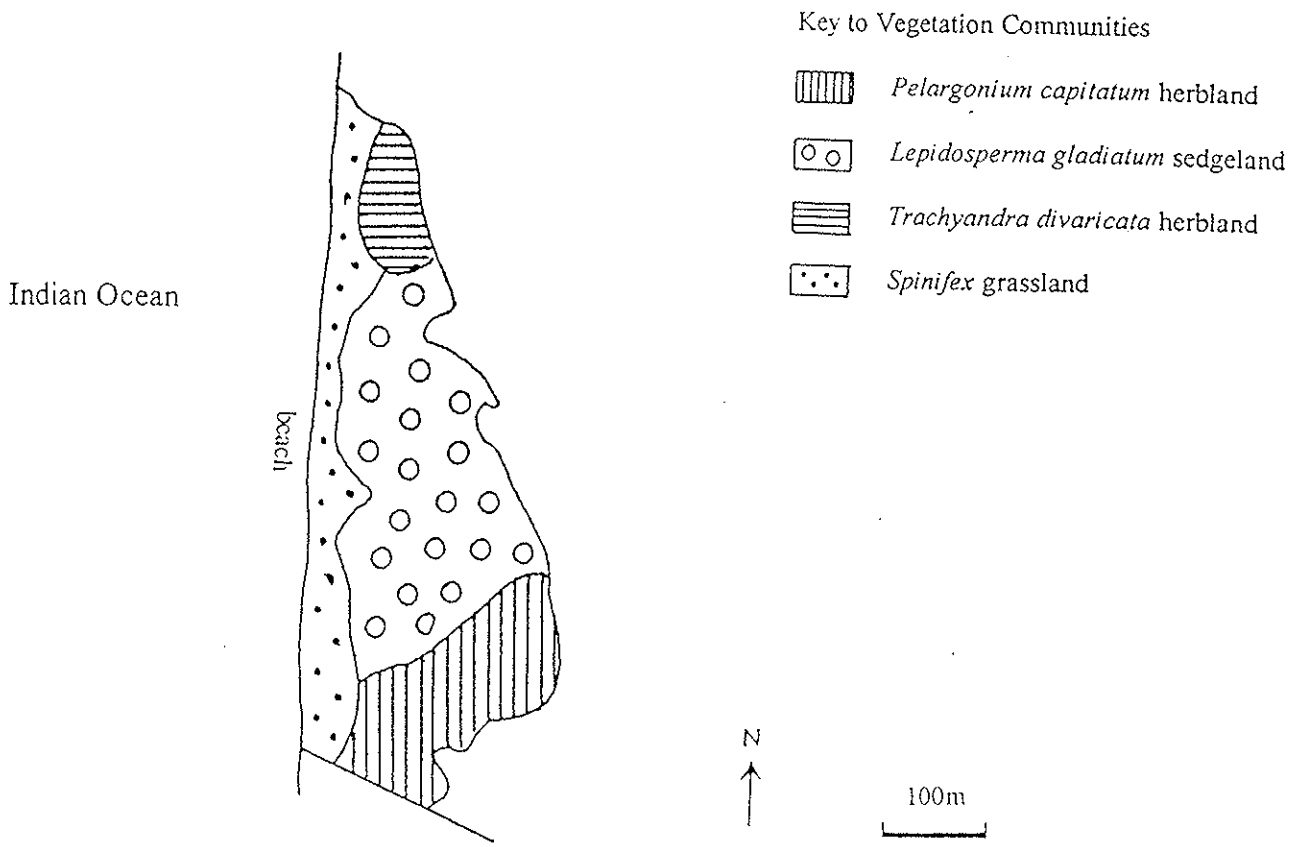
Communities identified are *Pelargonium capitatum* herbland, *P. capitatum* herbland/*Lepidosperma gladiatum* sedgeland (*L. gladiatum* sedgeland), *P. capitatum/Trachyandra divaricata* herbland (*T. divaricata* herbland) and *Spinifex* grassland/*Tetragonia decumbens* herbland (*Spinifex* grassland) (see Figure 6).

The *Spinifex* grassland community is found on the foredunes. The windward side of the dune is dominated to varying degrees by *Spinifex longifolius*, *S. hirsutus* and *Ammophila arenaria* (marram grass), while the top of the dune and the swale, by *T. decumbens*, *P. capitatum* and *Olearia axillaris*. *Cakile maritima* is unique to this community. The number of species recorded for the community is 11.

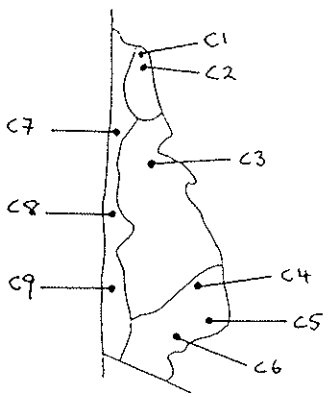
The *L. gladiatum* sedgeland and *T. divaricata* herbland are found in the parabolic dunes of the northern section. The number of species recorded for these communities is 20 and 14 respectively.

FIGURE 6

VEGETATION MAP OF CITY BEACH STUDY AREA



Quadrat Locations



C = quadrat number

These communities and the *Spinifex* grassland are very similar in terms of species present (apart from their respective dominants). Species commonly occurring in these communities which are not found in the *P. capitatum* herbland are *Tetragonia decumbens, Trachyandra divaricata* and *Isolepis nodosa*. They are relatively sparsely vegetated in comparison to the *P. capitatum* herbland and are also differentiated from the latter by their white soil: the *P. capitatum* herbland has some organic matter content reflected in its light brown subsoil. The *P. capitatum* herbland has a relatively high species richness (29 species) in comparison to the other three communities.

The *P. capitatum* herbland is found in the southern section of the study area which was burnt during the last fire. Species uniquely typical to this community are *Acanthocarpus preissii, Santalum acuminatum, Acacia lasiocarpa, Hemiandra pungens, Lomandra maritima, Hardenbergia comptoniana, Lepidosperma angustatum* and *Melaleuca acerosa*.

Overall Condition of the Study Area

The condition rating varies little across the whole study area: the *P. capitatum* herbland is rated 'good' to 'degraded' and the other communities are rated 'degraded'. This is a reflection of the density in which the weed species occur. *P. capitatum* is the most common weed in terms of presence and cover.

3. COMPARISON BETWEEN THE QUINNS ROCKS AND CITY BEACH STUDY AREAS

The TWINSPAN analysis revealed a distinct separation of most of the Quinns Rocks quadrats from the City Beach quadrats (see Figure 5), although City Beach quadrats C4, C5 and C6 are similar to the only 'completely degraded' Quinns Rocks quadrat (Q21).

A table of results for all quadrats is provided in Appendix 6, and a summary of these results is given in Table 1. The latter shows results of five variables recorded for each site: species richness; Shannon diversity indices; weed species present as a percentage of total species; weed cover as a percentage of total cover; and condition ratings.

T tests were performed on the first four of these variables (no test was performed on the condition ratings as this is a subjective assessment). All the tests showed a significant

difference between the variables at the two sites. The SPSS output is given in Appendix 8, and these are reported as follows:

Test 1

Test Variable: Number of species per quadrat

Test Result: The Quinns Rocks site has a significantly higher number of species per quadrat (M=28) than the City Beach site (M=19), t (40) = 3.44, p <.01.

Test 2

Test Variable: Shannon diversity index

Test Result: The Quinns Rocks site is significantly more diverse (M=3.17) than the City Beach site (M=2.73), t (40) = 3.58, p <.01.

Test 3

Test Variable: Weed species as a percentage of total species

Test Result: The City Beach site has significantly more weed species as a percentage of total species (M=49) than the Quinns Rocks site (M=30), t (40) = 3.44, p <.01.

Test 4a

Test Variable: Weed cover as a percentage of total cover (linear scale)

Test Result: The City Beach site has significantly greater weed cover as a percentage of total cover (M=54) than the Quinns Rocks site (M=27), t (40) = 4.77, p <.01.

Test 4b

Test Variable: Weed cover as a percentage of total cover (absolute scale)

Test Result: The City Beach site has significantly greater weed cover as a percentage of total cover (M=68) than the Quinns Rocks site (M=19), t (40) = 6.19, p <.01.

Although species richness and diversity is significantly higher at Quinns Rocks than City Beach, these tests do not give any indication of the condition of the sites as they do not differentiate between native and weed species. The other three tests however provide evidence that the Quinns Rocks site is in significantly better condition than the City Beach site. This is re-enforced by the condition ratings (3 at Quinns Rocks, and 5 at City Beach).

