BENNETT BROOK, EDEN HILL TO WEST SWAN

Boundary Definition: protected area/bushland boundary

SECTION 1: LOCATION INFORMATION

Bush Forever Site no. 305
Area (ha): bushland 119.9 (Site also includes open water.)
Map no. 42, 43
Map sheet series ref. no. 2034–II NE, 2034–II SE
Other Names: Contains Success Hill Reserve
Local Authorities (Suburb): Shire of Swan (West Swan, Caversham, Guildford, Midland, Beechboro), Town of Bassendean (Eden Hill, Bassendean)
System 6 (1983): Part M19, M41 area of bushland goes beyond System area boundaries, all bushland described

SECTION 2: REGIONAL INFORMATION

LANDFORMS AND SOILS
Pinjarra Plain
Guildford Formation (Qpa: Mgs1) (Qha: Mc1)
Bassendean Dunes
Bassendean Sands (Qpb: S8)
Bassendean Dunes/Pinjarra Plain
Bassendean Sands over Guildford Formation (Qpb/Qpa: S10)
VEGETATION AND FLORA
Vegetation Complex
Pinjarra Plain
Guildford Complex
Swan Complex
Combinations of Bassendean Dunes/Pinjarra Plain
Southern River Complex
Floristic Community Types
Supergroup 2: Seasonal Wetlands
S7 Northern woodlands to forests over tall sedgelands alongside permanent wetlands
REGIONAL WETLANDS
Wetland Types: floodplain, dampland, palusplain, river, creek, artificial channel, estuary (waterbody)
Natural Wetland Groups
Bassendean—Pinjarra transition OR Bassendean with fluvial features
Bennett Brook (B/P.4)
Bassendean Dunes
Jandakot (B.3)
Swan Coastal Plain Rivers
Swan River (R.2)
Wetland Management Objectives: Conservation (123ha, 293.6m), Resource Enhancement, Multiple Use
Swan Coastal Plain Lakes EPP: 20.4ha
THREATENED ECOLOGICAL COMMUNITIES
Not determined

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: open water, vegetated wetland, river, creek, estuary, vegetated uplands
Vegetation and Flora: limited survey (DEP 1996 (Benn 01–03), DEP 1999, EPA and WAWA 1990, Keighery, BJ, 1996b)
Structural Units: mapping (EPA and WAWA 1990)
Uplands: *Banksia attenuata* and *B. menziesii* Low Open Woodland
Wetlands: *Eucalyptus rudis* Woodland to Closed Forest; *Melaleuca rhaphiophylla* Low Open Forest to Low Closed Forest; *Casuarina obesa* and *Melaleuca rhaphiophylla* Low Woodland to Low Open Forest; *Eucalyptus rudis*, *Melaleuca rhaphiophylla* Low Open Forest; Open Low Heaths of *Halosarcia halocnemoides, H. lepidosperma, H. pergranulata* and *Sarcocornia quinqueflora*; Sedgelands to Closed Sedgelands dominated by *Bolboschoenus caldwellii* and **Typha orientalis*
Scattered Native Plants: *Eucalyptus rudis* Woodland
Vegetation Condition: >70% Good to Excellent, <30% Degraded, with areas of severe localised disturbance
Total Flora: 62 native taxa, 21 weed taxa (Keighery, BJ, 1996b) (estimated >75% expected flora)

Significant Flora: the co-occurrence of the four samphire species — *Halosarcia halocnemoides, H. lepidosperma, H. pergranulata* and *Sarcocornia quinqueflora* — is unusual (L. Pen pers. comm. in Keighery, BJ, 1996b); *Sarcocornia blackiana* (known from one other locality, L. Pen pers. comm. in Keighery, BJ, 1996b)
Fauna: structured surveys for birds (73 species) (Cooper *et al.* 1999, RAOU 1996 D) and native mammals (1 species), reptiles (12 species), amphibians (7 species) and native fish (5 species) (Cooper *et al.* 1999). Significant bird species: category 1 (2), category 3 (8) and category 4 (5). Significant mammal species: Quenda (Friend 1996 D, Cooper *et al.* 1999)
Linkage: adjacent bushland to the north (Site 304) and east (Site 302); part of Greenways 44, 24 (Tingay, Alan & Associates 1998a); part of contiguous and fragmented bushland/wetland linkages (Part A, Map 7)
Other Special Attributes: the largest and most diverse relatively intact lagoonal system on the Swan–Canning River Estuary (L. Pen pers. comm. in Keighery, BJ, 1996b); one of a very limited number of bushland areas on the Swan Estuary, naturally vegetated areas on the Swan Estuary having particular conservation value in providing habitat for fauna and linkage between areas of bushland; open space of regional significance (DCE 1983); contains part of a channel (Bennett Brook) recommended for conservation by Semeniuk, V&C Research Group (1992); contains 3183m of regionally significant river (WRC 1996a GIS)

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Subject to protection under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

Criteria: Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, Scientific or evolutionary importance, 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; Smith, P, existing Parks and Recreation Reserve, should be protected as a reserve with a conservation purpose. Part B: Regional Creekline Mechanism (with mapped vegetation) (see Table 3, Volume 1).

BENNETT BROOK, EDEN HILL TO WEST SWAN

Boundary Definition: protected area/bushland boundary

SECTION 1: CADASTRAL INFORMATION

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

Bushplan Site no. 305 **Map no.** 47, 52 **Map sheet series ref. no.** 2034–II NE, 2034–II SE

System 6 (1983): Part M19, M41 area of bushland goes beyond System area boundaries, all bushland described

Other Names

Contains Success Hill Reserve

Local Authorities (Suburb)

Shire of Swan (West Swan, Caversham, Guildford, Midland, Beechboro), Town of Bassendean (Eden Hill, Bassendean)

Ownership Categories

State Government, Private (including commercial organisation), Local Government, Not identified

Area (ha): total 179.3 (includes open water); bushland 119.9

Zoning

MRS: Parks and Recreation, Rural, Waterways, Railways, Controlled Access Highways, Important Regional Roads, Urban, Public Purposes-Hospital, Public Purposes-Special Uses

TPS: Landscape, General Rural, Swan Valley Rural, Private Clubs and Institutions, Single Residential

Lot/Location/Reserve numbers (Purpose), Street name

(Creekline and riverine lots not identified)

28 Meadow St; 1 West Swan Rd; 16, 17, 75, 76, 133, 10206 Lord St; 0, 9, 10, 11, 12, 13, 14, 15, 16, 17, 101, 102, 103 Bennett St; 0 Widgee Rd; 30, 31, 40, 104, 12781, 12782 Victoria Rd; 41 Borah Ct; 99, 100, 134 Patricia St; 1, 18, 96, 190, 601 Swan St; 14, 51 Market St; 2988, 3082 Harper St; 12350 Valley Brook Rd; 3, 12, 15, 23 Benara Rd; 5, 72, 73 Coast Rd; 10, 11 Marshall Rd; 12444, 12445 Brookside Gdns; 11 Valley Brook Rd

Crown Reserve

SECTION 2: REGIONAL INFORMATION

LANDFORMS AND SOILS

Pinjarra Plain

Guildford formation (Qpa: Mgs1) (Qha: Mc1)

Bassendean Dunes

Bassendean Sands (Qpb: S8)

Bassendean Dunes/Pinjarra Plain

Bassendean Sands over Guildford Formation (Qpb/Qpa: S10)

VEGETATION AND FLORA

Vegetation Complex

Pinjarra Plain

Guildford Complex

Swan Complex

Combinations of Bassendean Dunes/Pinjarra Plain

Southern River Complex

Floristic Community Types:

Supergroup 2: Seasonal Wetlands

S7 Northern woodlands to forests over tall sedgelands alongside permanent wetlands

REGIONAL WETLANDS

Wetland Types: floodplain, dampland, palusplain, river, creek, artificial channel, estuary (waterbody)

Natural Wetland Groups

Bassendean—Pinjarra transition OR Bassendean with fluvial features

Bennett Brook (B/P.4)

Bassendean Dunes

Jandakot (B.3)

Swan Coastal Plain Rivers

Swan River (R.2)

Wetland Management Objectives: Conservation (123ha, 293.6m), Resource Enhancement, Multiple Use

Swan Coastal Plain Lakes EPP: 20.4ha

THREATENED ECOLOGICAL COMMUNITIES

Not determined

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: open water, vegetated wetland, river, creek, estuary, vegetated uplands

Vegetation and Flora: limited survey (DEP 1996 (Benn 01–03), EPA and WAWA 1990, Keighery, BJ, 1996b)

Structural Units: mapping (EPA and WAWA 1990)

Uplands: *Banksia attenuata* and *B. menziesii* Low Open Woodland

Wetlands: *Eucalyptus rudis* Woodland to Closed Forest; *Melaleuca rhaphiophylla* Low Open Forest to Low Closed Forest; *Casuarina obesa* and *Melaleuca rhaphiophylla* Low Woodland to Low Open Forest; *Eucalyptus rudis, Melaleuca rhaphiophylla* Low Open Forest; Open Low Heaths of *Halosarcia halocnemoides, H. lepidosperma, H. pergranulata* and *Sarcocornia quinqueflora*; Sedgelands to Closed Sedgelands dominated by *Bolboschoenus caldwellii* and **Typha orientalis*

Scattered Native Plants: *Eucalyptus rudis* Woodland

Vegetation Condition: >70% Good to Excellent, <30% Degraded, with areas of severe localised disturbance

Total Flora: 62 native taxa, 21 weeds (Keighery, BJ, 1996b) (estimated >75% expected flora)

Significant Flora: the co-occurrence of the four samphire species — *Halosarcia halocnemoides, H. lepidosperma, H. pergranulata* and *Sarcocornia quinqueflora* — is unusual (L. Pen pers. comm. in BJ Keighery 1996b); *Sarcocornia blackiana* (known from one other locality, L. Pen pers. comm. in BJ Keighery 1996b)

Fauna: multiple and structured surveys by Cooper *et al.* (in press) and RAOU (1996 D) for birds (73), and by Cooper *et al.* (in press) for native mammals (1), reptiles (12) and amphibians (7). Significant bird species: category 1 (2), category 3 (8) and category 4 (5). Significant mammal species: Quenda (Friend 1996 D)

Linkage: adjacent bushland to the north (BS304) and east (BS302); part of proposed Greenways 21, 50 (Tingay, Alan & Associates 1997a); part of contiguous and fragmented bushland/wetland linkages (Volume 2A, Map 8)

Other Special Attributes: the largest and most diverse relatively intact lagoonal system on the Swan-Canning River Estuary (L. Pen pers. comm. in BJ Keighery 1996b); one of a very limited number of bushland areas on the Swan Estuary, naturally vegetated areas on the Swan Estuary having particular conservation value in providing habitat for fauna and linkage between areas of bushland; open space of regional significance (DCE 1983); contains part of a channel (Bennett Brook) recommended for conservation by Semeniuk, V&C Research Group (1992); contains 3183m of regionally significant river (WRC 1996a GIS)

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Not listed

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

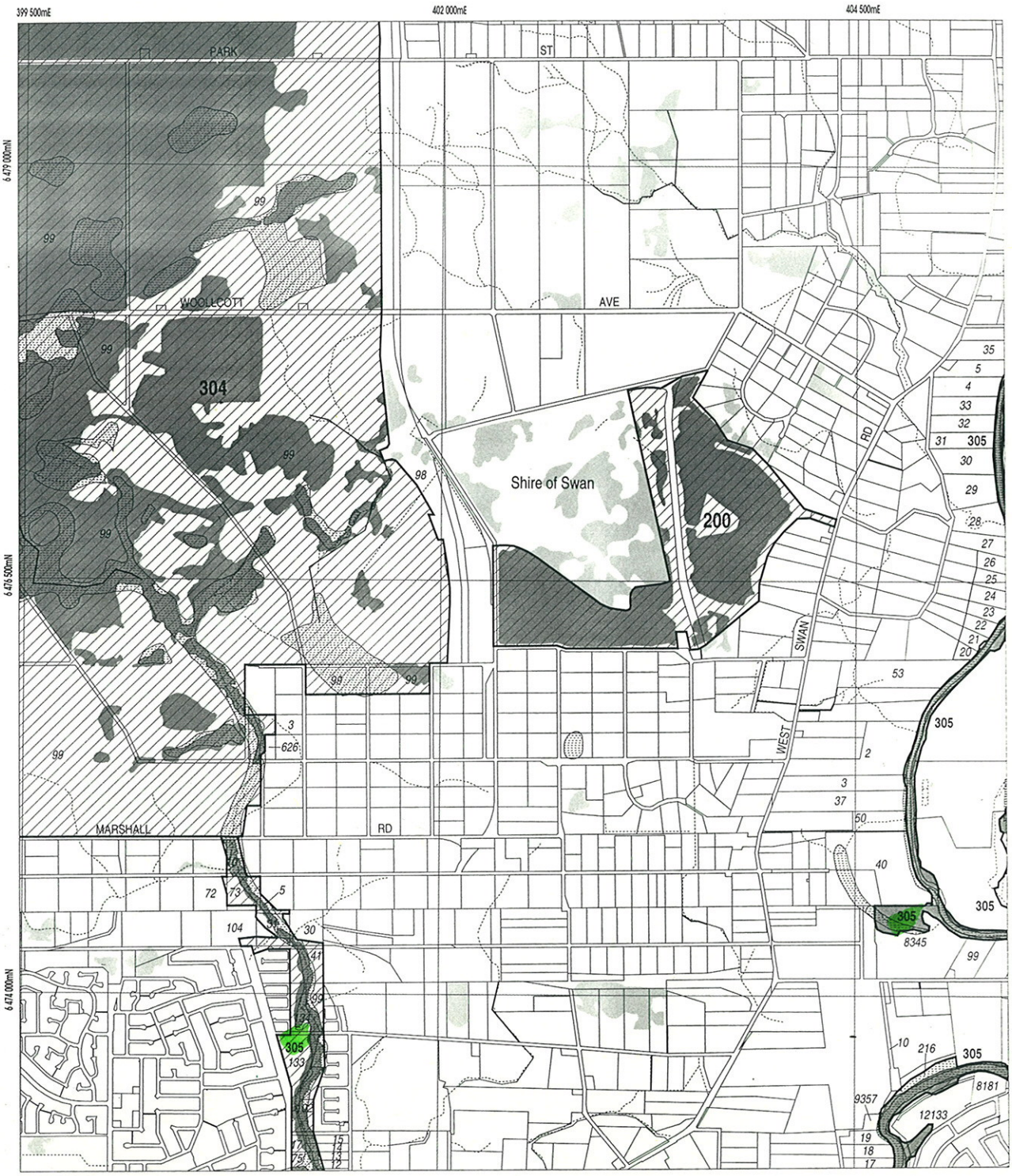
Criteria: Representation of ecological communities, Rarity, Maintaining ecological processes or natural systems, Scientific or evolutionary importance, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation, Criteria not relevant to determination of conservation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

Opportunities and/or Constraints

Opportunities: Bushplan Site/part Bushplan Site subject to Swan and Canning Rivers EPP, Swan Coastal Plain Lakes EPP; location of Scheduled Fauna, conservation category wetland; under MRS Parks and Recreation Reservation and TPS Zoning, Crown Reserve

Constraints: private land; under MRS Urban Zoning

Recommendation: The most appropriate mechanism for the protection of this Bushplan Site be considered through the public comment period in consultation with the land owner(s). Parts of this Bushplan Site are already reserved for Parks and Recreation in the Metropolitan Region Scheme and should be protected as a reserve with a conservation purpose.



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 - II NE

IV | I
2034
III | II (NW, NE, SW, SE) — 47

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

PERTH'S BUSHPLAN MAP INDEX

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_47.dgn

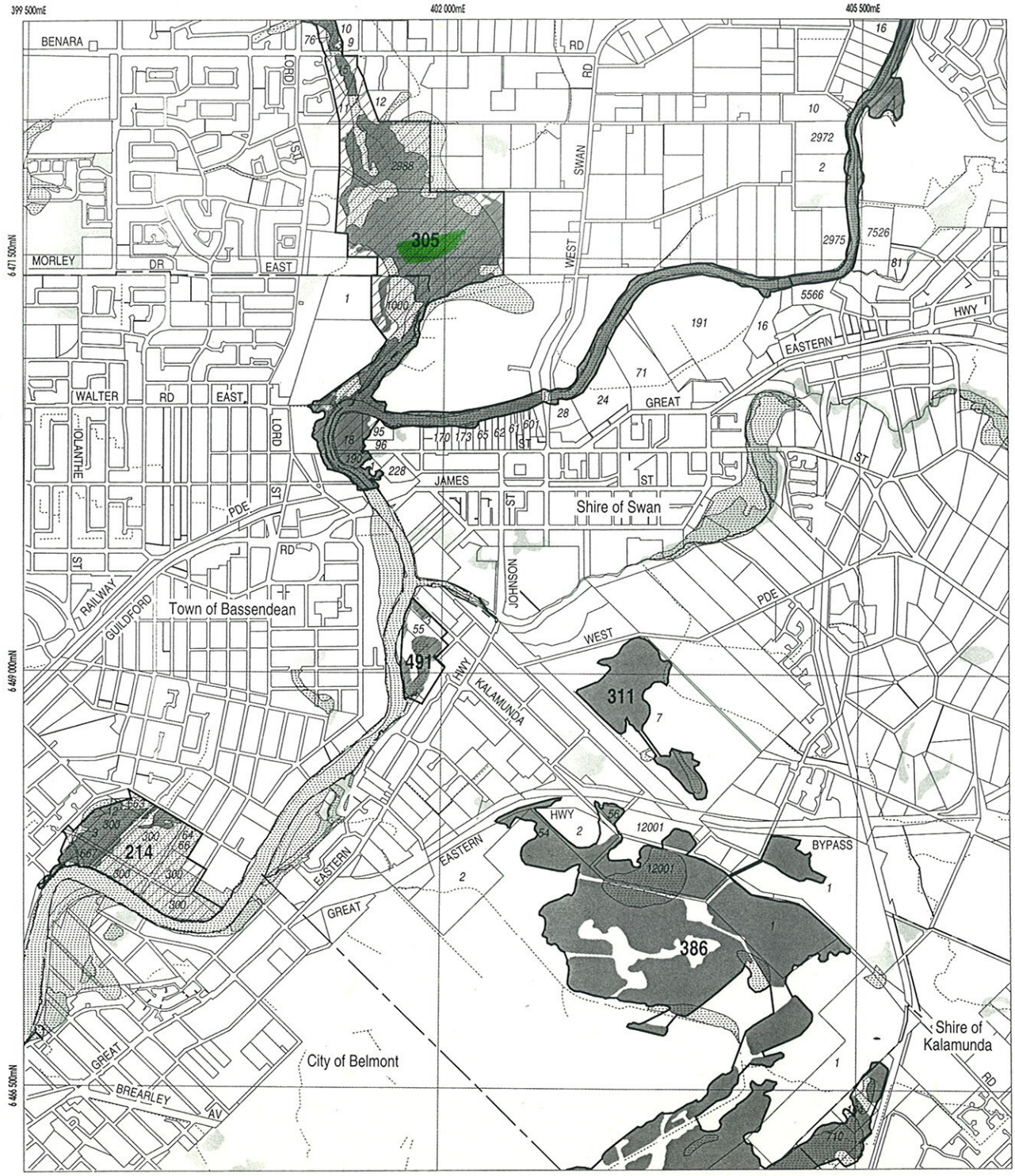
Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map

Map 47



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 - II SE

IV | I
2034
III | NW | NE
SW | SE (52)

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

PERTH'S BUSHPLAN MAP INDEX

1 2
3 4 5
6 7 8 9 10 11
12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
31 32 33 34 35 36
37 38 39 40 41 42
43 44 45 46 47 48
49 50 51 52 53 54
55 56 57 58 59
60 61 62 63 64
65 66 67 68 69 70
71 72 73 74 75 76 77
78 79 80 81 82 83 84
85 86 87 88 89 90 91
92 93 94 95 96 97
98 99 100 101 102
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-map18//environ/bushplan//bushv2_52.dgn

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

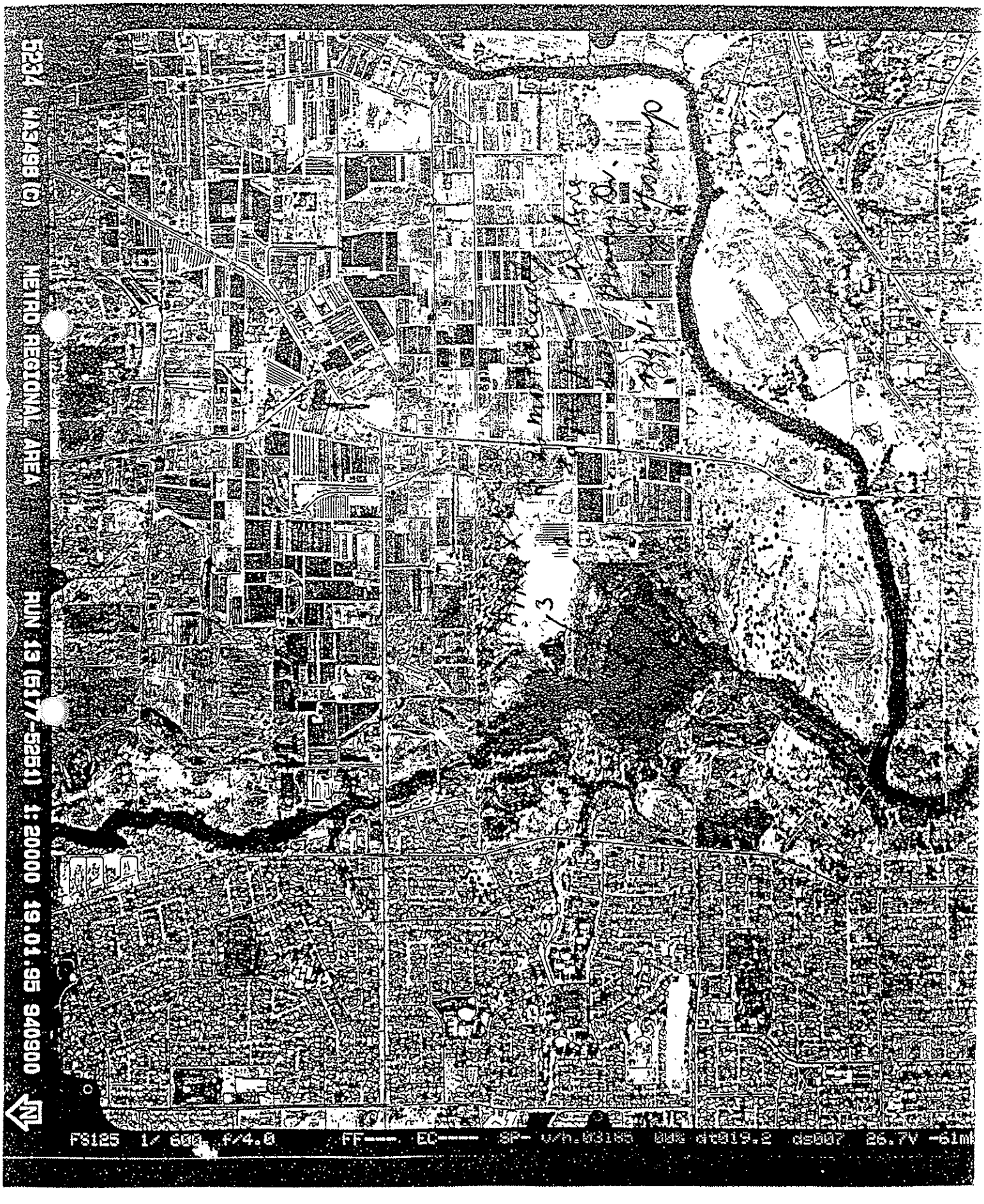
Wetlands Data supplied by Water and Rivers Commission

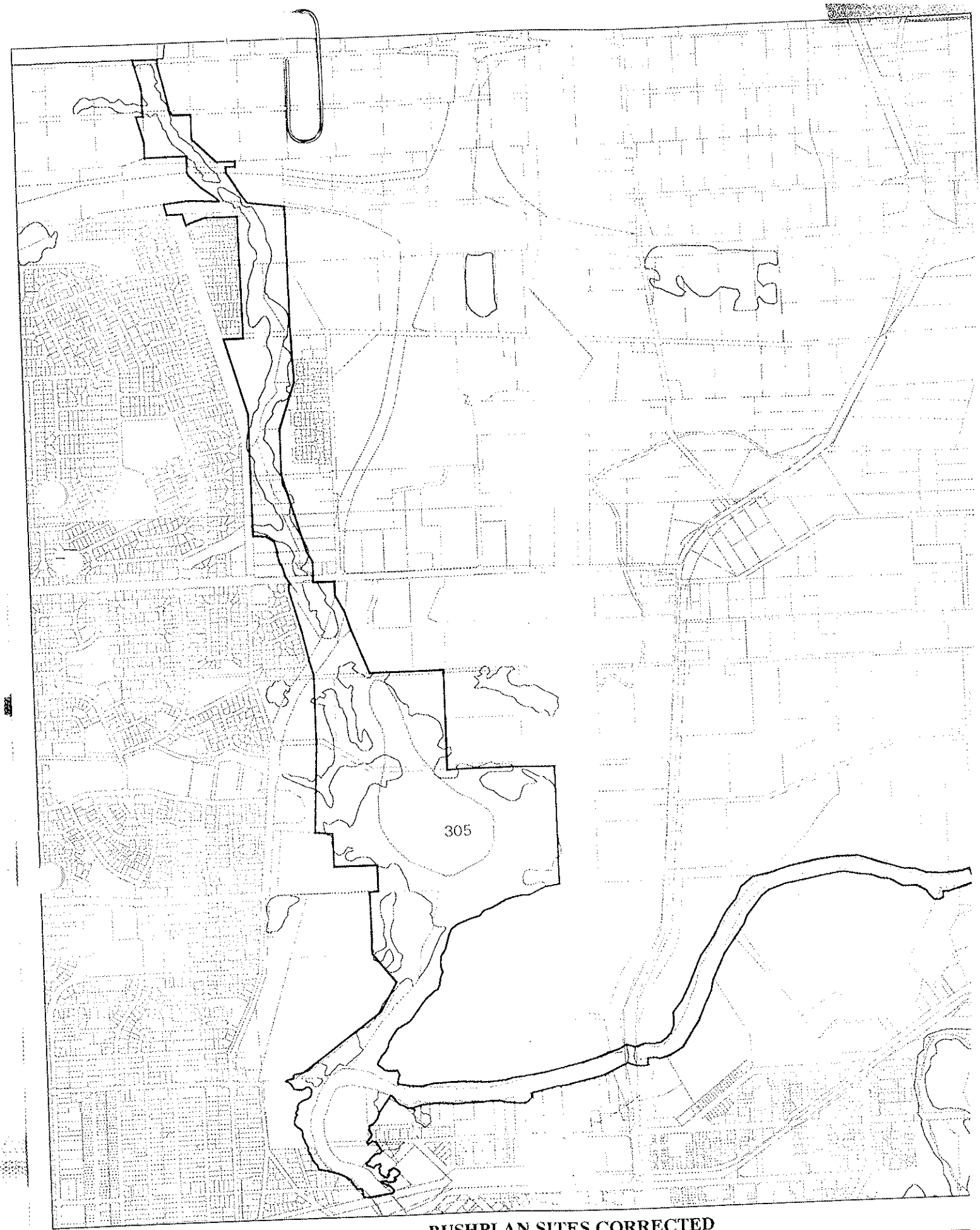
Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

Bushplan Site Map

Map 52

Photo Details.





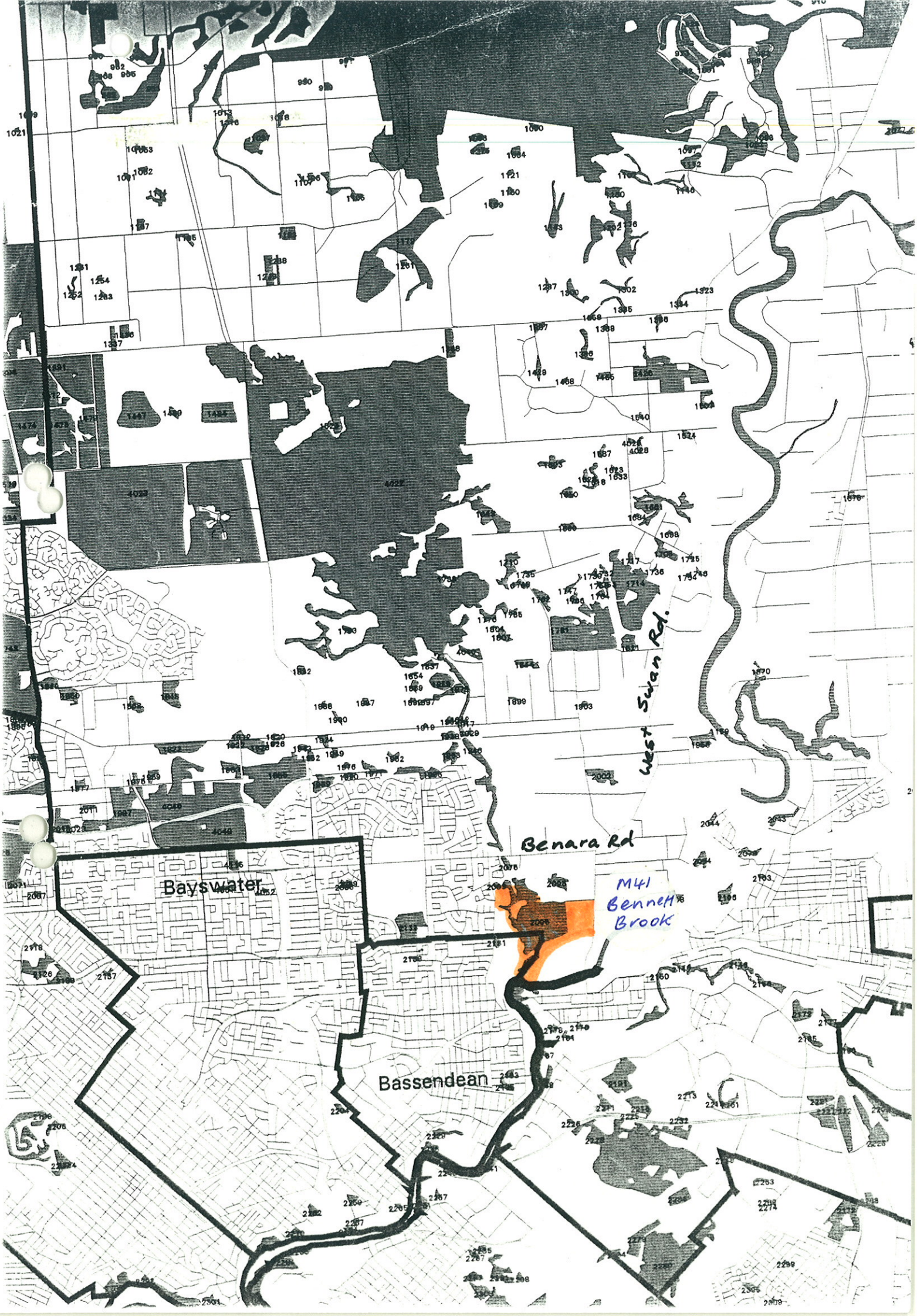
BUSHPLAN SITES CORRECTED

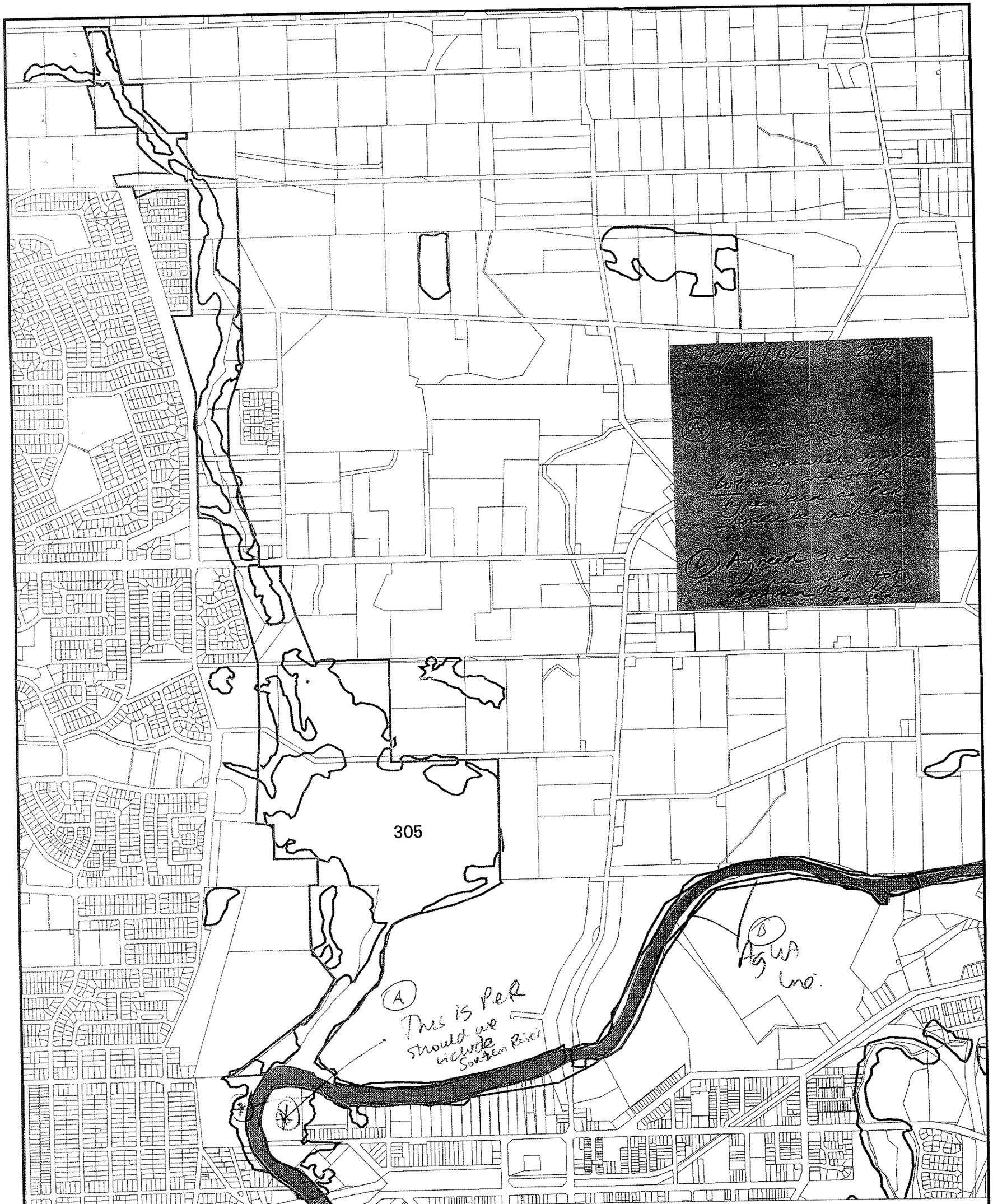
WESTERN AUSTRALIAN PLANNING COMMISSION

CUSTOMER FOCUS

S TB 2/10/98

N


West Swan Rd.
Benara Rd
M41
Bennett
Brook
Bayswater
Bassendean



bp site 305

Map Ident: plot980528_1	DATE: 28 May 98
Prepared By: Andrea Zappacosta	Prepared For:
Scale 1:AUTO	MFP INTERNAL USE ONLY

0 500 m

Bennett Brook 5/12/94

Specimens from flat adjacent to the Brickworks / Tile works

- upright bushes.
  - Halosarcia lepidosperma PW 10
  - Halosarcia ? peryramulata PW 10
  - Halosarcia halocnemioides PW 10
    = small red.
- prostrate / lying down bush.
  - Sarcocornia quinqueflora PW 10
    = large internodal distance
    red & grey (tallest)

Notes in blue notebook.

Friday 23.9.94

Kaye Pearson rang - their group would love to be involved in botanical survey work
- Would prefer during school holidays after 30th Sept. BUT not Oct 456 (Greening Aust. conference) or Oct 8,9 (Spring in the Valley)

8-9 people are interested (at least 6)

On Sunday 2nd Oct. the group is doing a bird survey so maybe we can combine the work.

Barnetts Creek Kaye 19/9/94

Floodplain
Remnant Woodland (Pyrton area)
Nyorgan Community (grazed)
Banksia Woodland
Claypits
(Valley Brook Estate)
Brickworks - bullrushes
= swamp
- paperbark
New Agricultural area

Pennant Brook

Stipa tenuifolia VSP

Neuraxhne alopecuroidea

Trig. procera large (var) VSP.

Bolboschoenus caldwellii

Callitriche ?flagellis

?? Rumex acetosella

Water cress.

Azolla

THE FLORA

- Limited Work
- Some intact areas along river

clay/loams
- Flooded Gum
- Sheoak
- Freshwater Paperbark
- Mapi

} alone & together

or. Sedgelands
Samphires

MAIN VALUES - MATURE TREES, THICKETS
Sands - Banksia Woodland Success Hill

- Scattered trees - Mature
- Recovery - Lowlands
  Use mature trees / thickets.
- FIRE Responses
  - resprouting
  - reseeding
    - perennial
    - annuals

- Mostly resprouters - weed = control time
- Reseeders. low in number eg Acacia dentifera

Weeds - incomplete list; slashing
ex.

13/6/97

Attendees Fire Brigade
Matt Stafford (FMP), SCRUB, Ashad, Margaret Jeffery, Robert Bropho, Tony Grafte, John Dell, Pete ?