DISCUSSION

COMPARISON OF RESULTS WITH OTHER STUDIES

Griffin (1993) in his study of the Quindalup Dunes between the Swan and Irwin Rivers, identified five sectors, each distinguished by variation in flora and vegetation, although many areas blended into a continuum. The Quinns Rocks study area forms part of Griffin's sector V5 which extends from Lancelin to Perth. Significant variation also exists within this sector.

In his entire study Griffin found between 1 and 47 native, and up to 13 introduced species in 10 x 10m quadrats. This is comparable to figures in this study (for quadrats located on the Quindalup Dunes), of up to 32 native, and up to 14 introduced species. Similarly to this study, he found the most common families to be Poaceae, Asteraceae, Myrtaceae and Fabaceae, and introduced species represented most commonly by Poaceae, Asteraceae and Brassicaceae. Of the 23 most common species in Griffin's study, 18 were commonly found in this study.

Introduced species represented 25% of the total in this study compared to Griffin's 17% across the entire study area. However he located quadrats in least disturbed areas whereas this study used a random sampling technique which increased the chance of sampling disturbed areas. He states that in sector V5, introduced species form an important element of the vegetation composition.

The "Floristic Survey of the Swan Coastal Plain" by Gibson et al (1994) (which used virtually the same methods of recording data as this study), identified 43 vegetation types and subtypes. The Quindalup communities, "Coastal shrublands on shallow sands" and "*Acacia* shrublands on taller dunes" (Types 29a and 29b respectively) are considered most closely comparable to the *Olearia axillaris* heath of this study. The Spearwood community "*Melaleuca huegelii - M. acerosa* shrublands of limestone ridges" (Type 26a) is most closely comparable to this study's *Acacia truncata* and *Dryandra sessilis* heaths.

These communities of the Swan Coastal Plain study had a higher mean number of species per quadrat, a better condition rating and lower occurrence of weeds. The differences in species richness may be accounted for by the fact that all quadrats were visited at least

twice at different times of the year by Gibson et al. The difference in condition rating and weed occurrence may be due to a non-random process of quadrat site selection.

The other five community types in this study could not be readily compared to any of the Swan Coastal Plain study. This does not imply that there are five communities in the study area that are not found anywhere else: it is more a reflection on the larger, less detailed nature of the Swan Coastal Plain study. However, one of the five communities, *Melaleuca cardiophylla* heath is apparently rare (Keighery & Keighery, 1992).

Although both the studies mentioned above and this study, used a numerical classification technique to help define community types, a direct comparison of the studies is difficult without combining the data and re-running the classification program.

OBJECTIVE 1:

An assessment of the ecological value of the study site within a regional perspective

The criteria used to assess the ecological value of vegetation community types (as previously stated) are:

- Presence at the site;
- Extent at the site;
- Overall distribution;
- Where in the overall distribution they occur;
- How previous development has effected them; and
- How well reserved they are in secure conservation reserves.

The vegetation simply by its occurrence at the site has an intrinsic value. From a human value perspective it also offers opportunity for conserving bio diversity, for research, education, enjoyment and as a genetic resource from which we may at sometime in the future be able to draw from for our own economic benefit or welfare.

The predominant vegetation types of the site include the Quindalup *Scaevola crassifolia* and *Olearia axillaris* heaths, and the Spearwood *Acacia truncata* and *Dryandra sessilis* heaths (see Figure 4). Although non of these communities are restricted to the site and they do occur at other localities along the Quindalup and Spearwood systems (Gibson et

al, 1994), their distribution has declined through clearing for urban development and agriculture. The trend of urban expansion is set to continue particularly in this North West Corridor (DPUD, 1992).

The Quindalup communities are well reserved between Greenough and Lancelin, however between Lancelin and Perth (a sector which shows distinct regional variation to those north of it), there are "significant deficiencies" in the conservation estate (Griffin, 1993, p.65). Trudgen & Keighery (1990) also refer to the regional variation of these community types between Lancelin and Mandurah. At these extremities they are moderately well reserved but there is no reservation of the variation in the middle of their distribution.

Other sources reveal that of the original Quindalup communities present at European Settlement in the Metropolitan area (between Mandurah and Yanchep), only 48% remains: of this only 3% are represented in reserves (S. Connell, pers. comm.).

The Spearwood communities, on a regional basis, are more extensive than those of the Quindalup system, and are better represented in reserves including Neerabup and Yanchep National Parks (see Figure 2 - inset) in the Metropolitan area. However these coastal communities, similarly to those identified at Ningana, represent the most westerly part of this variable system which is poorly represented in reserves (Trudgen & Keighery, 1990).

Gibson et al (1994, p.60) describe their Quindalup community types 29a and 29b (refer to Results) as "poorly reserved" (i.e. known from only one National Park or Nature Reserve) and "susceptible", and their Spearwood community type 26a as "unreserved" and "susceptible". Susceptible is defined as "A community of concern because there is evidence that it can be modified or destroyed by human activities, or would be vulnerable to new threatening processes." An obvious threatening process in this area is urban expansion.

A small community of particular concern in the study area, is the rare *Melaleuca cardiophylla* heath. This heath lies on the reserve boundary (see Figure 4) and will be extremely vulnerable to modification or destruction once adjacent development proceeds.

Similar criteria could be applied to assess the value of the landforms and flora of the area to which similar discussion as above would apply. The landforms are in a relatively undisturbed state and are not adequately reserved in the centre of their range.

There are 11 significant and unusual taxa whose value lies in their uniqueness, or because they are not well studied or reserved, or because they represent variation near the end of their range. Other taxa may be common across a wide range of community types, but there are also those that are common only within the Quindalup system. These include *Lomandra maritima* and *Pimelea ferruginea*. If these "common species are not adequately protected they will also become rare" (Trudgen & Keighery, 1990, p.34).

It is concluded therefore that the study site has a very high ecological value in a regional framework. As long as the opportunity for reservation of bushland continues to decrease with further urban expansion, so the ecological value of areas such as the study site will continue to rise.

OBJECTIVE 2:

An assessment of what changes may potentially occur to the vegetation once adjacent development proceeds

The vegetation of the Quinns Rocks site appears to be in good condition in comparison to the City Beach site: it has a lower level of weed invasion and a higher condition rating.

The current condition of the Quinns Rocks site can be at least partly attributed to the surrounding bushland which forms a continuum of relatively undisturbed vegetation. However future development of the adjacent land on the eastern (and by far the longest) boundary would result in the study area becoming fragmented and isolated from other areas of bush. This coastal 'remnant' will then be influenced by the changed conditions: factors in the surrounding landscape predominantly drive the dynamics of a remnant (Saunders et al, 1991).

As an example, fragmentation and isolation results in a reduced capacity for regeneration after disturbance. Following fire, species which are killed by fire, such as *Olearia axillaris* (Rippey & Rowland, 1995) (an important species at Quinns Rocks), rely on seed sources outside the area for regeneration. The future isolation of the Quinns Rocks site therefore means it will be susceptible to a reduction in diversity of native species if outside recruitment is reduced.

Other consequences of fragmentation include changes to physical processes, particularly around the edge of the remnant. These processes include levels of solar radiation, wind, water and nutrients, changes to which can have profound influences on the biota (Saunders et al, 1991). The long narrow shape of the future remnant at Quinns Rocks means that the edge to area ratio will be high, and so the extent of changes to these processes will also be relatively high.

The vegetation of the area is adapted to the existing set of physical processes. The future disturbed regime around the edge will provide an opportunity for invasion by introduced plants. The rare *Melaleuca cardiophylla* heath, located on the reserve boundary at Quinns Rocks, will be unavoidably subject to edge disturbance and its consequences, when the development proceeds.

The phenomenon of introduced species invading and often replacing native species in disturbed areas is well documented: "Without human disturbance of habitats in which they thrive [introduced] plants would be rare" (Fox & Adamson, 1986, p.249). The high level of weed cover (68%) at the City Beach site attests to this: much of its edge has been cleared of vegetation and it has a large edge to area ratio due to the five beach access tracks which traverse it.

Disturbance in the form of fire, is a natural part of the dune ecology. The native species have evolved with fire and are generally equipped with the ability to regenerate after fire (Rippey & Rowland, 1995). However since European settlement disturbances have increased with changed fire regimes, clearing of native vegetation and grazing by domestic stock and rabbits. Such disturbances leave the native vegetation more vulnerable to invasion by weed species. One of the reasons for this is that few native coastal plants are annuals whereas 60% of weed species are annuals. This life form has the advantage of being able to reproduce very quickly compared to native species (Rippey & Rowland, 1995).

There is already evidence of substantial disturbance at Quinns Rocks with the 4WD track (the edge of which is infested with Capeweed), areas of rabbit activity, and its known fire and grazing history. The most prolific weed, which is widespread at both sites, is *Pelargonium capitatum*. In disturbed areas, this native of South Africa often forms almost pure stands (Rippey & Rowland, 1995). Although it occurs only locally at the Quinns Rocks study site as dense cover, its widespread presence, along with the six previously

described annual weed species (refer to Results), provides a potential for increased infestation following further disturbance.

Other weed species that are localised at Quinns Rocks, *Romulea rosea*, *Lupinus cosentinii* and *Trifolium* sp., are listed by Keighery (undated) as significant environmental weeds of Western Australia. *R. rosea* is widespread and replaces native geophytes. *L. cosentinii* is able to invade coastal heathland, changes soil characteristics and replaces native shrubs. *Trifolium* species are widespread although their effects are little known. Again these species have the potential to spread with further disturbance.

Although the mean percentage cover of weeds for the Quinns Rocks site (19%) is not insignificant, there are areas of very low weed invasion: the *Acacia truncata* heath (with a mean of 5% weed cover), the *Frankenia pauciflora* shrubland (3%), and the *Melaleuca cardiophylla* heath (2%), are worthy of note in this respect. Unlike any of the City Beach community types, substantial areas of the Quinns Rocks site have retained a high degree of integrity. In order to maintain this once adjacent development proceeds, careful management will be required.

OBJECTIVE 3:

The conclusions reached from Objectives 1 and 2 are applied to determine the appropriateness of the proposed Hames Sharley recommendations for the Quinns Rocks study area

The Hames Sharley recommended plan for the study area is shown in Figure 2.

Their report recognises that the area has value from a conservation perspective: "... the vegetation is generally in good condition, despite numerous tracks and peripheral disturbance, and is intact in structure with few weeds" (p.15). They also acknowledge that "*Olearia axillaris* heath on Quindalup Dunes ... is poorly represented in reserves" (p.16). This study found substantial areas of this vegetation community.

Despite these statements their plan leaves little opportunity for conservation. The small pockets that are free of carparks and picnic facilities, such as the 150m wide by 600m long strip in the south of this study area, are traversed E-W by access tracks from the road to the beach, and N-S by a dual use path. It seems unlikely, considering previous discussion

on disturbance and shape of reserves, that these areas will maintain their viability in respect of vegetation, in the long term without intensive management. It is already evident that substantial weed invasion has occurred in the disturbed areas along the 4WD track and near the WAWA bore (see the *Pelargonium capitatum* herbland, Figure 4).

In the whole of their study (which extends from Jindalee, just north of this study area, to Burns Beach in the south), the only substantial section of the coastal reserve set aside for conservation, that is wider than 200m is an area of blow-outs in the dunes south of Mindarie Keys. (Even this is not secured for conservation as part of the area is subject to a development proposal (Halpern et al, 1995)). No consideration has been given to reserving relatively stable dunes, such as those found by this study, large enough to potentially maintain viability with minimal management in the long term.

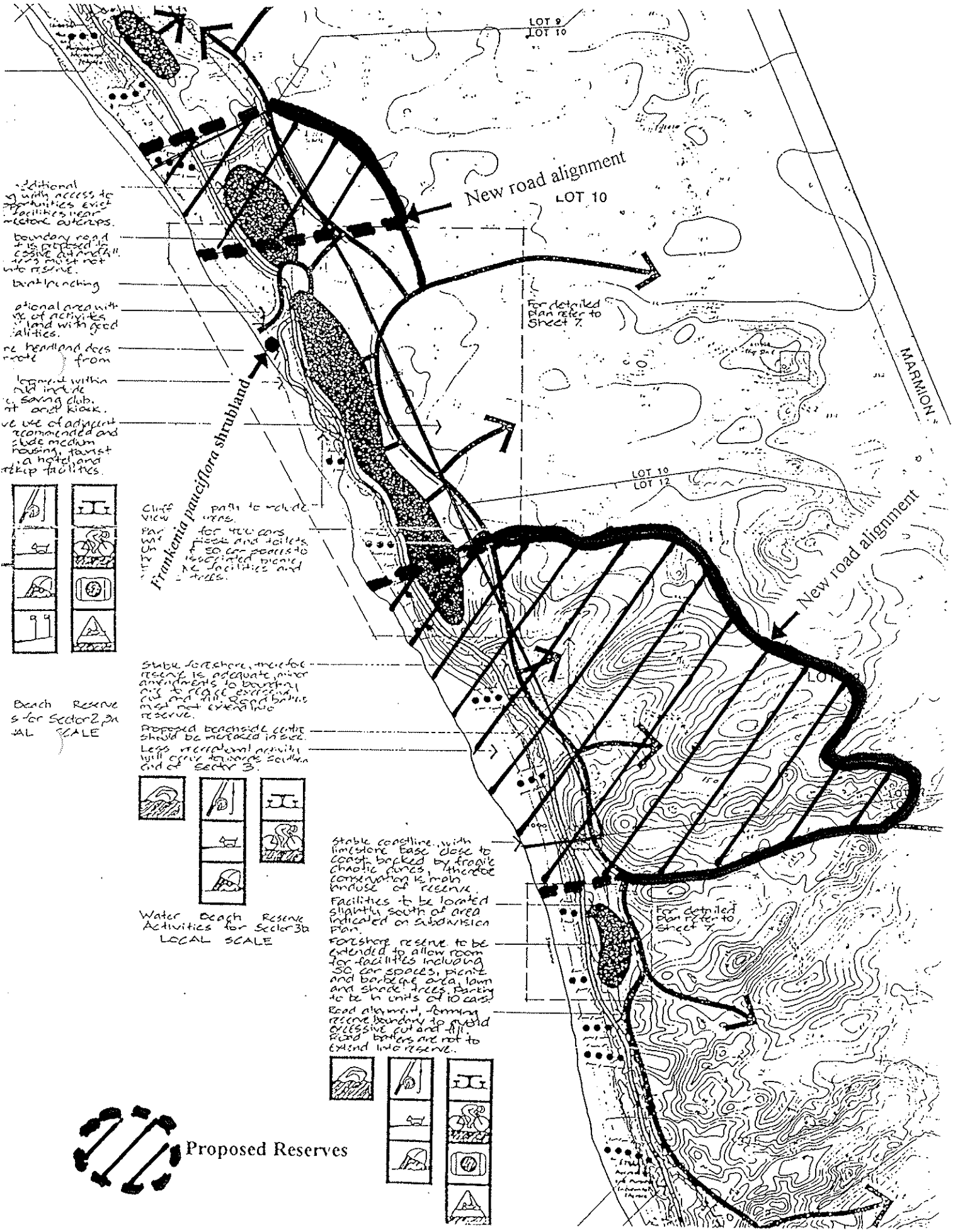
The report also recommends that public facilities should be built on the stable limestone. While this may be a sound policy from an engineering perspective, there is the danger that if the policy is constantly followed, the vegetation and landforms associated with limestone will eventually be lost for conservation.

Figure 7 is the author's idealised revision of the Hames Sharley plan. The new plan proposes two conservation zones: a relatively large one in the south and a smaller one in the north. It also proposes to protect the cliff top *Frankenia pauciflora* shrubland. *F. pauciflora* also occurs on coastal limestone cliffs south of Burns Beach. The EPA (in Hames Sharley, 1992), state that this area has special conservation value with some unusual species, one being *Frankenia pauciflora*. The Hames Sharley plan has placed a path along the cliff close to this community in the study area: the alignment of the path should be reviewed to ensure the shrubland has full protection from public access.

The proposed reserve in the southern section is more in keeping with the Wanneroo Shire Council proposal for a continual coastal strip of at least 400m wide (Hames Sharley, 1992). It incorporates good examples of parabolic dunes, limestone heath, the only area located in the study of rare *Melaleuca cardiophylla* heath, and *Olearia axillaris* heath rated 'very good' to 'excellent' which shows the variation between the heath dominated by *Lomandra maritima* and by *Spyridium globulosum*. It also incorporates some areas in relatively poor condition with *Pelargonium capitatum* infestation. This could provide an opportunity for a rehabilitation study/project for a community environmental group or educational institution. Although the area has not been extensively surveyed, most of it

FIGURE 7

PROPOSED AMENDMENTS TO HAMES SHARLEY PLAN



appears to be little disturbed and therefore potentially a suitable area for conservation. As previously discussed, both Spearwood and Quindalup vegetation and associated landforms are currently poorly represented in reserves.

It is proposed to retain the dual use path that follows the existing 4WD track behind the primary dune as proposed in the Hames Sharley plan. This would act as a fire break in the event of a fire to the east of it , thereby protecting the primary dune vegetation which if burnt would leave the dune susceptible to blow outs. However there should be no access tracks to the beach so that the integrity of the dune is maintained. It is felt there are sufficient access tracks along the rest of the dune. The plan for a beach side centre recommended by Hames Sharley would also be abandoned.