Robert Bropho

- 'One of the many sons of mother land'
- Burning season by season NOT walls of fire
- Last bushfire felt by rubbish and weeds too hot 'slaughtering fires'
- Firebreaks : fire always jumps over
- Whiteman Park / Success Hill : all plants going too much burning
  'Every time fire goes through Zm burnt too' (Success Hill)
- Stop all this bushland saved and preserved 'huge spread houses'
  Ellenbrook destroyed by housing
- Clear spring water gone under houses

13/6/97

John Dell
- litter / thickets needed for frogs / birds / invertebrates
- fire causing reduction diversity + density in species
- those that survive no cover, so eaten

Harry Cribb
Bennett Brook
- Horse Swamp = 20 ha } Bennett Brook
Large area (sites)

- 2,000 ha to be retained ~ 400 native species, high value flora + fauna

- Tributaries vegetated, too difficult to clean.

- extensively burnt in past

- present = two fire year 2ha 1990
1994 200 ha, > 400 ha back to 1978
P Machine

- 12 - 14 year rotation

- Some arson, control fire, Machinery, Steam engines (Cap museum)

◦ ~~protect~~ Risk: Brook, banksia, pasture, building

◦ Unable to try to control fire in Brook, too dense, too difficult have breaks in the brook

◦ Protection
  - protect bush
  - property
  - neighbours

◦ Principal action ~~to~~ keep fires small.

Features control - keep small + mop up,
◦ Fire rakes ⟨ 3m / 6m ⟩ use to 'clear' areas in bush

◦ 50m buffer
◦ Fire unit in summer always available
◦ min 12yr rotation for control burns (only one since 1990) use maps since 1978 to reduce hazard to stop loosing all bushland in one event
◦ education
◦ planning considerations
◦ training
◦ grazing (restricted to old farmland)

Particular Banksia Woodland: dangerous level 5-5 tonnes per hectare ie in about 3yrs but levels off 5-8 yrs
So in response to ~~the~~ biologist's data

Clive Burdon: Shire Swan

- Wildfire & Fire different
- Fire natural, principal species of the communities burn well.
- wildfire destroys habitat
- Look to

{1. Protect life
2. Protect property } balance
3. protect wildlife } BUT in priority area}

- not ~~when~~ if but when will it burn
- manage fire agency & risk before
- Managing risk
  - no natural causes
  - manage areas around the Brook
  - Strategic access
  - spread dieback (only on Success Hill)

Import in access and firebreak construction
  - keep fire small automatic

respose
  - water bombing
  - control / cool burning be part management, time spent practising

Matt Stafford - MFP

Experiences 15 yrs
('Holistic Approach to Managing Bushland'
- written for 'Fire and Rescue' newspaper
- Action for all response plans
- Plan for Fire + Res, Bushfires + others
- bushland being reserved need to

- Fire MP is for fire authority not for yourself
- Pre-agreed fire MP plan
- 2 people 18,000 ~~ppl~~ in bushland
- attend all fires but limited as cannot always be available, do not base on individual either from MFP or Fire & Rescue
- FMP need to be workable and will require people.
- Two parts.
  - (+) Management Plan for Reserve
    - fencing/signs
    - controlled access
    - police presence/surveillance
    - low fuel zones.

'Gone from rehabilitating the bush that was going to be destroyed but is a good park' re Signs + fences

- Fire Plan with fire agency ensure plan is workable through discussion

---

Use degraded areas as fire breaks
- Make sure that there is no issue of ~~fire~~ + life & property

(2) Fire Action Plan: 4 pages
- to be kept at Fire & Rescue / Shire / CMRM
- Job for all agencies
- automatic does not depend on individuals
- overkill fire go home early
- must come from top to bottom
- response depends on fire season for day.

Eg Lake Cadoongup
- major fire
- 3 weeks for last fire
- 2600 ha bush not available

All agencies all come with set duties

Notes - on access
- set up controls / plan to ensure some bush left

'No point doing above if agreement has not been reached with agencies it will not work'

Fire offices responsibilities change if begins to threaten houses

Eg 80m from old burn constructed firebreak as they are not aware and a single individual only knew. Idiot and could not be contacted

Environmental office to firms from any groups with knowledge

Show fire people you have worked with them, respect back also.

New tool GIS that allows completion detailed maps such as fire breaks access, materials access to up to date maps

Should enable all people have access into an GIS to analyse fire and calculate where to next fire

Example for Lake Cootharaba Showing
- fire breaks named
- blocks numbered
- houses

Amity Swamp
- compartments via limestone tracks in swamp to backburn from
- must know all have info

Fire & Rescue:

- Sensitive Urban Bushland identified.
- difficulty is not plan coming from FKR but should list come from Group.
- Group take plan to FKR to see what is possible.
- Jobs not for structures, now for bushland too.
- Hazard reduction only by Volunteers at request land holder.
- Continuous radar System
- organisation lost through regional offices
- resources able to commit depend on availability.

Identify the values and

E

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

AREA INFORMATION

System 6 Area (C or M) or Update Area (Update) 8 M 41

Conservation Area Bennett Brook	
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

aerial photograph	
orthophoto	
vegetation map	
soil map	

Supplied by Bronwen Keighery, Department of Environmental Protection, 28/6/95

Suggested plants suitable for direct seeding at Bennett Brook

COMMON NAME	SCIENTIFIC NAME	COMMENTS
Trees		
Eucalyptus marginata	Jarrah	D, R
# Eucalyptus calophylla	Marri	D/W, R
# Melaleuca preissiana	Moonah	W, R
Melaleuca rhaphiophylla	Swamp Paperbark	W, R
Allocasuarina fraseriana	Fraser's Sheoak	D, R
Acacia saligna	Orange Wattle	D/W, RT *
Banksia menziesii	Firewood Banksia	D, R
Banksia littoralis	Swamp Banksia	W, R
Banksia attenuata	Slender Banksia	D, R
Shrubs		
Melaleuca viminea	Mohan	W, ?R
Melaleuca lateritia	Robin Redbreast Bush	W, ?R
Allocasuarina humilis	Dwarf Sheoak	D, R
Hypocalymma robustum	Swan River Myrtle	D, R
Hypocalymma angustifolium	White Myrtle	D, R
Jacksonia furcellata	Grey Stinkwood	D, ?RT
Viminaria juncea	Swishbush	W, RT
Stirlingia latifolia	Blueboy	D, RTS
Eremaea pauciflora		D, R
Acacia pulchella	Prickly Moses	D/W, RT *
Xanthorrhoea preissii	Blackboy	D/W, R
Verticordia densiflora	Dense Featherflower	W, R *
Kunzea ericifolia	Spearwood	W, R
Daviesia decurrens		D, RT?
Bossiaea eriocarpa	Common Brown Pea	D, ?RT *
Climbers/Groundcovers		
Hardenbergia comptoniana	Native Wisteria	D, RT
Kennedia prostrata	Red Runner	D, RT
Herbs		
Conostylis aculeata	Prickly Conostylis	D, U *
Conostylis setigera	Bristly Conostylis	D, U
Anigozanthus manglesii	Mangles Kangaroo Paw	D/W, R
Anigozanthus humilis	Cats Paw	D, R
Grasses		
Stipa compressa		D, ?R

Key to COMMENTS - Horticultural information compiled with help from Bob Dixon at King's Park

D Species suitable for dryer slopes/uplands
W species suitable for wetter slopes/damplands
R readily available
?R common species, availability not known
RT readily available but seeds require pretreatment
U unlikely to be available, germination unlikely
RTS readily available, will need pretreatment with smoke
* many different forms, need to be aware of collecting seed from similar habitats within reasonable distance

Plant species of the rivers and creeks of the northern Swan Coastal Plain

Trees

Eucalyptus calophylla	Marri	4
# Eucalyptus rudis	Flooded gum	2-4
Melaleuca rhaphiopylla	Swamp paperbark	2-3
Casuarina obesa	Swamp sheoak	2-3 saline sites
# Melaleuca viminea		3-4 salt tolerant
Melaleuca preissiana	Modong	4
# Acacia saligna	Coojong	4

Tall shrubs

Melaleuca laterita	Red robin	2-3
# Astartea fascicularis		3
# Acacia pulchella	Prickly Moses	4
Agonis linearifolia	Swamp peppermint	3
Trimalium floribundum		3-4 near Scarp
Viminaria juncea	Golden spray	3-4 swampy
Paraserianthes lophantha	Albizia	3-4
Oxylobium lineare	River pea	3
Grevillea diversifolia		3-4 near Scarp
Labichea lanceolata		3-4 near Scarp

Tall sedges

Baumea articulata	Jointed twig rush	2
Schenoplectus validus		1-2
Lepidosperma tetraquetrum	Angled sword sedge	3 near Scarp

Medium sedges

Baumea juncea	Twig rush	2
Baumea riparia	River twig sedge	3
Baumea vaginalis	Sheath twig sedge	3
Baumea preissii	Broad twig sedge	3
Cyperus vaginatus		2-3
Lepidosperma effusum	Spreading sword sedge	3
Lepidosperma longitudinale	Pithy sword sedge	3-4
Isolepis nodosa	Club sedge	3-4 sandy sites
Juncus kraussii	Shore rush	2 saline sites
Juncus subsecundatus	Finger rush	3-4
Juncus pallidus	Pale rush	3
Typha domingensis	Cumbungi	3

Grass

Hemarthria uncinata	Mat grass	3 swampy sites

Herbs

Centella cordifolia		3 swampy sites

Emergent aquatic plants

Triglochin procera	Water ribbons	1

Key

1 below low water mark
2 between low and high water mark
3 around high water mark
4 above high water mark

Department of Environmental Protection System 6 Update: Site Based Flora List M41 Bennett Brook
(51 taxa: Benn Sites 1-3, B.J. Keighery, 31/3/95)

Apiaceae
Apium prostratum

Araceae
* Zantedeschia aethiopica

Asteraceae
* Aster subulatus
Cotula coronopifolia
* Lactuca serriola
Pogonolepis stricta
* Sonchus oleraceus

Callitrichaceae
* Callitriche stagnalis

Casuarinaceae
Casuarina obesa

Chenopodiaceae
Halosarcia lepidosperma
Halosarcia pergranulata
Sarcocornia quinqueflora

Cyperaceae
Baumea juncea
Bolboschoenus caldwellii
Carex appressa
Carex tereticaulis
Chorizandra enodis
Cyperus polystachyos
Isolepis cernua
Lepidosperma longitudinale

Gentianaceae
* Centaurium sp. scps

Iridaceae
* Babiana disticha
* Gladiolus undulatus
* Hesperantha falcata
* Romulea rosea
* Sparaxis bulbifera

Juncaceae
* Juncus bufonius
Juncus kraussii
Juncus pauciflorus

Juncaginaceae
Triglochin centrocarpum
Triglochin mucronatum
Triglochin procerum

Lobeliaceae
Lobelia alata

Lythraceae
* Lythrum hyssopifolia

Myrtaceae
Eucalyptus rudis
° Melaleuca lateritia w/?R

Myrtaceae
Melaleuca rhaphiophylla
° Melaleuca viminea w/?R

Onagraceae
Epilobium billardierianum

Papilionaceae
* Lotus angustissimus

Poaceae
Agrostis sp. scps
* Briza minor
Cynodon dactylon
Danthonia caespitosa
* Hordeum geniculatum
* Lolium rigidum
* Paspalum dilatatum
* Polypogon monspeliensis

Polygonaceae
* Rumex crispus

Primulaceae
Samolus junceus

Typhaceae
Typha domingensis

M41 Bennett Brook

Friends Advocate Management

Other Names:

Specific Study/studies Miscellaneous studies

Flora

Vegetation Map	1	2	3	
Flora list	1	2	3	4
Significant 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

AHC: National Estate- Listed / Interim / Nominated / Notified NT (WA): Heritage Classification

Notes
Biological Survey proposed 1994-1995
Site of significance to Aboriginal people

M41 Bennett Brook		
M41.1 Regional park recommendations be applied to this area.	Unresolved issues	At this stage there are no plans for the area to be included in a regional park . Swan River Management Strategy recommends that all the foreshore reserves and waterways of the Swan Canning Rivers be treated as a single entity for the purposes of planning and management.
M41.2 DPUD's proposal to Reserve Bennett Brook and adjacent areas from Whiteman Park to Swan River is endorsed.	Implemented	DPUD has reserved the area for Parks and Recreation.

Nicole Siemon

SHEET 2: System 6 - VERBAL Information Search Date 30/5/14

Area M41	Name	BENNETT	Brook			
Source		Mosquito	Strategy			
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				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			

Vegetation Condition				
Site based	Mapped	Units		
Disturbance Factors				
Phytophthora	observed		Other	Incidental
	tested			Itemised

Notes

A DESCRIPTION OF REMNANT VEGETATION OF BENNETT BROOK (SYSTEM 6 AREA M41)

B.J. Keighery April 1996
Department of Environmental Protection

INTRODUCTION

Bennett Brook (M41) was identified in the original System 6 study (Department of Environmental Protection 1983). As a consequence, an assessment of the vegetation of the area was part of the the 1994 -1996 System 6 Update (Department of Environmental Protection). This assessment involves placing the plant communities of the area in a regional perspective by comparing set area study sites to reference study sites on the Swan Coastal Plain according to the procedures used in Gibson *et al.* (1994). As a local group, the Success Hill Action Group, was embarking on a flora and fauna survey of the Bennett Brook area, including the System 6 area, this work was done in cooperation with the Group.

METHODS

The Bennett Brook area was visited on two occasions. On the first trip (6/10/1994) the System 6 Update field group and members of the Success Hill Action Group traversed the area south of Benarra Road. Native plants observed on the traverses were noted and three permanent 10 m x 10 m study sites were located in the areas of bushland in good condition or better (Keighery 1994).

Within each site all vascular plants were recorded and specimens collected according to the procedures described in Keighery (1994). Data on slope, aspect, vegetation structure and condition were collected from each site. Slope was scored on a one to three scale from flat to steep. Aspect was recorded as one of 16 cardinal directions. Vegetation structure was recorded and described according to Table 1, Appendix 1. Vegetation condition was scored on a five point scale with a score of one indicating vegetation in near natural condition and five indicating highly disturbed sites with significant weed invasion (after Keighery 1994). All sites were permanently marked with four steel fence droppers and had their position fixed using a GPS unit.

Several identification sessions were held in the WA Herbarium with the Success Hill Action Group to identify the plant specimens from the study sites and to prepare a field herbarium.

On the second visit (5/12/94) the System 6 Update field group revisited the sites and observed a transect through the wet flats on the eastern side of the Brook.

While all native plant species observed during the field work were recorded this study is not a comprehensive treatment of the flora of the Bennett Brook area. It is expected that the flora recorded (Appendix 2) accounts for 70% of the flora present but this could be as low as 60%. Also, while all non-native taxa were recorded in the study sites no attempt was made to record non-native taxa in the cleared areas.

A list of plants suitable for direct seeding was also compiled in consultation with Robert Bropho (Appendix 3) for rehabilitation of roadside areas.

SOILS

The general soils of the study area are described by Gozzard (1986), Bennett Brook being located at the interface of the Bassendean Dune System and the Pinjarra Plain. As a

consequence the surface soils to the west of the Brook are sandy, being dunes of Bassendean sands of various depths over Pinjarra Plain (S8 and S10). The soils to the east are are pebbly silts (Mgs1). The banks and wet flats of the Brook are clayey silts (Mc1) deposited by the Brook. To the east in the areas with a high clay content are a series of clay mines. Clay also appears to have been mined in similar deposits on the western bank adjacent to study site 2.

VEGETATION

Much of the area encompassed in the System 6 boundary has been cleared of native vegetation. The areas of relatively intact vegetation occur along banks and wet flats associated with the Brook being confined to the clayey silts. There is insufficient remaining vegetation on the uplands associated with the Brook to give a description of the plant communities of this area but the remaining remnant individual native species and the soil maps of the area give some indications of the expected vegetation of the upland areas. There would have been quite different communities on the eastern and western uplands.

Uplands to the West of Bennett Brook

The Bassendean Sands on the west of Bennett Brook occurr as
(i) Dunes (S8): *Banksia* Woodland similar to that represented on Success Hill would have been typical of these soils.
(ii) Sandy flats, low relief dunes (S10): *Banksia* Woodland would also have been found on these soils but the underlying heavier soils and proximity to ground water would have resulted in Marri (*Eucalyptus calophylla*) and *Melaleuca preissianna* being important components of the vegetation as well as a series of understorey species characteristic of low lying *Banksia* Woodlands.

The Lightening Swamp area probably contains communities similar to those that would have been found in this area.

Bennett Brook banks and wet flats

Western side of Bennett Brook

The western wet flats contain a mosaic of communities which depend on the relief and degree of inundation, principally Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland with areas of *Casuarina obesa* and *Melaleuca rhaphiophylla* Woodland on the more extensive wet flats with patches of *Melaleuca viminea* Tall Shrubland *and Melaleuca rhaphiophylla* Low Woodland along the banks of the Brook. While these sites are broadly similar floristicaly different sedge species are dominant in sites one and two and shrubs are dominant in the understorey in site 3 (Appendix 1). Site 3 is apparently more saline than sites 1 and 2, the species present being typically associated with areas subject to salinity at some time in the year. In the past there were probably areas of *Casuarina obesa* Woodland along the Brook that had a fresh water understorey, as found elsewhere on the Plain, but these would have been selectively cleared.

Eastern side of Bennett Brook

The vegetation of the eastern flats ranges from *Casuarina obesa* Forest, *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland, *Melaleuca viminea* Tall Shrubland, Samphire Open Low Heath, *Bulboschoenus caldwellii* Closed Sedgeland and *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland on the margins of the Brook and extending into the area of shallow water. Zonation was more evident as the wetflats are broader on the eastern side of the Brook and the wetflats grade into similar soils rather than sands. The *Casuarina obesa* woodlands are more disturbed and less waterlogged than those on the west.

The area of *Bulboschenus caldwellii*. Sedgeland indicates that there are fresh water seepages associated with the wetflats, a typical feature of such areas.

Although limited in area the relatively intact vegetation of the banks and wetflats of the Bennett Brook provide significant habitat for the fauna associated with the wetland. This vegetation is also significant in that there are relatively few areas of vegetation along the river and creeklines of the Swan Coastal Plain.

Eastern Side of Bennett Brook

It is difficult to say what the vegetation was on the pebbly silts as there are apparently no significant remnants in the Swan Valley on these soils. Remnant trees in the area are Flooded Gum, Marri and Wandoo but these are rarely associated with other native vegetation. Marri and Flooded Gum are found in the Bennett Brook area.

Floristic Community Types

The plant communities sampled along the Bennett Brook (Department of Environmental Protection 1996) form a wetland grouping not represented in the regional study of the Swan Coastal Plain by Gibson *et al.* (1994). This is not unexpected as Gibson *et al.* (1994) did not generally sample communities associated with lakes, creeks or rivers This floristic group has been located at three other locations on the Swan Coastal Plain all are small areas associated with lakes, creeks or rivers. Of these locations the greatest development of the floristic group is along Bennett Brook.

FLORA

Sixty one native taxa (species, subspecies and varieties) were recorded from the study area. This is a comparatively low diversity of taxa for an area on the Swan Coastal Plain, especially one that contains areas of heavy soil wetlands. This can be accounted for by the high degree of clearing of the area and the nature of heavy soil wetlands. On the Swan Coastal Plain the species diversity of wetlands drops with increasing salinity and the length of inundation. That is wetlands that are inundated through winter, spring and all or part of summer and/or are saline have limited species diversity. Both of these conditiona are present at Bennett Brook.

The co-occurence of *Halosarcia halocnemoides*, *H. lepidosperma*, *H. pergranulata* and *Sarcocornia quinqueflora* is significant being one of the few locations where these four samphires occurr together (L. Pen pers. comm.). Also it appears that *Sarcocornia blackiana* is also in the area and this taxon is currently known from only one other location on the Swan River (L. Pen pers. comm.).

The presence of *Juncus pauciflorus* is significant as this is not listed in the Flora of the Perth Region (Marchant et al. 1983) however it is recorded for the Serpentine River (Keighery, Keighery and Gibson 1994).

Vegetation Condition

As discussed previously most of the Bennett Brook area has been cleared, the remaining vegetation being confined to the wetflats and banks associated with the Brook. The condition of this vegetation ranges from degraded to excellent. There is significant weed invasion of these communities, 21 weeds being recorded for the three study sites (Appendix 1).

CONCLUSION

The vegetation of the Bennett Brook area is restricted to the banks and wet flats of the Brook. However considering that drainage line vegetation on the Swan Coastal Plain is predominantly cleared and/or highly modified the vegetation is significant. It also constitutes the largest remaining and most diverse relatively intact lagoonal system on the Swan - Canning River Estuary (L. Pen pers. comm.).

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Appendix 1: Vegetation Descriptions

The vegetation descriptions are made from a series of sites indicated on the maps. Each site is given a general unit based on the dominant overstorey species.

Keys to the terminology used for the vegetation descriptions and specific condition ratings.

Table 1: Key to vegetation description terminology

Table 2: Site condition scales

Vegetation Condition Scale (Keighery 1994)

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.

Permanent Sites - wet flats on western side of Bennett Brook

Site 1 - Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland

Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Carex appressa* Closed Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous weeds.
Soil: grey brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 2 - Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Open Low Woodland

Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Chorizandra enodis, Lepidosperma longnitudinale* and *Juncus pauciflorus* Closed Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 3 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Woodland
Casuarina obesa and *Melaleuca rhaphiophylla* Woodland over Samphire Open Low Heath and exotic Very Open Grassland, *Samolus juncea* and *Cotula corynopifolia* Herbland and *Juncus krausii* Very Open Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Sites - wet flats on eastern side of Bennett Brook

Site 4 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland over exotic Grassland
CONDITION Rating Degraded
Comments: The understorey contains significant grassy weeds.
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged

Site 5 - Samphire Open Low Heath
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till December

Site 6 - *Bolboschoenus caldwellii* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till mid summer

Site 7 - *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till ?mid summer/all year

Appendix 2:
Flora from sites 1 -3 and opportunistic records made by the System 6 Update field team.

Key

Column 1 Family

Column 2 Taxon
Names follow Gibson *et al.* (1994). A * preceeding the name indicate a weed while # preseeding the name indicates an opprrtunistic record.

Columns 3 - 7

Column 3 =	W =	Bennett Brook
Column 4 =	WF	Wet flats along Bennett Brook
Column 5 =	Us	Upland, sands
Column 6 =	Uc	Upland, clay
Column 7 =	D	Drainage line into Bennett Brook

	W	WF	Us	Uc	D
FERNS					
# Azolla filicoides	•				
FLOWERING PLANTS					
Anthericaceae					
# Caesia micrantha (blue flowered form GJK 10857)			•		
# Chamaescilla corymbosa			•	•	
# Thysanotus dichotomus			•		
# Tricoryne elatior			•	•	
Apiaceae					
Apium prostratum		•			
# Homalosciadium homalocarpum			•		
Araceae					
* Zantedeschia aethiopica		•			
Asteraceae					
* Aster subulatus		•			
Cotula coronopifolia		•			
* Lactuca serriola		•			
Pogonolepis stricta		•			
* Sonchus oleraceus		•			
Callitrichaceae					
* Callitriche stagnalis		•			
Casuarinaceae					
Casuarina obesa		•			
Chenopodiaceae					
# Halosarcia halocnemoides		•			
Halosarcia lepidosperma		•			
Halosarcia pergranulata		•			
Sarcocornia quinqueflora		•			

	W	WF	Us	Uc	D
Cyperaceae					
Baumea juncea		•			
Bolboschoenus caldwellii		•			
Carex appressa		•			
Carex tereticaulis		•			
Chorizandra enodis		•			
Cyperus polystachyos		•			
Isolepis cernua		•			
Lepidosperma longitudinale		•			•
Dasypogonaceae					
# Lomandra micrantha			•		
Droseraceae					
# Drosera erythrorhiza			•		
Frankeniaceae					
# Frankenia pauciflora		?•			
Gentianaceae					
* Centaurium sp.		•			
Goodeniaceae					
# Dampiera alata					•
Haemodoraceae					
# Haemodorm simplex			•		
Iridaceae					
* Babiana disticha		•			
* Gladiolus undulatus		•			
* Hesperantha falcata		•			
* Romulea rosea		•			
* Sparaxis bulbifera		•			
Juncaceae					
* Juncus bufonius		•			
Juncus kraussii		•			
Juncus pauciflorus		•			
Juncaginaceae					
Triglochin centrocarpum		•			
Triglochin mucronatum		•			
Triglochin procerum		•			
Lemnaceae					
# Lemna disperma	•				
Lobeliaceae					
Lobelia alata		•			
Lythraceae					
* Lythrum hyssopifolia		•			
Menyanthaceae					
# Villarsia sp	•				

	W	WF	Us	Uc	D
Myrtaceae					
# Eucalyptus calophylla			•	•	•
Eucalyptus rudis		•		•	
Melaleuca preissiana					•
Melaleuca rhaphiophylla	•	•			
Melaleuca viminea		•			
# Verticordia densiflora				•	
Mimosaceae					
# Acacia dentifera		•			
# Acacia pulchella			•	•	
# Acacia saligna		•	•	•	
Onagraceae					
Epilobium billardierianum		•			
Orchidaceae					
# Microtis unifolia			•		
# Thelymitra campanulata			•		
Papilionaceae					
# Gompholobium marginatum					
# Hardenbegia comptoniana			•		
* Lotus angustissimus		•			
# Viminaria juncea		•	•		
Poaceae					
Agrostis sp.		•			
* Briza minor		•			
* Cynodon dactylon		•			
Danthonia caespitosa		•			
* Hordeum geniculatum		•			
* Lolium rigidum		•			
# Neurachne aleopecuroidea				•	
* Paspalum dilatatum		•			
* Polypogon monspeliensis		•			
# Stipa tenuifolia			•		
Polygonaceae					
* Rumex crispus		•			
Primulaceae					
Samolus junceus		•			
Proteaceae					
# Hakea prostrata					•
Stylidiaceae					
# Stylidium bulbiferum				•	
# Stylidium piliferum			•		
Typhaceae					
Typha domingensis	•	•			
#* Typha orientalis	•				

Bennett Brook Baseline Study of Flora and Fauna

A National Land Care Community Project
funded under the One Billion Trees
and Save The Bush Programs 1994-95

Edited by K. Pearson and C. Tedeschi

Success Hill Action Group Inc.
Bassendean, December, 1996
Published in WA, 1999

BFF305 (120)

Cover: Bennett Brook Wetland, Caversham

Courtesy Tim Larcombe

This photograph shows the location of the Bennett Brook Wetland in relation to Waugal's Bend, on the Swan River at Success Hill Reserve, Bassendean and the City of Perth 12km away. This photograph also illustrates why integrated catchment management is essential for the protection and management of valuable conservation areas.

CONTENTS

APPENDICES

LIST OF MAPS

FIGURES

FOREWORD

We sincerely acknowledge and thank National Landcare for funding this Community Project under the One Billion Trees and Save the Bush Program 1994-1995. We would like share with you the sequence of events which the Community members experienced in bringing this project to completion.

The initial twelve month setback to data collection happened on Christmas day 1994 when a bushfire spread from Success Hill Reserve through the study area and up to the Nyungah Community boundary.

During 1994 -1996 the Community groups worked on the project whilst also writing submissions to prevent further environmental impact on the study area. The Community was opposed to the Perth-Darwin National Highway and the Ellenbrook Development Plan. These major developments pose serious long term threats to the environmental and social/cultural integrity of the Bennett Brook wetland and the Swan River.

At a subsequent public meeting, members of the Community initiated and supported the formation of the Bennett Brook Catchment Group (BBCG).
Members of the Community have since invested time and energy in establishing and implementing the aims of BBCG. These have included the implementation of revegetation, fire management, water testing, establishing the Bennett Brook Environmental Centre, Community Education, and a Fish Survey.

During the past fifteen months, the local Community has actively fought to prevent a proposed development plan to locate a women's minimum-security prison on the Pyrton land, adjacent to the Study site.

The wider community has given their support for the concept of an environmental and cultural centre to be located on the Pyrton site.

Public awareness has been raised as to the ethnographic and environmental significance of the Bennett Brook area.

The outcomes from the original funded project have had far reaching effects.
We look forward to the fruition of the aspirations of this Community, that is, the protection of the natural and cultural heritage of this unique wetland system.

The Fight to Save Bennett Brook

It is all that is left of
part of the occupation
of a nation
for forty thousand years
The brook now bears
an alien name
The sound of trucks
and whorls of dust bring shame
and paint phantom figures
in the air
and strain and anguish shows
on the faces of those
the remnants standing there
We are but swamp reeds
standing in the sun
but resilient
bending with each blow
as each day is run
And we will tell to all
this too is their need
then we will proudly show
to all the world what we have done

Jack Davis, 1992.
Published in Black Life, University of Queensland Press

Lord Street Rally, 1994. Photograph C. Tedeschi

INTRODUCTION

Discussion among local groups revealed a common concern about the effects of further urbanisation on Bennett Brook, a remnant bushland in the Perth metropolitan region, adjacent to the Swan River.

This resulted in the Success Hill Action Group, Bassendean Preservation Group and Swan Valley Nyungah Community decision to support an application for a community grant after investigation showed that only a few studies have been done on Bennett Brook. While the wetland area of Bennett Brook had been classified and mapped by La Provst et al (1987) and studied by Arnold (1990) no other plant or fauna identification studies were found.

The Bennett Brook Project was funded under the National Land Care (NLC) One Billion Trees and Save The Bush Community grants in September 1994 to collect data on the flora, vertebrae fauna and water quality of the study area. Members of the above mentioned community groups coordinated or participated in various parts of the project. Many professionals working in areas related to aspects of this project also contributed. The successful completion of this project would not have been possible without the support of these people and their departments or organisations.

Project Aims

- Study the flora and vertebrae fauna of the System 6 Area of Bennett Brook south of Benara Road Caversham.

- Monitor the quality of water flow into Bennett Brook and the Swan River.

- Make recommendations for a management plan to preserve, protect and lead to the restoration of the flora and fauna of the project area.

As the project progressed it became increasingly obvious that to implement project recommendations it would be necessary to form an Integrated Catchment Management Group. The outcome of a public meeting sponsored by the Office of Catchment Management in November 1995, and organised by members of the NLC project group, has resulted in the formation of the Bennett Brook Catchment Group (BBCG). Community and government cooperation will be necessary to preserve this magnificent wetland /bushland site for future generations.

This report consists of a number of sections, which provide background information about the study area, the flora and fauna studies and water testing program. The collection of valuable data on flora, fauna and water through the Bennett Brook NLC Project and the formation of the BBCG is due to the support which the project has received from many people and organisations committed to its preservation.

Acknowledgements

The coordinators of the Bennett Brook NLC Project gratefully acknowledge the following individuals, landowners, leasees and organisations for their expertise assistance, and time given to this project.

Geoff Addison
Jan Addison
Mike Bamfield
Lisa Buckelton
Robert Bropho
David Brown
Bevan Carter
Jenny Carter
Norah Cooper
Michael Cooper
Mark Cowan
Lucy Crake
Jack Davis
John Dell
Andrew Delmarco
Jim Dixson
Judi Evans
David Gardiner
Anne Goodhue
Harry Gratte
Judith Hamersley
Gillian Harris
Anne Hollingsworth
Val Humphrey
Margaret Jeffery
Bromwen Keighery
Tim Larcombe
Greg McClelland
Eric McCrum
Neil McMurtrie
Peter Melling
Margo O'Byrne
Kaye Pearson
Peter Pearson
Greg Peterson
Nicola Peterson
Paul Rieffer
Helen Rose
Theresa Rowan
Ray Schultz
Zan Talbort
Clelia Tedeschi
Natalie Thorning
Ron Van Delft
Dorothy Van Wees

Bassendean Preservation Group
Bassendean Town Council
Bristile Tile Pty Ltd
Department of Land Administration
Disabilities Service Commission
Ministry of Planning Western Australia
Royal Australian Ornithological Union WA.
Swan River Trust
Success Hill Action Group Inc
Shire of Swan
University of Queensland Press
Waters and Rivers Commission

EXECUTIVE SUMMARY

Bennett Brook is a significant environmental resource, which should be managed to preserve and protect the wetland and adjacent buffer areas for future generations. This project has highlighted the need to preserve, protect and restore not only the study area but also the whole of Bennett Brook from its source in Whiteman Park to where it enters the Swan River - Canning Estuary adjacent to Success Hill Reserve at Bassendean.

Bennett Brook is the largest remaining and most relatively intact lagoonal system on the Swan-Canning River Estuary (L. Penn, 1996, personal communication). It is a significant conservation area for fauna, flora and Aboriginal spiritual and cultural heritage. The continued maintenance of water quality and water levels is also essential for the health of the wetland and the Swan River.

Flora

- Bennett Brook south of Benara Road has a significant co-occurence of samphire species on the Swan Coastal Plain (L. Penn, 1996).
- Species Sarcornia blackiana is only known on one other location of the Swan River (L. Penn, 1996).
- The presence of species Juncus paurciflorus, found in Bennett Brook, has only previously been recorded in one other area of the Perth Flora Region for the Serpentine River (Kieghery, Kieghery and Gibson, 1994).
- Of research conducted to date the greatest development of floristic groups associated with lakes, creeks or rivers on the Swan Coastal Plain occurs in Bennett Brook south of Benara Road.

Fauna

- Most of the land along the edge Bennett Brook to Horse Swamp has been cleared over grazed and is subject to urbanisation. The remaining riverine bushland along its length is an important transit corridor for fauna between the Swan River and the conservation reserves, especially Ellen Brook (J.Dell, 1996) to the north of Whiteman Park.
- The study area has a population of the gazetted Scheduled 1, rare and endangered Quenda (J. Dell, 1996).
- Five species of native fish of the Swan Coastal Plain, which are declining in numbers,were identified in the project area. (J. Dell, 1996).
- Bennett Brook has seven species of frogs. This is a moderately rich frog fauna for a coastal plain wetland (J.Dell, 1996).

- The lizard fauna of Success Hill/Bennett Brook is rich with nine species of skink lizards. one of which, the Swamp Skink is now rarely recorded on the Swan Coastal Plain (How and Dell, 1994) and the presence of Gould's Monitor lizard which is also rarely found in the Perth metropolitan area.

- The study area has conservation significance for birds associated with the extensive swamp system on the eastern side which consists of wooded wetland, Casuarina obesa and Melaleuca rhaphiophylla and Viminaria tall shrublands which are now relatively rare on the eastern side of the Swan coastal Plain (J. Dell, 1996). The swampland is significant feeding and roosting area for many species of birds especially herons, cormorants and ducks. (Dell, 1996).

- Van Delft (1996) and J. Dell (1996) both found that the Bennett Brook study area's conservation value also lies in the diversity of waterbirds and occurrence of habitat specific insectivorous passerines which have become less common in the Perth Metropolitan area. Insectivorous passerines such as the Grey Shrike-thrush, Splendid Fairy-wren, White-winged Fairy-wren, White-browed Scrub Wren, Inland Thornbill and Yellow-rumped Thornbill were all recorded at Bennett Brook (Van Delft, 1996).

- Bennett Brook is also the nearest location to Perth where species such as the Splendid Fairy - wren and Grey Shrike-thrush has been recorded.

- In all out of 174 species of birds recorded in the Perth metropolitan region 100 species were observed in the Bennett Brook area during this project. Thirty-eight species were waterbirds. The number of waterbird species regularly recorded on 75% or more of surveys at any site (Appendix 4) indicates a medium to high level of waterbird diversity (Van Delft, 1996).

- Out of 57 wetlands in Perth metropolitan area by number of waterbird species Bennett Brook ranks equal ninth in that list (Van Delft, 1996).

- Bennett Brook is an important site for the Yellow-billed Spoonbills and significant in the context of the Perth metropolitan region as only two other sites in the Perth Metropolitan Bird Project recorded Yellow-billed Spoonbills on more than 50% of surveys (Van Delft, 1996).

- While the data collected is different to other locations around Perth the record of 23 species of nesting and young birds in the areas indicates that Bennett Brook has conservation value for breeding.

- Other species uncommon in the Perth metropolitan area recorded at Bennett Brook included the Red Capped Robin, Glossy Ibis and Chestnut Teal.

Aboriginal Spiritual and Cultural Heritage

- Bennett Brook, Success Hill Reserve and the land adjacent to the Swan River have spiritual and cultural significance for Aboriginal people.

- The Nyungah Spiritual belief is in the whole of the land.
  The Waugal Dreaming is very old dreaming (R. Bropho, 1996).

- As keepers and custodians of the land the Nyungah people have the knowledge and right to be considered to ensure that their spiritual, cultural and environmental heritage is understood, protected and survives.

- Our generation and those who follow in the future need to be taught to appreciate and protect all aspects of the environment of Bennett Brook and Success Hill Reserve.

Water Quality

- Ongoing water monitoring within the Bennett Brook region is vital to ensure the maintenance of ground water and surface water quality. This includes monitoring of nutrients, contamination and investigating other long term environmental effects associated with the urbanisation of sensitive wetlands, waterways, and river systems.

Future Management of Bennett Brook

- Bennett Brook's unique lagoonal environment is the ecological habitat of a diverse bird population, and other fauna, some of which are rare in the metropolitan region. The vegetation within Bennett Brook, System 6 sustains the wildlife and provides a corridor that reaches beyond Whiteman's Park.

Crown Land

The future use of highly significant adjoining parcels of land such as Pyrton must be carefully considered in future planning. In the interests of the wetland ecological system and its connection to Perth's river and groundwater systems, it is recommended that this land be allocated to community uses. Urbanisation or other environmentally insensitive uses of this land would have long term disastrous effects upon water quality, the natural and cultural environments, and associated wildlife. Suitable buffer zones must be allocated to avoid detrimental effects of adjacent land use on Bennett Brook. The buffer zone issue should be legislated.

Bennett Brook entering the Swan River at Success Hill, Bassendean.
Photograph: K Pearson.

1 BENNETT BROOK AND SUCCESS HILL RESERVE

Kaye Pearson

Bennett Brook is a unique wetland. The extensive Melaleuca swamp with its fringing remnant vegetation provides a natural corridor and link between Whiteman Park to the north and the Swan River at Guildford. The elevation of the land to the western side and north east, with its rural zoning form part of the natural boundary of the Swan Valley and contributes to the picturesque outlook when entering the Valley from Benara Road or West Swan Road.

The adjacent area of Success Hill Reserve on the Swan River is part of the river's landscape. For thousands of years Bennett Brook and Success Hill Reserve have been significant cultural and spiritual grounds for Nyungah People.

Bennett Brook and Bennett Brook (M41) the System 6 reference name refer to the permanent creek channels (Bennett Brook and Preston's Creek) and the remnant wetland (also known locally as Grogan's Swamp) which connects Horse Swamp and Mussell Pool to the wetland and Swan River. Local, interstate and international visitors who visit Whiteman Park also enjoy Bennett Brook. Bennett Brook is the name given to the catchment area which drains via Bennett Brook into the Swan River. This catchment role is expected to increase as further urbanisation occurs in the north east metropolitan region of Perth.

Location And Landownership

The study area for this project is the portion of Bennett Brook which lies south of Benara Road, Caversham and the adjacent bushland area of Success Hill Reserve. This reserve joins Bennett Brook as it meets the Swan River. Bennett Brook south of Benara Road is bound by Lord Street to the west, Success Hill Reserve and the Swan River to the south and West Swan Road to the east. Harper Street provides access to the Bristile Tile factory and the Brook on the eastern side.

The study area, shown on the aerial photograph, Map No 1, is located in two local government areas. The continuation of a line drawn from Morley Drive on the western side along the boundary of Pyrton to Bennett Brook forms the local government boundary between the Swan Shire Council and Town Council of Bassendean.

The land ownership of the study area within the above named roads and the river includes land vested in the Disabilities Service Commission of Western Australia,

Ministry For Planning, Swan Shire Council, Swan Valley Nyungah Community, Bassendean Town Council and individual landowners and leaseees. Under the Metropolitan Regional Scheme the Bassendean Town Council is responsible for Success Hill Reserve. The small park on the northern side of the study area between Valley Estate and Bennett Brook is the responsibility of the Shire of Swan. The future of the Disabilities Service Commission of Western Australia Pyrton Training Centre site is unknown. Its operation as a training centre has ceased and various groups currently work from the existing buildings. In 1995 the whole Pyrton site was claimed by the Swan Valley Nyungah Community as being under the Traditional First Law of the Land and International Law (Appendix A).

State Legislation And Policies

Many wetland areas are protected by a number of State and Commonwealth government laws and policies. Success Hill Reserve and Bennett Brook itself is a registered Aboriginal Site as is the entire study area, within which are separate Registered Aboriginal Sites. The importance of the area to Aboriginal people is discussed in Chapter 2 *The Last of the River People*.

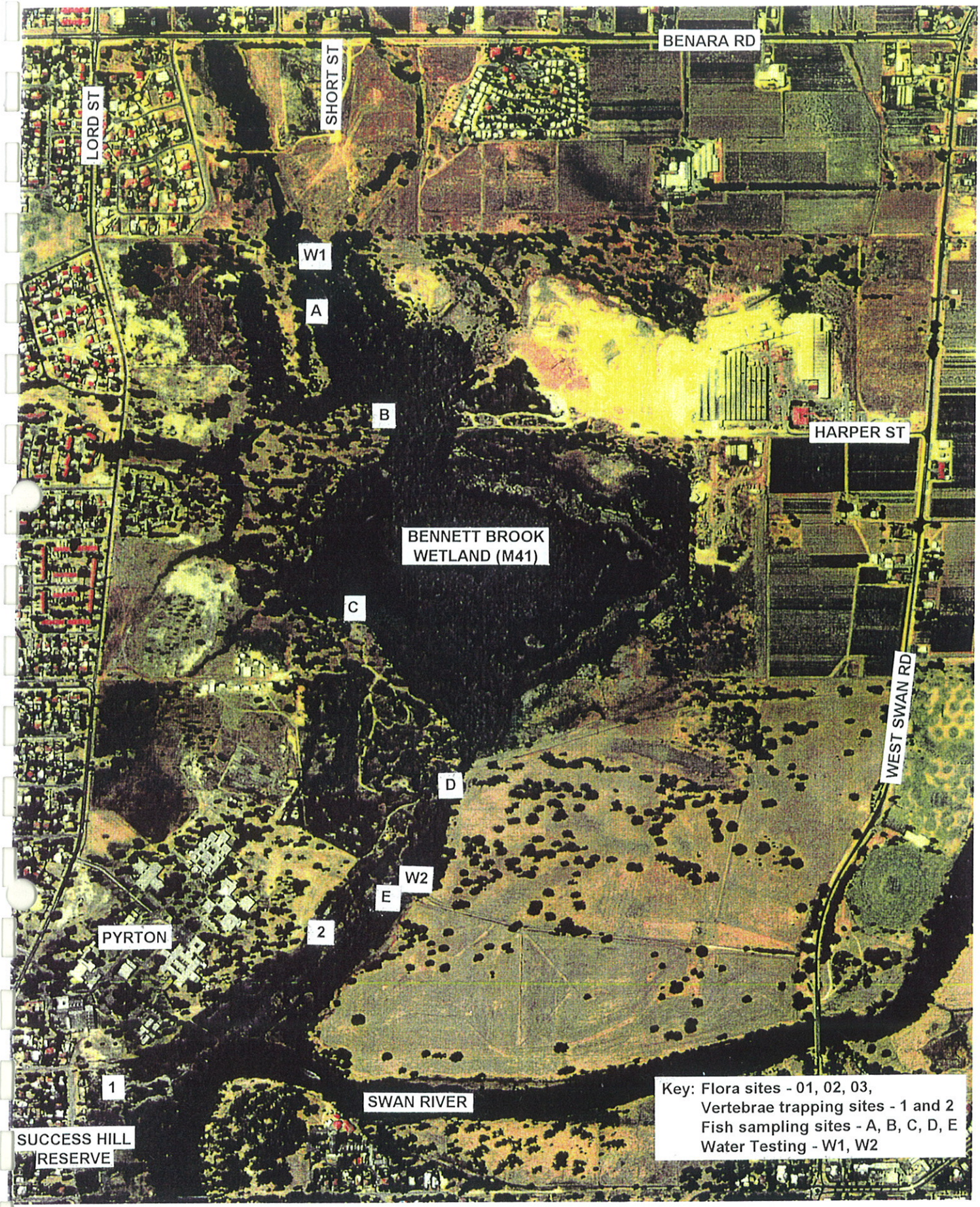
The next part of this report describes legislation and policies which apply to the subject area and/or Bennett Brook as a whole in a historical manner, with sub headings, to highlight some the issues which are under revision or to date remain unresolved.

System 6

The total Bennett Brook (M41) System 6 area extends from the Swan River to Whiteman Park and covers an area of approximately 218 ha (Department of Planning and Urban Development, 1994). The EPA made two specific recommendations for Bennett Brook in the Darling Range - System 6 Conservation Reserves in 1986. Recommendation M.41 advised that planning and management of Regional Parks be applied to this area. Recommendation M.41.2 endorsed ...

> the Metropolitan Regional Planning Authority's proposal to reserve Bennett Brook and adjoining significant environmental areas, including its flood plain, as a continuous link from Whiteman Park to the Swan River. (Department of Conservation and Environment Western Australia, 1993 p 215).

The Parks and Recreation Reservation (Recommendation M41.2) for Bennett Brook was implemented to enable the conservation of both environmental and cultural values, water quality control, protection of environmentally sensitive flora and fauna, and the prevention of injury or desecration to the areas considered important



Map 1 Aerial photograph of the Success Hill/Bennett Brook area showing locations of flora quadrats and vertebrae trapping sites

Aerial photograph project 940900, Metro Regional Area, WA 3498(c), run 13, photo 5234 reproduced by permission of DOLA.

to the Aboriginal people (Metropolitan Regional Scheme Amendment No 626/33 Perth: Western Australia May, 1987, p11).

The Parks and Recreation zoning and System 6 reservation recognises Bennett Brook (M41) is a natural regional recreation, open space and conservation area.
One of the Department of Planning and Urban Development (now the Ministry of Planning) proposed objectives for the North East Corridor Structure Plan is to implement System 6 recommendations (Department of Planning and Urban Development, 1994, p 86). As yet no plans have been drawn up to include Bennett Brook in a regional park ...the Swan River Management Strategy, recommends that all foreshore reserves and waterways of the Swan and Canning Rivers be treated as a single entity for the purpose of planning and management. (The Environmental Protection Authority, 1993, *Status Report,* p76). Map No 2 shows the Swan River Trust Management area and the System 6 area for Bennett Brook south of Benara Road.

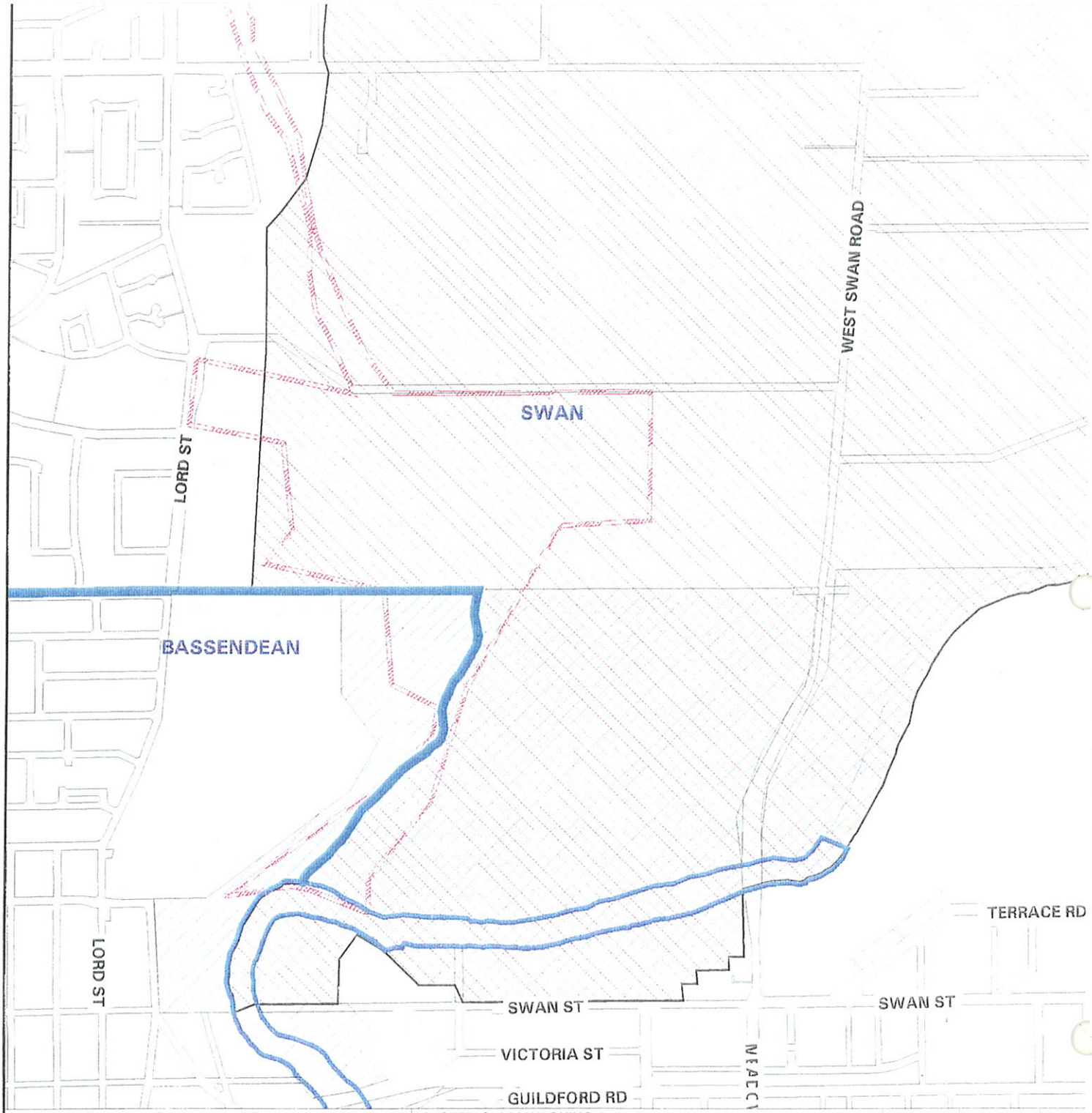
In 1995 the Department of Environmental Protection commenced a two year program to update the EPA System 6 recommendations. Data gathered from the Bennett Brook project will be submitted to this program.

Swan Valley Legislation 1994

The Swan Valley Planning Act 1994 defined the area of the Swan Valley. Under this act most of the Bennett Brook M.41 System 6 area is included in the Rural B Planning Area of the Swan Valley Planning Area (see Map No 2). The Swan Valley Planning Bill 1994 established a committee to advise on or determine objectives for land use, planning and development in the Swan Valley Planning Area. The Planning Objectives for Area B aim to promote and retain the character of the valley through the protection of viticulture, by maintaining the landscape, rural and traditional activities of the Swan Valley.

Metropolitan Rural Policy

The Metropolitan Rural Policy Statement (December, 1995) identified the northern properties that join Bennett Brook as both being rural land and part of the land recommended to be kept as a rural landscape and conservation area in the Perth Metropolitan Region. Yet the MRS Amendment No 974/33 April, 1996 sought to rezone the land (Lots 12, 13, and 14) adjacent to the Bennett Brook Project study area from Rural to Urban. However this zoning was subsequently rejected.



System Six Reserves : Department of Environmental Protection.

STREETS : Main Roads Department of W.A.

LOCAL AUTHORITY BOUNDARIES : Australian Bureau of Statistics

Cadastre : Dept. of Land Administration, Western Australia

SWAN RIVER TRUST BOUNDARY
Supplied by the Swan River Trust and Waterways Commissions.
Captured by the Ministry for Planning, Perth, Western Australia

Swan Valley Planning Act : Ministry For Planning Perth, W.A.

SYSTEM 6 *** WARNING ***
The DPUD North West Corridor Structure Plan (1993) adopted modifications to the boundaries of M1 and M3. These changes have not yet been absorbed into this cover, pending discussions with EPA.

SWAN RIVER TRUST BOUNDARY
This data should only be used to establish whether a referral to Swan River Trust is required for statutory applications. The data should not be used as an accurate definition of the Swan River Trust Management Area which is yet to be accurately defined by that authority.

Swan Valley Planning Act *** WARNING ***
Any use of this data should be referred to the Author(s)
- Nick Leong / Ian Patterson

EPA System 6 Boundary

Local Government Areas - Metro

Street frontage

Water

Swan River Trust Management Area

Swan Valley Planning Act 1995

Ministry for Planning
WESTERN AUSTRALIA

Map Ident: plot960416_3

0 250 m

Map 2 Bennett Brook Management & Policy Areas

Bennett Brook

Management and

Policy Areas

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Prepared by: lisa buckston	Prepared for: Nationa
Date: 16 Apr 96	Scale 1:10000

Geological Formation And Environmental Units

The Swan Coastal Plain as we know it today formed on top of Mesozoic and Paelozoic marine sediments (sandstone, shale and siltstone) which were deposited between 65 - 400 million years ago when the Perth Basin was covered by shallow seas. The Perth Basin extends from Cape Leeuwin in the south to the Canarvon Basin in the north. On the eastern side the Perth Basin extends as far as the Precambrium Yilgarn Block. The Darling Scarp Fault line separates these old crystalline rocks from the Swan Coastal Plain. The Bennett Brook project area is located on the central section of the Swan Coastal Plain where the Pinjarra Plain and Bassendean Sands intersect on the northern side of the Swan River, about 9.5 km from the Darling Scarp to the east and about 20 km from today's coastline to the west at Scarborough. The Pinjarra Plain and Bassendean Sands, Quindalup and Spearwood Dunes are each geomorphic units of the Swan Coastal Plain formed from sediments that are the result of marine, aeolian (wind) and alluvial (riverine) deposition (Balla, 1994).

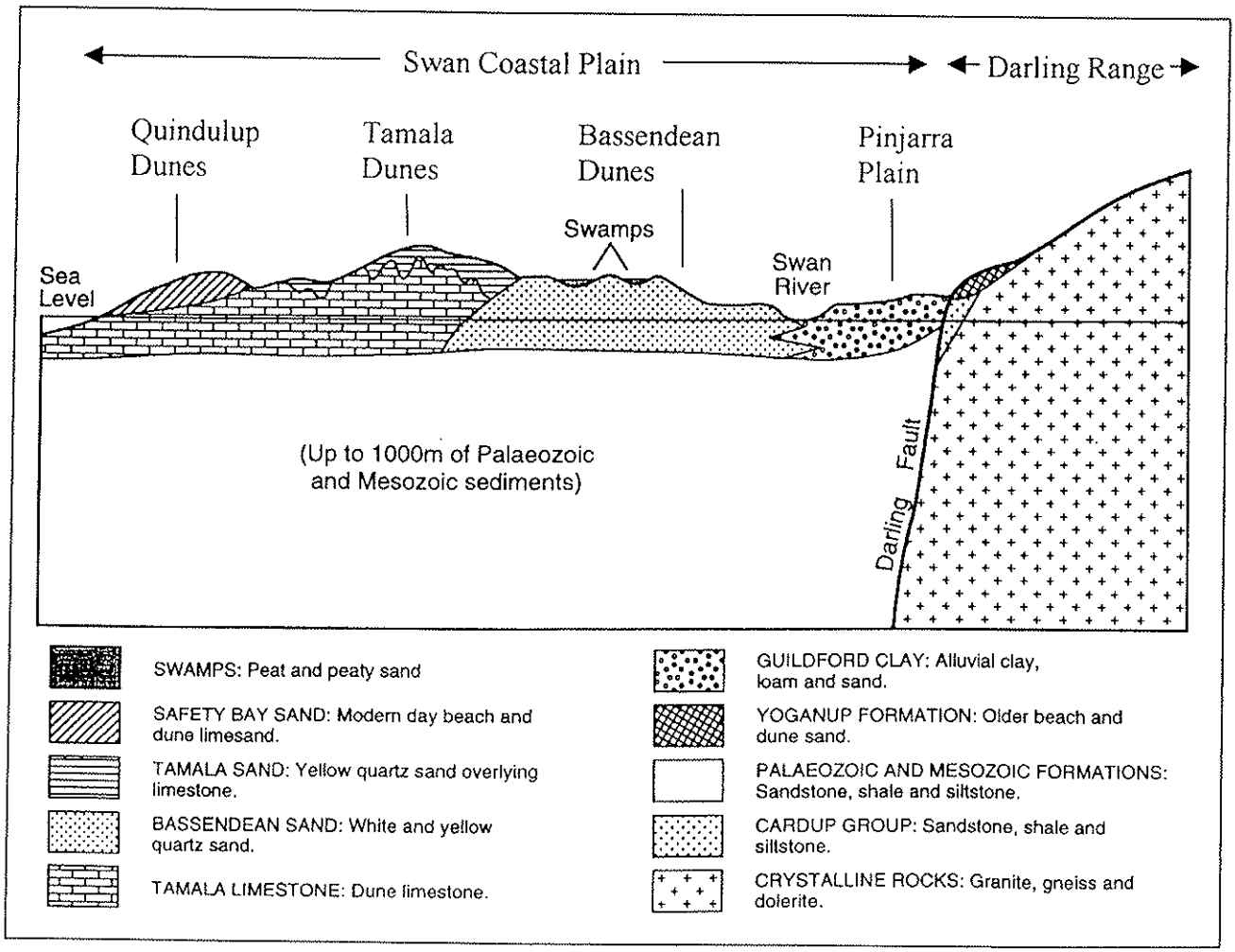
The geological structure of the Perth metropolitan region shown in Figure 1 can be traced back to when Australia was part of Gondwanaland over 500 million years ago. The crystalline rocks of the Darling Scarp and land to the east (the Darling Ranges and Yilgarn Block) are over 2600 million years old. Millions of years ago while Australia and the other continents of India, Africa, South America and Antartica were separating from Gondwanaland and each other, the earth's surface was not very stable. There was a lot of land movement, changes in climate and sea levels. The Continental Drift Theory explains how Australia was once part of Gondwanaland. The drift of the Australian continent and events such as the Ice Ages contributed to the climate changes and changes in sea levels which shaped the landforms of the Perth metropolitan region.

The Darling Fault line is a very old fault line. Land along the eastern side of this fault line generally continued to rise while land on the western side slowly subsided and was covered with alluvial sediments and soils. The main subsidence of the Perth Basin took place from the middle of the Triassic to the Lower Cretaceous period (Seddon, 1972). Other minor fault lines also occur in the Perth Basin. Detailed studies of the stratigraphy of the Perth Basin reveal that the minor fault lines have moved sections of the central Swan Coastal Plain. These details are not shown on the generalised cross section of the geological structure of the Perth metropolitan region provided in Figure 1.

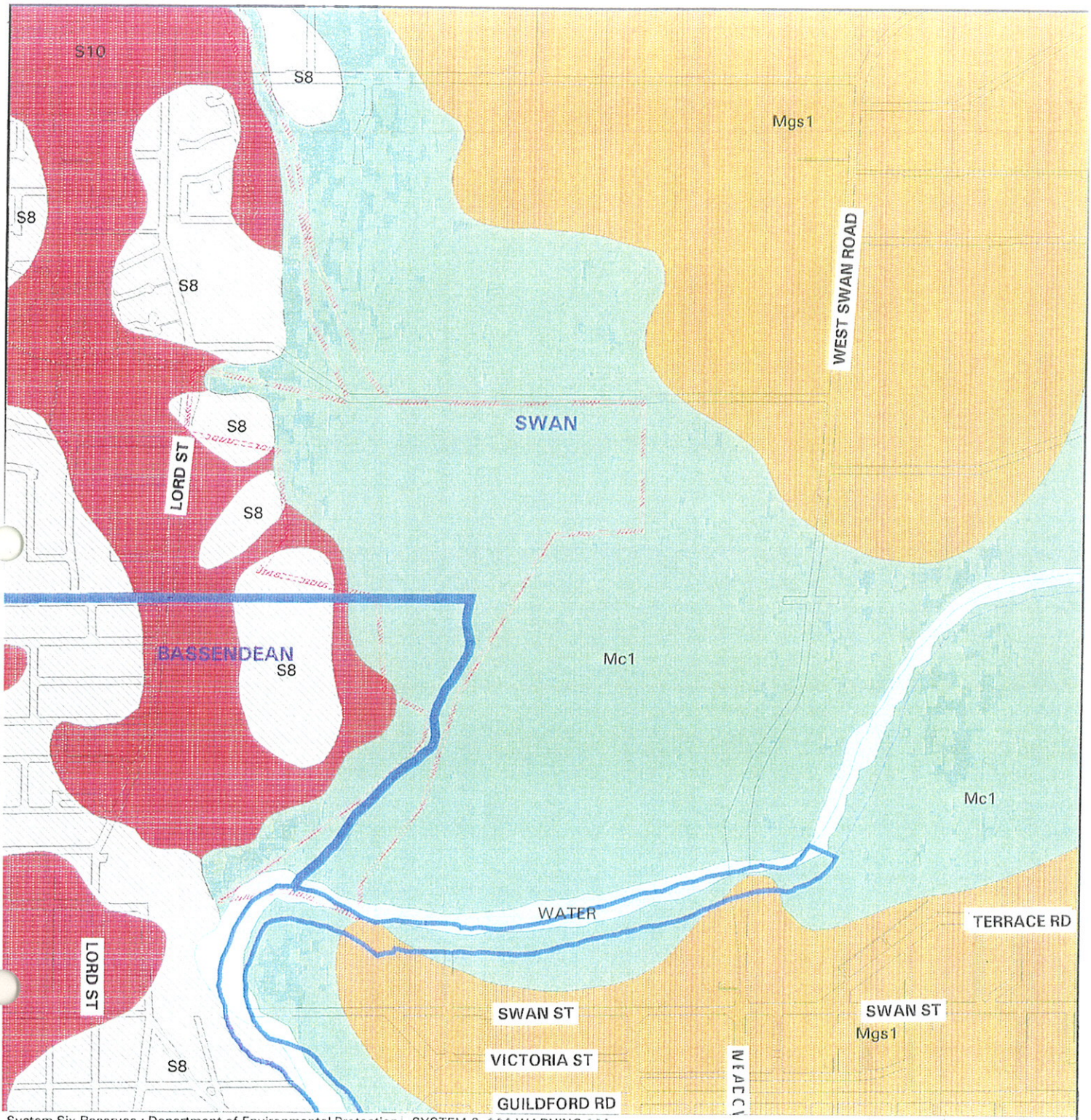
The sea once covered all of the Swan Coastal Plain as far inland as the Darling Scarp during the Tertiary and Quartenary Periods (Davidson, 1995) between 65 - 2 million years ago. The Yoganup Formation is a very eroded beach deposit which overlies older sandstone shale and siltstone. The Pinjarra Plain is a piedmont and valley flat alluvial plain predominantly of clayey alluvium that has been transported from the Darling and Dangaragan Plateaus (Davidson, 1995). When the sea retreated about 240 000 years ago (Balla, 1994) the streams deposited sediment and formed alluvial fans at the base of the scarp on top of the Mesozoic and Paelozoic marine sediments. These fans built up and coalesed into the Pinjarra Plain.

The Bassendean Dune Systen today consists of a low aeolian (windblown) sand plain. The dunes probably accumulated as shoreline deposits and coastal dunes during interglacial periods of high sea level and originally consisted mostly of lime sand with quartz sand and minor fine-grained, black heavy mineralisation (Davidson, 1995). Most of these aeolian deposits have been completely leached to form the Bassendean Sands which are pale grey porous fine to medium quartz sands. These sands are found in the Bassendean Sand Unit shown on Map 3. Bassendean Sand S8 indicates the thicker deposits of sand which developed near the dunal crests and Bassendean Sand 10 are thinner sand deposits of the dunal trough. The Bassendean Sands are between 10 -14 000 years old.

Figure 1 Generalised cross section of the geological structure of the Perth Metropolitan Region.
(Public Affairs Branch, Department of Minerals and Energy Western Australia 1996)



Map No 3 shows that the study area has three main Environmental Geological Units, the Bassendean Sands, Alluvium and the Guildford Clay Member. The Alluvium and Guildford Clay Member units occur where the Bassendean Dune System meets with the Pinjarra Plain.



System Six Reserves : Department of Environmental Protection.

Streets : Main Roads Department of W.A.

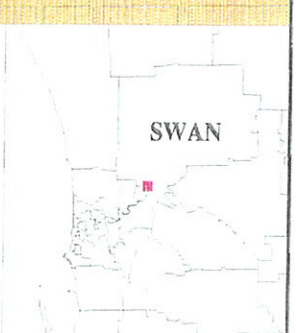
Local Authority Boundaries: Australian Bureau of Statistics.

Cadastre : Dept. of Land Administration, Western Australia

Environmental Geology : Department of Minerals and Energy

SYSTEM 6 *** WARNING ***
The DPUD North West Corridor Structure Plan (1993) adopted modifications to the boundaries of M1 and M3. These changes have not yet been absorbed into this cover, pending discussions with EPA.

ENVIRONMENTAL GEOLOGY *** WARNING ***
Spatial accuracy ranges from 25 to 50 metres.
A new, correct and more extensive version should be available in early 1996.



EPA System 6 Boundary

Local Government Areas - Metro

Street frontage

Water

Mc1 : Alluvium

Mgs1 : Guildford Clay Member

S10 : Bassendean Sand

S8 : Bassendean Sand

WATER :

Bennett Brook

Geology

Ministry for Planning
WESTERN AUSTRALIA

Map Ident: plot960416_4

0 250 m

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Prepared by: lisa buckleton	Prepared for: National
Date: 16 Apr 96	Scale 1:10000

Map 3 Bennett Brook Geology

The Guildford Clay or Guildford Formation found in the Guildford area consists of pale-grey, blue, but predominently brown silty and slightly sandy clay (Davidson, 1995). The Guildford Clay member is also likely to contain shelly sand in the Swan Valley area (Davidson, 1995) because of its association with older remnant Tertiary to Quaternary dune deposits such as the Ascot and Yoganup Formations. (Davidson,1995). The Guildford Clay Member is a younger formation which overlies the Ascot and Yoganup formations.

The Alluvium unit mostly contains the wetlands and this unit probably formed by the action of the Brook and Swan River flowing, flooding and depositing heavier sediments on most of the floodplain and palusplain areas of Bennett Brook as far as the bank of the Swan River. Main soil types found in the study area have formed as aeolian soils (Bassendean and Karakatta) alluvial soils (Guildford, and Swan) and aeolian over alluvial soils (Southern River). The Bassendean soil association consists of the grey sands of the Bassendean Dune System as previously discussed. The Karakatta soil association are described as yellow sands with limestone at depth (Powell & Keighery, 1995). Bettenay et al. (1960) associates the Karrakatta soils with the easternmost fringe of the Spearwood Dune System. The Southern River association, forming the easternmost fringe of the Bassendean dune system, consists of leached siliceous sandy dunes and numerous sandy and clay swamp flats (Bettenay et al., 1960).

Wetland Classification

Semenuik (1987) devised a local system of classification for wetlands of the Swan Coastal Plain based upon landforms and water permanence (Balla, 1994). Le Provost, et al. (1987) examined the significance of wetlands in the Perth to Bunbury Region and found that Bennett Brook was representative of the consanguineous Bennett Brook (BP/P4) Suites. Wetlands within a given consanguineous suite have similar stratigraphy and developmental history, salinity, hydrological dynamics and origin (Western Australian Water Authority, 1995).

Wetlands of the Bennett Brook (B/P4) Suite have the following characteristics.

Geomorphic setting:	Bassendean, Pinjarra transition or Bassendean with fluvial features.
Stratigraphy:	Quartz sands, or clay overlying quartz sand.
Origin:	Depressions which intersect the water table. Precipitation is ponded by clay.
Primary wetland:	Sumplands, creeks, palusplain, floodplains

(Le Provost, Semeniuk, & Chalmers 1987, p 27).

Semeniuk (1987) in an evaluation of the wetland found Bennett Brook to have high, significant, regional and state conservation significance. The Western Australian Water Resource Council (WAWRC) also recognised that Bennett Brook was a Regionally significant wetland for the ecosystem maintenance and cultural purposes. Specifically, the WAWRC recognised the Aboriginal significance, scientific and educational value of this wetland.

Arnold (1990) also found the Melaluca swamp to be an example of a swamp on an alluvial plain. The extent of the Bennett Brook wetland (Grogan's Swamp) its floodplain and palusplain is shown on Map No 4.

Arnold (1994, p 376) found Bennett Brook to:

- be a seasonal tributary of the Swan River with a complex water supply which included discharge from Bennett Brook, surface run off from the flood plains, flood events in the Swan River system and groundwater seepage

- contain a total wetland area of 93 ha with a modified wetland area approximately 15.6 ha and 4.4 ha of open water.

The two deep clay pits (which exist from when the area was mined for clay) form the modified wetland area referred to by Arnold. Vegetation has now regenerated around these pits and they are part of the habitat for ducks, swans, fish and the long necked tortoise and reptiles.

Bennett Brook Catchment

The natural water source for Bennett Brook is derived from Gnangara ground water seepage, Mussell Pool and Horse Swamp, Whiteman Park. Horse Swamp is fed mostly by surface run off from Caversham Airbase between June and December each year as the rainfall occurs. As Horse Swamp fills, Bennett Brook flows naturally from about June to December each year.

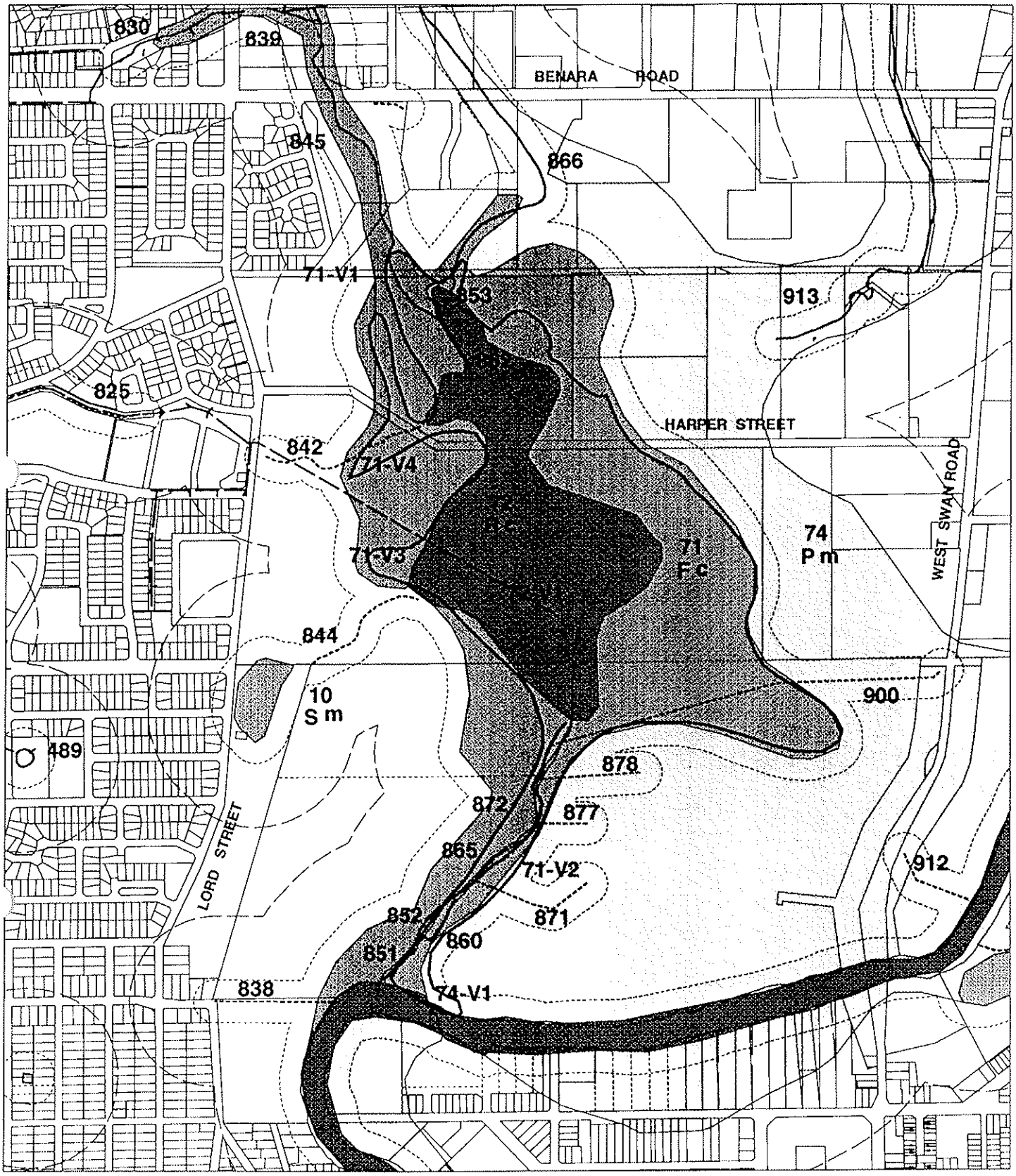
A number of small seasonal streams also drain the surrounding land along the Brook's length from Whiteman Park to Bennett Brook south of Benara Road. Many of these natural creek lines as well as those located in the study area are used by the Water Authority for drainage of Pepperwood (formerly known as Lockridge), Eden Hill, and Ballajura urban areas.

Water now flows all year round from the Wanga Main Drain located just north of Benara Road into Bennett Brook north of the Clay Pits and Grogan's Swamp. Another creek/drainage line drains vineyards and rural land before entering the swamp from the north eastern side. This creek line flows through Lots 12, 13 and 14 Caversham and is the conservation area shown adjacent to Bennett Brook on the

Map 4 Geomorphic Wetland Mapping

Waters and Rivers Commission

WETLANDS OF THE BENNETT BROOK AREA (PART OF MAP 2034 II SE)



BASIN AND FLAT WETLANDS

- lake (permanently inundated), estuary (permanently inundated)
- sumpland, floodplain (seasonally inundated), estuary (peripheral)
- vegetated section of extensive wetland
- dampland, palusplain (seasonally waterlogged)
- vegetated section of extensive wetland
- other basin wetlands

CHANNEL WETLANDS

- River (permanently inundated)
- Creek (seasonally inundated)
- Artificial channel
- Gravity or Pressure Drainage Pipes (metro area)

WETLAND TYPE

L	Lake
CR	Creek
S	Sumpland
D	Dampland
AL	Artificial Lake
F	Floodplain
P	Palusplain
R	River
EW	Estuary (Waterbody)
E	Estuary (Peripheral)
PS	Palustope

PRELIMINARY WETLAND MANAGEMENT CATEGORY

c	Conservation
r	Resource Enhancement
m	Multiple Use
ns	Not Assessed

Note All vegetated sections of extensive wetlands are assigned a Management Category of Conservation

ZONES OF INFLUENCE

- Zone of Critical Influence 50 metre boundary
- Zone of Secondary Influence 200 metre boundary
- Road Boundary
- Property Boundary

WETLAND MAP IDENTIFICATION NOS. EG. 12, 12-V1

Map Identification Numbers have been assigned to each wetland according to their type and method of classification.
Map Identification Numbers less than 300 represent wetlands mapped by the V & C Semeniuk Research Group for the Water Authority.
'V' denotes a vegetated selection of a wetland eg 12-V2

Map Identification Numbers ranging from 301 to 600 have been assigned to basin wetlands (mostly rock pools and dams) and numbers 601 and greater to channel wetlands (rivers, creeks, and artificial channels). Wetlands numbered 301 and greater have been described from complimentary DOLA digital hydrographic mapping.