The eastern boundary is demarcated by the road which has been arbitrarily placed to follow the contours: it is proposed to align it as low in the profile as possible. This endorses the Hames Sharley strategy of placing road cuttings so that landforms are not degraded.

The proposed reserve in the northern section incorporates a large rock outcrop with an exposed cliff to the west. The limestone heath of this area is in 'excellent' to 'pristine' condition. The eastern boundary would again be demarcated by the road which has been re-aligned to follow an existing 4WD track. The dual use path proposed by Hames Sharley would be retained as it follows the current 4WD track passing below the cliff and not through the heath.

Both these reserves should be fenced to restrict access and to maintain their relatively undisturbed state, and some form of rabbit control should be implemented. Baiting with 1080 poison is suggested as an effective measure which has little impact on native mammals (Siewart et al., 1994).

The more compact shape of these reserves with a smaller edge to area ratio, inherently provides better protection against weed invasion from outside than linear reserves, as previously discussed. Their management would involve regular monitoring and control of weeds. Again this could be undertaken by environmental groups or educational institutions.

The idealised plan is an attempt to provide a constructive alternative to fulfil the objectives of this project. Realistically however the planning process is too far advanced to be able to gain any secure and long term viable reserves for conservation in such a small area.

CONCLUSION

The area has high ecological value with representation of a variety of vegetation communities in good condition. However it certainly has a potential to become degraded by increased weed invasion as has occurred at City Beach.

The Hames Sharley plan has been devised in the context of the adjacent area being zoned as suitable for urban development, and the need to plan for management of the coastline with the associated increase in human use. The deficiency of conservation zones in the study area, and in the Metropolitan area as a whole however, raises questions concerning the adequacy of the planning process in identifying and securely conserving areas of high ecological value ahead of the drive for development.

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APPENDIX 1

DATA RECORDING SHEETS

BUSHLAND PLANT SURVEY RECORDING SHEET 1- use pencil only

BUSHLAND AREA _____ SITE NUMBER _____

DATE TRIP _____ RECORDERS _____

DATE TRIP _____ RECORDERS _____

DATE TRIP _____ RECORDERS _____

BOTANIST _____

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

1. LOCATION of the QUADRAT

Mud Map Draw a sketch of the location of the site below.

N

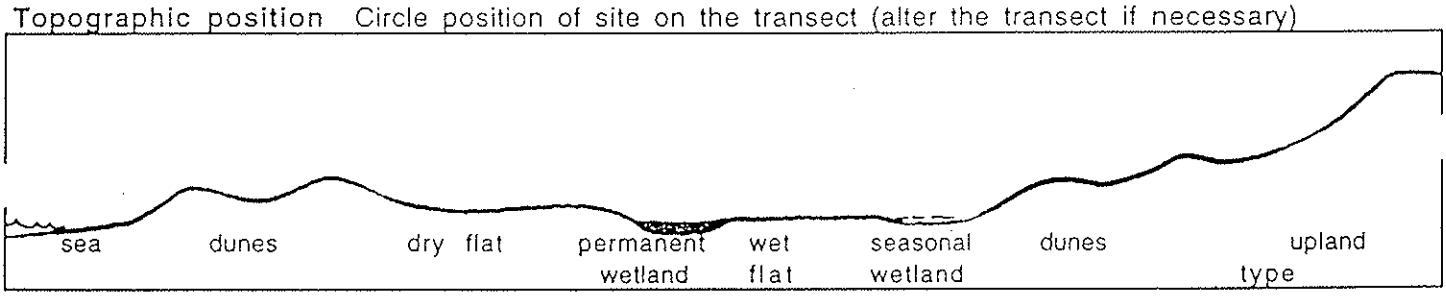
Road Location

Geographic Location Latitude S Longitude E Altitude

Reference Map

Photograph Photographer's Name Photo No

Topographic position Circle position of site on the transect (alter the transect if necessary)



2. SITE DATA Circle the correct response.

Slope flat gentle steep *Aspect* N NE E SE S SW W NW

Surface Soil *Colour*

Exposed rock *type* % surface

Sub-surface Soil *Colour*

Rock *type* depth to rock

Drainage well mod poor depth water cm *Wet* all year winter/spring

Litter	% cover	*Bare Ground*	%cover
Depth	cm		

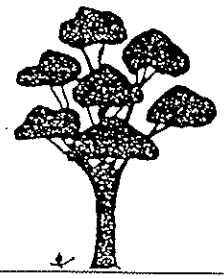
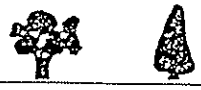
BUSHLAND PLANT SURVEY RECORDING SHEET 2 - use pencil only

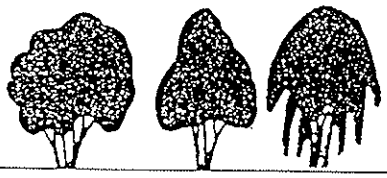
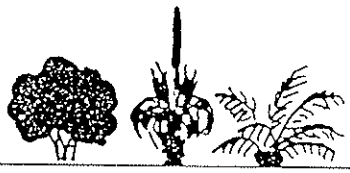
3. VEGETATION STRUCTURE AND COVER

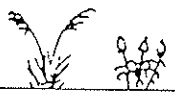
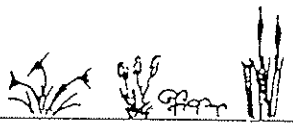
From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

For each layer record - appropriate life form, cover class (see below).and dominant species in each layer.

Cover Class 2-10% 10-30% 30 - 70% over 70%

	TREES			MALLEES	
	over 30m	10 - 30m	under 10m	over 8m	under 8m
LIFE FORM					 30m 10m
COVER CLASS (%)					
DOMINANT SPECIES					

	SHRUBS		SHRUBS
	over 2m	2m - 1m	under 1m
LIFE FORM			 2 m 1 m
COVER CLASS (%)			
DOMINANT SPECIES			

	GRASSES	HERBS	SEDGES	OTHER
LIFE FORM				1m
COVER CLASS (%)				
DOMINANT SPECIES				

4. VEGETATION CONDITION

1 'PRISTINE'		COMMENTS
2 EXCELLENT		
3 VERY GOOD		
4 GOOD		
5 DEGRADED		

BUSHLAND PLANT SURVEY RECORDING SHEET 3 - use pencil only

5. SPECIES PRESCENCE

SITE No

Date

Label each plant with plants number, site code, date and plant's name or working name if required

Record on Sheet

- Column 1 plant name
- Column 2 plant number
- Column 3 cover class (see below)
- Column 4 flowering time- TICK if species flowering
- Column 5 identification check

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

TREES	No.	c.c.	Fl	ID
MALLEES				
SHRUBS				
HERBS				

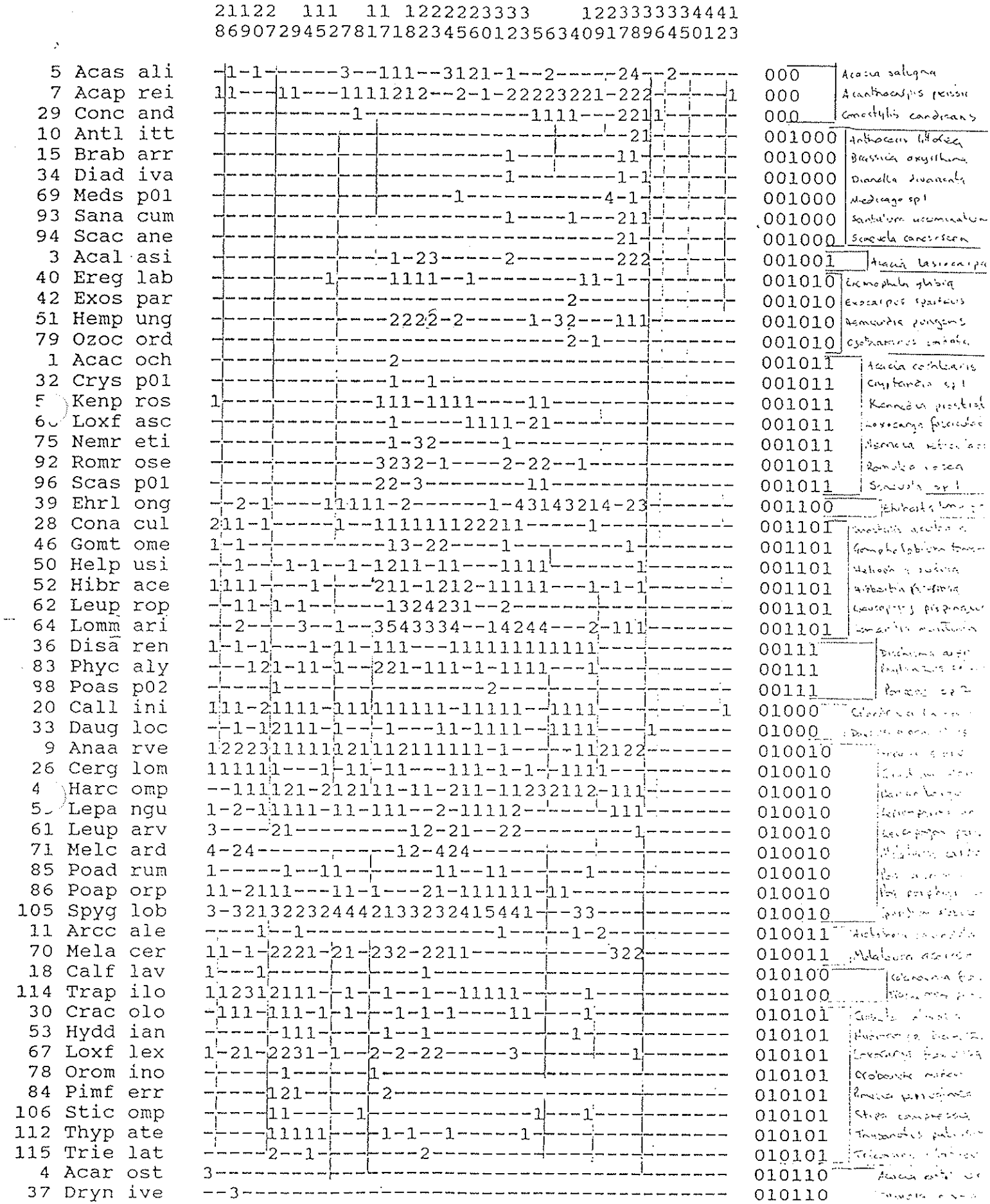
SHRUBS (cont.)	No.	c.c.	Fl	ID
GRASSES				

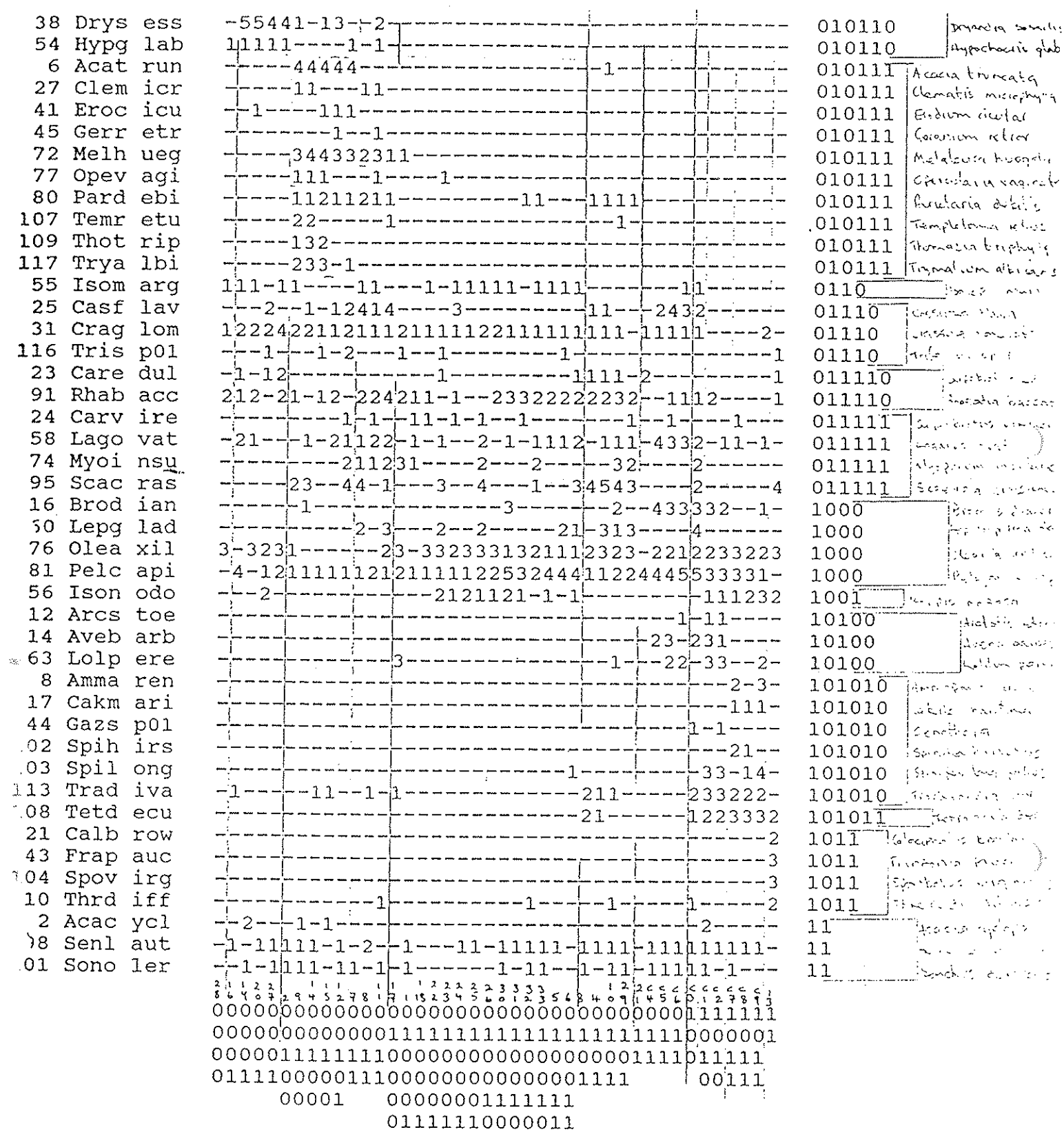
HERBS (cont.)	No.	c.c.	Fl	ID
SEDGES				

Cover Class 1 = <2%, 2 = 2-10%, 3 = 10-30%, 4 = 30-70%, 5 = >70%

APPENDIX 2

TWINSPAN OUTPUT




38 Drys ess
54 Hypg lab
6 Acat run
27 Clem icr
41 Eroc icu
45 Gerr etr
72 Melh ueg
77 Opev agi
80 Pard ebi
107 Temr etu
109 Thot rip
117 Trya lbi
55 Isom arg
25 Casf lav
31 Crag lom
116 Tris p01
23 Care dul
91 Rhab acc
24 Carv ire
58 Lago vat
74 Myoi nsu
95 Scac ras
16 Brod ian
50 Lepg lad
76 Olea xil
81 Pelc api
56 Ison odo
12 Arcs toe
14 Aveb arb
63 Lolp ere
8 Amma ren
17 Cakm ari
44 Gazs p01
02 Spih irs
03 Spil ong
113 Trad iva
08 Tetd ecu
21 Calb row
43 Frap auc
04 Spov irg
10 Thrd iff
2 Acac ycl
98 Senl aut
01 Sono ler
010110
010110
010111
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010111
010111
0110
01110
01110
011110
011110
011111
011111
011111
1000
1000
1000
1000
1001
10100
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10100
101010
101010
101010
101010
101010
101010
101011
1011
1011
1011
11
11
11

APPENDIX 3

STRUCTURAL CLASSIFICATION OF VEGETATION

Table 3: Structural Classification
Adapted from Muir (1977) and Aplin (1979).

Life form/Height Class	Canopy Cover (percenatge)			
	100 - 70	70 - 30	30 - 10	10 - 2
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10 - 30m	Closed Forest	Open Forest	Woodland	Open Woodland
Trees under 10m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub
Mallee				
Shrubs over 2m	Closed Tall Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland
Shrubs 1 - 2m	Closed Heath	Open Heath	Shrubland	Open Shrubland
Shrubs under1 m	Closed Low Heath	Open Low Heath	Low Shrubland	Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

Other layers may be present yet not listed on this table, such as Hummock Grassland, Vines etc. Add these layers as necessary following the same format as in Grasses, Herbs etc.