NORTH

0 0.5 1 1.5 2
kilometres

Water Resources Planning Branch (1993) *Natural Wetland and Resource Map Folios Wetlands and Management and the Conservation Estate Wetlands Map Sheet 2034 11 SE.*

Today the swamp contains a large permanent section of open water. The widest section of the swamp is approximately 800m. The Mary Crescent Drain from Eden Hill and Pepperwood flow into Grogan's Creek as it flows under Lord Street and on into the western side of the swamp. Another natural creek and drainage line also joins Bennett Brook on the south eastern side just before the Brook reaches the Swan River. Map No 4 shows the location of the channels and drains in the study area.

The significance of permanent water in the wetland all year round and its effect on the remnant vegetation in and around the edges of the swamp need to be noted and monitored as urbanisation occurs in the catchment area.

Land Use

Balla (1994) reports that Aboriginal land use was associated with bodies of water for camping, meeting grounds, hunting and food gathering. Fish, birds, long necked tortoise, frogs, fresh water mussels and vegetable foods were found near the wetland areas. Paperbark was also collected because it was a good water proof building material. Large groups appeared to gather around the lakes and swamps of the Coastal Plain in summer and moved back to the hills in smaller family groups during late autumn until spring.

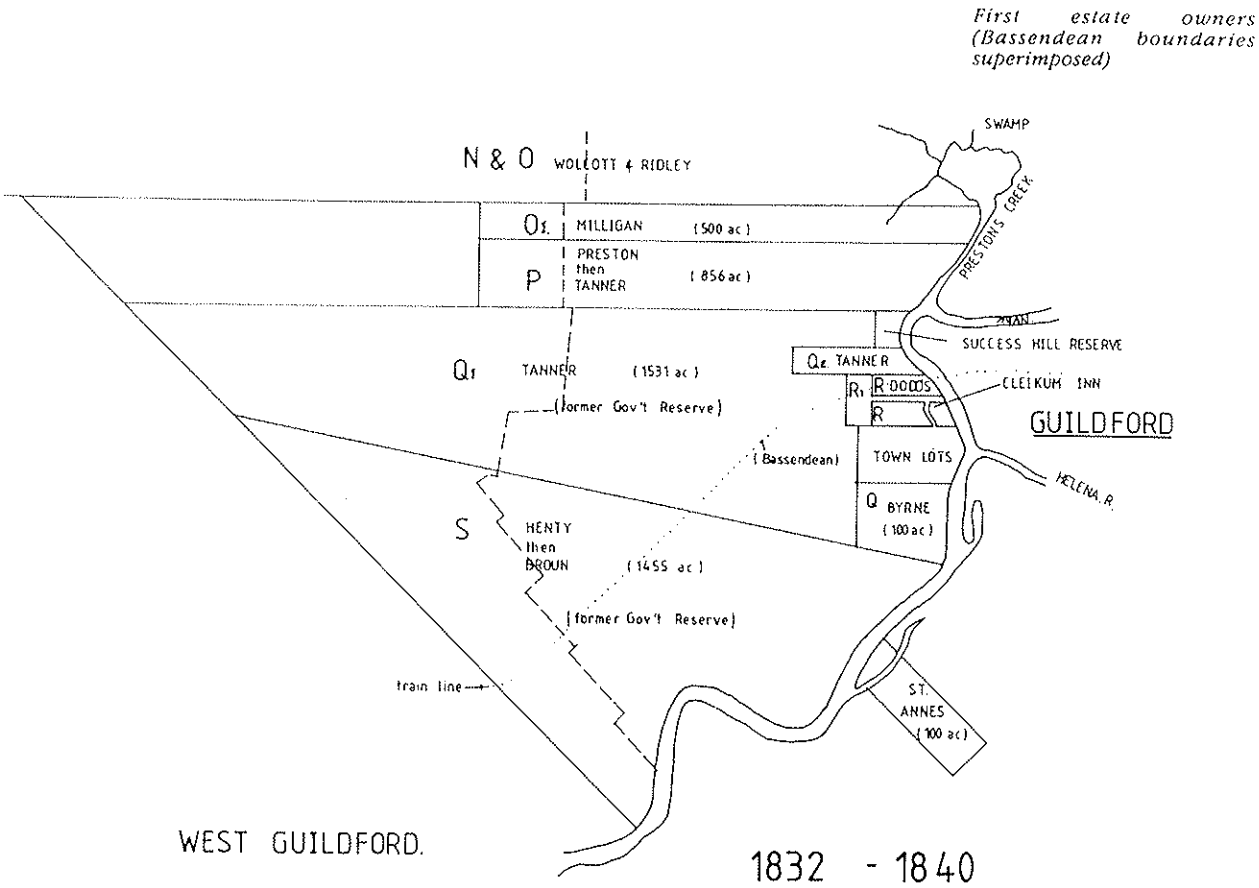
The spiritual significance of the land to the Nyungah people and their association with the land is evident from the numerous registered sites, ancient burial grounds, meeting areas and camp sites throughout the North East Corridor from Success Hill Reserve to Twin Swamps Reserve near Bullsbrook (Chapter 2).

Carter (1986) researched the early history of West Guildford and Bassendean. The following information about the early land use in our study area is documented in Jennie Carter's book, Bassendean A Social History 1829 – 1979.

Stirling and Fraser both noticed that parkland adjacent to the river had been modified probably by Aboriginal use of "fire stick farming" (Carter,1986, p. 16). This method was used by the Aboriginal people for hunting and regeneration of the vegetation. The first farms were established in the West Guildford area about 1830 just after the arrival of the first European settlers to Perth. West Guildford was later renamed Bassendean. The early farmers probably first farmed on the areas that had been partially cleared by use of fire and along the river's edge. Between 1830 - 40 these farmers found it difficult to sustain animal grazing on land away from the small belt of alluvial soil along the river's edge.

By 1841 Swan Location P (1211 ha) - adjacent to Success Hill Reserve had changed hands several times (Map 5). It was first owned by Lieutenant Preston in 1830. William Tanner who was known for his innovative agriculture methods acquired the land in 1832 and established an experimental garden near Preston's Creek (Bennett

Brook). Edward Hamersley purchased the Lockeridge property (Location P) in 1841 and Lot 001 in 1842 which he named Pyrton after the Hamersley family seat in Oxfordshire. Locations N and O were also given the modernised spelling of Lockridge.



Map No 5 West Guildford 1832 - 1840 (Carter, 1886) Courtesy of B. & J. Carter

In the early 1900's Chinese market gardens and fruit orchards were established at Bennett Brook near Pyrton and remained up until about the Second World War. Along with the market gardens, the Chinese gardeners also bred carp in a stream (Bennett Brook) at the corner of Waugal's Bend on the Swan River. In 1955 the Pyrton site was taken over by the Mental Health Services to use as a Training Centre for disabled children taken out of the Claremont Mental Asylum, as it was then known.

Commercial clay deposits existed on the Hamersley Estate - Pyrton locality, which extended as far as the Swan River near Lilac Park The deposit behind the Pyrton Training Centre was mined in latter years of the nineteenth century and the early 1900's. A large brick kiln was located adjacent to the area being mined near the

cutaway behind the current Pyrton site. Mrs Judith Hamersley explained that a miniature railway (for kiln carts) ran from this kiln just below the bluff and along the west bank (just above the high water mark) to the mouth of Bennett Brook, where the bricks were loaded onto barges and transported down the Swan River.

The area between Pyrton and the Swan Valley Nyungah Community now has a series of low clay banks with no top soil on which plants are struggling to grow. This area appears to have been mined although much of the clay for the kiln is reported to have been mined from a from a deep pit on Pyrton. Mining was abandoned from this site when the pocket of suitable brick clay ran out.

In 1962 some of the the Success Hill Reserve area was cleared and sand from this site was used to level part of the Pyrton Training Centre site and build the banks of the Bassendean Oval.

Mrs Hamersley also explained that the filling of the Pyrton site destroyed another wetland area and a natural spring which was located at the back of Pyrton.
Clay was also mined during this century from the clay pits which are located in the north eastern section of the study area. In 1951 Brisbane and Wunderlich purchased Brooke's brickyard at Caversham. This site was one of the last small brickyards in the metropolitan area (Moore 1987). The Caversham tile plant was built on this site and opened in 1953. Today Bristile Tile Pty Ltd no longer undertake any mining on this site and they use the area behind their factory for storage of raw materials.

The land on the south eastern corner of Lord Street and Benara Road has been urbanised and developed. Valley Brook Estate now occupies this area and is separated from Bennett Brook by a road and park on the banks of the Brook. Environmentally sensitive housing is being built by the Aboriginal Community on a small area of their land, which has been returned to Lord Street. A rural village and urbanization planned for land north of Benara Road between Patricia Street and Reid Highway adjacent to Bennett Brook will also impact on Bennett Brook and its wetland unless these impacts are counteracted in some way, because all the the creek lines from these areas naturally drain into Bennett Brook and Grogan's Swamp. All current drainage plans indicate that these creeks and existing drains will take the urban run off to the Swan River via Bennett Brook. The use of other intermediary strategies between the urbanisation areas and the river as yet have not proven that they will cope with nutrient pollution from urbanisation.

Today the land use in and around the Bennett Brook System 6 Area needs to be managed to enhance and protect the fragile remnant bushland and its fauna. Some of the adjacent land is still used for grazing cattle and horses, which need to be fenced off from the edges of the Brook and River to ensure that all of the remnant riparian vegetation in the study area is protected.

Bennett Brook NLC Study Area

Bennett Brook (south of Grogan's Swamp)

Open Water Bennett Brook Wetland (Grogan's Swamp)

Clay Pit (north of Grogan's Swamp)

(Photographs K. Pearson)

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Waugal's Bend, Swan River, Bassendean.
Background Success Hill and Pyrton with Fish Market Reserve on the left, Bennett Brook and the floodplain in the foreground.

Photograph: Courtesy Tim Larcombe

2 THE LAST OF THE RIVER PEOPLE

Clelia Tedeschi

Areas of land within the Swan Valley and Swan Coastal Plain, Ellen Brook, Bennett Brook, Jane Brook, Blackadder Creek and all associated waterways and wetlands have timeless religious and cultural significance for its keepers and protectors, the Nyungah people, who speak of themselves as the Last of the River People.

Social History

The Nyungah Ancestors of the present Lockridge/Success Hill region have connections with many other areas of the Swan Coastal Plains and other parts of Nyungah country, including the Busselton area. The historical association of the Ancestors of the present Nyungah people with this land can be dated from at least the 1890's (Baines,1984). However, this association is likely to be older than white settlement. The presence of human occupation dates back to over 30,000 years (Carter,1986) whilst Pearce (1981) sets the date between 40,000 years minimum, and 100,000 years, maximum.

The Nyungah people of the south-west region have a rich and complex culture.Their social structure is embedded in the spiritual attachment they have to the land (Carter, 1986). This relationship is expressed in their Beliefs, Dreaming Tracks and Songlines which have been handed down and have endured to the present from generation to generation since the beginning of time (R. Bropho, personal communication, March, 1996). The Nyungah people have a reciprocal relationship with the land, their Mother, whom they respect and nurture as she does them. Bropho (1996) states "From the land comes the Law and from the Law comes community living." Another Nyungah elder, affirmed: "We are all Traditional people. We are all Tribal people. We are all Culture people." (Len Culbong, 1989)

The 'Run'

Baines (1984, p.6-8) refers to the 'run' a term used by the south west Nyungahs to describe an area of land within which individuals or families move. These runs relate to stories about sacred places and spirits within the area. Familial experiences that consolidate their understanding of the land are traditionally passed down through family members and so remain within the different family groups. To know these stories equates to being custodians of a particular place and each Nyungah family has its own stories. Any harm which occurs to the Ancestral Spirits of their place will have a negative impact upon the well being of its present day inhabitants. Belonging to a place is central to the Aboriginal people's sense of identity.

Nyungah Settlement after the War and Planning Issues 1980's-90's

Carter (1986) states that many of the Nyungah families who moved back onto Nyungah homegrounds in Bassendean during the 1940's had come from the South Guildford Reserve, (later known as Allawah Grove in South Guildford) before the war. This reserve had been taken over by the military forces to be used as an army camp and so the Nyungah inhabitants had to get out. The Native Welfare Department set up a reserve at Widgee Road, but some of the Nyungah people returned to camp life at Eden Hill (Bropho, 1980). For many of the fringedwellers, the Hamersley family's properties at Pyrton/Lockridge, which included traditional Aboriginal home grounds around Success Hill and Bennett Brook, provided a refuge for over a hundred years (Carter, 1986).
In 1976 the Nyungah people's camps, that is their homes at Widgee Road, Beechboro, were resumed by a housing development of 1,200 residential lots, shops and schools. Hence, the Nyungah community again were made a displaced people disempowered of their rights (McDonald, 1977).

During the 1980's the Nyungah Community has had to be outspoken on a range of proposals that threatened and continue to threaten their spiritual and cultural beliefs. Some examples include the proposal to extend Morley Drive, (State Planning Commission, 1984) the widening and extension of Lord Street, (1994) the proposed route of the Reid Highway (Main Roads Department, 1995) the Bennett Brook Parks and Recreation Reservation (MRS Amendment No626/33, SPC 1986-1987) and other issues such as the SEC gas pipeline, (1983) and a local company's intention to mine clay in Bennett Brook.
In 1995 the Nyungah Circle of Elders voiced their concern to the Government about the planning process which was followed and resulted in an unacceptable style of housing development at Bennett Gardens where the houses were situated less than 30 metres away from the Creek and its Basin. The Nyungah Circle of Elders (1995) reiterated to the Government bodies and developers that the urbanisation and road development in the area of Bennett Brook and its catchment seriously threatened their Religious Beliefs and the cultural and natural environment.
This example typifies how, in contemporary times, the Nyungah Community's consistent requests for their views to be heard and represented in balanced consultation processes go largely unheeded
The Nyungah Community has a strong historical relationship to the area bounded by Benara Road in the south, Lord Street in the west of Bennett Brook, Bennett Street to the east of Bennett Brook and Patricia Street to the north, and Bennett Brook north of Patricia Street and any development in this region will threaten the Dreaming Track of the Waugal. This area is steeped in Aboriginal cultural and spiritual history and it is known to contain classified Aboriginal sites which must be protected.

Spiritual Sites in the North East Corridor

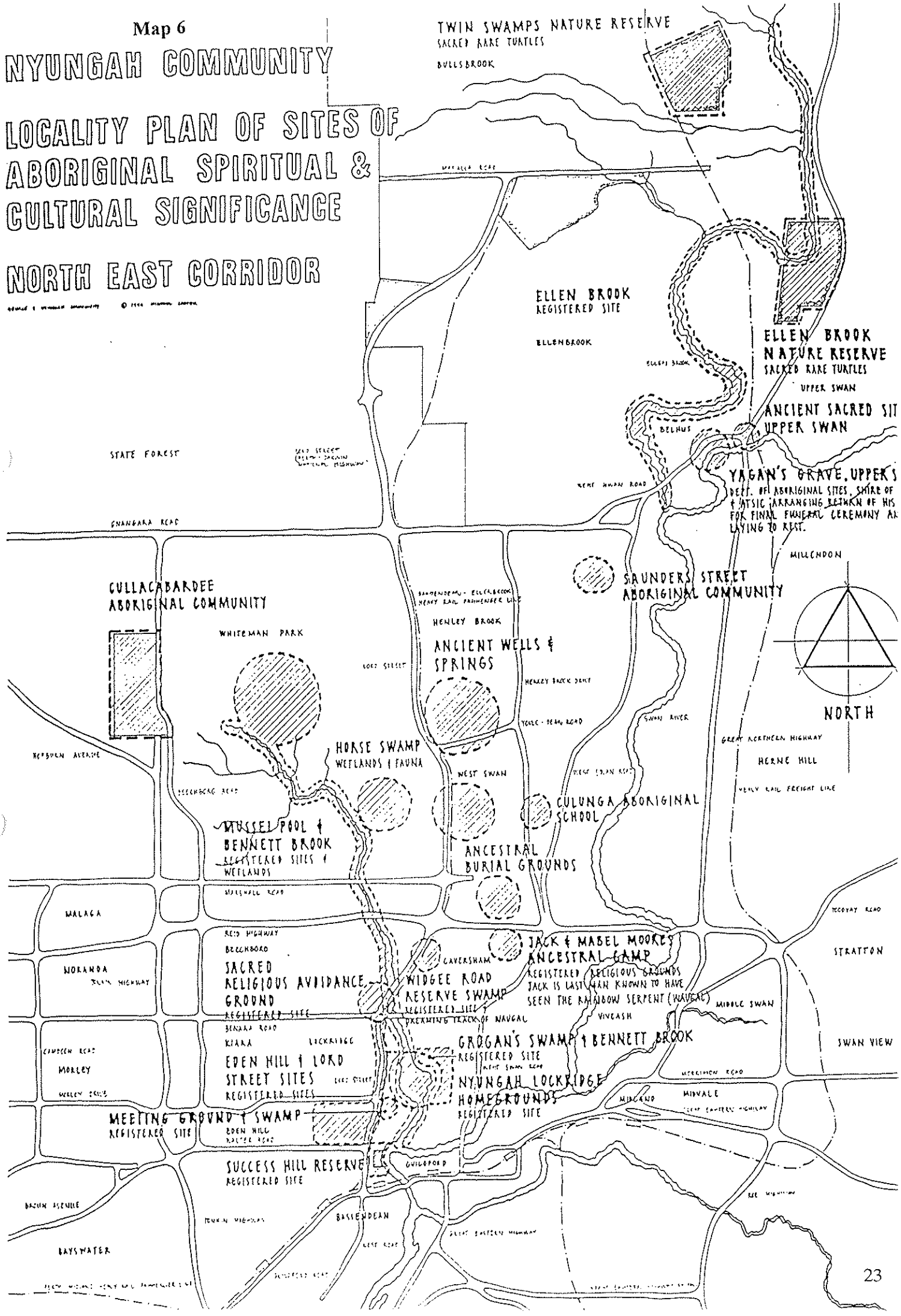
Map 6 shows the location of some specific spiritual sites within the north east corridor. The nature of the water flow through this environmentally sensitive region has

Map 6

NYUNGAH COMMUNITY

LOCALITY PLAN OF SITES OF ABORIGINAL SPIRITUAL & CULTURAL SIGNIFICANCE

NORTH EAST CORRIDOR



Aboriginal spiritual significance. Any environmental damage that occurs to the water or land, especially where sacred sites are located, has serious ramifications for the spiritual, physical and social well being of the Nyungah people.

Development of the North East Corridor

In their submission to the State Government about the Metropolitan Region Scheme Amendment 950/33 regarding the urbanisation and transport routes proposed for the north east corridor, the Nyungah Circle of Elders (1994) warned that many registered sites were threatened. The north east corridor development plans will impact upon Bennett Brook, West Swan, Caversham, Henley Brook and parts of Whiteman Park, posing serious threats to spiritual ancestral sites including:

1. Yagan's grave.
2. The Ancient Sacred Site of our Ancestors located at Upper Swan. This is one of Australia's oldest sacred sites, and is one of the oldest sites of continuous human occupation in the World.
3. The Dreaming Track of the Rainbow Serpent, the Waugal in Bennett Brook and the Swan River.
4. Jack and Mabel Moore's Religious Grounds.
5. Other religious sites connected to the wetlands and creeks.

The Culunga Aboriginal School and the Cullacabardee Aboriginal Community are threatened by future road developments.

The effects of urbanisation and road development on their spiritual homeland is a serious ongoing concern for the Nyungah community as a whole. Subsequently they have asked the State Government for the crown land at Lockridge which adjoins the Nyungah Community and upon which Pyrton is situated (see Appendix A).

Spiritual Significance of Bennett Brook

The Nyungah people's association with Pyrton/Success Hill, the sleeping place of the Waugal, predates any white settlement. The current custodians are spiritual descendants of Nyungah predecessors of the area who gave them their stories (Baines, 1984). Robert Bropho was born on the Dreaming Track of the Waugal where he has continued to live, and which he describes as being part of Aboriginal Belief that began with the beginning of time (Bropho, 1996). The Waugal lives in Bennett Brook where it flows into a bend of the Swan River, below Success Hill, and is referred to by Nyungah's as Waugal's Bend and by white people as the 'Devil's Elbow.' Traditionally, the powerful Waugal is said to inhabit the dark water of pools and swamps and it is held responsible for the well being or illness of those who come into its presence (Carter, 1986). Robert Bropho (1996, p.2) explains how the Waugal Spirit was responsible for "creating the waterways

and the creating of life". The Waugal is central to Aboriginal religious life and experience in the Swan Valley, and sums up their relationship to the land. Bennett Brook is one of the homes of the Waugal. Any destruction to the watercourse where the Waugal's children live will anger, sicken, or kill the Waugal spirit and cause it to be driven away. In effect, any environmental disruption to the Waugal's Dreaming Track will have serious ramifications for the spiritual and physical well being of the Nyungah people as a whole, for they are the last custodians of this spiritual heritage. As the Nyungah Circle of Elders (1994, p.7) state:

> Our religion is the Brook, the Dreaming Track of the Rainbow Serpent, our Waugal, and it will become polluted and destroyed. All that water goes into Bennett Brook and down to where we live and down into the Swan River and it is our Belief. If we lose those sacred sites coming down the Bennett Brook area, we'll have nothing left....We are under a death threat as a Nyungah people, and our last home is going to be destroyed.

Registered Sites within Bennett Brook

Baines (1984) describes the specific registered sites within Bennett Brook which directly concerns at least nine Nyungah tribal family groups. Besides Bennett Brook itself, which is the whole Basin of the Brook created by the Waugal, there is an underground cave, Grogan's Swamp, associated avoidance grounds, the home grounds of Nyungah ancestors, certain trees, and all the soaks, springs and waterways of Bennett Brook as it flows down from Whiteman's Park and into the Swan River at Success Hill.

Community

Currently, homesites and permanent buildings are being built by the Swan Valley Nyungah Community at what is their Lockridge campsite. Their history is told by Robert Bropho (1980) whose vision remains steadfast against the odds that continue to threaten the well being of the land and water he calls our Mother.
The environmental damage caused by inadequate Government planning and development will pollute and destroy the well being of all living things associated with the 'now' and 'everywhen' of this fragile and intensely spiritual corridor. As custodians of this place, the Nyungah people keep their spiritual heritage, which is deeply entwined in the landscape, alive for all of us, and their voice must be heard. There is an urgent need for appropriate and just consultation processes to be implemented prior to any development being planned. An ethnographical and environmental study would safeguard the significance of this region for the future. As creators of a living destiny (Bropho, 1980) the Swan Valley Nyungah Community seek to protect and rehabilitate Bennett Brook, working collaboratively alongside Government bodies and the local community.

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Cutaway Bridge Bennett Brook
Photograph: K. Pearson

IF YOU BELIEVE IN THE DREAM YOU'VE GOT TO BE TRUE TO THE DREAM

The Land is our Mother .....

In the Beginning, not just 200 years
our Belief is here since the Beginning of Time
way back through a lot of yesterdays
to the First Beginning.
The land was dry
and the Waugal, the Rainbow Serpent
started looking for water
and he started moving as a snake moves
and made designs in the sand
and the rain came
and they deepened and deepened
and began streams and rivers.

We lived with the land
All our Beliefs are there, all the stories
the same as stories you get from the Bible.

Before the coming of you the white people
there was all bush
and we lived in the big hills
and with our Mother the Land
and there were streams, rivers,
plenty of kangaroos.
Nyungah people lived here
and fished in the Swan River
and the Swamps and the streams.

Leave our Religion and Culture alone
under the ground in peace
like a dead person buried
in our Mother the Land.

The Rainbow Serpent, the Waugal
starts from Rottnest Island
to the mouth of the Swan River now,
to the Swan Brewery
right up to Success Hill
and on up Bennett Brook
up to Upper Swan
where the rivers split up
and become underground streams
going in all directions underground.

The Land is our Bible..
The Swan River is one chapter of many chapters.
It is the Sacred Grounds of the Waugal,
Bennett Brook and the Swamps and the waterbirds
and many Camps, our Homegrounds
where the Old People sat around the Campfires
and told the stories.
This is what the Waugal means to us
It is not just a big serpent with fire coming up.
It deals with the creating of Waterways
and the creating of Life.

We belong to the land
and we want to live close to the land.
We live on the Dreaming Track of the Waugal
near Bennett Brook
and we know all the stories of the Swan River
and Bennett Brook.
We used to sit down, and do dances and tell stories
and we still do.

We are very sad in more ways than one.
They have already legislated,
little meetings in Parliament
so they could go and destroy these places.
It is like all the churches,
going and smashing them all down.
We sit down at night time and think about it.
It has made us sick.

We want our children to continue on
to be told all this,
all the stories.

The Blackfellas are time travellers.
We survived.
We were here before the whitefella came.
You come here,
you say the land belongs to you,
you come with guns and bayonets up against us,
we stand with spears and boomerangs.
We wanted to share with you then
but you did not want
our way of sharing.
The whitefella took advantage of us
and took everything from us,
our Mother the Land.

This generation, now we are saying
'Can we have a truce?
We want to keep and preserve and protect these places,
your progress - go that way over there,
you can have what you want there!'.
But they say 'No. We want this land
and the Sacred Areas and the Springs in it'.
But it is our Place of Worship, our Holy Place.
Where are we going to go and worship?
You make our Waugal really sad.
You cause him to start grieving.

We want to sit down and talk here
and tell the Dreaming Stories,
us Old Men and Women
and tell our children about it,
and you fellas and your children learn about it too.
Our grandchildren will have no identity.
They'll be lost in the concrete jungle of the cities,
they'll be lost, stealing cars, in gaol,
grab a bottle of wine, no future.

Without our Beliefs we are like an empty shell.

In the ground is our Sacred Dreamings,
what we call 'the moist' in there.
Everything in there is sacred to us,
the moist, every grain of sand,
the cunyenarks, the jitti-jittis,
the red gums, the twenty-eights,
the bornas and the yornas,
the turtles and the crows
and all the waterbirds.
It is in the sun and the wind and the rain
and the flow of the water.
All that is sacred to us.

Each grain of sand is spiritual.
They are laying there in peace.
The Spiritual Belief is in it
in each Grain of Sand,
Pebble, Rock, Leaf,
Grassroots of the Tree,
the Wind, the Night, the Day,
the Air we breathe.

The Spiritual Belief is in the Whole of the Land.

The Waugal Dreaming is a very old Dreaming.

Robert Bropho
Spokesperson for the Nyungah People of the Swan Valley
18.6.96

3 WATER TESTING: BENNETT BROOK

Bevan Carter and Peter Pearson

INTRODUCTION

Site Choice

Two sites were chosen to carry out the water testing. The first site is at the northern end of the wetland on Bennett Brook and called the horse site because of the yards there. The second site is at the southern end where an old bridge crosses the Brook (at the cutaway). These sites were selected because they were relatively easy to access and it was thought at the time that these were the points at which water flowed into or out of the wetland. Subsequent investigation has revealed two main drains flowing in from the urban areas to the west may also be a significant factor in water flows.

Details of Test Equipment

Temperature of the water was taken in degrees centigrade using a simple alcohol thermometer.

The pH of the water was measured using a simple battery powered pH meter (- pH scan 1/ or TPS LC8OA).

The conductivity of the water in microsiemens was measured using a battery powered meter (TPS LC81).

The turbidity of the water was measured using a Morgan turbidity tube. This test involved adding water to the tube until the black pattern on the white bottom could no longer be seen. The depth of the water is then read against the scale on the side of the tube in nephelometric turbidity units (NTU).

Both phosphate and nitrate were determined using a Palintest Photometer kit. The final results were expressed in milligrams phosphate and nitrogen (as nitrate) per litre of solution.

Dissolved oxygen was measured with a chemical method using a Hach kit. The measurement obtained was in milligrams of oxygen per litre of water.

RESULTS

Temperature

There are no thermal sources likely to pollute the Bennett Brook Wetland. The temperatures recorded were mainly as a guide to seasonal variation and to put the DO recordings in perspective.

pH

pH is a measure of the acidity or alkalinity of the water. A pH of 1 is significantly acidic and a pH of 13 is alkaline. Soils and natural water courses may be expected to have a pH between 5 to 9. Values outside of this range usually indicate some form of pollution.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
pH	7.3	7.6	7	6.7	6.7	6.8	6.8			7	7	7

All pH readings in the table were between 6.7 and 7.6 which is very close to neutral and is normal.

Salinity

Water is considered fresh if the conductivity is less than 800 micro siemens and considered salty if the conductivity is greater than 5000. Readings between these two indicate the water is brackish. The conductivity of the water is a direct function of the amount of salts it contains. The dissolved salt in most cases is simple sea salt (NaCl) and its concentration in mg/l can be calculated directly from the conductivity in micro siemens/cm by multiplying by 0.55. The results are reported here in micro siemens for consistency.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
Conduct	605	780	545	697	570	520	23000		1300	770	690	630

Except for two readings from the Cutaway Bridge site in March and May readings were less than 800. The southern end of the swamp is tidal and the reading of 23000 is about half that for sea water. These readings are acceptable and indicate the water flowing into the wetland from the north is fresh and in fact meets drinking water standard, with respect to salt content.

Turbdity

Readings of less than 15 NTU indicate that the water is clean while readings abovev30 NTU are regarded as high.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
Turbidity	12	< 6	13	14	13	< 10	10		17	15	35	15

Only two readings at the Cutaway Bridge were in excess of 15 NTU. These were most likely the result of livestock disturbing the creek bed since there is no fence protecting the waterway.

Nitrates

A reading less than 0.05 milligrams/litre indicates the nitrate level is low, while a reading greater than 0.4 milligrams/litre indicates the level of nitrate is high.

Nitrate results measured by the group have not been reported since subsequent test work has revealed that the method used was seriously flawed and hence the results were meaningless. Some laboratory results for nitrate and total nitrogen are reported. The total nitrogen results are comparable with other drains and creeks entering the Swan River (Refer Swan River Report No 20 December 1994). An analysis program currently in progress will use a refined method and these results will be reported through the Swan Avon Integrated Catchment Management Program.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
NO3 (Lab)			0.28		0.351	0.07			0.037		0.041	
Total N (Lab)					1.3	1.4					1.3	1.5

The few results available would indicate that the nitrate levels range from low to medium. The presence of tannin in the Bennett Brook water reduces the potentially harmful effects of nitrogen by blocking light and supressing algal growth. Observations of the plant and algal life in the waterway would suggest the level of nitrogen is not a significant problem.

Phosphorus

Phosphorus was also measured using the Palintest, chemical method. The same samples collected for nitrogen were also analysed at the laboratory for phosphorus.

The measurements given refer to total phosphorus. A reading less than 0.01 milligrams/litre indicates the phosphorus reading is low and a reading between 0.01 and 0.2 mg/l is moderate.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
PO4 (Lab)			0.007						0.014			
Field PO4	<0.01	0	0.12		0.03	0.26	0.75		0.08		0.09	0.34
Total P (Lab)			0.04		0.06	0.02			0.05		0.09	0.04

Phosphorus results with the exception of three samples obtained by the group are consistently in the low to moderate range as defined by R. Donahue and W. Horwood.

The three results in the low to high range were all read carefully, and also repeated. Unfortunately the results were not confirmed by laboratory analysis. All the laboratory analysis (0.02 to 0.09) indicate phosphorus in the moderate range. Observation of life in the creek indicate that the nutrient levels are only moderate.
A subsequent test program work building on the experience gained is being undertaken in association with the Swan Avon ICM Centre. These results would resolve some of the current uncertainties with respect to the phosphorus.

Dissolved Oxygen

A reading between 80% and 120% is normal. A reading less than 55% or greater than 135% indicates high pollution levels.

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
Diss)(mg/l)	4.5	6	5	4	6	4	<1			4	6	4
Diss O(%)	50	60	50	40	60	40				36	60	45

The dissolved oxygen levels are somewhat low. Some readings were checked with a meter and found to be correct. This may suggest the guidelines may be a little stringent because there was plenty of life in the stream.

All Results

	Horse Site						Cutaway Bridge					
Date	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95	25.3.95	29.4.95	20.5.95	1.7.95	7.10.95	28.10.95
Temp	21.5	14	13.5	14	17	19	24		13	11	17	20
Conduct	605	780	545	697	570	520	23000		1300	770	690	630
Turbidity	12	< 6	13	14	13	< 10	10		17	15	35	15
pH	7.3	7.6	7	6.7	6.7	6.8	6.8			7	7	7
NO3 (Lab)			0.28		0.351	0.07			0.037		0.041	
Total N (Lab)					1.3	1.4					1.3	1.5
PO4 (Lab)			0.007						0.014			
Field PO4	<0.01	0	0.12	0.84	0.03	0.26	0.75		0.08	0.72	0.09	0.34
Total P (Lab)			0.04		0.06	0.02			0.05		0.09	0.04
D.O.(mg/l)	4.5	6	5	4	6	4	<1			4	6	4
D.O.(%)	50	60	50	38	60	45				36	60	45
Flow	3	4	6	10	10	13	0			10		15

Other Indicators

To get another measure of the health of the Brook Ribbons of Blue habitat survey was conducted on the Horse site. This gave the site A Stream Quality Rating of Fair/good which would indicate the Brook is in a reasonable condition.

SUMMARY

The water currently flowing into the wetland near the mouth of Bennett Brook is of fairly good quality and the stream sustains a variety of aquatic life including several species of native fish. The threat to this reasonably good state of affairs will come from the future urban developments planned for Bennett Brook catchment. The stormwater runoff from these housing areas will contain significant levels of Phosphorous and Nitrogen. Unless this water is cleaned up before allowing to enter the Brook the nutrients will promote algal growth and potentially damage the aquatic environment of the Bennett Brook and further degrade the Swan River. The current knowledge of 'nutrient stripping' technology as applied on the Swan coastal plain is limited and it is unlikely that long term nutrient reduction in the runoff will be successful. As the North East Corridor is developed the future for the water quality in Bennett Brook looks bleak.

Water Testing, at the Horse Site
(From left to right. V. Humphry, B. Carter, K. Pearson, P. Pearson and Paul Reiter). Photograph: G. Peterson

Sampling For Macroinvertebrates
(B. Carter and V. Humphry)

Ribbons of Blue Water Sampling Kit
Photographs: K. Pearson

REFERENCE

Ribbons of Blue. Environmental Awareness to Action: A Water Quality Monitoring Program for Secondary Students: Waterways Commission, Perth, W.A.

Swan River Trust. Understanding Water quality on the Swan Coastak Plain, Waters and Rivers Commission Perth.

Samphire Plants Bennett Brook
Photograph: C. Tedeschi

4 BENNETT BROOK: COMMUNITY VEGETATION STUDY

Anne Hollingsworth

INTRODUCTION

The Bennett Brook vegetation study region encompasses land on the western bank of Bennett Brook from Success Hill Reserve along behind Pyrton and the Nyungah Community to the horse paddock just South of Benara Road. Much of the vegetation study area is a seasonal wetland lying within the Town of Bassendean at the Success Hill end, while the complementary Northern end falls within the Shire of Swan. The vegetation study area is located in the System 6 M41 conservation area (Department of Conservation & Environment, 1983).

Aims

The immediate aims of the vegetation study were to:

- assess the condition of the remnant native vegetation fringing the Brook
- identify botanic communities at various points along the Brook
- set up permanent specific plant study quadrats in the System 6 area
- obtain a floristic survey by sampling from the specific sites
- complement the site vegetation data by observation and opportunistic sampling
- collect and preserve a verified field herbarium of plants from the System 6 study area.
- consider ways of protecting, conserving and restoring Bennett Brook bushland
- consult on the native flora with the local Nyungah Community
- identify exotics encroaching on the natural vegetation in the region

M41 Soils and Typical Associated Vegetation

The M41 soil types in the region, and depth to ground water combined with any previous landuse, will reflect the type of natural vegetation the land supports (Powell and Keighery, 1995). In general, soils at the foot of the Darling Scarp on the Swan Coastal Plain West of the Forrestfield soils fall into three groups, namely alluvial, aeolian, and estuarine soils (Powell, 1990). Soils along Bennett Brook in the System 6 region appear to contain a mixture of these three soil types which have been referred to by different names on various soil maps.

Map no 7 shows the soils for the System 6 region based on aerial photographs of remnant vegetation and the Heddle complex. The soil types are Guildford Complex, alluvial soil and Southern River Complex (aeolion over alluvial).

A 1955 Land Capability Study for Horticulture in the Swan Valley showed the M41 Vegetation Study Area contained component regions of Karrakatta sand - grey phase, (at the Northern end,) Valley Complex soils in low lying valleys, Clay Loam, Clay Pits, Bellevue Clay Loam and Clay, Pyrton Clay where the drainage is poor, and Saline Flats in boggy patches bordering the wetter part.

Keighery (1996) described the surface soils at locations around System 6 on both sides of the Brook. Field observation and research was used to explain the heterogenous nature of these soils, attributable to their geologic placement at the interface of the Bassendean Dune System and the Pinjarra Plain and to deposition by Bennett Brook. Map No 3 shows the environmental geological units for the study area comprising of alluvium, Guildford clay member and Bassendean sands.