APPENDIX 4
SPECIES LIST FOR QUINNS ROCKS SITE

Key to Vegetation Communities:

1 = Melaleuca cardiophylla heath
2 = Dryandra sessilis heath
3 = Acacia truncata heath
4 = Spyridium globulosum/Melaleuca huegelii heath
5 = Olearia axillaris heath
6 = Scaeola crassifolia heath
7 = Pelargonium capitatum herbland
8 = Frankenia pauciflora shrubland

* Introduced species
\# Opportunistically sampled

	FAMILY / Species	VEGETATION COMMUNITY 1	2	3	4	5	6	7	8
	AIZOACEAE								
*	Carpobrotus edulis		+			+	+	+	+
	Carpobrotus virescens			+	+	+	+		
*	Tetragonia decumbens						+		+
	ANTHERICACEAE								
	Thysanotus patersonii			+		+			
	Tricoryne elatior			+		+			
	APIACEAE								
	Daucus glochidiatus		+	+	+	+	+		
	Hydrocotyle diantha			+		+	+		
	Trachymene pilosa	+	+	+	+	+	+		
	ASPHODELACEAE								
*	Asphodelus fistulosus			+					
*	Trachyandra divaricata		+	+	+	+	+		
	ASTERACEAE								
*	Arctotheca calendula		+	+		+	+	+	
	Calocephalus brownii								+
*	Hypochaeris glabra	+	+	+	+				
	Olearia axillaris	+	+	+	+	+	+		+
	Ozothamnus cordatus						+		
	Sencio lautus		+	+	+	+	+		
*	Sonchus asper							+	
*	Sonchus oleraceus		+	+	+	+	+		
	BRASSICACEAE								
*	Brassica oxyrrhina					+			
# *	Cakile maritima								
*	Heliophila pusilla		+	+	+	+			
	CARYOPHYLLACEAE								
*	Cerastium glomeratum	+	+	+	+	+	+	+	
*	Silene gallica			+					

		1	2	3	4	5	6	7	8
	CHENOPODIACEAE								
#	Halosarcia indica subsp bidens								
	Rhagodia baccata	+	+	+	+	+	+		+
	Threlkeldia diffusa				+	+	+		+
	CRASSULACEAE								
	Crassula colorata		+	+	+	+	+		
*	Crassula glomerata	+	+	+	+	+	+	+	
	CYPERACEAE								
	Isolepis marginata	+	+	+	+	+			
	Isolepis nodosa		+			+			+
	Lepidosperma angustatum	+	+	+	+	+			
	Lepidosperma gladiatum				+	+	+		
	DASYPOGONACEAE								
	Acanthocarpus preissii	+	+	+	+	+	+		+
	Lomandra maritima		+	+	+	+	+		
	Lomandra sp 1		+						
	DILLENIACEAE								
	Hibbertia racemosa	+	+	+		+	+		
	EPACRIDACEAE								
#	Acrotriche cordata								
	Leucopogon parviflorus	+		+		+			
	Leucopogon propinquus		+	+		+			
	EUPHORBIACEAE								
	Phyllanthus calycinus		+	+	+	+	+		
	FABACEAE								
	Gompholobium tomentosum	+	+			+			
	Hardenbergia comptoniana		+	+	+	+	+		
#	Jacksonia stricta								
	Kennedia prostrata					+			
*	Lupinus cosentinii							+	
*	Medicago sp 1					+		+	
	Nemcia reticulata					+			
	Templetonia retusa			+	+		+		
*	Trifolium sp 1		+	+		+			+
	FRANKENIACEAE								
	Frankenia pauciflora								+
	GERANIACEAE								
*	Erodium cicutarium		+	+					
	Geranium retrorsum			+	+				
*	Pelargonium capitatum		+	+	+	+	+	+	
	GOODENIACEAE								
#	Lechenaultia linarioides								
	Scaevola crassifolia			+	+	+	+		+
	Scaevola sp1					+			

	1	2	3	4	5	6	7	8
HAEMODORACEAE								
Conostylis aculeata	+	+		+	+	+		
Conostylis candicans				+	+	+		
IRIDACEAE								
* Romulea rosea					+	+		
LAMIACEAE								
Hemiandra pungens					+	+		
LAURACEAE								
Cassytha flava		+	+	+	+	+		
MIMOSACEAE								
Acacia cochlearis					+			
Acacia cyclops		+	+					
Acacia lasiocarpa					+			
Acacia rostellifera	+							
Acacia saligna		+		+	+			
Acacia truncata			+			+		
MYOPORACEAE								
Eremophila glabra			+		+	+		
Myoporum insulare			+	+	+	+		
MYRTACEAE								
Melaleuca acerosa	+	+	+	+	+			
Melaleuca cardiophylla	+	+			+			
Melaleuca huegelii			+	+	+			
OLACACEAE								
# Olax benthamiana								
ORCHIDACEAE								
Caladenia flava	+	+			+			
Caladenia latifolia					+			
Microtis unifolia				+				
Pterostylis sp 1			+					
OROBANCHACEAE								
* Orobanche minor			+		+			
PHORMIACEAE								
Dianella divaricata					+			
POACEAE								
* Bromus diandrus			+		+	+		
* Ehrharta longiflora		+	+	+	+	+	+	
* Lagarus ovatus		+	+	+	+	+		
* Lolium perenne					+	+		
Poa drummondiana	+		+	+	+	+		
Poa porphyroclados	+	+	+	+	+	+		
? Poaceae sp 1			+					
? Poaceae sp 2			+		+			
? Poaceae sp 3					+	+		
Spinifex longifolius					+			
Sporobolus virginicus								+
Stipa compressa			+	+	+	+		

	1	2	3	4	5	6	7	8
PORTULACACEAE								
Calandrinia liniflora	+	+	+	+	+	+		+
PRIMULACEAE								
* Anagallis arvensis var caerulea	+	+	+	+	+	+	+	
PROTEACEAE								
Dryandra nivea		+						
Dryandra sessilis		+	+	+				
Grevillea preissii subsp preissii		+						
Hakea lissocarpha		+						
RANUNCULACEAE								
Clematis microphylla			+	+				
RESTIONACEAE								
Loxocarya fasciculata					+			
Loxocarya flexuosa	+	+	+	+	+			
RHAMNACEAE								
Cryptandra sp 1					+			
Spyridium globulosum	+	+	+	+	+	+		
Trymalium albicans			+					
RUBIACEAE								
Opercularia vaginata			+	+	+			
SANTALACEAE								
Exocarpus sparteus						+		
# Leptomeria priessiana								
Santalum acuminatum					+	+		
SAPINDACEAE								
Diplopeltis huegellii var huegellii					+			
SCROPHULARIACEAE								
* Dischisma arenarium	+	+	+	+	+	+		
STERCULIACEAE								
Thomasia triphylla			+					
THYMELAEACEAE								
Pimelea ferruginea			+		+			
URTICACEAE								
Parietaria debilis			+	+	+	+		
VIOLACEAE								
# Hybanthus calycinus								

Total number of families = 44
Total number of genera = 90
Total number of species = 113

Native species = 83
Introduced species = 27
Unknown = 3

APPENDIX 5

VEGETATION CONDITION SCALE

Table 2: Vegetation Condition Scale

Modified from Trudgen 1991 by B. J. Keighery for the Swan Coastal Plain Survey 1993.

1 = 'Pristine'

Pristine or nearly so, no obvious signs disturbance.

2 = Excellent

Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species

For example damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.

3 = Very Good

Vegetation structure altered, obvious signs of disturbance.

For example disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

4 = Good

Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate to it.

For example disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

5 = Degraded

Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.

For example disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

6 = Completely Degraded

The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

APPENDIX 6
TABLE OF RESULTS FOR ALL QUADRATS AT QUINNS ROCKS AND CITY BEACH

VEGETATION COMMUNITY and QUADRAT NUMBER *
(Grouped according to the TWINSPAN analysis - see Figure 5)

	QR1	QR2				QR3					QR4			QR5														QR6				QR7	CB1			CB2	CB3		CB4			QR8	
	Q28	Q16	Q19	Q20	Q27	Q2	Q9	Q14	Q15	Q12	Q7	Q8	Q11	Q17	Q1	Q18	Q22	Q23	Q24	Q25	Q26	Q30	Q31	Q32	Q33	Q5	Q6	Q3	Q4	Q10	Q29	Q21	C4	C5	C6	C3	C1	C2	C7	C8	C9	Q13	
Number of species	25	21	33	24	25	39	38	33	28	26	30	33	22	30	41	30	28	33	26	34	25	26	22	42	27	28	26	21	27	31	30	10	27	30	30	20	15	13	13	9	13	13	
Mean number of species per vegetation community	25	26				33					28			30														27				10	29			20	14		11			13	
Shannon diversity index	3.07	2.86	3.37	3.05	3.07	3.56	3.51	3.35	3.20	3.12	3.25	3.40	2.91	3.30	3.60	3.27	3.23	3.38	3.14	3.41	3.08	3.10	2.92	3.62	3.14	3.20	3.11	2.90	3.15	3.31	3.29	2.17	3.17	3.27	3.25	2.85	2.63	2.45	2.38	2.10	2.45	2.45	
Mean Shannon diversity index per vegetation community	3.07	3.09				3.35					3.18			3.25														3.16				2.17	3.23			2.85	2.54		2.31			2.45	
Number of weed species	5	8	10	7	10	5	8	9	8	11	7	10	7	11	9	8	8	3	5	8	5	8	4	10	7	9	8	8	9	14	7	10	9	11	10	9	8	9	7	4	9	3	
Mean number of weed species per vegetation community	5	8.8				8.2					8			7.4														9.5				10	10			9	8.5		6.7			3	
Percentage weed species	20	38	30	29	40	13	21	27	29	42	23	30	32	37	22	27	29	9	19	24	20	31	18	24	28	32	31	38	33	45	23	100	33	37	33	45	53	69	58	44	69	23	
Mean percentage weed species per vegetation community	20	34				26					28			25														35				100	34			45	61		57			23	
Cover : Linear Scale **																																										
Total cover	38	31	53	39	40	55	57	49	39	40	46	45	36	49	55	48	48	52	44	55	39	36	34	57	43	42	41	36	42	45	43	23	48	54	47	36	32	25	21	16	26	26	
Weed species total cover	5	14	13	9	17	8	9	9	9	13	7	13	8	17	11	12	9	3	5	11	7	14	6	13	13	15	13	13	11	17	8	23	18	23	22	18	19	17	13	9	16	4	
Weed cover as % of total cover	13	45	25	23	43	11	16	18	23	33	15	29	22	35	20	25	19	6	11	20	18	39	18	23	30	36	32	36	26	38	19	100	40	43	47	50	59	68	62	56	62	15	
Mean weeds as % of total cover	13	34				20					22			24														30				100	43			50	64		60			15	
Cover : Absolute Scale **																																											
Total cover	278	151	289	199	241	226	311	294	232	197	246	159	230	311	191	344	354	259	299	274	196	201	246	176	243	198	242	237	263	247	246	173	263	360	315	215	329	266	171	119	225	225	
Weed species total cover	5	69	22	15	116	9	12	8	12	19	7	22	11	117	17	65	12	3	5	20	13	126	53	19	105	111	65	65	58	26	11	173	160	219	234	139	257	164	113	106	119	7	
Weed cover as % of total cover	2	46	8	8	48	4	4	3	5	10	3	14	5	38	9	19	3	1	2	7	7	63	22	11	43	56	27	27	22	11	5	100	61	61	74	65	78	62	66	89	53	3	
Mean weeds as % of total cover	2	27				5					7			22														16				100	65			65	70		69			3	
Vegetation condition rating ***	2	4/5	2/3	2/3	4/5	2	1/2	2	3/4	2/3	2/3	3	2/3	3/4	2	3	2	2	2/3	2/3	2/3	5/6	3/4	2/3	4/5	4/5	4	3	2/3	3/4	3/4	6	4	4	5	5	5	5	5	5	5	6	2/3	
Mean condition rating for vegetation community	2	3/4				2/3					2/3			3														3				6	4/5			5	5		5			2/3	
Surface soil colour ****	LB	YB	B	B	B	DB	DB	DB	DB	B	B	DB	B	B	W	LB	B	B	LB	W	LB	G	LB	LG	LG	W	WB	W	W	LB	LG	B	W	W	LG	W	W	W	W	W	W	DB	
Subsurface soil colour ****	LB	YB	B	B	9	DB	DB	rock	DB	rock	Y	DB	B	B	W	W	?	LB	?	LB	LB	LG	LB	LG	LG	W	WB	LB	LB	DB	LG	YB	LB	LB	LB	W	W	W	W	W	W	DB	
Percentage exposed limestone						45	30	30	15	40																																	

* KEY TO

QUINNS ROCKS VEGETATION COMMUNITIES
QR1 = Melaleuca cardiophylla heath
QR2 = Dryandra sessilis heath
QR3 = Acacia truncata heath
QR4 = Spyridium globulosum/Melaleuca huegelii heath
QR5 = Olearia axillaris heath
QR6 = Scaevola crassifolia heath
QR7 = Pelargonium capitatum herbland
QR8 = Frankenia pauciflora shrubland

CITY BEACH VEGETATION COMMUNITIES
CB1 = Pelargonium capitatum herbland
CB2 = Lepidosperma gladiatum sedgeland
CB3 = Trachyandra divaricata herbland
CB4 = Spinifex grassland

QUADRAT NUMBERS
Q prefix = Quinns Rocks quadrats
C prefix = City Beach quadrats

** COVER SCALES

LINEAR		ABSOLUTE
1	=	1%
2	=	5%
3	=	20%
4	=	50%
5	=	70%

*** KEY TO VEGETATION CONDITION RATING
1 = Pristine
2 = Excellent
3 = Very Good
4 = Good
5 = Degraded
6 = Completely Degraded

**** KEY TO SOIL COLOUR
W = white
G = grey
LG = light grey
B = brown
LB = light brown
DB = dark brown
YB = yellow brown
WB = white brown

APPENDIX 7
SPECIES LIST FOR CITY BEACH SITE

Key to Vegetation Communities:

1 = Pelargonium capitatum herbland
2 = Lepidosperma gladiatum sedgeland
3 = Trachyandra divaricata herbland
4 = Spinifex grassland

* Introduced species
\# Opportunistically sampled

	FAMILY / Species	VEGETATION COMMUNITY 1	2	3	4
	AIZOACEAE				
	Carpobrotus virescens	+			+
*	Tetragonia decumbens		+	+	+
	ANTHERICACEAE				
	Thysanotus arenarius	+			
	APIACEAE				
	Daucus glochidiatus		+		
	ASPHODELACEAE				
*	Trachyandra divaricata		+	+	+
	ASTERACEAE				
*	Arctotis stoechadifolia	+		+	
	Olearia axillaris	+	+	+	+
	Sencio lautus	+	+	+	+
*	Sonchus oleraceus	+	+	+	+
	BRASSICACEAE				
*	Brassica oxyrrhina	+			
# *	Cakile maritima				+
*	Heliophila pusilla	+			
	CARYOPHYLLACEAE				
*	Petrorhagia velutina	+			
	CASUARINACEAE				
#	Casuarina sp 1				
	CHENOPODIACEAE				
	Rhagodia baccata	+	+	+	
	Threlkeldia diffusa		+		
	CRASSULACEAE				
*	Crassula glomerata	+	+		+

		1	2	3	4
	CYPERACEAE				
	Isolepis marginata	+	+		
	Isolepis nodosa			+	+
	Lepidosperma angustatum	+			
	Lepidosperma gladiatum		+		
	Schoenus grandiflorus	+			
	DASYPOGONACEAE				
	Acanthocarpus preissii	+			
	Lomandra maritima	+			
	DILLENIACEAE				
	Hibbertia racemosa	+			
	EPACRIDACEAE				
	Leucopogon parviflorus	+			
	EUPHORBIACEAE				
# *	Euphorbia paralias				
	FABACEAE				
	Gompholobium tomentosum	+			
	Hardenbergia comptoniana	+			
*	Medicago sp 1	+			
	GERANIACEAE				
*	Pelargonium capitatum	+	+	+	+
	GOODENIACEAE				
	Scaevola canescens	+			
	Scaevola crassifolia		+		
	HAEMODORACEAE				
	Conostylis candicans	+	+		
	LAMIACEAE				
	Hemiandra pungens	+			
	LAURACEAE				
	Cassytha flava	+	+		
	MIMOSACEAE				
	Acacia cyclops			+	
	Acacia lasiocarpa	+			
	Acacia saligna	+		+	
	MYOPORACEAE				
	Eremophila glabra	+			
	Myoporum insulare		+		
	MYRTACEAE				
	Calothamnus quadrifidus	+			
# *	Leptospermum laevigatum				
	Melaleuca acerosa	+			

	1	2	3	4
ONAGRACEAE				
* Oenothera sp 1		+	+	
PHORMIACEAE				
Dianella divaricata	+			
POACEAE				
* Ammophila arenaria				+
* Avena barbata	+	+	+	
* Bromus diandrus	+	+	+	+
* Ehrharta longiflora	+			
* Lagarus ovatus	+	+	+	+
* Lolium perenne	+		+	+
Spinifex hirsutus				+
Spinifex longifolius			+	+
PRIMULACEAE				
* Anagallis arvensis var caerulea	+			
RESTIONACEAE				
Loxocarya flexuosa	+			
SANTALACEAE				
Santalum acuminatum	+			
SOLANACEAE				
Anthoceris littorea	+			

Total number of families = 31
Total number of genera = 52
Total number of species = 58

Native species = 37
Introduced species = 21

APPENDIX 8

SPSS *T* TESTS OUTPUT

26 Oct 95 SPSS for MS WINDOWS Release 6.0

t-tests for independent samples of SITE

Variable	Number of Cases	Mean	SD	SE of Mean
SPECIES				
SITE 1	33	28.0909	6.907	1.202
SITE 2	9	18.7778	8.243	2.748

Mean Difference = 9.3131

Levene's Test for Equality of Variances: F= 1.490 P= .229

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	99% CI for Diff
Equal	3.44	40	.001	2.705	(1.995, 16.631)
Unequal	3.11	11.25	.010	2.999	(-.004, 18.630)