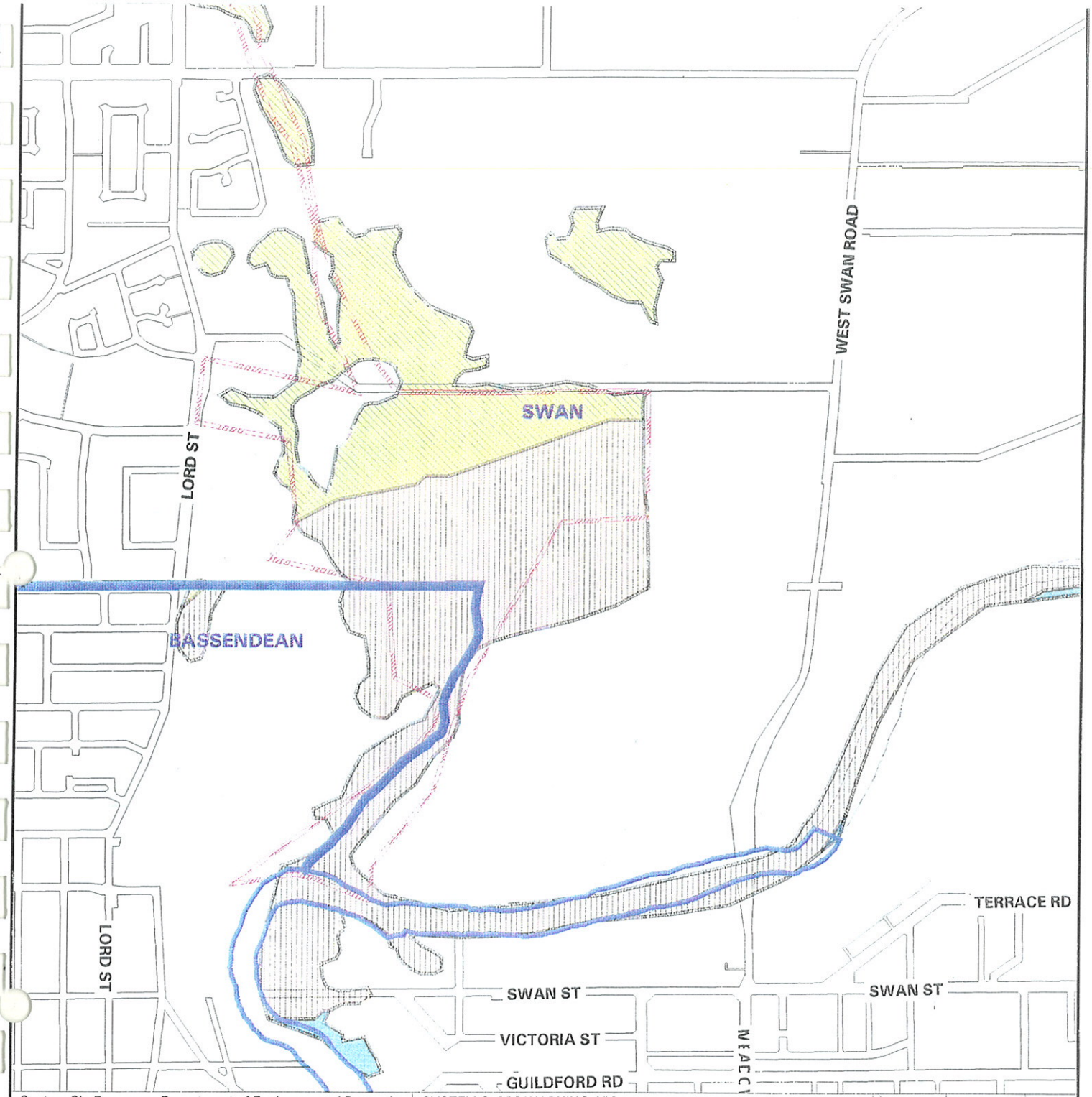
Given the mixed nature of soil types indicated on these maps and reports for the System 6 area, it is reasonable to expect that the associated flora communities would by their different structures and species, reflect (and to an extent map) the varying nature of the surface soil types. However in many parts of the System 6, vegetation has been cleared or greatly modified by disturbance factors. Hence classification of soil types on the basis of the remnant vegetation alone, might yield a limited field interpretation of some of the soils present.

It is usual to encounter flooded gums, (*Eucalyptus rudis*), and paperbarks (*Melaleuca*) on these poorly drained alluvial soils. Estuarine soils (or Vasse) are associated with sheoak (*Casuarina obesa*) and samphire, rushes and sedges, as well as the gums and paperbark. Southern River (a combination soil type) may support stands of marri (*Eucalyptus callophylla,)* where drainage permits and flooded gum (*Eucalyptus rudis*) in the damper areas. (Powell and Keighery, 1995).

Observation of Bennett Brook vegetation affirmed this general link between the soils. Arnold (1990) mapped the Bennett Brook wetland and produced a diagrammatic cross section (see Appendix B Map 1, & Figure 1) which showed these linked environmental factors. This diagram described the Brook and associated wetlands within the context of their typological surroundings by indicating soil and vegetation types, wetland area, altitude, and current land uses for the region. In all, the M41 wetland occupies 93 ha., of which 4.4 ha. is open water, 15.6ha. is modified wetland, 9.6ha. is Samphire/Halophytes, 4.0 ha. is Sedgeland, and 59.7ha. is occupied by paperbark and flooded gum (Arnold, 1990, p.376).

Past Observations of Vegetation

Accounts recording those early European observations of plant life along the Swan River noted how the explorers related to the land and its vegetation by assessing its potential for farmland and settlement sites. The Dutch explorer William Vlamingh recorded in 1696 that the coastline and the lower Swan River were " ..a barren, bare, desolate region, "... although he probably did not extend his exploration quite as far up the Swan River as Bennett Brook (Gathe, 1995).



System Six Reserves : Department of Environmental Protection.

Local Authority Boundaries: Australian Bureau of Statistics.

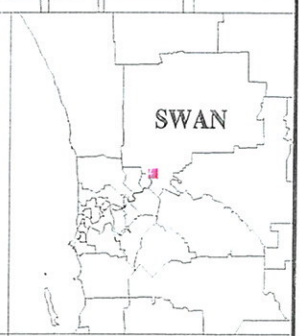
Cadastre : Dept. of Land Administration, Western Australia

Streets : Main Roads Department of W.A.

REMNANT VEGETATION COMMUNITIES:
Formed from intersection of Remnant Vegetation PMR (1994) data developed by Ministry for Planning, and the Vegetation Complex data developed by the Dept of Conservation and Land Management.

SYSTEM 6 *** WARNING ***
The DPUD North West Corridor Structure Plan (1993) adopted modifications to the boundaries of M1 and M3. These changes have not yet been absorbed into this cover, pending discussions with EPA.

REMNANT VEGETATION - COMMON
The imprecision of the Vegetation 'Darling System' boundaries defining the vegetation communities is reflected in this coverage. All vegetation polygons less than .5 hectare in area have been excluded.
NOTE: This dataset has not been properly validated by GRAPE



Ministry for Planning
WESTERN AUSTRALIA

Map Ident: plot960416_4

0 250 m

- EPA System 6 Boundary
- Local Government Areas - Metro
- Street frontage
- Water
- Guildford Complex
- Swan Complex
- Southern River Complex

Map 7 System 6 Reserves

Bennett Brook

Remnant Vegetation

Heddle Complexes

MFP INTERNAL USE ONLY

Prepared by: lisa buckleton	Prepared for: National U
Date: 16 Apr 96	Scale 1:10000

Banksia menziesii, Success Hill Reserve
Photgraph: G. Peterson

In 1827, a British exploratory team led by Captain James Stirling made a ten day reconnaissance trip along the Swan River. Stirling was impressed by the scenic beauty of their tour, as described in his journal entry for the 13th of March 1827 " the bright foliage of the shrubs, the majesty of the surrounding trees" (Gathe, 1995 .)

The Colonial Botanist Fraser who accompanied Stirling on the ten day exploration of the Swan River mentioned that gum trees grew at about ten or less to the acre, and were accompanied by the local wattle (Gathe, 1995). Naturally, vegetation density was an important consideration when thinking in terms of building, or of clearing grazing land (Education Department, 1979). Moreover Fraser reported seeing "...strips of good forest land, covered with a profusion of plants and stupendous angophoras (marri)" which led him to think the land was superior to any he had seen previously in N.S.W (Gathe, 1995, p.2).

However not all of the migrant observers were so favourably impressed with the idea that the profusion of native plants fringing the Swan River indicated the region was good fertile farming country. In 1830 Robert Brown, a botanist, compared Fraser's plant collection with the riverine vegetation in King George Sound. In particular, Brown noted that the *PROTEACEAE, MYRTACEAE* and *LEGUMINACEAE* plant families dominated Fraser's Swan River plant specimen collection. He further observed that from within those families all of the genera in Fraser's collection were present in the King George's Sound collection, while many of the plant specimens from the two collections were identical even to species level. This observation led him to infer that the soils in the vicinity of the Swan River could be similarly unsuitable for sustained cultivation (Gathe, 1995).

In hindsight Brown's surmise is given credence when it is studied in conjunction with records of a complaint James Henty made about his Swan River pasture land. James Henty was the original owner of the Bassendean estate. In mid 1830, he wrote to the Governor (Stirling) to complain that the quality of his livestock was on the decline due to the "inferior and scanty herbage the land affords." (Carter, 1986, p.16).

There is an apparent variance between the favourable vegetation reports given by Stirling and Fraser in 1827 and the more disparaging comments made a scant three years later by both Brown and Henty, who suggested that the land was too poor for agricultural use. These differing views illustrate how fragile the riverine ecosystems were and they suggested that unsuitable land use and management practices could rapidly lead to a decline in native and other vegetation, negatively affecting the carrying capacity of the M41 soils in general.

Vegetation and the Indigenous People

Early historical accounts suggest widespread Aboriginal bushland management practices were well established before the Europeans settled along the Swan River. In 1838, James Backhouse, a Quaker missionary, wrote a book about the Swan River Settlement which mentioned the Aboriginal vegetation management practice of "fire-stick farming". He observed that Aborigines fired the scrub in various places "to

facilitate their hunting and to afford young herbage to the kangaroo" (Education Department, 1979, p.12).

Similarly Lieutenant H.W. Bunbury noted the skill with which the Aboriginals kept the country free of "underwood and other obstruction" with "judgement and good effect" by this fire-stick farming technique (Education Department, 1979, p.12) A modern day social historian has suggested that when the Aboriginal people came together for ceremonies some groups would band together to manage these controlled burns (Carter, 1986).

In 1995, the Swan Valley Nyungah community celebrated its custodial link with the land in a joint community ceremony to replant an area associated with a spring at Success Hill Reserve.

METHOD

Bushland Plant Survey

Community members who undertook the plant survey initially walked Bennett Brook from Success Hill to the horse paddock in October 1994, to determine the general appearance and condition of remnant bushland. Foot transects were undertaken to record floristic surveys of both the native vegetation and the exotic plant species present. Then, under the supervision of Bronwen Keighery and her assistants from the Department of Environmental Protection, DEP, the members of the community learnt how to conduct and record methodical plant surveys.

Opportunistic plant sampling was conducted throughout the study area. The sites were revisited and resampled with each seasonal change during the year. The DEP System 6 Team led by Bronwen Keighery visited the eastern side of Bennett Brook and surveyed four more quadrants to update the System 6 recommendations for the Coastal Plain and Darling Range, for the DEP (Keighery, 1996).

Selecting and Recording Quadrat Sites

Three vegetation sites, each one of 10 x 10 square metres, were set up. The sites for the quadrats were chosen because they represented diverse plant communities from within the M41 region and were assessed to be in either good or very good condition. These sites represented different plant communities and showed a relatively undisturbed amount of native vegetation cover.

The quadrat sites were recorded on survey sheets by drawing mud maps, noting dominant, identifiable features, site data, and topographic information. A photograph was taken of each site location. A G.P.S. reading was taken and recorded for each site, and the quadrat was then marked by pegs. For the first site, BENN 01, the method of

placing the marker pegs, plant sampling and recording was demonstrated. The group split into two working parties to undertake the survey of the second and third quadrats. The information was documented on a standard survey recording sheet for each of the three plant quadrat sites. This field work took thirty five working hours. The opportunisitc sampling was conducted throughout the remaining project area.

Specimens

Plant specimens were gathered from each survey site and all specimens were tagged. Dates and sites were recorded on each label and if possible the plants were identified. This information was recorded on the site data sheets. The specimens were pressed and freeze dried. The sites were revisited on 5/12/94 by the System 6 team to take samphire samples from the eastern side of the study area for positive identification at the W.A. State Herbarium.

Community members went into the WA Herbarium on four occasions with Bronwen Keighery, who taught and supervised the plant identification process, and verified the identifications. This activity at the WA State Herbarium took the group a total of fifty six working hours. The collected specimens were placed in a field herbarium for future reference and a number of specimens have been submitted for the WA State Herbarium.

RESULTS

Bushland plant communities

The wetland supported a range of plant communities generally grown in association with wetland areas, including dense stands of swamp paperbark, sedges, samphire communities and open woodlands where flooded gums were the dominant overstorey species. On higher ground and along the ridges further from the wetland areas the understorey was fragmented due to disturbance factors. In some cases small clusters and associations of various wildflower species had formed. Remnant communities of wildflower species were still evident and presented more understorey colour and diversity than we were able to observe in the wetlands, sedgelands and samphire regions. However at this time no floristic survey sites have been established for these disturbed M41 areas away from the Brook.

Vegetation Structures in Quadrat Sites

The vegetation structure observed in BENN 01, the first site, was mostly an open low woodland, open low grasses, and dense tall sedges. The sedges over 0.5m tall were assessed to give a cover of greater than 70% of the quadrat. The presence of scattered herbaceous weeds and blackened trees, with some suckering on the *Melaleuca raphiophylla*, indicated that the area had been burnt and had a degree of degradation.

BENN 02 contained open woodland and open low woodland trees of the same species as the first site, (i.e. *Eucalyptus Rudis* the dominant canopy species, with *Melaleuca raphiophylla* below) and open low grass and dense tall sedges as the understorey. The vegetation condition was considered to be good, with extensive sedgeland, and extensive grass beneath (Keighery, 1996).

BENN 03 consisted of open woodland with an understorey of low heath, dominated by samphire heath, as well as isolated miscellaneous exotic grasses, herbs and open sedges. The Botanist noted that in spite of occasional patches of grassy weed, the vegetation was in very good condition.

Plant Families recorded on the sites

Overall among the native plants represented in the sites the *CYPERACEAE* family were the most profuse, with 8 species. The remainder of the site based floristic families present were composed of: *APIACEAE* (1), *ARACEAE* (*1), *ASTERACEAE* (2, *3), *CALLITRICHACEAE (*1), CASUARINACEAE (1), CHENOPODIACEAE (3), CYPERACEAE* (8), *GENTIANACEAE (*1), IRIDACEAE (*5), JUNCACEAE (2, *1), JUNCAGINACEAE (3), LOBELIACEAE* (1), *LYTHRACEAE (*1), MYRTACEAE (4), ONAGRACEAE (1), PAPILIONACEAE (*1), POACEAE (3, *5), POLYGONACEAE (*1), PRIMULACEAE (1),* and *TYPHACEAE* (1). (* indicating introduced vegetation.). Compiled from a listing provided for the project by Botanist Bronwyn Keighery, DEP System 6 Update: Site based Flora List for M41 Bennett Brook (BENN sites 1-3, B.J. Keighery 14/3/1995).

Species observed

The Bennett Brook Project vegetation study area contained at least fifty one plant species within the three quadrats studied. Of these thirty one were native, and twenty were introduced species. Outside the quadrats a further thirty species were identified in the general study area during opportunistic sampling. Only three of these opportunistically observed and recorded plants were introduced species, although there were other exotics within some areas of the study region.

BENN 01

Bennett Brook site number BENN 01 is situated on the floodplain on the Western side of the Bennett Brook. This site is a seasonal wetland with a grey/brown clay surface soil. Benn 01 was assessed to have poor drainage, and to be wet in winter and spring. The nearest road location is Lord Street. BENN 01 is behind and North of Pyrton, 50 metres from the water course.

BENN 02

The second quadrat, BENN 02, is a flat stretch of dark brown clay with poor drainage, and assessed to be wet in winter. The nearest road is Lord Street. BENN 02 is located behind the Nyungah community dwellings.

BENN 03

The third quadrat is a flat wet area, with dark brown clay soil, wet in winter/spring, with poor drainage. This site is located behind the Nyungah community and south of Morley Drive (refer Map 1 for site locations).

Photographs K. Pearson

Introduced Plants

As well as many plants commonly regarded as weeds, such as dock and couch, etc., a number of exotics existed in bushland closer to the grazing lands near the Northern horse paddock end of the M41 and these were not recorded on any of the plant survey sheets. Among the introduced plants were Ficus sp., the climbing rose known as "Dorothy Perkins", Japanese peppercorn trees, Olive trees, Arum lilies and Lantana.

DISCUSSION

On going vegetation monitoring is desirable not only in the original three quadrats established for this study, but also throughout the M41 region. In time more quadrats may be established, with a view to monitoring other places or plant communities along the Brook. This monitoring would allow a management team to assess any changes brought about for example by implementing weeding or revegetation programmes, by imposed changes such as fires, or by other high impact changes in nearby land use, and by changes to levels of inundation or water quality.

Preserving good bushland condition

Keeping the System 6 bushland vegetation in good condition is vital to the preservation of the region so it remains an important nature conservation reserve. The native plants need to be thick enough to provide a living mulch and ground cover to help prevent erosion (Roberts, 1992) and to deter weeds (Bradley, 1988) although some sandy patches may need to be retained for the needs of fauna, for example turtle or reptile egg beds. The vegetation needs to be diverse enough to provide fauna with food and habitat, (Roberts, 1992) and should be carefully managed to avoid fire in fauna habitat (Smith, 1995). The Brook surroundings need to be stable to ensure natural bush regeneration can occur (Bradley, 1988).

Revegetation

In areas where some of the bush is degraded, but the structure of the bushland is still basically preserved, natural bush regeneration is the ideal way to allow revegetation to occur. However sometimes a decision is taken to augment this process by seed collection and germination programs, using seed or plant material gathered from the local remnant bushlands. If a decision were taken for sections of the System 6 to be direct seeded or planted out with local seedlings, care would have to be taken to ensure that the correct types of local plants were placed in areas where they would best respond.

Otherwise varying soil types, disturbance factors, levels of inundation and general drainage patterns, might make the bush replanting programme less successful than it could otherwise be. (A list of plants suitable for revegetating roadside plantings along some stretches of the System 6 is available from Bob Dixon, Kings Park).

Another consideration when planting, is to plan low borders to fire control regions, so that fire fighters can gain access and confine the fire to small areas instead of loosing the whole strip along the Brook in the event of a fire. At present some areas of the region have a fair amount of native vegetation, so maintenance there may only involve a little weeding. Bush degraded by grazing, mining, frequent fires and other disturbance factors would benefit from increased bushland cover.

The bare ground of the horse paddock could recover if the horses were penned back from the Brook. The *E. rudis* which remains there has some healthy looking saplings which could, if an understorey cover was added and fringing reeds were increased, provide a real and effective buffer zone between the Brook and developed areas, serve as a nutrient filter for runoff entering the Brook (Davis, 1990) and continue to screen the wildlife corridor as envisaged in the Metropolitan Regional Planning Authority's proposal for Bennett Brook.

Controlling weeds and exotics

Frequent fires, movement of stock, and disturbances to the soil favour weed invasion (Pigot & Loneragan, 1995). To restore the bush, the weeds and exotics have to be slowly, carefully and methodically cleared, with as little disturbance to the soil and native vegetation as possible. The Bradley Method is a proven Australian weed and exotic plant removal technique in bush regeneration method. Bradley (1988) advocates working from the good areas out into the weed infested ones, causing minimal disturbance and letting the rate of natural native plant regeneration dictate the rate of weed removal. It is not desirable to try to remove all weeds on a badly infested site in one attempt. Dixon and Keighery (1996) promote a three phase approach to weed control, namely primary weeding, secondary weeding, and long term maintenance.

The removal of exotics from the bushland is necessary as otherwise many of these introduced species will naturalise and spread to outcompete natural bush. (e.g. Lantana at Success Hill near the mouth of Bennett Brook, and Sydney Golden Wattle - *Acacia longifolia* - in bushland at Caversham Air Base near Whiteman Park in the upper catchment area for Bennett Brook.) Allowing rampant exotics to spread, as the Arum Lillies have at various points along the Brook, makes the possibility of good quality bushland self maintenance unlikely, unless control strategies are implemented to eradicate the weeds first. (Many examples of strategies for controlling exotics are given in Table five, Greening Australia 1995, pp. 65-141).

Fire threat

The impact of alterations to the fire regime experienced in recent years around Bennett Brook has led to some degradation in the vegetation cover. Not only is much of the understorey vegetation directly removed by fires, the litter layer is also removed, injuring and killing fauna and removing bird nesting sites, taking away shelter and habitat range for any small fauna which may have escaped the fire, as well as influencing the soil micro-organisms and exposing the bare soil to the elements (Dell & How, 1995). Fire frequency is a disturbance factor which affects the bushland's ability for self maintenance and creates an ideal growing condition for fast growing weeds at the expense of the native vegetation.

Some Australian plants will readily resprout or reseed after fire and some Australian plant seeds germinate more readily after a fire. When fires regularly occur in an area there is no time for new plants to form, mature and set viable seed. This negatively affects diversity in the bushland structure, altering distribution patterns, so that entire species can and will be lost from the area (Keighery, 1994, pp.53-54). The loss of bushland structure will also alter microclimates in the region, disrupt the complexity of the food web, and impact on niche heirarchies. While these types of disturbances affect some species more than others, frequent and continued disruptions to natural cycles do not auger well for retaining good condition bushland.

Introduced animals

One of the problems facing the M41 flora is that posed by introduced animals. Feral rabbits, foxes, domestic pets and introduced grazing animals can contribute to land degradation there by digging, trampling, and grazing; and will have a negative effect on native fauna numbers (Scheltema, 1995). Land degradation due to plant loss in the M41 region include increased runoff which carries more nutrients and sediments into the Brook, altering nutrient loads in water entering the Swan River. Compaction and grazing discourage native seed germination, and these bare patches of earth create a foothold for the exotics and weeds or enable erosion and fires to further perpetuate the cycle of vegetation removal and land degradation. This is particularly evident in the North of the M41 region, where stock are ranging, grazing or penned along the edge of the Brook.

Vegetation Photographs

December '95 regrowth after November '94 bushfires. Photograph K. Pearson

Cattle erosion of eastern bank of Bennett Brook Photograph K. Pearson

Arum lilies
Grogan's Swamp, 1995
Photograph K. Pearson

Vegetation as Fauna Habitat

Maintaining the M41 bushland in good condition will also assist in preserving the level of fauna habitat for the M41 area, so that transitory and permanent-residence native fauna can continue to have their feeding, nesting and habitat needs met. The living bush vegetation should be maintained in good condition; and potential fauna habitat such as dead trees, hollow logs, fallen branches and leaf litter should be left where they occur (Smith, 1995) unless they are assessed to be too great a fire hazard, in which case hand clearing is the preferred method of removal (Bradley, 1988).

Jarrah Dieback

A microscopic fungus from the tropics has been accidentally introduced into Australia which has the capacity to devastate our bushland, by rotting plant roots. This water and soil borne plant pathogen called *Phytophthora cinnamomi* lives in the soils and can therefore be transported into a new area by human activity such as planting infected soil along with seedlings, introducing soil from infected areas for roads or pathways, or it may be carried on shoes or vehicles moving through infected areas. Although the common name for *Phytophthora cinnamomi* is Jarrah Dieback, many other native plants beside "Jarrah" (*Eucalyptus marginata*) are in fact susceptible to this disease (Shearer and Tippett,1989). Often the health of these other susceptible plants is used as an indicator in assessing the possible presence of Dieback in an area (C.A.L.M., 1994). Several plant species in the M41 could be at risk from Jarrah dieback which is present at nearby Success Hill Reserve, where various host plants grow (Shivas, 1989). The best known method of control for *Phytophthora cinnamomi* is to prevent practises likely to allow it to spread (Bailey, 1995).

In some other districts whole bushland areas are being sprayed or individual at-risk trees are innoculated to try to halt the spread of this disease. At nearby Success Hill Reserve, Jarrah Dieback has been identified as the probable cause of Banksia tree and other plant losses on slopes leading to the Swan River near the mouth of Bennett Brook. Jarrah Dieback is thought to have been accidentally brought to this bushland Reserve via the introduced gravel pathways.

CONCLUSION

Bennett Brook System 6 is an example of a wetland ecosystem under threat from encroaching urbanisation. Many other urban wetland areas have been destroyed by being drained or filled in to provide places for housing, or commercial development. As urbanisation extends into the Swan Valley, and towards the Gnangara water mound, the Bennett Brook catchment area will face the challenge of polluted urban run off. Unless successful removal strategies can be implemented the nutrients, sediments and hydrocarbons in this water will affect the System 6 area and flow on into the Swan River. Retaining the Brook as a natural regional park could help to slow the amount and rate of this potentially harmful discharge into the river. Although, if water levels rise as a result of altered urban drainage, the remnant flora and fauna in the System 6 area will be affected.

Many features of the System 6 wetland make it a very worthwhile area to preserve. The area is of significant conservation value to birds and fauna, and it provides one of the few remaining urban examples of remnant samphire and wetland sedges in relatively good condition. The higher adjacent land still supports some of its original wildflower understorey species in an open woodland setting. Unless the area is protected for the future, disturbance factors could continue to lessen native vegetation cover, further degrading the System 6 bushland, and threatening the existence of the birds, animals, reptiles and amphibians for which the area is still a sustaining host.

According to Benson & Howell " bushland is scarce; there is no more being made, indeed it cannot be made - it is not just a garden, where plants depend on human intervention for their propagation and survival. Rather, it is an assemblage of interacting plant populations, each species responding to a variety of influences and able to continue its life cycle " (National Trust of Australia, WA, 1993, p.21).

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Remnant Vegetation Bennett Brook
Photograph: K. Pearson

5 A DESCRIPTION OF REMNANT VEGETATION: BENNETT BROOK (System 6 Area M41)

B.J. Keighery.
Department of Environmental Protection, April, 1996)

INTRODUCTION

Bennett Brook (M41) was identified in the orginal System 6 study (Department of Environmental Protection 1983). As a consequence, an assessment of the vegetation of the area was part of the 1994 -1996 System 6 Update (Department of Environmental Protection). This assessment involves placing the plant communities of the area in a regional perspective by comparing set area study sites to reference study sites on the Swan Coastal Plain according to the procedures used in Gibson *et al.* (1994). The Success Hill Action Group, (SHAG) embarked on a flora and fauna survey of Bennett Brook, which included the System 6 area, and so this work was done in cooperation with the community group.

METHODS

The Bennett Brook area was visited on two occasions. On the first trip (6-10-94) the System 6 Update field group and SHAG members traversed the area south of Benara Road. Native plants observed on the traverses were noted and three permanent 10 m x 10 m study sites were located in the areas of bushland in good condition or better (Keighery, 1994).

Within each site all vascular plants were recorded and specimens collected according to the procedures described in Keighery (1994). Data on slope, aspect, vegetation structure and condition were collected from each site. Slope was scored on a one to three scale from flat to steep. Aspect was recorded as one of 16 cardinal directions. Vegetation structure was recorded and described according to Appendix C, Table 1). Vegetation condition (see, Appendix C, Table 2) was scored on a five point scale with a score of one indicating vegetation in near natural condition and five indicating highly disturbed sites with significant weed invasion (after Keighery, 1994). All sites were permanently marked with four steel fence droppers and had their position fixed using a GPS unit.

Several identification sessions were held in the WA Herbarium with the community group to identify plant specimens from the study sites and to prepare a field herbarium.

On the second visit (5-12-94) the System 6 Update field group revisited the sites and observed a transect through the wet flats on the eastern side of the Brook.

While all native plant species observed during the field work were recorded this study is not a comprehensive treatment of the flora of the Bennett Brook area. It is expected that the flora recorded (Appendix C, Table 3) accounts for 70% of the flora present but this could be as low as 60%. Also, while all non-native taxa were recorded in the study sites no attempt was made to record non-native taxa in the cleared areas.

A list of plants suitable for direct seeding was also compiled in consultation with Robert Bropho (Appendix C, Table 4) for rehabilitation of roadside areas.

SOILS

The general soils of the study area are described by Gozzard (1986), Bennett Brook being located at the interface of the Bassendean Dune System and the Pinjarra Plain. As a consequence the surface soils to the west of the Brook are sandy, being dunes of Bassendean sands of various depths over Pinjarra Plain (S8 and S10). The soils to the east are pebbly silts (Mgs1). The banks and wet flats of the Brook are clayey silts (Mc1) deposited by the Brook. To the east in the areas with a high clay content are a series of clay mines. Clay also appears to have been mined in similar deposits on the western bank adjacent to study site 2.

VEGETATION

Much of the area encompassed in the System 6 boundary has been cleared of native vegetation. The areas of relatively intact vegetation occur along banks and wet flats associated with the Brook being confined to the clayey silts. There is insufficient remaining vegetation on the uplands associated with the Brook to give a description of the plant communities of this area but the remaining remnant individual native species and the soils maps of the area give some indications of the expected vegetation of the upland areas. There would have been quite different communities on the eastern and western uplands.

Uplands to the West of Bennett Brook

The Bassendean Sands on the west of Bennett Brook occur as
(I) Dunes (S8): *Banksia* Woodland which is similar to that represented on Success Hill and would have been typical of these soils.
(ii) Sandy flats, low relief dunes (S10): *Banksia* Woodland would also have been found on these soils but the underlying heavier soils and proximity to ground water would have resulted in Marri (*Eucalyptus calophylla*) and *Melaleuca preissianna* being important components of the vegetation as well as a series of understorey species characteristic of low lying *Banksia* Woodlands.

The Lightning Swamp area probably contains communities similar to those that would have been found in this area.

Bennett Brook Banks and Wet Flats

Western side of Bennett Brook

The western wet flats contain a mosaic of communities which depend on the relief and degree of inundation, principally Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland along the banks of the Brook. While these sites are broadly similar floristically different sedge species are dominant in sites one and town and shrubs are dominant in the understorey in site 3 (Appendix C). Site 3 is apparently more saline than sites 1 and 2, the species present being typically associated with areas subject to salinity at some time in the year. In the past there were probably areas of *Casuarina obesa* Woodland along the Brook that had a fresh water understorey, as found elsewhere on the Plain, but these would have been selectively cleared.

Eastern side of Bennett Brook

The vegetation of the eastern flats ranges from *Casuarina obesa* Forest, *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland, *Melaleuca viminea* Tall Shrubland, Samphire Open Low Heath, *Bulboschoenus cladwellii* Closed Sedgeland and *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland on the margins of the Brook and extending into the area of shallow water. Zonation was more evident as the wetflats are broader on the eastern side of the Brook and the wetflats grade into similar soils rather than sands. The *Casuarina obesa* woodlands are more disturbed and less waterlogged than those on the west.

The area of *Bulboschenus caldwellii* Sedgeland indicates that there are fresh water seepages associated with the wetflats, a typical feature of such areas.

Although limited in area the relatively intact vegetation of the banks and wetflats of the Bennett Brook provide significant habitat for the fauna associated with the wetland. This vegetation is also significant in that there are relatively few areas of vegetation along the river and creeklines of the Swan Coastal Plain.

Eastern side of Bennett Brook

It is difficult to say what the vegetation was on the pebbly silts as there are apparently no significant remnants in the Swan Valley on these soils. Remnant trees in the area are Flooded Gum, Marri and Wandoo but these are rarely associated with other native vegetation. Marri and Flooded Gum are found in the Bennett Brook area.

Floristic Community Types

The plant communities sampled along the Bennett Brook (Department of Environmental Protection, 1996) form a wetland grouping not represented in the regional study of the Swan Coastal Plain by Gibson et al. (1994). This is not unexpected as Gibson et al. did not generally sample communities associated with lakes, creeks, or rivers. This floristic group has been located at three other locations on the Swan Coastal Plain and all are small areas associated with lakes, creeks, or rivers. Of these locations, the greatest development of the floristic group is along Bennett Brook.

FLORA

Sixty one native taxa (species, subspecies and varieties) were recorded from the study area. This is a comparatively low diversity of taxa for an area on the Swan Coastal Plain, especially one that contains areas of heavy soil wetlands. This can be accounted for by the high degree of clearing of the area and the nature of heavy soil wetlands. On the Swan Coastal Plain the species diversity of wetlands drops with increasing salinity and the length of inundation. That is wetlands that are inundated through winter, spring and all or part of summer and/or are saline have limited species diversity. Both of these conditions are present at Bennett Brook.

The co-occurence of *Halosarcia halocnemoides, H. lepidosperma, H. pergranulata* and *Sarcocornia quinqueflora* is significant being one of the few locations where these four samphires occur together (L. Penn, personal communication). Also it appears that *Sarcocornia blackiana* is also in the area and this taxon is currently known from only one other location on the Swan River (L. Penn, personal communication, 1996).

The presence of *Juncus pauciflorus* is significant as this is not listed in the Flora of the Perth Region (Marchant et al., 1983). However, it is recorded for the Serpentine River (Keighery, Keighery & Gibson, 1994).

Vegetation Condition

As discussed previously most of the Bennett Brook area has been cleared, the remaining vegetation being confined to the wetflats and banks associated with the Brook. The condition of this vegetation ranges from degraded to excellent. There is significant weed invasion of these communities, 21 weeds being recorded for the three study sites (Appendix C).

CONCLUSION

The vegetation of the Bennett Brook area is restricted to the banks and wet flats of the Brook. However, considering that drainage line vegetation on the Swan Coastal Plain is predominantly cleared and/or highly modified the vegetation is significant. It also constitutes the largest remaing and most diverse relatively intact lagoonal system on the Swan - Canning River Estuary (L. Penn, personal communication, 1996).

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Gould's Monitor *Varanus gouldii* Bennett Brook
Photograph: K. Pearson

6 THE VERTEBRATE FAUNA OF BENNETT BROOK, CAVERSHAM, AND SUCCESS HILL RESERVE, BASSENDEAN.

N.K.Cooper and J.Dell

INTRODUCTION

The social and political importance of urban bushland to the community has been highlighted by the formation of many local interest groups which have united under a single voice known as the Urban Bushland Council. Local Shire Councils have recognised community concern by retaining and protecting local reserves.

Recent work by the Western Australian Museum in particular has illustrated the significance of urban bushland remnants to the fauna of the Perth region (How & Dell,1989, 1993, 1994 and Cooper,1995). Reserves as small as 4ha have been shown to be important to fauna conservation but many species persist on smaller reserves .

This study was initiated by the Success Hill Action Group (Inc.) to determine the vertebrate fauna of the small remnant of native bushland at Success Hill and the adjacent and contiguous Bennett Brook area northwards to Benara Road, in Caversham. This study was funded by a 1994/95 National Landcare Programme, One Million Trees and a Save The Bush Programme grant to the Successs Hill Action Group Inc.

STUDY AREA AND METHODS

Success Hill Reserve is vested with the Bassendean Town Council and occupies an elevated area overlooking the Swan River. It is bounded by the Swan River to the east and housing to the west. The area has been isolated by roads and the Swan River for many decades but is contiguous with the riverine woodlands of Bennett Brook to the north.

Success Hill Reserve is situated on the Bassendean Dune Systems. It is a remnant Banksia woodland consisting of Candlestick Banksia, *Banksia attenuata* and Firewood Banksia, *B. menziesii* with an overstorey of Jarrah, *Eucalyptus marginata*. There is a shrub and heath understorey. The Swan River has a fringing forest of Flooded Gum, *E. rudis*, Paperbark, *Melaleuca rhaphiophylla* and She-oak, *Casuarina obesa*. This riverine forest extends, patchily, along the entire length of Bennett Brook. Additionally, the Paperbark has extensive woodlands associated with the swamp system on the eastern side of Bennett Brook. These vegetation types are illustrated on Map 1.

Much of the shrub vegetation along Bennett Brook has been modified or eliminated by various land use practices especially cattle and horse grazing.

Sampling Sites

This study aimed to record the vertebrate assemblage of each vegetation type in the Success Hill, Bennett Brook area. In order to obtain an assessment of the seasonal faunal assemblage it was decided to undertake sampling surveys at several times of the year. Accordingly, surveys were undertaken to examine the fauna during September and November 1994, January, February, March, April, May, July, October and November 1995.

Terrestrial vertebrate sampling sites were established in January 1995 when nine 20 litre buckets, placed 10 m apart, were used as pitfall traps. A seven metre flywire fence standing 30 cm high was placed vertically over each trap when they were opened and operational. Two sites were chosen for intensive sampling, one on Success Hill and one on the slopes below Pyrton (Map 1).

These two sites were chosen to represent the range of habitats available in the elevated dry sandy areas. The lowland sites close to Bennett Brook were not chosen for intensive sampling as pitfall traps cannot be located in areas that become waterlogged during winter rains.

The traps were opened and examined on seven consecutive days during February, March, July, October and November 1995. Traps were closed and sealed and the flywire fence removed between trapping periods. Traps were examined daily and all reptiles, amphibians and mammals were identified, measured, and released.

Extensive searches were also made of the entire area to record reptiles and amphibians. In particular all surface rubbish and timber, bark and leaf litter was turned over and examined to reveal hidden species. Nocturnal surveys were undertaken with head torches on three occasions to reveal species which are only active at night.