26 Oct 95 SPSS for MS WINDOWS Release 6.0

t-tests for independent samples of SITE

Variable	Number of Cases	Mean	SD	SE of Mean
DIVINDEX				
SITE 1	33	3.1660	.297	.052
SITE 2	9	2.7264	.426	.142

Mean Difference = .4396

Levene's Test for Equality of Variances: F= 3.980 P= .053

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	99% CI for Diff
Equal	3.58	40	.001	.123	(.107, .772)
Unequal	2.91	10.21	.015	.151	(-.039, .919)

26 Oct 95 SPSS for MS WINDOWS Release 6.0

t-tests for independent samples of SITE

Variable	Number of Cases	Mean	SD	SE of Mean
PCWEEDS				
SITE 1	33	29.8485	14.959	2.604
SITE 2	9	49.0000	14.116	4.705

Mean Difference = -19.1515

Levene's Test for Equality of Variances: F= .578 P= .452

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	99% CI for Diff
Equal	-3.44	40	.001	5.563	(-34.200, -4.103)
Unequal	-3.56	13.34	.003	5.378	(-35.354, -2.949)

26 Oct 95 SPSS for MS WINDOWS Release 6.0

t-tests for independent samples of SITE

Variable	Number of Cases	Mean	SD	SE of Mean
COVERLIN				
SITE 1	33	26.7273	16.375	2.851
SITE 2	9	54.1111	9.584	3.195

Mean Difference = -27.3838

Levene's Test for Equality of Variances: F= .360 P= .552

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	99% CI for Diff
Equal	-4.77	40	.000	5.739	(-42.907, -11.861)
Unequal	-6.40	22.28	.000	4.282	(-39.455, -15.313)

26 Oct 95 SPSS for MS WINDOWS Release 6.0

t-tests for independent samples of SITE

Variable	Number of Cases	Mean	SD	SE of Mean
COVERABS				
SITE 1	33	19.2727	22.600	3.934
SITE 2	9	67.6667	10.886	3.629

Mean Difference = -48.3939

Levene's Test for Equality of Variances: F= 2.876 P= .098

t-test for Equality of Means Variances	t-value	df	2-Tail Sig	SE of Diff	99% CI for Diff
Equal	-6.19	40	.000	7.819	(-69.543, -27.244)
Unequal	-9.04	28.14	.000	5.352	(-63.186, -33.602)

APPENDIX 9

TABLE OF COVER CLASSES FOR ALL SPECIES AT QUINNS ROCKS AND CITY BEACH BY QUADRAT

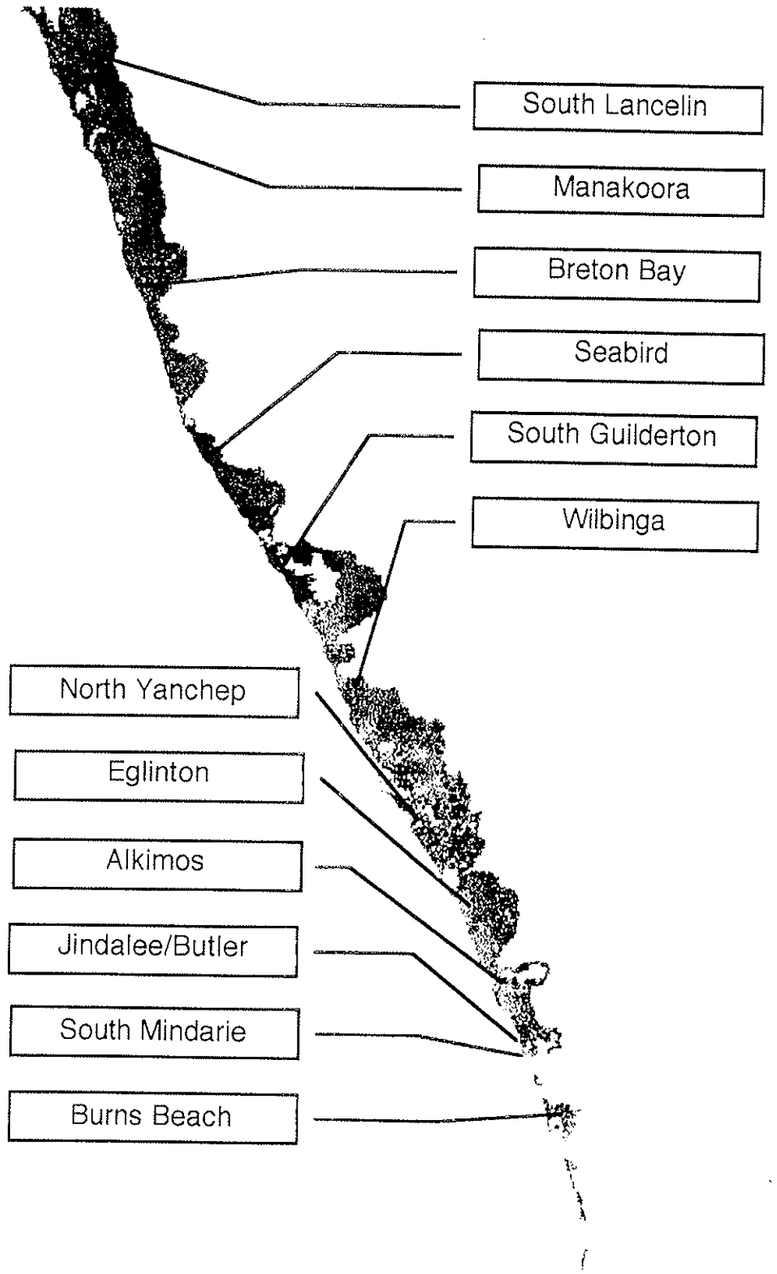
	Quadrat Number																																
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	C20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	C1	C2	C3	C4	C5	C6	C7	C8	C9
Acacia cochlearis	2																																								
Acacia cyclops									1																																
Acacia lasiocarpa	1														1																		2								
Acacia rossettiana																						2	3									2				3	3	3			
Acacia saligna	3						2	3																		3															
Acacia truncata		4		1						4						1	1	1						3	1	2		1		1	2	1	7			2	4				
Acanthocarpus preissii	2	1	3	2	2	2	1	1	4		2	1	4	4	4																										
Ammophila arenaria										1											2				2											2	3	3			
Anagallis arvensis var caerulea	1	1					1	2	1	1	1	1	1	1	2	1	2	2	2	3	2	1	1	1	1	3	1	1	1	1	2	2						2		2
Arctotheca calendula									1					1																						1	2	2			
Arctotheca populifolia																					2															2	1				
Arctotis stoechadifolia																																									
Asphodelus fistulosus														1																				1	1						
Avena barbata																																									
Brassica geyrnana																																		3	1	2	2	3			
Bromus diandrus																																					1	1				
Cakile maritima									1	2																								3	2	3	4	3	3			1
Calendula flora																																							1	1	1
Calendula tenuata																																									
Calomeria hirtiora	1	1	1	1			1	1	1	1		1	1	1	1	1	1					1	1	1		1	2	1	1	1	1	1	1								
Calocephalus brownii												2																													
Calomeria quadrifidus																																									
Carpobrotus edulis			1							1						1																					1				
Carpobrotus virescens	1										1										1	2	1				2														
Cassytha flava			1	1			4	1	1		4	2			1		1				3		1		1			1		1						1		1		
Cerastium glomeratum	1	1			1					1	1	1				1				2		3													2	2	4	3			
Chamaesyce inaequilatera		1					1	1									1	1		1																				
Vicia sativa	1						1																																		
Vicia sativa																																								
Vicia sativa																																								
Cicendia filiformis		1																																						
Crassula glomerata	1	2	1	1	1	1	1	2	1	1		1		1		1					1		1			1														
Crypsandra sp 1																																									2
Ductus glochidiatus	1	2	1	1			1		1	1				1	1						1																				
Daucus glochidiatus																				

BS 397 (b)

Halpern
Glick
Maunsell

Burns Beach Property Trust

Distribution of Quindalup Dune Vegetation and Coastal Landforms in the Whitfords to Lancelin Subsector



Response to Department of Environmental Protection Request

M2

Eglinton Beach resort

Ocean Dunes Pty Ltd

Report and recommendations of the Environmental Protection Authority

COASTAL

BS 397 Q

Full document available on request

Environmental Protection Authority
Bulletin 500
February 1991

M2

Mindarie Keys

Smith Corporation Pty. Ltd.

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Report and Recommendations
by the
Environmental Protection Authority

Full document
available
on request

Department of Conservation and Environment
Perth, Western Australia
Bulletin 200 July 1985

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