Frogs were sampled during favourable weather conditions throughout the year and fish were sampled on two occasions at set sample sites (Map 1) along the entire length of Bennett Brook in autumn and the beginning of winter. Afternoon and evening surveys were also conducted on four occasions to record calling frogs. All surface fresh water was examined with nets for the presence of tadpoles.

Birds were recorded opportunistically whilst checking the fenced pitlines and during all other reptile and frog surveys.

A search was carried out of relevant literature to find historical records of vertebrates from the region. In particular we used Bush *et al.* (1995) and How and Dell (1994) for reptiles, Storr and Johnstone 1988) for birds , Tyler *et al.* (1994) for amphibians and Sarti and Allen (1978) for freshwater fish.

RESULTS

MAMMALS

During these surveys, only the introduced House Mouse, *Mus musculus* was trapped . Numerous signs of House Mouse were recorded throughout the area where old nests and burrows were located under various large items of rubbish. Both Success Hill Reserve and the Bennett Brook area are used by domestic cats and dogs. Rabbits , *Oryctolagus cuniculus*, were widespread but not abundant in the area. Signs of Foxes, *Vulpes vulpes*, were widespread in the area. A fox den had the remains of Swamphens, Black Ducks, Ring-necked Parrots, Dusky Moorhens and freshwater crustaceans.

The Quenda or the Southern Short-nosed Bandicoot, *Isoodon obesulus*, was recorded. Characteristic feeding diggings were located around the edges of the inundated areas after the heavy rains during the winter of 1995. These animals were presumably forced out of their habitat along Bennett Brook and the Swan River. Two dead Quendas were also located on Benara Road near the junction of Bennett Brook during heavy rain.

One species of bat was heared calling in the area during nocturnal surveys This was the White-striped Mastiff Bat, *Tadarida australis*, which is the only local bat whose echolocation sounds can be heard by the human ear. A search of the literature, especially of Strahan, 1995, indicates that as many as nine other bat species are known from the region but How and Dell, 1993, suggest that many are no longer found in the region.

AMPHIBIANS

Seven species of amphibians were recorded during these surveys. They are listed in Appendix D, Table 5, together with habitat types in which they were recorded. Each species is described below together with information on their breeding biology.

TREE FROGS Hylidae

Slender Tree Frog *Litoria adelaidensis*

This elegant, slender frog varies in colour from green to brown with a distinctive dark brown stripe along the side of the head and body. This wide stripe is ususally edged with a narrow white stripe. This frog is a good jumper with long legs and discs on fingers and toes for climbing. Males grow up to 45mm long and females are a little larger. The call is a loud grating screech which was only recorded in the bullrush swamps.

At Bennett Brook, it breeds in early spring in the bullrush swamps at the base of the hill below Pyrton. Calling males were abundant in these swamps between August and October. The egg masses were attached to the rush stems just below the surface of the water. Tadpoles were present in late spring and summer. When not breeding they tend to disperse widely and can be found throughout Bennett Brook and the adjacent Melaleuca

swamps and were trapped in February mainly in the Bracken Fern at Pyrton. The tadpoles have a dark lateral line and deep, vertical tail fins. The eyes are on the side of the head.

Motorbike Frog *Litoria moorei*

This large frog is variable in colour from pale brown to green with dark patches. This colour can change rapidly according to the light. There is usually a narrow, paler stripe down the centre of the back. The back legs are very powerful; the hind feet are webbed and there are small discs on both fingers and toes. The ear drum or tympanum is very prominent. Males grow upto 68mm and females to 80mm. As its name suggests its call is like that of a revving engine of a motorbike changing gears.

This frog breeds through late spring and summer. Eggs are laid in strings. Tadpoles grow up to 70mm long and have deep tail fins, silvery gold abdomens and lateral eyes. Only one Motorbike Frog was trapped in the Bracken Ferns at Pyrton during this survey.

GROUND FROGS Leptodactylidae

Quacking Frog *Crinia georgiana*

This wide flattened frog has short legs and can be smooth or rough on top with a granular belly. The back pattern is very variable, mainly greys and browns and there is invariably a red patch in the groin and golden or red upper eyelids. Adult males range between 25-32mm and the females are slightly bigger up to 36mm.

This frog is rarely seen but is easily recorded by its loud duck-like *quack quack* call which is common in all fresh water seepage areas in winter and early spring. Many individuals were captured in the pit traps both on Success Hill and at Pyrton . They were captured in all sampling periods.

This frog breeds in shallow seepages along the entire western side of Bennett Brook northwards from the base of Success Hill. The large eggs are laid from mid-winter and were found throughout the shallow seepage areas. These tadpoles mature rapidly and the tiny froglets emerge from the water when they are less than a month old. Tadpoles are a uniform dark brown to black. Emerging frogs are very small, being only 10-15mm long.

Glauert's Froglet *Crinia glauerti*

This is the smallest frog in the area and they are often difficult to identify from the next species. They are highly variable in colour with a pattern of blotches and lines in grey, brown, black and white. The under surface of the female always has a prominent black and white pattern and males have a darkened throat extending back to legs. Males grow to 22mm and females to 25mm. The call is a distinctive series of rattles which have been described like a dried pea being rattled in a can.

This frog is common along Bennett Brook especially in the bulrush swamps and the seasonally inundated areas that occurred in the winter of 1995. This frog bred in large numbers in all the freshwater areas that remained after these heavy rains. The eggs are laid in water where they sink to the bottom and become coated in silt making them difficult to find.

Squelching Froglet *Crinia insignifera*

This frog is very similar to the previous species and females are slightly larger ranging up to 29mm. The belly is granular and is marbled in white and black or greyish. The males have a dark border around the chin which is a useful character to separate the sexes of the adults. As its name suggests the call is a long drawn out squelch.

This is the commonest frog in the area and was present throughout the Melaleuca swamps. It bred in large numbers in the inundated areas after the heavy winter rains in 1995. The eggs are laid in water the same as Glauert's Froglet, *Crinia glauerti.*

Moaning Frog *Heleioporus eyrei*

This is a large rounded frog with short legs. The back is brown or grey with a variable pattern of pale grey or yellow blotches. There is a pale vertical stripe from the lips to the nostrils. This frog grows up to 66mm long. Its call is a low monotonous moan which is given by the male from inside a breeding burrow from autumn to the beginning of winter.

Only 3 individuals were trapped in the Success Hill and Pyrton areas. Although not recorded breeding on this survey, they probably breed around the margins of the seepage areas. Males excavate a burrow after the first autumn rains and the egg mass is laid at the bottom of the burrow. Tadpoles grow to 50mm; they have dark brown bodies with thin light coloured lines on either side of the body and head. Tadpoles swim from burrows as they become inundated from rising water levels.

Banjo Frog *Limnodynastes dorsalis*

This is a large frog with a large oval gland on the upper surface of the back leg. The back is variable in colour from pale to dark browns with green or olive patches. There is always a narrow pale cream or yellowish stripe down the centre of the back and the groin is bright red. Males grow up to 66mm and females up to 78mm. Its call is a single, loud *bonk* which may be repeated in chorus with other males while floating on the surface of the water, though it always hides under vegetation. They were captured at both Success Hill and Pyrton and calling males were heard in the Melaleuca swamp in winter and spring.

No egg masses were recorded during this survey. This frog produces a large white frothy egg mass which is hidden on the surface of the water amongst dense vegetation especially bullrushes. Tadpoles reach 70mm in length. They are dark brown with numerous darker spots. Tadpoles are slow growing and can take more than 12 months to develop into frogs. Therefore they need long-lasting water.

REPTILES

Thirteen species of reptiles were recorded during these surveys. They are listed in Appendix D, Table 5, together with habitat types in which they were recorded. Each species is described below together with information on their breeding biology.

SKINK LIZARDS Scincidae

Swamp Skink *Bassiana trilineata*

Several individuals were located in winter under rubbish around the margins of the inundated areas at the base of the slopes above the old bridge. This species is widespread in southwestern Western Australia from Gingin to Israelite bay. It is mainly found in damp locations and has been severley affected by clearing on the Swan Coastal Plain. It is now found in few localities in urban areas (How and Dell, 1994). The eggs are laid among humus on the ground. This lizard has a body up to 70mm long, the tail is about 110mm.

Wall Skink *Cryptoblepharus plagiocephalus*

This species is widespread in the area and found on many trees including Paperbark, *Melaleuca rhaphiophylla* ; Swamp Sheoak, *Casuarina obesa*; Fooded Gum, *Eucalyptus rudis*. It occupies crevices and gaps among peeling bark. The eggs are laid among fallen bark or rotting wood inside tree trunks. This lizard is widespread throughout most of Western Australia. They have a body up to 50mm long and a tail up to 85mm long.

Striped Skink *Ctenotus fallens*

This fast-running, diurnal species is widespread throughout Success Hill and the slopes northwards to Pyrton. They have a body up to 90mm long and a tail up to 200mm. They have a yellow belly. Eggs are laid in burrows in November and December and the hatchlings, when they emerge in February, are about 35mm long.

Limestone Skink *Ctenotus lesueurii*

This species is very similar to the previous species but has a slightly brighter pattern of stripes; a longer tail and a white belly. It is scarce in the area and only 2 individuals were trapped at Success Hill. The eggs hatch in February and the young are slightly larger than the young of the previous species.

Two-toed Skink *Hemiergis quadrilineata*

Only one individual was trapped in May on the slopes below Pyrton. This skink has only 2 fingers and toes and is only found on the Swan Coastal Plain. These lizards have a body about 50mm long with a tail about twice that length. The belly is bright yellow. This lizard is one of only a few in the Perth area that gives birth to live young.

Elegant Lerista *Lerista elegans*

This tiny lizard is widespread in the area and was trapped on Success Hill and located among leaf litter under the flooded gums along Bennett Brook. They have 4 fingers and toes and grow to about 45mm long with a reddish tail which is twice as long as the body. This species only lives on sand and is found from Perth northwards to the Pilbara coast. The eggs are laid among rotting vegetation below the ground.

Worm Lerista *Lerista praepedita*

This elongated, burrowing lizard is probably rare in the area as only 1 was trapped on Success Hill. It has no front legs and the hind leg is a minute stump. It is only found in coastal sands from Mandurah to North West Cape. The eggs are presumably laid under ground.

Grey's Skink *Menetia greyii*

This is one of Australia's smallest lizards with an adult body of about 30mm. When the juveniles hatch from the eggs in January/February they are tiny, about 16mm long. They have 4 fingers and 5 toes. They live among fallen leaves and are widespread and probably the most abundant lizard in the area.

Flecked Morethia *Morethia obscura*

This lizard is scarce in the area as only 1 was sighted among the she-oaks near the brickworks on the eastern side of Bennett Brook. This egg-laying lizard has a similar appearance to the swamp skink but lives in drier habitats.

GOANNAS Varanidae

Gould's Monitor *Varanus gouldii*

Only 1 subadult was sighted under the remains of an old car on the slopes below Pyrton after the fire in January, 1995. This large carnivorous lizard which grows up to 1.5m, survives poorly on urban bushlands and is rarely recorded (How and Dell, 1994). They hunt during the day and feed on invertebrates as well as small vertebrates. Large adults will sometimes feed on rabbits. The females excavate a nesting burrow in bare sand in

November or December and the summer heat incubates the eggs which hatch in February.

FRONT-FANGED SNAKES Elapidae

Tiger Snake *Notechis scutatus*

Tiger snakes are scarce but widespread in the area especially around the Melaleuca swamps and the seasonally inundated areas. They feed on frogs, small lizards and mice and give birth to live young. Tiger snakes are blackish on top and gold on the belly. The gold bands usually, but not always, extend over the back. This snake comes out to bask in the daytime but does most of its feeding at night.

Dugite *Pseudonaja affinis*

Dugites grow to about 1.5m and are fast moving, daytime-hunting species which mostly feed on the introduced House Mouse. It is widespread in the area. Dugites come out of hibernation during warm days in late spring and lay their eggs in November or December among rotting leaves or under decaying logs or rubbish. These hatch in February and the young are about the thickness of a pencil.

SIDE-NECKED TURTLE Cheluidae

Long-necked Tortoise *Chelodina oblonga*

This tortoise is common throughout the fresh water swamps along Bennett Brook and also occasionally occurs in the brook itself. When the peripheral waters evaporate in summer, some individuals aestivate in the drying mud to emerge with the following winter rains. Adult females leave the water to lay their eggs in dry sandbanks particularly along the western side of Bennett Brook.

FISH

Five species of native and two introduced fish species were recorded in Bennett Brook during these surveys. They are listed in Appendix D, Table 6. Each species is described below together with information on their breeding biology.

NATIVE MINNOWS Galaxiidae

Western Minnow *Galaxias occidentalis*

These small fish grow to a maximum of 15cm long. They are scaleless and swim close to the surface usually in flowing water. These tiny eel-like fish can often be seen swimming against the current in the fastest running parts of Bennett Brook. They are relatively common in Bennett Brook in the upper parts of the study area, downstream at least to the old cuttaway bridge.

LIVE-BEARING MINNOWS Poeciliidae

Mosquito Fish *Gambusia holebrooki* (often called *affinis* in some books)

This is an exotic species which is extremely abundant in Bennett Brook and the extensive Melaleuca Swamps, even in the shallow weedy seasonal wetlands around the margins. Populations fluctuate markedly in Bennett Brook as this is a very fecund species which produces up to 80 live young several times during the year. This is the smallest species in Bennett Brook with adults only growing to 6cm long.

AUSTRALIAN PERCHES Perchichthyidae

Nightfish Bostockia porosa

This fish grows to a maximum of 17cm and feeds at night. During the day time it is very hard to find as it secretes itself away among stones or vegetation at the bottom of the stream. It prefers running water and was found in the upper reaches of Bennett Brook downstream to the old cuttaway bridge.

PYGMY PERCHES Kuhliidae

Western Pygmy Perch *Edelia vittata*

This tiny fish grows to a maximum of 7cm long. This fish was found throughout the length of Bennett Brook downstream to where the freshwater meets the tidal waters of the Swan River. It was found among water weeds and vegetation debris.

GOBIES Gobiidae

Swan River Goby *Pseudogobius olorum*

This is an abundant native fish in the Swan River and was found in the lower reaches of Bennett Brook. It grows to a maximum of 7cm long. This fish is a slow swimming species and was hard to locate as it spends most of its time resting among submerged vegetation.

Bigmouth Goby *Favonigobius lateralis*

This fish behaves in a similar manner to the Swan River Goby but is much bigger growing to 15cm long.

CARPS Cyprinidae

Golden Carp *Cyprinus auratus*

This is an exotic species and was introduced into Australia as an ornamental fish. Only two individuals were found in the middle sections of Bennett Brook. Both of these were juveniles. Adults are known to grow up to 38cm long and weigh 1.5kg. In other parts of Australia it is a problem species where it feeds on smaller fish and invertebrates. The seasonal nature of Bennett Brook suggests that it is unlikely to become a major problem here.

BIRDS

Seventy eight species of birds were recorded during this survey. They are listed in Appendix D, Table 7. Not surprisingly, most species are associated with the extensive swamp system on the eastern side of Bennett Brook. Wooded wetlands such as these are now relatively scarce on the eastern side of the Swan Coastal Plain. Accordingly, this swampland is a significant feeding and roosting area for many species of bird especially herons, cormorants and ducks.

Table 7 (Appendix D) also includes a number of small insectivorous landbirds such as thornbills, fairy-wrens, scrub-wrens and Grey Fantails which require natural vegetation for their survival. Each of the species in this group have declined markedly on the Swan Coastal Plain as a result of habitat fragmentation (How and Dell, 1993). The corridor of mature trees along Bennett Brook provide an important linkage between the riverine corridor of the Swan River and conservation reserves, especially Ellen Brook to the north.

DISCUSSION

Conservation Significance

This study shows that the Successs Hill/ Bennett Brook area is significant in that it has a population of the Quenda, which is a gazetted Schedule 1, Rare and Endangered Species under the Wildlife Conservation Act. Bennett Brook has 5 species of native fish all of which have declined on the Swan Coastal Plain. The frog fauna which includes 7 species is also moderately rich for a coastal plain wetland. The area has a rich lizard fauna with 9 species of skink lizards. The most significant species is the Swamp Skink which is now rarely recorded on the Swan Coastal Plain bushlands (How and Dell, 1994).

The conservation significance of the area for birds has been highlighted above. The swamplands support a large number of waterbirds and the riverine forest is an important transit corridor linking the Swan River with conservation reserves to the north.

Management Considerations

The Success Hill/Bennett Brook area needs specific management planning and practices to protect the multiple objectives of conservation (both wildlife and flora) and human recreation and aesthetic values. In particular, the damaging processes of fire, environmental weeds, feral animals, grazing animals and human disturbance need addressing. Some need immediate attention e.g. wildfire control and others need longer term considerations as processes increase with time.

Fire

Fire has both short-term as well as long-term effects on native fauna. These were summarised in a symposium organised by the Urban Bushland Council in 1995, and highlighted in a paper by Dell and How, 1995. They indicated that vertebrate as well as invertebrate animals were inimicably affected by fire. In particular, habitat specific, dietary specialist, sedentary species were worst affected. Some species disappeared completely after fire and others were slow to recolonise burnt areas from unburnt patches.

The severe wildfire of December, 1994 had a devastating effect on native fauna at Success Hill. Many slow moving, above-ground reptile species such as Bobtails, legless lizards and some skinks were killed outright by the fire. Others which occupied burrows emerged after the fire to face considerably increased predator pressure because their protective cover had been removed.

Fire management needs to address the following objectives and strategies.

Objectives

- minimise the risk of fire to human life
- maintain and enhance the diversity and abundance of plant and animal species especially those most affected by wildfire
- reduce the frequency and restrict the spread of wild fires

Strategies

- fire prevention is effective if a system of narrow, 50-100m wide buffers are burnt at strategic intervals at right angles across the length of Bennett Brook . Ground litter levels within these buffers should be reduced annually by means of controlled burns prior to each summer. The edges of these buffers should have a mown strip to assist fire control access and maintain the edge of the controlled fire. Areas between fire buffers should have a fire exclusion policy unless scientific data demonstrates that fire is necessary to enhance biological diversity or values
- wildfire suppresion may be necessary if a wildfire occurs in a particular zone. Accordingly mown strips should be sited to allow access by fire fighting vehicles and plans of these should be made available to the appropriate fire control agencies
- an actively conducted public education and awareness campaign should be undertaken to highlight the damaging effects of fire on native flora and fauna.

Environmental Weeds

Weeds are non-native plant species that have been introduced either accidentally or deliberately from other regions and become acclimatised. A large number of exotic grasses and other plants occur in the Success Hill/Bennett Brook area and all contribute to changes to native plant and animal communities, displace sensitive native species, reduce regeneration of native species, disposess native animals of habitat or food resources, increase flammability of native vegetation and result in more frequent and increased fire intensity. They also affect the soil surface and change natural water and nutrient cycles.

Several objectives and strategies need to be followed to prevent present weeds from increasing and new weeds from becoming established.

Objectives

- prevent introduction and establishment of new weeds by annual inspections to detect new weeds

- control or if practicable eradicate selected weeds which are likely to cause major environmental problems

- care must be exercised to ensure that the physical or chemical effects of weed removal do not damage the environment

Strategies

- current weed incidence and frequency should be mapped and monitoring should be undertaken to document the location, extent and rate of spread of weeds and where practicable their ecological effects

- undertake physical or chemical control of problem weeds in conservation priority areas, e.g. Success Hill. Weeds such as Pelargonium, *Pelargonium officiale,* should be eradicated immediately they appear as they severely deplete reptile habitats

- eradicate small outbreaks of new weeds immediately while control is easy

- conduct education programmes to increase public awareness of severe environmental weeds to promote weed control on adjoining lands

Feral Animals

Non-native species of vertebrates such as foxes, cats, rabbits and Golden Carp compete for resources against native species and a number of them predate on native fauna. Rabbit overgrazing can result in soil erosion, weed invasion and the loss of native plant species. foxes and cats prey upon ground animals and can seriously affect the population of the Rare and Endangered Quenda. They also destroy nests of ground-nesting birds or those that nest close to the ground.

Objectives

- new feral animals should be prevented from being introduced to the Success Hill/ Bennett Brook area

- feral animals likely to or known to cause environmental problems should be eradicated or controlled

Strategies

- liaise with Agriculture Western Australia to determine appropriate control of rabbits, foxes and cats in the Success Hill/Bennettt Brook area

- conduct education programmes to increase public awareness of the severe detrimental effects of domestic cats and the need to encourage voluntary cat curfews

Grazing Animals

Grazing animals have a severe effect on the native vegetation particularly low shrubs and frequently prevent the regeneration of native trees. Specialised habitats such as seasonal wetlands which are important for some frog and reptile species and bird breeding habitats are severely damaged by horses and cattle. The soil surface is severely affected and results in increased erosion which deposits silt in the Bennett Brook and associated swamps.

Objectives

- to reduce the effects of grazing animals on the native vegetation and fauna
- to encourage the natural regeneration of plants

Strategies

- provide adequate fencing to prevent domestic stock from straying onto reserve land
- liaise with land owners or lessees to fence off habitat sensitive areas such as seasonal wetlands and Bennett Brook so that domestic stock are excluded from these areas

Human Disturbance

Native vegetation is easily damaged by human trampling. This also causes increased erosion and spread of weeds. Fertiliser and chemical use (herbicide and pesticide) should be discouraged in adjacent areas to reduce their effects in Bennett Brook as these affect water quality and the consequent survival of native fish and frogs.

Strategies

- walk trails currently in use in Success Hill should be maintained and surfaced with crushed limestone. This encourages people to remain on the paths and reduces damage to the vegetation and disturbance to native fauna
- education and interpretive displays should be provided at strategic points at Success Hill to highlight the conservation significance and biological diversity of the area
- an education campaign should be conducted with adjacent landowners to inform them of the effects of herbicides and pesticides on native flora and fauna

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Bird Nests - Open Water Grogan's Swamp
Photograph: K. Pearson

7 Bennett Brook Bird Survey November 1994 to January 1995

Ron Van Delft

INTRODUCTION

In November 1994 a bird survey was organised for the Success Hill Action Group as part of a larger survey of flora and fauna of Bennett Brook from the Swan River to Benara Road. The bird survey area extended from Success Hill Reserve to Lord Street along Bennett Brook and the Swan River (See Map 1).

METHOD

An advertisement was placed in WA Bird Notes and personal contact made with local birdwatchers. As a result, nine people participated in the survey. Table 1lists the sites surveyed, the number of surveys of each site and the primary observers for each site. When the primary observers were unable to do their survey, other observers helped.

Table 1

Sites and observers for the Bennett Brook bird survey

Site Name	Abbreviation	Primary Observers	No surveys
North West	NW	Henk & Dorothy Van Wees	12
Horse Paddock	H	Peter Melling	19
North East	NE	Neil McMurtrie & Lucy Crake	5
South	S	Geoff & Jan Addison	11
General	G	Ray Shultz, Ron Van Delft	4
Waterbird	W	Ron Van Delft & David Brown	4
		SUB TOTAL	54

WAM

Western Australian Museum opportunistic sightings

Map 8 shows the approximate location of the bird survey sites.

Except for the Waterbird site, observers were asked to record bird sightings on a presence/absence basis, the survey date and time and to send the information to the author on Perth Metropolitan Bird Project Field Record Cards for subsequent collation and analysis.

At the Waterbird site, observers counted the number of each waterbird species seen, recorded exceptional or unusual bush-bird sightings, and recorded the date and time of the surveys.

Observers were asked to follow approximately the same route for each survey. This was not possible in winter due to flooding of much of the site. One observer recorded in August 1995 "many areas impossible to walk in, even with gumboots".

The General survey site is not a specific site, but includes miscellaneous surveys.

Surveys in the North East site ceased after April 1995 due primarily to extensive flooding of this area.

Staff of the Western Australian Museum also recorded opportunistic observations during their other survey work.

RESULTS AND DISCUSSION

Appendix E contains various tables summarising bird survey results, including sightings recorded by staff of the Western Australian Museum (Appendix E, Table 14).

Except where specifically noted, the results below collate information for all sites except Waterbird which is covered later in the Chapter, and opportunistic observations by staff of the Western Australian Museum.

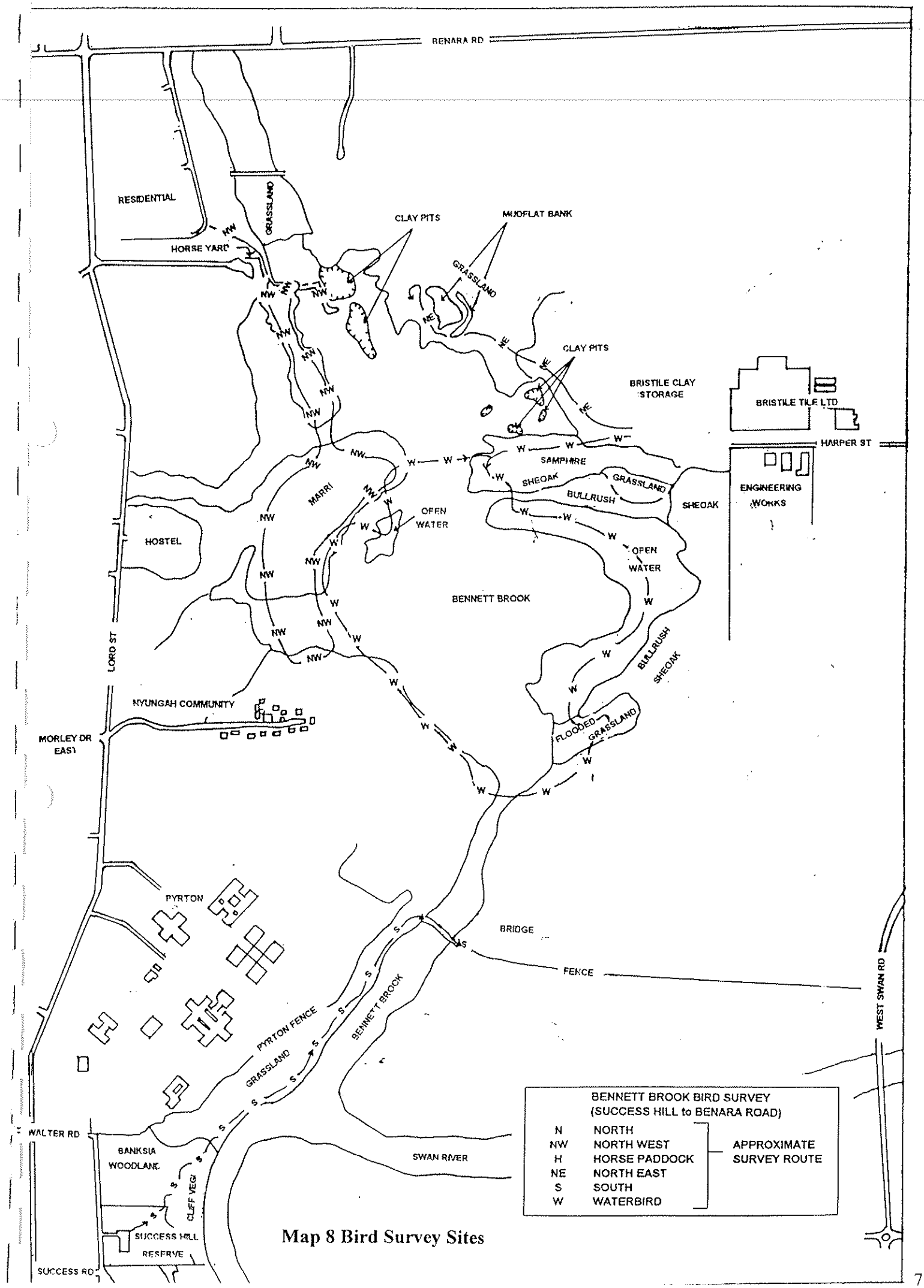
All inclusive, one hundred species of birds were seen (92 over all the sites in Table 1 including three which were only seen at Waterbird, and an additional eight species which were recorded by the Western Australian Museum).

Survey effort

Between November 1994 and January 1995 observers undertook 51 surveys and recorded 1 403 sightings. Four surveys were undertaken at the Waterbird site during this period.

The total survey time which included Waterbirds has been estimated at 147 hours and 50 minutes. This assumes that surveys at the sites where times were not recorded averaged one and three-quarter hours, that Waterbird surveys took two hours, and takes into account the number of people observing on each survey.

Actual recorded times show the average time taken per survey to be one hour and 46 minutes. The time taken per survey ranged from 45 minutes to two hours and 50 minutes, with 22 of the 31 surveys (i.e. 70%) taking from one and a half to two hours. The total survey hours per site varied considerably.



Map 8 Bird Survey Sites

Survey effort vs number of species

Graph 1 shows overall survey effort compared with the cumulative number of species seen, and Graph 2 shows survey effort compared with the cumulative number of species for each site.

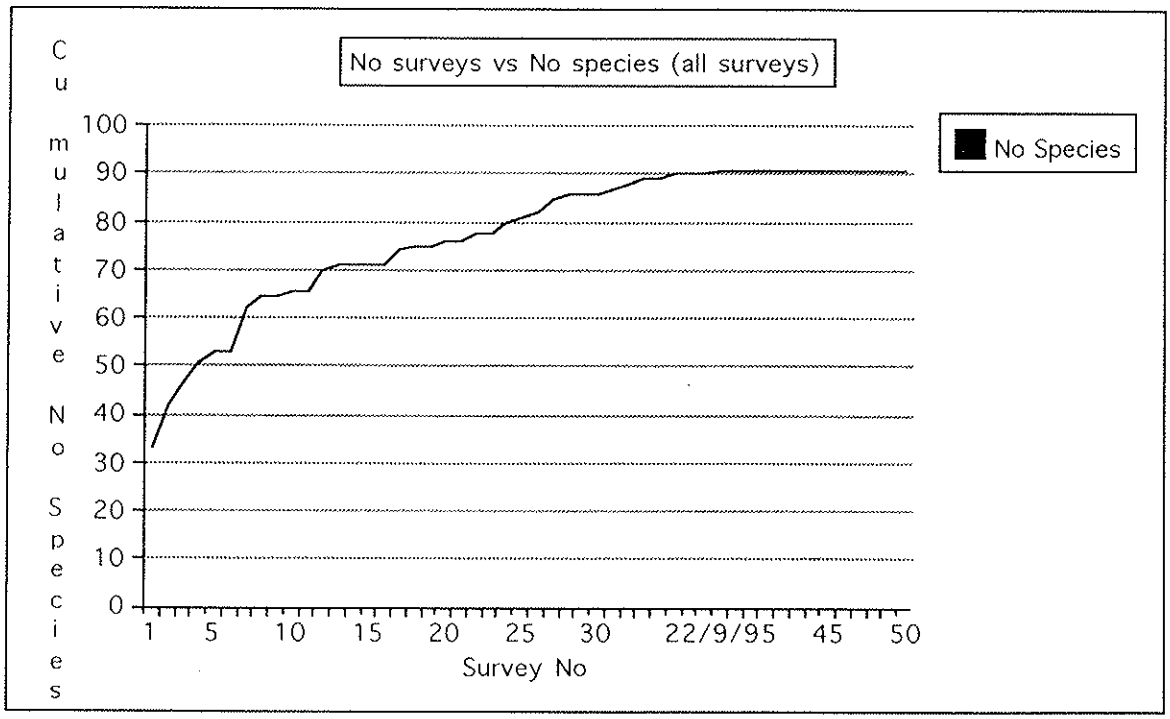
Both graphs illustrate the relationship between survey effort and new species seen.

Graph 1 shows that after a total of 89 species had been recorded by all observers on the 38th survey on 25 September 1995, no new species were seen in the following twelve surveys.

Graph 2 shows that new species were recorded at individual sites beyond 25 September 1995. However, the new species had already been seen at other sites.

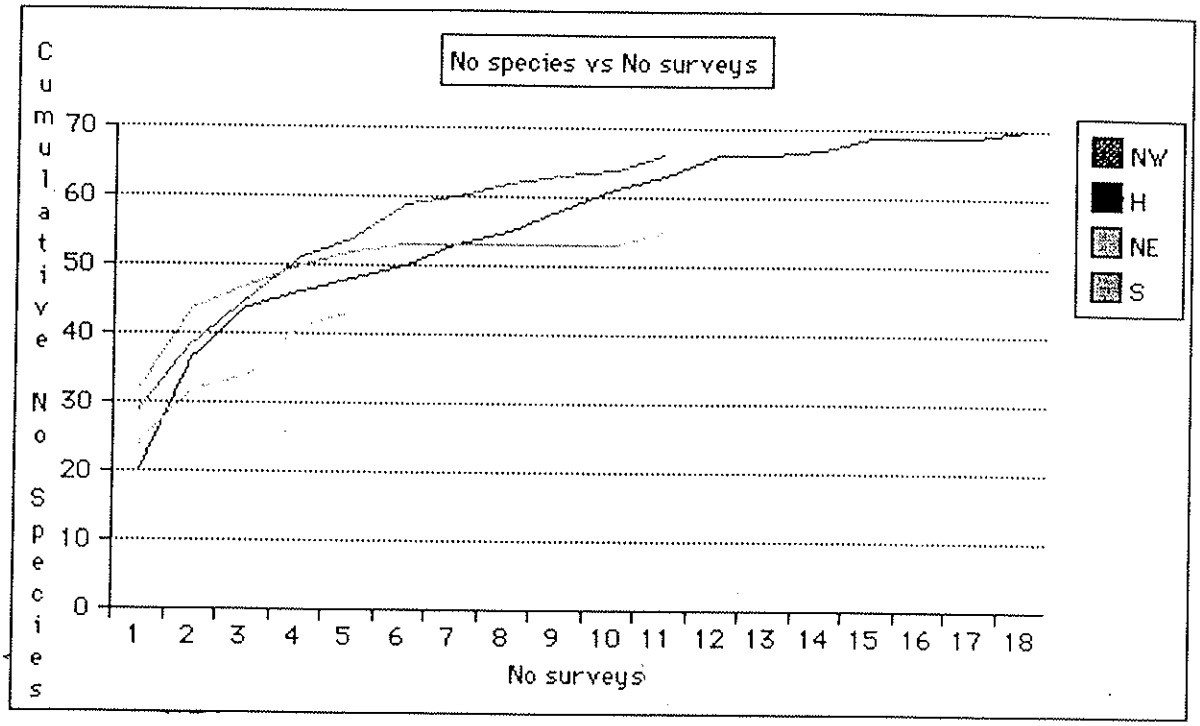
The survey effort results indicate the site has been adequately surveyed to detect the species present along the routes surveyed.

Graph 1: No surveys vs No species (all survey)[1]

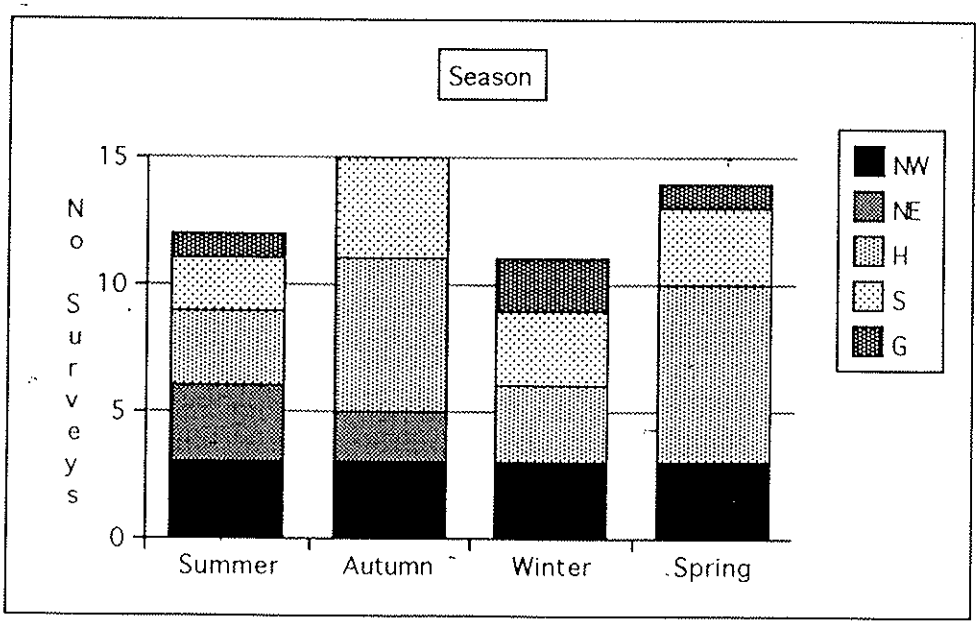


(1) Due to an oversight this data does not include 18 June 1995 survey at the NW site.

Graph 2 No species vs No surveys for each site[1]



Graph 3: Survey effort (No of surveys) by season by site



Overall survey effort by season per site

The seasons referred to here are those used by the RAOU, and are as follows;

Summer	Dec to Feb	Winter	Jun to Aug
Autumn	Mar to May	Spring	Sep to Nov

The survey effort per season varied. Graph 3 shows the survey effort (No of surveys) by season and site. It shows that fewer surveys were conducted in Summer and Winter than in other months, particularly for the Horse Paddock site. The North East site was only surveyed from January to April.

Number of species per survey

On average, each observer recorded 27.8 species of bird per survey. The number of species of bird per survey ranged from 11 to 41, with 33 of 51 surveys recording from 25 to 35 species per survey.

Species seen by frequency of sighting

Appendix E, Table 8, sorts species by frequency of sighting, with species seen on 50% or more surveys at any one site at the top of the table. The ten most frequently and ten least frequently seen species on an overall basis are reproduced in Table 2 below.

Four of the most frequent species recorded were also recorded as being among the nine most frequent species recorded in the Perth Metropolitan Bird Project.

Table 2

The ten most and ten least frequently seen species

Species	No	%	Species	No	%
Australian Magpie	47	92	Pied Butcherbird	1	2
Grey Fantail	46	90	Western Spinebill	1	2
Australian Raven	43	84	White-winged Fairy-wren	1	2
Striated Pardalote	43	84	Fan-tailed Cuckoo	1	2
Pacific Black Duck	42	82	Crested Tern	1	2
Australian Ringneck	42	82	Caspian Tern	1	2
Western Gerygone	41	80	Spotless Crake	1	2
Australian White Ibis	41	80	Brown Falcon	1	2
Silvereye	39	76	Swamp Harrier	1	2
Galah	36	70	Nankeen Night Heron	1	2

Of the ten least frequent species, the sighting of the White-winged Fairy-wren is notable (Refer Table 11 Appendix E).

Comparison of sites

Appendix E, Table 9 shows for each species recorded and the three sites regularly surveyed, the number of sightings, percentage of surveys recording that species for that site and provides possible explanations for the differences for some species [1]. By using different styles of border or fonts differences and similarities between sighting frequency between sites are highlighted.

By examining Table 9 of Appendix E it is clear that there are many differences in recording frequency between the sites, even if only those birds which had been seen on more than 50% of surveys at any one site are considered. Table 9 shows only 15 of the 38 species recorded more than 50% at any one survey site could be said to occur at a similar frequency across all sites. The information in Table 10, Appendix E, which considers species seen on less than 50% of but more than 6% of surveys (6% equates to three sightings, or one sighting per site), supports the conclusion drawn from Table 8, Appendix E. The extent of differences between the sites suggests differences in habitat between the sites.

The types of habitat present along the routes surveyed included:

- the Swan River;
- the claypits and lake, which have deep water;
- flooded grassland, samphire and mudflats surrounding the lake;
- bulrushes around the lake and claypits;
- flooded gum and paperbark along the Bennett Brook creekline;
- banksia woodland and open grassland between Success Hill & Pyrton; and
- marri woodland (without understorey) in the NW site.

For waterbirds possible explanations for the differences between sites are generally based on known habitat preferences for the species under consideration. With regard to bushbirds, possible explanations have only been provided for the Corella and Carnaby's Black Cockatoo.

Each site recorded species not seen at the other sites.

Breeding and young birds seen

Appendix E, Table 11, lists observers' comments with respect to breeding and the presence of young birds, and includes the date when the comments were made and the site where the comments were recorded.

[1] Due to an oversight this analysis does not include the 18 June 1995 NW survey data

Table 3

Species recorded nesting, with young or other evidence of breeding and rearing of young

Species	Observations	Species	Observations
203 Black Swan	Nesting & young	326 Sacred Kingfisher	Nesting & young
207 Australian Shelduck	Young	329 Rainbow Bee-eater	Nesting
208 Pacific Black Duck	Young	381 Red-capped Robin	Young
211 Grey Teal	Young	361 Grey Fantail	Nesting
215 Hardhead	Young	364 Willie Wagtail	Carrying nesting material
202 Australian Wood Duck	Young	532 Splendid Fairy-wren	Young?
221 Brown Goshawk	Nesting & young	463 Western Gerygone	Nesting
222 Collard Sparrowhawk	Young	486 Yellow-rumped Thornbill	Old nest found
056 Dusky Moorhen	Young	976 Striated Pardalote	Nesting
059 Eurasian Coot	Young	705 Australian Magpie	Young
291 Australian Ringneck	Nesting	930 Australian Raven	Young
337 Pallid Cuckoo	Laying		

Nine species were recorded at a nest with or without young, a further 10 species were recorded with young birds (i.e. chicks or juveniles) present, one species was recorded carrying nesting material, and an abandoned nest was found for a further species. The young and females of Splendid Fairy-wrens are difficult to differentiate but young may have been present. This make a total of 23 species which probably use the area for nesting or the rearing of young birds. Table 3 above summarises the information contained in Table 11, Appendix E.

Interesting observations

Table 4 provides extracts from observer record sheets relating to bird behaviour and sightings of uncommon species.

Table 4

Interesting observations of bird behaviour and sightings of uncommon species

Site	Date	Comment
S	4 Feb 1995	Corella - approximately 250 birds seen
NW	7 Feb 1995	Galah - One started rolling and flapping in the sand, apparently enjoying a dust bath
NW	14 Mar 1995	The Great Egret was in water almost up to its belly & each time it moved it jumped up out of the water and flapped its wings instead of walking
G	19 Jun 1995	White-winged Fairy-wren - good view of male in breeding plumage
W	6 Jul 1995	Sacred Kingfisher seen - overwintering!
S	24 Oct 1995	Red-capped Robin - got to within 2.5 m of mature male on two occasions
S	22 Dec 1995	Cockatiel seen (probably an aviary escape)
S	22 Dec 1995	Corella - eight birds seen with long bills

As indicated in Birding Sites Around Perth, sightings of Red-capped Robin are not common on the Swan Coastal Plain.

Habitat specific insectivorous passerines

The Western Australian Museum has recorded a general loss of habitat specific insectivorous passerines in the Perth Metropolitan area. Six of these species, namely the Grey Shrike-thrush (2 sightings), Splendid Fairy-wren (19 sightings), White-winged Fairy-wren (1 sighting), White-browed Scrubwren (5 sightings), Inland Thornbill (14 sightings) and Yellow-rumped Thornbill were recorded at Bennett Brook.

Species not seen close to Perth

During the Perth Metropolitan Bird Project the Grey Shrike-thrush and Splendid Fairy-wren were not recorded closer than 13 and 10 km from Perth General Post Office respectively. There were two observations of Grey Shrike-thrush, and Splendid Fairy-wrens were seen on 19 of 51 surveys.

White-winged Fairy-wren

Although the Atlas of Australian Birds records this species in Perth and east of Perth, there were no sightings of this species more than 5 km from the coast in the Perth Metropolitan Bird Project.

Corella

The Western Australian Museum consider that the flocks of Corella now seen in Perth originate from aviary escapes. The flock of Corella have been seen at other localities around Bassendean, and it is larger than the flock of about 50 recorded during in the Maylands, Karrinyup and Point Walter area during the Perth Metropolitan Bird Project.

Seasonality

Differences in the survey effort by season per site, the time taken per survey, and variability in bird activity due to weather-related factors, the low number of sites surveyed and the number of species with few sightings meant that seasonal differences picked up through any analysis of data would probably not be meaningful (i.e. statistically valid).

However, data for birds which are migrants or found to exhibit seasonal variations in the surveys for the Atlas of Australian Birds was analysed by season. The results are provided in Appendix E, Table 12, and confirm that the factors mentioned above mask any seasonal pattern except for the full migrants.

With regard to the Mistletoebird it is interesting to note that the Perth Metropolitan Bird Project recorded an influx of birds in July/August and January/February, but all sightings at Bennett Brook were during Summer & Autumn (i.e. December to May).

Waterbird survey results

The Waterbird survey results are shown in Appendix E, Table 13.

Many waterbird species were recorded by the regular presence/absence surveys which were not recorded on the waterbird surveys. Including the results from the presence/absence surveys, 38 waterbird species were seen. This compares favourably with other wetlands in the greater metropolitan region (A H Burbidge pers comm.).

No migratory waders were seen.

Uncommon waterbird species sighted include a Glossy Ibis and Chestnut Teal. Neither of these species was observed by bushbird surveys.

The Waterbird surveys found between 320 and 365 waterbirds using the lake during the Summer and Autumn surveys, and between 80 and 91 during Winter and Spring. Between 13 and 18 species of waterbirds were seen, with Grey Teal, Australian Shelduck and Eurasian Coot being the most numerous species.

The number of birds seen here is not outstanding. Larger wetlands record several thousand birds. However, the sighting of 15 Yellow-billed Spoonbill warrants particular mention.

Conservation value and management of Bennett Brook

Using presence/absence surveys, there are few (if any) criteria which can be used to compare the conservation value of different sites. Species diversity (i.e. the number of species recorded) would seem a useful measure, but this figure is affected by factors such as survey effort, the area and range of habitats covered, the season and birds which were recorded once or twice but were just passing through.

Notwithstanding problems with this measure, recording 100 of the 174 species of birds recorded in the Perth metropolitan area by the Perth Metropolitan Bird Project indicates the site has some conservation value. Also the number of species regularly recorded at any one of the sites (i.e. those species which were recorded on 75% or more of surveys at any site - indicates a medium to high level of diversity).

Although the actual number of waterbirds counted does not make the site outstanding for waterbirds, recording 38 species of waterbirds shows the area has a good diversity of waterbirds and habitats. In the RAOU South-West Waterbird Project which surveyed 197 reserves between 1981 and 1985, 37 species ranked equal twenty-second. A H Burbidge (unpublished) has ranked 57 wetlands in and near the Perth Metropolitan area by the number of species, and Bennett Brook ranks equal ninth in that list.

The number of breeding records is often considered an important measure of the conservation value of a site. However, the figure recorded is affected by the same factors as species diversity, and by the experience of observers. As previously noted some 23 species were recorded using the area either for nesting or as young birds, but this information is not directly comparable with easily extractable data from other locations around Perth. The author considers that the records of nesting and young birds indicate the area does have conservation value.

The site is probably important for Yellow-billed Spoonbills. In the Perth Metropolitan Bird Project, only two sites recorded Yellow-billed Spoonbill on more than 50% of surveys. In this survey both the North West and Horse Paddock sites recorded them more frequently than 50% of surveys and they were recorded on every Waterbird survey. The sighting of 15 Yellow-billed Spoonbill may be significant in a metropolitan context. During the South-West Waterbird Project the abundance (i.e. the maximum number of birds counted over all sites in any month) was 122 birds, and the maximum sighted on any one survey was 78.

The results highlight several uncommon species which were seen at Bennett Brook.

The Western Australian Museum has recorded a general loss of habitat specific insectivorous passerines in the Perth Metropolitan area. Six of these species, namely the Grey Shrike-thrush (2 sightings), Splendid Fairy-wren (19 sightings), White-winged

Fairy-wren (1 sighting), White-browed Scrubwren (5 sightings), Inland Thornbill (13 sightings), and Yellow-rumbed thornbill (33 sightings) were recorded at Bennett Brook.

It is not possible to determine the linkage value of Bennett Brook from Whiteman Park to the Swan River based on a presence/absence survey. This would involve bird banding, and would be a useful and interesting exercise.

Unfortunately it is not possible to draw management recommendations from the bird survey, except to conclude that the existing environment, particularly the diversity of waterbird habitats and water regime should be maintained.

CONCLUSION

The survey effort results show that survey effort was adequate to prepare a comprehensive list of species which use the Bennett Brook area.

A total of 100 species were seen, of which 38 species were waterbirds. This compares with 174 species recorded for the Perth Metropolitan Bird Project. There were differences in the frequency of sighting of species between each site surveyed, probably reflecting the level of habitat diversity around Bennett Brook. Known habitat preferences presented possible explanations for several species.

Twenty three species were recorded either nesting or as young birds at Bennett Brook indicating its value for breeding.

A high diversity of waterbird species was recorded probably reflecting the habitat diversity, although the numbers of waterbirds was not high.

The site is probably important for Yellow-billed Spoonbill and is one of the nearest locations to Perth where Splendid Fairy-wrens and Grey Shrike Thrush have been seen. Six species of habitat specific insectivorous passerines which have become less common in Perth were recorded at Bennett Brook. Other species uncommon in the Perth Metropolitan area recorded include Red-caped Robin, Glossy Ibis and Chestnut Teal.

Bennett Brook's conservation values lie in the diversity of waterbirds and occurrence of habitat specific insectivorous passerines.

A management recommendation which can be drawn from this survey is that the diversity of waterbird habitats and the original water regime should be maintained.

Further study to determine the linkage value of Bennett Brook would be of interest.

Bushfire Success Hill Reserve and Bennett Brook
December 25, 1995
Photograph: G. Peterson

Bushfire Success Hill Reserve - east of Pyrton
December 25, 1995
Photograph: K. Pearson

Recommendations

In concluding this report the Project Team has prepared a list of management remmendations based upon the studies research and observations which were done during the NLC Bennett Brook project. The NLC project team believe that various state department, local government councils, landowners, community members and community groups such as the Bennett Brook Catchment Group need to work towards implementing the following recommendations in the near future.

Fire Management Recommendations

- 50 -100m wide buffers need to be burnt at strategic intervals at right angles across the length of Bennett Brook to for effective prevention and management of fire (Dell, 1996).

- Ground litter within the buffers areas should be reduced annually by means of controlled burns prior to each summer (Dell, 1996).

- Buffer areas should have a mown strip to assist with fire control access and maintain the edge of the controlled fire (Dell, 1996).

- Areas between fire buffers should have a fire exclusion policy unless scientific data demonstrates that fire is necessary to enhance biological diversity or values of specific buffer sections (Dell, 1996).

Environmental Weeds

- Current weed incidence and frequency should be mapped and monitoring undertaken to document the location, extent and rate of spread of weeds and where practicable their ecological effects (Dell, 1996).

- Undertake physical or chemical control of problem weeds in conservation priority areas, e.g. Success Hill. Weeds such as Pelargonium, *Pelargonium offiale*, should be erradicated immediately they appear as they severely deplete reptile habitats (Dell, 1996).

- Eradicte small outbreaks of new weeds immediately while control is easy (Dell,1996).

- Conduct education programmes to promote weed control on adjoining land (Dell, 1996).

Feral Animals

- Control or eradicate known feral animals likely to cause environmental damage (Dell, 1996).

- Conduct education programmes to increase public awareness of the severe detrimental effects of domestic cats and the need to encourage voluntary cat curfew (Dell, 1996).

Grazing Animals

- Provide adequate fencing to prevent domestic stock from straying onto reserve land (Dell, 1996).

- Liaise with land owners or leasees to fence off habitat sensitive areas such as seasonal wetlands and Bennett Brook so that domestic stock are excluded from these areas (Dell, 1996).

Human Disturbance

- Walk paths currently in use in Success Hill should be to protect flora, prevent spread of weeds, encourage use of paths and reduce damage to vegetation and disturbance to native fauna (Dell, 1996).

- Education campaigns should be conducted with adjacent landowners to inform them of the effects of herbicides and pesticides on native flora and fauna (Dell, 1996).

- Education and informative displays should be provided at stategic points at Success Hill to highlight the conservation significance of biological diversity of the area (Dell, 1996).

Native Fauna

- Maintain quality of water and vegetation for survival of waterbirds and diversity of birds in the area (Van Delft, 1996).

- Conduct further studies to identify migration pattern of animals between nearby wetlands and linkage value of Bennett Brook corridor.

Native Flora

- Undertake replanting of riparian edges of Bennett Brook that have been eroded by domestic stock.

- Undertake collection of local seeds and replant the understory cover in specific areas along and adjacent to the Brook to assist in the restoration and ongoing biological diversity of the area.

- Implement strategies such as encouraging the public to use paths to prevent/contain futher spread of Jarrah Dieback (Phytophthora cinnamomi) through the area and treat affected trees and plants as appropriate especially in Success Hill Reserve.

- Replant some existing upland area where native plants are surviving to provide barriers against weeds enroaching on the creek lines and Bennett Brook wetland.

Conservation of Aboriginal Spiritual, Religious, and Cultural Beliefs and Heritage

- Preserve and protect all aspects of Aboriginal Significance.
- Document the Aboriginal spiritual and cultural significance of the area by conducting an ethnographic, archeological and historical study.
- Support Nyungah Elders in conducting Cultural Walks to assist their Culture and Beliefs to be understood by all people, especially young people.
- Inform landholders and leasees of the Aboriginal Cultural areas of the Brook and surrounding areas and how they can assist in the protection and enhancement of these cultural values.

Water Quality

- Continue to monitor nutrients and entering the study area to maintain quality of water.

- Establish and maintain water levels required to ensure conservation areas of Bennett Brook.

- Control weed invasion along creek lines and 'so called' drains entering Bennett Brook on Lord Street and Benara Road, replant and restore these areas to become "living streams".

Rubbish

- Remove rubbish from the area and conduct education campaign to prevent rubbish from being dumped in the area.

Urbanisation and Land Use

- Management plans should be required of all developments along Bennett Brook and these plans should contain conditions which must be met to ensure the ongoing protection, maintanence and/or improvement of Bennett Brook System 6 area.

- Land use for Bennett Brook Catchment needs to be carefully examined and planned in line with current thinking and policies being introduced into the Swan-Canning Middle Catchment area. These policies and practices have identified the need to plan and establish conservation buffer zones and drainage structures which lesson and the impact of urbanisation on sensitive conservation areas.

- Urbanisation and land use should in Bennett Brook Catchment should not adversely impact on the sensitive conservation areas of Bennett Brook or its water sources from the Gnangara Mound and Whiteman Park.

- Land use and or rezoning of rural land immediately adjoining Bennett Brook such as Lots 12 and 13 Short Street need to be such that its use has no impact on the Brook and should retain the existing floodplain and buffer zone areas shown on Map 4.

- The 50m zone of critical influence and beyond this to 200 m a secondary zone of influence should be implemented on land like Lots 12 and 13 which have an immediate association and /or effect on Bennett Brook.

Diversion of Lord Street

- An alternative plan should be found for the intersection of Lord Street and Benara Road along the western side of Lord Street. Difficulties in building a long span bridge and a road diversion across Bennett Brook south of Benara Road will increase the weed invasion into the wetland and lead to further destruction of the Brook and its conservation areas, as well as the feeding areas for water and bushbirds in the wetlands buffer zone area. It would seriously impact on a particular area of great Aboriginal significance on the west side of Bennett Brook and on the cultural and spiritual meaning of the Brook.

- Similarly the continuation of Perth Darwin National Highway from the intersection of Reid Highway into a four lane regional road to intersect with Benara Road on the proposed diverted section of Lord Street should also be moved further east to Waldeck Street. This intersection should remain a T junction intersection to minimise effects of roads and traffic on Bennett Brook.

Appendix A

Swan Valley Nyungah Community Claim

SWAN VALLEY NYUNGAH COMMUNITY
ABORIGINAL CORPORATION.
C/o Post Office Guildford
Western Australia 6055
T : 09 377 3550
09 279 6706
F : 09 377 3559

To:
The Director General of the United Nations
~~The Governor General of Australia~~
The Governor of Western Australia
The Premier of Western Australia
The Prime Minister of Australia
The Leader of the Opposition of Western Australia
The Chief Officer of the Aboriginal Affairs Department

As of today the 30th day of the 6th Month 1995 we the Swan Valley Nyungah Community are Claiming and we are Verifying that we are claiming the Whole of the Pyrton Land back whick is what we have said all along under our Traditional Law of the Land and International Law.

The Claim is not to be looked on as a Mabo type claim.

We're Claiming under our Traditional First Law of the Land of Australia which we are part of the Aboriginal Nation and under International Law.

We're going back all the days of our lives through our Mothers and Fathers. This Community of Nyungahs hasn't left our Traditional Homegrounds, therefore our claim overrides all other Nyungah people who have left this area. We haven't left. We've lived and suffered here all our lives and died here. We are part of the Land and its Sacredness. We are the Last of the River People living on the Dreaming Track of the Rainbow Serpent Waugal

This letter is to inform the State Government and all Persons concerned with our Traditional Rights where the First Law of the Land is concerned. We claim all Crown Land and the whole area of Pyrton from East of Lord Street to the Banks of Bennett Brook and right back from South of the Lockridge Camps going in a southerly direction right through to Success Hill down to the junction where Bennett Brook meets the Swan River and north of the Lockridge Camps all through Grogans property right down to Bennett Brook again and all through Grogans Swamp & East of Grogans Swamp and all across to Bristiles and North to the south of Valencia's fenceline.

We ask the Aboriginal Affairs Department to assist us in getting this our Homegrounds back.

Noel Harris
Robert C Bropho
Wanda Bropho
Harvey Bropho
Robert Bropho
Derek Bropho
Edna Bropho
Robert Bropho
Peter Mom
F J BROPHO
Linda Rose Bropho
Arthur C Stack
Edmund
Sharon Bropho
Barry Parfitt
Sands
R. Bropho
Bropho
BROPHO
Kathy Clarkson
Bella Bropho

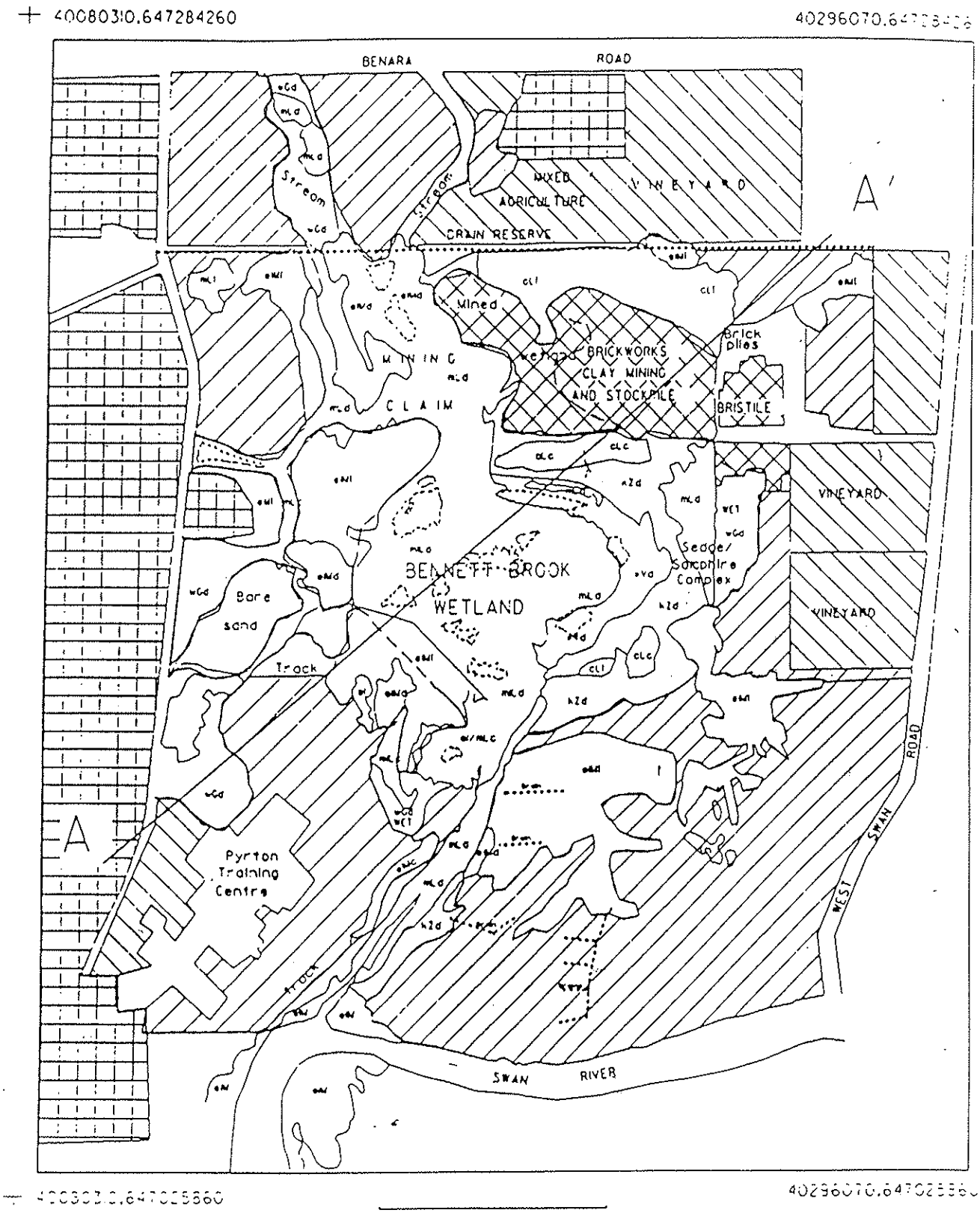
SWAN VALLEY NYUNGAH ABORIGINAL CORPORATION COMMON SEAL

Swan Valley Nyungah Community
Anne M Dorscher

Appendix B

Map and Diagrammatic Cross-section of the Bennett Brook Wetland
Arnold (1990)

Map 9 **Bennett Brook wetland: wetland plant communities and surrounding land use.** (Arnold, 1990, p.377). Reproduced with permission from the Dept. of Environmental Protection Authority



Land Use

Uncleared bushland
Partly or fully cleared land; uses can include pasture cropping, pine plantations, easements and no current use.
Fully cleared and irrigated or used for recreation
Intensive animal production, quarries, landfill, liquid waste disposal sites and industrial areas
Urban areas or sealed areas (e.g. car parks)

Arnold, 1990. p15 – 16.

General Legend

Wetland Boundary
Metropolitan Region Scheme Boundary
Drain – Main (M)
Local (L)
Informal (I)

Fence
Sump
Groundwater Flow

Vegetation Map: Mapping Notation and Formulae.

Consists of three letters, viz:

(a) dominant genus and species – lower case on left:
(b) physiognomy of dominant stratum – upper case letter in centre: and
(c) projective vegetation cover – lower case letter on right.

Example: m1 Ld – Melaleuca rhaphiophylla: low trees < 10 m tall: dense > 70%

(a) Dominant genera and species

a	Acacia	k	Halophytes e.g. samphire
b2	Banksiaa littoralis	l	Leptocarpus
c	Casuarina	m	Melaleuca sp
c1	Baumea articulata	m1	Melaleuca rhaphiophylla
c2	Baumea juncea	m2	M. preissiana
d	Dryandra	m3	M. lateritia
e1	Eucalyptus rudis	m4	M. teretifolia
e2	Eucalyptus gomphocephala	m5	M. cuticularis
e3	E. marginata	p	Callitris
e4	E. calophylla	s	Scirpus
e5	E. todtiana	t	Typha
g	Ghania trifida	w	Weeds or introduced grasses e.g. kikuyu
h	Coastal heath		
j	Juncus	x	Mixed or other

(b) Physiognomy of Dominant Stratum

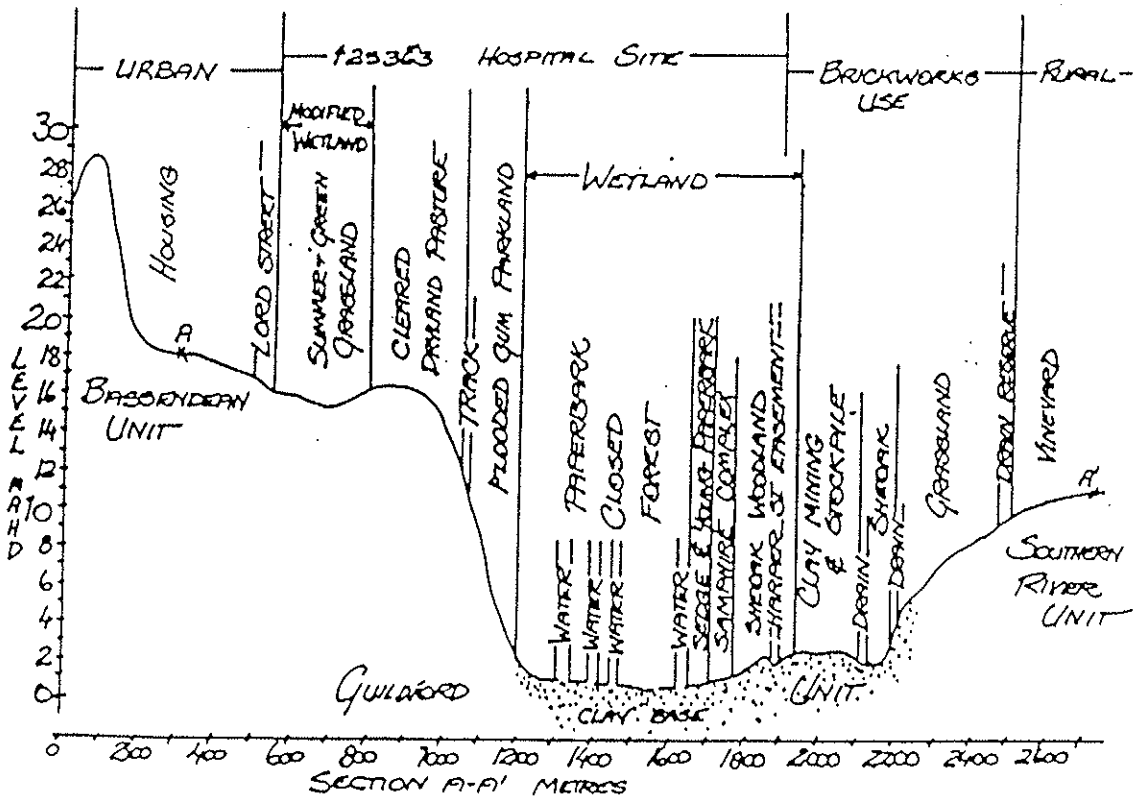
T	Tall trees > 30 m tall	V	Rushes and sedges < 1 m tall
M	Medium trees 10 – 30 m tall	G	Bunch grasses
L	Low trees < 10 m tall	H	Hummock grasses e.g. Spinifex
S	Shrubs > 1 m tall	F	Forbs
Z	Dwarf shrubs < 1 m tall	L	Lichen and mosses
R	Rushes and sedges > 1 m tall	C	Succulents

(c) Canopy Cover

d	Dense Cover > 70% foliage cover
c	Mid dense 30 – 70% foliage cover
i	Incomplete Canopy - open, not touching
r	Rare but conspicous foliage cover < 10%
b	Vegetation largely absent
p	Scattered groups – no definite foliage cover

Arnold, 1990. p 15 –16.

Figure 2 **Bennett Brook wetland: diagrammatic cross-section** (Arnold, 1990, p.378). Reproduced with permission from the Dept. of Environmental Protection.



Appendix C

(See Chapter 5)

TABLE 1

Vegetation Descriptions
Structural Classification (Adapted from Muir (1977) and Aplin (1979)

Lifeform/Height Class	Canopy Cover (percentage)			
	100 -70	70 - 30	30 -10	10-2
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10-30	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 Shrub	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

Other layers may be present yet not listed on this table as Hummock Grassland, Vines etc. Add these layers as necessary following the same format as in Grasses, Herbs etc.

TABLE 2

Site condition scales

Vegetation Condition Scale (Keighery 1994)

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.

Permanent Sites - wet flats on western side of Bennett Brook

Site 1 - Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Carex appressa* Closed Sedgeland.

CONDITION Rating Very Good

Comments: The understorey contains significant herbaceous weeds.

Soil: grey brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 2 - Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Open Low Woodland
Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Chorizandra enodis, Lepidosperma longnitudinale* and *Juncus pauciflorus* Closed Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 3 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Woodland
Casuarina obesa and *Melaleuca rhaphiophylla* Woodland over Samphire Open Low Heath and exotic Very Open Grassland, *Samolus juncea* and *Cotula corynopifolia* Herbland and *Juncus krausii* Very Open Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Sites - wet flats on eastern side of Bennett Brook

Site 4 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland over exotic Grassland
CONDITION Rating Degraded
Comments: The understorey contains significant grassy weeds.
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged

Site 5 - Samphire Open Low Heath
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till December

Site 6 - *Bolboschoenus caldwellii* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till mid summer

Site 7 - *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till ?mid summer/all year

TABLE 3

Flora from sites 1 -3 and opportunistic records made by the System 6 Update field team. Flora from sites 1 -3 and opportunistic records made by the System 6 Update field team.

Key
Column 1 Family
Column 2 Taxon
Names follow Gibson *et al.* (1994). A * preceeding the name indicate a weed while # preseeding the name indicates an opprrtunistic record.
Columns 3 - 7

Column 3 =	W =	Bennett Brook
Column 4 =	WF	Wet flats along Bennett Brook
Column 5 =	Us	Upland, sands
Column 6 =	Uc	Upland, clay
Column 7 =	D	Drainage line into Bennett Brook

	W	WF	Us	Uc	D
FERNS					
# Azolla filicoides	•				
FLOWERING PLANTS					
Anthericaceae					
# Caesia micrantha (blue flowered form GJK 10857)			•		
# Chamaescilla corymbosa			•	•	
# Thysanotus dichotomus			•		
# Tricoryne elatior			•	•	
Apiaceae					
Apium prostratum		•			
# Homalosciadium homalocarpum			•		
Araceae					
* Zantedeschia aethiopica		•			
Asteraceae					
* Aster subulatus		•			
Cotula coronopifolia		•			
* Lactuca serriola		•			
Pogonolepis stricta		•			
* Sonchus oleraceus		•			
Callitrichaceae					
* Callitriche stagnalis		•			
Casuarinaceae					
Casuarina obesa		•			
Chenopodiaceae					
# Halosarcia halocnemoides		•			
Halosarcia lepidosperma		•			
Halosarcia pergranulata		•			
Sarcocornia quinqueflora		•			

	W	WF	Us	Uc	D
Cyperaceae					
Baumea juncea		•			
Bolboschoenus caldwellii		•			
Carex appressa		•			
Carex tereticaulis		•			
Chorizandra enodis		•			
Cyperus polystachyos		•			
Isolepis cernua		•			
Lepidosperma longitudinale		•			•
Dasypogonaceae					
# Lomandra micrantha			•		
Droseraceae					
# Drosera erythrorhiza			•		
Frankeniaceae					
# Frankenia pauciflora		?•			
Gentianaceae					
* Centaurium sp.		•			
Goodeniaceae					
# Dampiera alata					•
Haemodoraceae					
# Haemodorm simplex			•		
#					
Iridaceae					
* Babiana disticha		•			
* Gladiolus undulatus		•			
* Hesperantha falcata		•			
* Romulea rosea		•			
* Sparaxis bulbifera		•			
Juncaceae					
* Juncus bufonius		•			
Juncus kraussii		•			
Juncus pauciflorus		•			
Juncaginaceae					
Triglochin centrocarpum		•			
Triglochin mucronatum		•			
Triglochin procerum		•			
Lemnaceae					
# Lemna disperma	•				
Lobeliaceae					
Lobelia alata		•			
Lythraceae					
* Lythrum hyssopifolia		•			
Menyanthaceae					
# Villarsia sp	•				

	W	WF	Us	Uc	D
Myrtaceae					
# Eucalyptus calophylla			•	•	•
Eucalyptus rudis		•		•	
Melaleuca preissiana					•
Melaleuca rhaphiophylla	•	•			
Melaleuca viminea		•			
# Verticordia densiflora				•	
Mimosaceae					
# Acacia dentifera		•			
# Acacia pulchella			•	•	
# Acacia saligna		•	•	•	
Onagraceae					
Epilobium billardierianum		•			
Orchidaceae					
# Microtis unifolia			•		
# Thelymitra campanulata			•		
Papilionaceae					
# Gompholobium marginatum					
# Hardenbegia comptoniana			•		
* Lotus angustissimus		•			
# Viminaria juncea		•	•		
Poaceae					
Agrostis sp.		•			
* Briza minor		•			
* Cynodon dactylon		•			
Danthonia caespitosa		•			
* Hordeum geniculatum		•			
* Lolium rigidum		•			
# Neurachne aleopecuroidea				•	
* Paspalum dilatatum		•			
* Polypogon monspeliensis		•			
# Stipa tenuifolia			•		
Polygonaceae					
* Rumex crispus		•			
Primulaceae					
Samolus junceus		•			
Proteaceae					
# Hakea prostrata					•
Stylidiaceae					
# Stylidium bulbiferum				•	
# Stylidium piliferum			•		
Typhaceae					
Typha domingensis	•	•			
#* Typha orientalis					

TABLE 4
Suggested plants suitable for direct seeding at Bennett Brook as supplied for roadside revegetatin 28/6/95 (horticultural advice from Bob Dixon, Kings Park and Botanic Garden).

SCIENTIFIC NAME	COMMON NAME	COMMENTS
Trees		
Eucalyptus marginata	Jarrah	D, R
# Eucalyptus calophylla	Marri	D/W, R
# Melaleuca preissiana	Moonah	W, R
Melaleuca rhaphiophylla	Swamp Paperbark	W, R
Allocasuarina fraseriana	Fraser's Sheoak	D, R
Acacia saligna	Orange Wattle	D/W, RT *
Banksia menziesii	Firewood Banksia	D, R
Banksia littoralis	Swamp Banksia	W, R
Banksia attenuata	Slender Banksia	D, R
Shrubs		
Melaleuca viminea	Mohan	W, ?R
Melaleuca lateritia	Robin Redbreast Bush	W, ?R
Allocasuarina humilis	Dwarf Sheoak	D, R
Hypocalymma robustum	Swan River Myrtle	D, R
Hypocalymma angustifolium	White Myrtle	D, R
Jacksonia furcellata	Grey Stinkwood	D, ?RT
Viminaria juncea	Swishbush	W, RT
Stirlingia latifolia	Blueboy	D, RTS
Eremaea pauciflora		D, R
Acacia pulchella	Prickly Moses	D/W, RT *
Xanthorrhoea preissii	Balga	D/W, R
Verticordia densiflora	Dense Featherflower	W, R *
Kunzea ericifolia	Spearwood	W, R
Daviesia decurrens		D, RT?
Bossiaea eriocarpa	Common Brown Pea	D, ?RT *
Climbers/Groundcovers		
Hardenbergia comptoniana	Native Wisteria	D, RT
Kennedia prostrata	Red Runner	D, RT
Herbs		
Conostylis aculeata	Prickly Conostylis	D, U *
Conostylis setigera	Bristly Conostylis	D, U
Anigozanthus manglesii	Mangles Kangaroo Paw	D/W, R
Anigozanthus humilis	Cats Paw	D, R
Grasses		
Stipa compressa		D, ?R

Key to COMMENTS

D Species suitable for dryer slopes/uplands
W species suitable for wetter slopes/damplands
R readily available
?R common species, availability not known
RT readily available but seeds require pretreatment
U unlikely to be available, germination unlikely
RTS readily available, will need pretreatment with smoke
* many different forms, need to be aware of collecting seed from similar habitats within reasonable distance

Appendix D

(see Chapter 6)

Vertebrae Fauna of Bennett Brook and Success Hill Reserve

TABLE 5

Frogs and Reptiles sampled systematically by trapping and observed opportunistically.
SH, Success Hill; PY, Pyrton; SO, Sheoak; BB, Bennett Brook; SS, Small Swamps; SA, Samphire area;OB, Old Bridge; MS, Main Swamp.

	Systematic		Opportunistic							
Species	SH	PY	SH	PY	SH	BB	SS	SA	OB	MS
AMPHIBIANS										
Slender Tree Frog *Litoria adelaidensis*		X				X	X			
Motorbike Frog *L.moorei*		X								
Quacking Frog *Crinia georgiana*	X	X	X	X	X	X	X		X	
Glauert's Froglet *C.glauerti*			X	X	X		X		X	X
Squelching Froglet *C.insignifera*					X	X	X		X	X
Moaning Frog *Heleioporus eyrei*	X	X		X						
Banjo Frog *Limnodynastes dorsalis*	X	X					X			
REPTILES										
Swamp Skink *Bassiana trilineata*								X	X	
Wall Skink *Cryptoblepharus plagiocephalus*			X	X	X	X	X	X	X	X
Striped Skink *Ctenotus fallens*	X	X						X		
Limestone Skink *C.leueurii*	X									
Two-toed Skink *Hemiergis quadrilineata*		X								
Elegant Lerista *Lerista elegans*	X									
Worm Lerista *L.praepedita*	X									
Grey's Skink *Menetia greyi*	X		X	X	X	X	X	X	X	
Flecked Morethia *Morethia obscura*					X					
Gould's Monitor *Varanus gouldi*									X	
Tiger Snake *Notechis scutatus*					X	X	X	X		
Dugite *Psedonaja affinis*				X	X			X		
Long-necked Tortoise *Chelodina oblonga*						X	X		X	X

TABLE 6

List of Fish recorded at Success Hill/Bennett Brook during surveys in1994 - 1995.
*** = species which have been introduced by man.**

SPECIES
GALAXIIDAE
Western Minnow *Galaxias occidentalis*
POECILIIDAE
*Mosquito Fish *Gambusia holebrooki*
PERCHICTHYIDAE
Nightfish *Bostockia porosa*
KUHLIIDAE
Western Pygmy Perch *Edelia vittata*
GOBIIDAE
Swan River Goby *Pseudogobius olorum*
Bigmouth Goby *Favonigobius lateralis*
CYPRINIDAE
*Golden Carp *Cyprinus auratus*

TABLE 7

Birds recorded at Success Hill/Bennett Brook during surveys in1994-1995

+ = species which have colonised the area through natural expansion, * = species which have been introduced by man.

SPECIES

PODICIPEDIDAE
Black-throated Grebe *Podiceps novaehollandiae*
PELECANIDAE
Australian Pelican *Pelecanus conspicillatus*
PHALACROCORACIDAE
Little Black Cormorant *Phalacrocorax sulcirostris*
Great Cormorant *Phalacrocorax carbo*
Little Pied Cormorant *Phalacrocorax melanoleucos*
Darter *Anhinga melanogaster*
ARDEIDAE
Pacific Heron *Ardea pacifica*
White-faced Heron *Ardea novaehollandiae*
Great Egret *Egretta alba*
Rufous Night Heron *Nycticorax caledonicus*
THRESKIORNITHIDAE
+Sacred Ibis *Threskiornis aethiopicus*
+Straw-necked Ibis *Threskiornis spinicollis*
+Yellow-billed Spoonbill *Platalea flavipes*
ANATIDAE
Black Swan *Cygnus atratus*
Mountain Duck *Tadorna tadornoides*
Black Duck *Anas superciliosa*
Grey Teal *Anas gibberifrons*
Wood Duck *Chenonetta jubata*
Blue-billed Duck *Oxyura australis*
Musk Duck *Bizura lobata*
ACCIPITRIDAE
Black-shouldered Kite *Elanus caeruleus*
Whistling Kite *Haliastur sphenurus*
Brown Goshawk *Accipiter fasciatus*
FALCONIDAE
Peregrine falcon *Falco peregrinus*
Australian Kestrel *Falco cenchroides*
RALLIDAE
Dusky Moorhen *Gallinula tenebrosa*
Buff-banded Rail *Rallus philippensis*
Spotless Crake *Porzana tabuensis*
CHARADRIIDAE
Black-fronted Plover *Charadrius melanops*
COLUMBIDAE
*Spotted Dove *Streptopelia chinensis*
*Laughing Dove *Streptopelia senegalensis*
*Domestic Pigeon *Columba livia*
PSITTACIDAE
*Rainbow Lorikeet *Trichoglossus haematodus*
Ringnecked Parrot *Platycercus zonarius*
Redcapped Parrot *Platycercus spurius*
Carnaby's Cockatoo *Calyptorhynchus latirostris*
+Galah *Cacatua roseicapilla*
*Little Corella *Cacatua sanguinea*
CUCULIDAE
Pallid Cuckoo *Cuculus pallidus*
Fantailed Cuckoo *Cacomantis flabelliformis*
Shining Bronze Cuckoo *Chrysococcyx lucidus*
ALCEDINIDAE
*Laughing Kookaburra *Dacelo gigas*
Sacred Kingfisher *Halcyon sancta*
MEROPIDAE
Rainbow Bee-eater *Merops ornatus*
HIRUNDINIDAE
Welcome Swallow *Hirundo neoxena*
Tree Martin *Hirundo nigricans*
MOTACILLIDAE
Richard's Pipit *Anthus novaeseelandiae*
CAMPEPHAGIDAE
Black-faced Cuckoo-shrike *Coracina novaehollandiae*
PACHYCEPHALIDAE
Rufous Whistler *Pachycephala rufiventris*
MONARCHIDAE
Grey Fantail *Rhipidura fuliginosa*
Willy Wagtail *Rhipidura leucophrys*
ACANTHIZIDAE
Western Flycater *Gerygone fusca*
Weebill *Smicornis brevirostris*
Broad-tailed Thornbill *Acanthiza apicalis*
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*

Purple Swamphen *Porphyrio porphyrio* Eurasian Coot *Fulica atra* MALURIDAE Splendid Fairy-wren *Malurus splendens* SYLVIIDAE Clamorous Reed-Warbler *Acrocephalus stentoreus* Little Grassbird *Megalurus gramineus* DICAEIDAE Mistletoebird *Dicaeum hirundinaceum* PARDALOTIDAE Spotted Pardalote *Pardalotus punctatus* Striated Pardalote *Pardalotus striatus* ZOSTEROPIDAE Grey-breasted White-eye *Zosterops lateralis* MELIPHAGIDAE Brown Honeyeater *Lichmera indistincta* Singing Honeyeater *Meliphaga virescens*	White-cheeked Honeyeater *Phylidonyris nigra* Tawny-crowned Honeyeater *Phylidonyris melanops* New Holland Honeyeater *Phylidonyris pyrrhoptera* Western Spinebill *Acanthorhynchus superciliosus* Little Wattlebird *Anthochaera chrysoptera* White-browed Scrubwren *Sericornis frontalis* Red Wattlebird *Anthochaera carunculata* EPTHIANURIDAE White-fronted Chat *Epthianura albifrons* GRALLINIDAE Magpie-lark *Grallina cyanoleuca* CRACTICIDAE Grey Butcherbird *Cracticus torquatus* Australian Magpie *Cracticus tibicen* CORVIDAE Australian Raven *Corvus coronoides*

Appendix E

(see Chapter 7)

TABLE 8

Species sorted by frequency of sighting greater and less than 50% overall or at particular sites (n=No of surveys)

	Overall		NW		H		S		NE
Species	n=50		n=11		n=19		n=11		n=5
	No	%	No	%	No	%	No	%	No
705 Australian Magpie	46	**92**	11	**100**	15	**79**	11	**100**	5
361 Grey Fantail	45	**90**	11	**100**	17	**89**	9	**82**	4
930 Australian Raven	42	**84**	11	**100**	12	**63**	11	**100**	4
976 Striated Pardalote	42	**84**	11	**100**	17	**89**	7	**64**	3
208 Pacific Black Duck	42	**84**	11	**100**	14	**74**	11	**100**	3
294 Australian Ringneck	41	**82**	10	**91**	14	**74**	11	**100**	2
463 Western Gerygone	40	**80**	11	**100**	18	**95**	7	**64**	1
179 Australian White Ibis	40	**80**	9	**82**	16	**84**	7	**64**	5
574 Silvereye	39	**78**	11	**100**	16	**84**	8	**73**	1
273 Galah	36	**72**	8	**73**	14	**74**	10	**91**	1
202 Australian Wood Duck	35	**70**	10	**91**	15	**79**	6	**55**	2
211 Grey Teal	34	**68**	10	**91**	10	**53**	6	**55**	4
597 Brown Honeyeater	33	**66**	11	**100**	10	**53**	9	**82**	2
486 Yellow-rumped Thornbill	32	**64**	8	**73**	17	**89**	2	**18**	2
401 Rufous Whistler	32	**64**	9	**82**	18	**95**	2	**18**	1
059 Eurasian Coot	30	**60**	9	**82**	13	**68**	3	**27**	2
058 Purple Swamphen	29	**58**	7	**64**	16	**84**	1	**9**	1
188 White-faced Heron	29	**58**	5	**45**	10	**53**	6	**55**	4
415 Magpie-lark	28	**56**	10	**91**	10	**53**	5	**45**	1
702 Grey Butcherbird	27	**54**	11	**100**	5	**26**	8	**73**	0
364 Willie Wagtail	27	**54**	8	**73**	8	**42**	5	**45**	2
424 Black-faced Cuckoo-shrike	27	**54**	8	**73**	8	**42**	6	**55**	3
608 Singing Honeyeater	26	**52**	3	**27**	10	**53**	8	**73**	2
182 Yellow-billed Spoonbill	26	**52**	6	**55**	10	**53**	4	**36**	3
988 Laughing Turtle-Dove	25	**50**	5	**45**	6	**32**	9	**82**	2
465 Weebill	20	**40**	10	**91**	1	**5**	5	**45**	1
524 Clamorous Reed-Warbler	21	**42**	8	**73**	12	**63**	0	**0**	1
322 Laughing Kookaburra	24	**48**	8	**73**	7	**37**	6	**55**	1
359 Tree Martin	20	**40**	7	**64**	5	**26**	7	**64**	0
326 Sacred Kingfisher	22	**44**	7	**64**	8	**42**	5	**45**	1
207 Australian Shelduck	23	**46**	6	**55**	9	**47**	0	**0**	4
638 Red Wattlebird	23	**46**	6	**55**	3	**16**	11	**100**	0
228 Whistling Kite	17	**34**	3	**27**	12	**63**	0	**0**	0
Corella	23	**46**	1	**9**	11	**58**	10	**91**	0
100 Little Pied Cormorant	17	**34**	4	**36**	3	**16**	9	**82**	0
101 Darter	18	**36**	3	**27**	3	**16**	7	**64**	4
476 Inland Thornbill	13	**26**	1	**9**	2	**11**	6	**55**	0
097 Little Black Cormorant	12	**24**	1	**9**	4	**21**	6	**55**	0

The overall survey results include the General surveys but not 18 June 1995 NW survey. Survey of 18 June 1995 at NW site not included. For NE surveys, % have not been given because too few surveys.

TABLE 8 cont'd

Species sorted by frequency of sighting greater and less than 50% overall or at particular sites (n=No of surveys)

	Overall		NW		H		S		NE
Species	n=50		n=11		n=19		n=11		n=5
	No	%	No	%	No	%	No	%	No
187 Great Egret	21	**42**	3	**27**	8	**42**	5	**45**	2
061 Australasian Grebe	19	**38**	5	**45**	7	**37**	2	**18**	2
532 Splendid Fairy-wren	19	**38**	5	**45**	8	**42**	5	**45**	0
056 Dusky Moorhen	17	**34**	4	**36**	7	**37**	3	**27**	1
989 Spotted Turtle-Dove	17	**34**	5	**45**	6	**32**	5	**45**	0
329 Rainbow Bee-eater	13	**26**	4	**36**	7	**37**	0	**0**	1
203 Black Swan	12	**24**	5	**45**	3	**16**	0	**0**	2
144 Black-fronted Dotterel	11	**22**	0	**0**	9	**47**	0	**0**	1
254 Rainbow Lorikeet	11	**22**	2	**18**	4	**21**	5	**45**	0
357 Welcome Swallow	9	**18**	1	**9**	6	**32**	0	**0**	0
180 Straw-necked Ibis	8	**16**	3	**27**	3	**16**	0	**0**	0
342 Horsfield's Bronze-Cuckoo	8	**16**	2	**18**	5	**26**	1	**9**	0
337 Pallid Cuckoo	8	**16**	2	**18**	5	**26**	1	**9**	0
221 Brown Goshawk	8	**16**	3	**27**	4	**21**	1	**9**	0
564 Mistletoebird	8	**16**	2	**18**	1	**5**	2	**18**	2
488 White-browed Scrubwren	5	**10**	0	**0**	5	**26**	0	**0**	0
146 Black-winged Stilt	5	**10**	1	**9**	0	**0**	0	**0**	1
217 Musk Duck	5	**10**	4	**36**	0	**0**	0	**0**	0
222 Collared Sparrowhawk	5	**10**	0	**0**	0	**0**	4	**36**	0
977 Cattle Egret	4	**8**	0	**0**	3	**16**	0	**0**	0
132 Red-kneed Dotterel	4	**8**	0	**0**	1	**5**	0	**0**	2
106 Australian Pelican	4	**8**	1	**9**	0	**0**	0	**0**	2
266 Carnaby's Black-Cockatoo	4	**8**	0	**0**	1	**5**	3	**27**	0
125 Silver Gull	4	**8**	0	**0**	0	**0**	3	**27**	0
522 Little Grassbird	3	**6**	0	**0**	3	**16**	0	**0**	0
240 Nankeen Kestrel	3	**6**	0	**0**	3	**16**	0	**0**	0
225 Little Eagle	3	**6**	1	**9**	2	**11**	0	**0**	0
212 Australasian Shoveler	3	**6**	1	**9**	1	**5**	0	**0**	0
232 Black-shouldered Kite	3	**6**	2	**18**	1	**5**	0	**0**	0
344 Shining Bronze-Cuckoo	3	**6**	3	**27**	0	**0**	0	**0**	0
216 Blue-billed Duck	3	**6**	3	**27**	0	**0**	0	**0**	0
290 Red-capped Parrot	2	**4**	1	**9**	1	**5**	0	**0**	0
215 Hardhead	2	**4**	1	**9**	1	**5**	0	**0**	0
189 White-necked Heron	2	**4**	1	**9**	1	**5**	0	**0**	0
213 Pink-eared Duck	2	**4**	0	**0**	0	**0**	0	**0**	1
957 Feral Pigeon	2	**4**	2	**18**	0	**0**	0	**0**	0
046 Buff-banded Rail	2	**4**	0	**0**	1	**5**	1	**9**	0

The overall survey results include the General surveys but not 18 June 1995 NW survey. Survey of 18 June 1995 at NW site not included. For NE surveys, % have not been given because too few surveys.

TABLE 8 Cont'd

Species sorted by frequency of sighting greater and less than 50% overall or at particular sites (n=No of surveys)

235 Australian Hobby	2	4	0	0	0	0	1	9	0
	Overall		NW		H		S		NE
Species	n=50		n=11		n=19		n=11		n=5
	No	%	No	%	No	%	No	%	No
408 Grey Shrike-thrush	2	4	0	0	0	0	2	18	0
381 Red-capped Robin	2	4	0	0	0	0	2	18	0
096 Great Cormorant	2	4	0	0	0	0	2	18	0
338 Fan-tailed Cuckoo	1	2	0	0	1	5	0	0	0
051 Spotless Crake	1	2	0	0	1	5	0	0	0
219 Swamp Harrier	1	2	0	0	1	5	0	0	0
192 Nankeen Night Heron	1	2	0	0	1	5	0	0	0
700 Pied Butcherbird	1	2	0	0	0	0	0	0	1
535 White-winged Fairy-wren	1	2	0	0	0	0	0	0	0
239 Brown Falcon	1	2	0	0	0	0	0	0	1
592 Western Spinebill	1	2	1	9	0	0	0	0	0
115 Crested Tern	1	2	0	0	0	0	1	9	0
112 Caspian Tern	1	2	0	0	0	0	1	9	0

The overall survey results include the General surveys but not 18 June 1995 NW survey. Survey of 18 June 1995 at NW site not included. For NE surveys, % have not been given because too few surveys.

TABLE 9

Examination of site differences based on sighting frequency of species.

Species	Overall n=50		NW n=12		H n=19		S n=11		Dist-ribu-tion	Possible explanations or habitat note
	No	%	No	%	No	%	No	%		
101 Darter	18	**36**	3	**25**	3	**16**	7	**64**	<N	Common along river
097 Little Black Cormorant	12	**24**	1	**8**	4	**21**	6	**55**	<N	Common along river
100 Little Pied Cormorant	17	**34**	4	**33**	3	**16**	9	**82**	<N	Common along river
188 White-faced Heron	29	**58**	5	**41**	10	**53**	6	**55**	Even	
179 Australian White Ibis	40	**80**	10	**83**	16	**84**	7	**64**	Even	
182 Yellow-billed Spoonbill	26	**52**	7	**58**	10	**53**	4	**36**	Even	
207 Australian Shelduck	23	**46**	6	**50**	9	**47**	0	**0**	<S	
208 Pacific Black Duck	42	**84**	11	**91**	14	**74**	11	**100**	Even	
211 Grey Teal	34	**68**	10	**83**	10	**53**	6	**55**	Even	
202 Australian Wood Duck	35	**70**	11	**91**	15	**79**	6	**55**	Even	
228 Whistling Kite	17	**34**	3	**25**	12	**63**	0	**0**	<S	
058 Purple Swamphen	29	**58**	8	**66**	16	**84**	1	**9**	<S	Sightings and habitat in Bulrush
059 Eurasian Coot	30	**60**	9	**75**	13	**68**	3	**27**	<S	
988 Laughing Turtle-Dove	25	**50**	6	**50**	6	**32**	9	**82**	<N	
273 Galah	36	**72**	8	**66**	14	**74**	10	**91**	Even	
Corella	23	**46**	1	**8**	11	**58**	10	**91**		Territory appears focussed on sout
294 Australian Ringneck	41	**82**	11	**91**	14	**74**	11	**100**	Even	
322 Laughing Kookaburra	24	**48**	9	**75**	7	**37**	6	**55**	Even	
326 Sacred Kingfisher	22	**44**	7	**58**	8	**42**	5	**45**	Even	
359 Tree Martin	20	**40**	8	**66**	5	**26**	7	**64**		
424 Black-faced Cuckoo-shrike	27	**54**	8	**66**	8	**42**	6	**55**	Even	
401 Rufous Whistler	32	**64**	10	**83**	18	**95**	2	**18**	<S	
361 Grey Fantail	45	**90**	12	**100**	17	**89**	9	**82**	Even	
364 Willie Wagtail	27	**54**	8	**66**	8	**42**	5	**45**	Even	
524 Clamorous Reed-Warbler	21	**42**	8	**66**	12	**63**	0	**0**	<S	Sightings and habitat in Bulrush
465 Weebill	20	**40**	11	**91**	1	**5**	5	**45**		
463 Western Gerygone	40	**80**	12	**100**	18	**95**	7	**64**		
476 Inland Thornbill	13	**26**	2	**16**	2	**11**	6	**55**	<N	
486 Yellow-rumped Thornbill	32	**64**	9	**75**	17	**89**	2	**18**	<S	
638 Red Wattlebird	23	**46**	7	**58**	3	**16**	11	**100**		
608 Singing Honeyeater	26	**52**	4	**33**	10	**53**	8	**73**		
597 Brown Honeyeater	33	**66**	11	**91**	10	**53**	9	**82**		
976 Striated Pardalote	42	**84**	12	**100**	17	**89**	7	**64**	<S	
574 Silvereye	39	**78**	12	**100**	16	**84**	8	**73**	Even	
415 Magpie-lark	28	**56**	11	**91**	10	**53**	5	**45**		
702 Grey Butcherbird	27	**54**	11	**91**	5	**26**	8	**73**		
705 Australian Magpie	46	**92**	12	**100**	15	**79**	11	**100**	Even	
930 Australian Raven	42	**84**	11	**91**	12	**63**	11	**100**		

Site differences for species seen on more than 50% of surveys. Lowest frequency sightings in border, and if two lowest sightings shadow text shows lowest sighting frequency. Species are arranged in taxonomic order

The overall survey results include the General surveys but not 18 June 1995 NW survey.

Table 10

Examination of site differences based on sighting frequency of species.

	Overall		NW		H		S			
Species	n=50		n=12		n=19		n=11		**Dist-**	**Possible explanations**
	No	%	No	%	No	%	No	%	**ribut**	**or habitat note**
A. Less than 50% but more than 6 surveys										
061 Australasian Grebe	19	**38**	5	**41**	7	**37**	2	**18**	<S	Likes deep water in claypits
187 Great Egret	21	**42**	4	**33**	8	**42**	5	**45**	<NW	
180 Straw-necked Ibis	8	**16**	3	**25**	3	**16**	0	**0**	<S	Flooded grassland north end of lak
203 Black Swan	12	**24**	6	**50**	3	**16**	0	**0**	<S	
221 Brown Goshawk	8	**16**	3	**25**	4	**21**	1	**9**	<S	
056 Dusky Moorhen	17	**34**	4	**33**	7	**37**	3	**27**	Even	
144 Black-fronted Dotterel	11	**22**	0	**0**	9	**47**	0	**0**	One site	
989 Spotted Turtle-Dove	17	**34**	5	**41**	6	**32**	5	**45**	Even	
254 Rainbow Lorikeet	11	**22**	2	**16**	4	**21**	5	**45**	<N	
337 Pallid Cuckoo	8	**16**	2	**16**	5	**26**	1	**9**	<S	
342 Horsfield's Bronze-Cuckoo	8	**16**	2	**16**	5	**26**	1	**9**	<S	
329 Rainbow Bee-eater	13	**26**	4	**33**	7	**37**	0	**0**	<S	
357 Welcome Swallow	9	**18**	1	**8**	6	**32**	0	**0**	<S	
532 Splendid Fairy-wren	19	**38**	5	**41**	8	**42**	5	**45**	Even	
564 Mistletoebird	8	**16**	2	**16**	1	**5**	2	**18**	<H	
B. More than 3 but less than 6 surveys and only seen at one site										
977 Cattle Egret	4	**8**	0	**0**	3	**16**	0	**0**		
216 Blue-billed Duck	3	**6**	3	**25**	0	**0**	0	**0**		Likes deep water in claypits
217 Musk Duck	5	**10**	4	**33**	0	**0**	0	**0**		Likes deep water in claypits
222 Collared Sparrowhawk	5	**10**	0	**0**	0	**0**	4	**36**		
240 Nankeen Kestrel	3	**6**	0	**0**	3	**16**	0	**0**		
125 Silver Gull	4	**8**	1	**8**	0	**0**	3	**27**		Sightings along the river
266 Carnaby's Black-Cockatoo	4	**8**	0	**0**	1	**5**	3	**27**		Likes pine trees at Success Hill
344 Shining Bronze-Cuckoo	3	**6**	3	**25**	0	**0**	0	**0**		
522 Little Grassbird	3	**6**	0	**0**	3	**16**	0	**0**		
488 White-browed Scrubwren	5	**10**	0	**0**	5	**26**	0	**0**		

Site differences for species seen on less than 50% but more than 6% (3)of surveys. Lowest frequency sightings in border, and if two lowest sightings shadow text shows lowest sighting frequency. Species are arranged in taxonomic order.

The overall survey results include the General surveys but not 18 June 1995 NW survey.

TABLE 11

Records of nesting and young

Site	Date	Comment
Water	Jul 6, 1995	Black Swan - nest with 3 eggs in bulrush patch in middle of eastern open water
H	Sep 15, 1995	Black Swan - seen with five young
NW	Nov 14, 1995	Black Swan - seen with 3 cygnets
Water	Jul 6, 1995	Australian Shelduck - pair with 12 young
H	Sep 8, 1995	Australian Shelduck - seen with two young
H	Sep 25, 1995	Pacific Black Duck - young seen
NW	Oct 10, 1995	Pacific Black Duck - seen with young
H	Sep 8, 1995	Grey Teal - seen with six young
H	Sep 25, 1995	Grey Teal - 10 adults and 12 young seen
NW	Oct 10, 1995	Grey Teal - seen with young
H	Oct 16, 1995	Grey Teal - total 12 young seen
H	Oct 16, 1995	Hardhead - two adults and one young seen
H	Oct 30, 1995	Australian Wood Duck - two adults and 10 young seen
H	Dec 12, 1995	Brown Goshawk - seen at nest
NW	Dec 18, 1995	Brown Goshawk - had near perfect views of the young goshawk
H	Jan 3, 1996	Brown Goshawk - two birds seen at nest
S	Dec 22, 1995	Collard Sparrowhawk - Three young Sparrowhawks seen
NW	Nov 14, 1995	Dusky Moorhen - seen with chicks
NW	Oct 10, 1995	Eurasian Coot - seen with young
H	Sep 8, 1995	Australian Ringneck - nesting
H	Oct 2, 1995	Pallid Cuckoo laying
H	Oct 30, 1995	Sacred Kingfisher - nesting
H	Dec 12, 1995	Sacred Kingfisher - with young in nest
H	Oct 30, 1995	Rainbow Bee-eater - nesting
H	Dec 12, 1995	Rainbow Bee-eater - nesting
S	Apr 3, 1995	Red-capped Robin - saw one female and one young
NW	Nov 14, 1995	Grey Fantail -seen feeding young in a nest
NW	Jul 22, 1995	Willie Wagtail - We saw a Willie Wagtail carrying nesting material into the trees near the stables
S	Apr 3, 1995	Splendid Fairy-wren - One male partially coloured and three females or young
H	Oct 30, 1995	Western Gerygone - nesting
H	Jan 3, 1996	Yellow-rumped Thornbill - nest found at fox hole entrance
H	Sep 8, 1995	Striated Pardalotes - seen active at tree hollow - nesting
H	Jan 3, 1996	Striated Pardalote - one nest seen
H	Sep 8, 1995	Australian Magpie - seen with young
H	Sep 15, 1995	Australian Raven - juvenile seen

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TABLE 12

Seasonality records from Bennett Brook for known migrants or birds which exhibit seasonal movement in the South West of WA

No surveys		12	14	11	14	F or	
Species		Sum-	Aut-	Win-	Spr-	P	Max present in
		mer	umn	ter	ing		
189 White-necked Heron	2	1	0	0	1	F	Winter
977 Cattle Egret	4	0	0	1	3	F	Autumn/Winter
337 Pallid Cuckoo	8	0	2	1	5	F	Winter/Spring
338 Fan-tailed Cuckoo	1	0	0	1	0	P	Winter/Spring
342 Horsfield's Bronze-Cuckoo	8	0	0	0	7	P	Winter/Spring
344 Shining Bronze-Cuckoo	3	1	0	0	1	F	Spring
326 Sacred Kingfisher	22	9	0	0	11	P	Summer
329 Rainbow Bee-eater	13	7	0	0	6	F	Summer
359 Tree Martin	20	4	3	4	6	P	Summer
381 Red-capped Robin	2	0	1	0	1	P	Winter
361 Grey Fantail	45	9	12	6	13	P	Summer
524 Clamorous Reed-Warbler	21	5	7	0	6	F	Summer
463 Western Gerygone	40	10	10	4	13	P	Summer
638 Red Wattlebird	23	4	7	5	6	P	Winter
564 Mistletoebird	8	3	4	0	0	P	Influxes
976 Striated Pardalote	42	8	12	6	13	P	Summer
Total No Surveys	50						
F = Full migrant, P = Partial migrant							

TABLE 13

Waterbird survey results

	Number of birds seen			
Survey Date	2/4/95	4/22/95	7/6/95	11/95
061 Australasian Grebe		5	2	1
Cormorant & allies			1	
106 Australian Pelican	3			5
097 Little Black Cormorant				1
100 Little Pied Cormorant		1	1	
Heron and allies				
188 White-faced Heron	4	10	1	2
187 Great Egret	1	1		1
185 Little Egret			1	
192 Nankeen Night Heron	1	1		1
Ibis and Spoonbill				
178 Glossy Ibis	1			
179 Australian White Ibis		2	12	6
180 Straw-necked Ibis				
182 Yellow-billed Spoonbill	15	3	2	10
Ducks and Swans				
203 Black Swan	2	3	8	
207 Australian Shelduck	50	48	16	14
208 Pacific Black Duck			9	10
211 Grey Teal	200	210	16	4
210 Chestnut Teal		3		
212 Australasian Shoveler		1	8	
213 Pink-eared Duck	15			1
215Hardhead			3	1
202 Australian Wood Duck		1	2	6
216 Blue-billed Duck				4
217 Musk Duck			1	1
Rail and allies				
056 Dusky Moorhen			1	
058 Purple Swamphen	5	3	3	4
059 Eurasian Coot		60	4	9
Waders and Plovers				
144 Black-fronted Dotterel	18	13		
146 Black-winged Stilt	5			
No Species seen	13	16	18	18
No birds seen	320	365	91	81

TABLE 14
Additional species sighted by theWestern Australian Museum

237 Peregrine Falcon
337 Pallid Cuckoo
647 Richard's Pipit
637 Little Wattlebird
631 New Holland Honeyeater
632 White-cheeked Honeyeater
593 Tawny-crowned Honeyeater
448 White-fronted Chat

Bennett Brook - Fire management and the Flora

Bronwen Keighery

Introduction

• Urban bushland areas are generally isolated islands in a sea of hostile environments which form barriers between areas and impact on the bushland in a variety of ways. Many of these impacts constitute unnatural disturbance regimes, that is they affect the bushland's capacity for self maintenance.

• Natural areas in the Bennett Brook area are essentially OH

- bushland (intact overstorey and understorey) on the loams and clays banks and flats of the Bennett Brook and associated wet patches OH
  - dominated by Flooded Gum (*Eucalyptus rudis*)
  - dominated by Marri (*Eucalyptus calophylla*)
  - dominated by Wetland Sheoak (*Casuarina obesa*)
  - dominated by Freshwater Paperbark (*Melaleuca rhaphiophylla*)

- Success Hill, remnants of *Banksia* Woodland all the elements but has lost the structure

- pasture with scattered trees such Flooded Gum and Marri

- revegetated areas, present and future aim for canopy and thickets species such as Flooded Gum, Marri,

• Discuss characteristics of each area's flora/vegetation and relationship with habitat especially

- thickets formed by Freshwater Paper Bark, *Acacia dentifera, Melaleuca viminea*

• Disturbance (potential and actual)

- Bushland - partial clearing; fragmentation; fire frequency, both periodicity and intensity; weed invasion; changes in water regime (flooding, drainage and watering); nutrient influx; mining (particularly that for roadworks); grazing (stock); proliferation of tracks, fire breaks and walk trails; and use as service corridors by the SEC, Main Roads, Water Authority

- scattered natives/revegetation - fire frequency, both periodicity and intensity; weed density; changes in water regime (flooding, drainage and watering); rubbish dumping; waterways nutrient influx; mining (particularly that for roadworks); grazing (stock); proliferation of tracks, fire breaks and walk trails; off road vehicle use and use as service corridors by the SEC, Main Roads, Water Authority (Keighery, 1994).

• While change in response to periodic natural disturbance is a feature of bushland much of this disturbance in urban bushland does not occur in natural systems or the pattern of disturbance is unlike that found in natural systems.

• Fire is essentially a natural disturbance in Western Australia and bushland plants and animals have mechanisms for recovering from fire events. However in urban bushland the pattern of fires is generally not natural and this affects the bushland's ability to regenerate. Differences relate to: fire frequency (generally too often), intensity, time of fire; floristics of individual bushland areas and interaction with each of these and other disturbance regimes.

• Most of the mainland communities (encompassing Eucalypt woodlands, *Banksia* woodlands, heaths and shrublands from Becher Point, Bold Park, Wandi and Talbot Road) contain similar proportions of resprouters (48-62%) to reseeders (25-36%).

BUT note individual differences - a high proportion of plants that resprout from bulbs and tubers. That is while some areas have similar regenerative strategies at this very broad level there are still significant differences between areas.

• Weeds of most areas are predominantly annuals BUT clay based wetlands bulbous/tuberous weeds are very common,

Managing Urban Bushland After Fire - Opportunities Missed

While fires causes immediate massive destruction in urban bushland sensitive, informed management after fires can augment the natural regeneration and create opportunities to deal with past disturbance regimes. Accessibility within the burnt area effectively creates opportunities for post-fire actions to

- remove and control weeds (also rapidly growing resprouters will be most vulnerable to herbicides)
- remove dumped soil
- sterile ash beds for seed

Fire Management in Urban Bushland - An Individual Approach

Know the flora of your bushland.

To understand the effects of fire on the flora of each bushland area it is necessary that each area be well documented before the fire. To be most useful in monitoring this documentation should include some reference sites and refer listed flora to mapped communities. Identify the values you wish to protect, in this case habitat ie mature trees and thickets

Using local native annuals

Determine which species would fill the role of annual species such as Stipa *compressa* , Apiaceae species and Asteraceae species in your bushland area. Implement strategies for maintaining the soil stored seed bank of these species which may require direct seeding into bushland before the fire or after a fire.

Consider the values of the bushland as paramount.

Focus on the values of the bushland, protecting the bushland from fire and from disturbance associated with fighting the fire

Avoid dilemmas about protecting property by not building structures in or alongside bushland. - Any structures that must be built in bushland should be designed to be fire proof

, this includes buildings, fences and boardwalks

- Inappropriate recreation facilities in bushland should be avoided such as:
  - fireplaces for barbecues, particularly wood burning barbecues, that indicate it is acceptable to light fires in bushland as well as encouraging collection of wood in the bushland
  - grassed areas which are watered, fertilized and mown as well as creating nodes for weed invasion, all disturbances which raises the level of weed invasion and consequent fire risk.

Interrupting Fire

Fire retardant belts

Low fuel load by slashing, mowing

Belts of fire retardant vegetation should be used in place of traditional fire breaks.

Rationalise firebreaks.

Areas surrounded by roads are effectively firebreaked by the road and the verge

Patch burning

Caution using control fire, In the past when bushland covered the state regeneration after fire would not only have been from seed and pereniating organs within the area of the fire but from seed dispersing into the fire area from unburnt areas. This effect can be replicated on a

small scale in remnant bushland.

The action plan should be simple with clear aims, goals and be accountable (ie: no waffle about 'desirable' management activities which will not happen in the life of the plan) with responsibilities and resources allocated to management rather than a focus on capital expenditure. Monitoring of all major management actions should be detailed to enable an audit of the plan to be undertaken at periodically. These are not new concerns and most are periodically raised at seminars on bushland management (for example see Australian Institute of Urban Studies Seminar 1993).

Integral with this problem of lack of sensitive effective management is the general lack of appreciation, knowledge or feeling for the Australian bushland prevalent amongst many urban dwellers and the people responsible for putting management plans into action. Normal European horticultural practices (irrigated lawns, fertilizers, inappropriate plantings) are not appropriate for complex areas of natural Australian bushland. While community based groups of people who have this appreciation and understanding of bushland are working and will continue to work tirelessly on such sensitive effective management an "Urban Bushland Advisory Service" as promised in the Government's Urban Bushland Strategy (1995) is urgently needed. This service should be responsible for developing and disseminating the broad principles of urban bushland management and supporting the local groups in developing the individual approach required in each bushland area.

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Appendix 2:
Flora from sites 1 -3 and opportunistic records made by the System 6 Update field team.

Key

Column 1 Family

Column 2 Taxon
Names follow Gibson *et al.* (1994).
* weed
# preseeding the name indicates an opportunistic record.

Response to Fire
1 = perennial seeder
2 = annual seeder
3 = sprouter from underground parts
4 = sprouter from above ground parts

Columns 3 - 7
Column 3 = W = Bennett Brook
Column 4 = WF Wet flats along Bennett Brook
Column 5 = Us Upland, sands
Column 6 = Uc Upland, clay
Column 7 = D Drainage line into Bennett Brook

	W	WF	Us	Uc	D
FERNS					
# Azolla filicoides (floating aquatic)	•				
FLOWERING PLANTS					
Anthericaceae					
3 # Caesia micrantha (blue flowered form GJK 10857)			•		
3 # Chamaescilla corymbosa			•	•	
3 # Thysanotus dichotomus			•		
3 # Tricoryne elatior			•	•	
Apiaceae					
3 Apium prostratum		•			
2 # Homalosciadium homalocarpum			•		
Araceae					
* Zantedeschia aethiopica		•			
Asteraceae					
2 * Aster subulatus		•			
2 Cotula coronopifolia		•			
2 * Lactuca serriola		•			
2 Pogonolepis stricta		•			
2 * Sonchus oleraceus		•			
Callitrichaceae					
2 * Callitriche stagnalis		•			

			W	WF	Us	Uc	D
		Casuarinaceae					
	1/4	Casuarina obesa		•			
		Chenopodiaceae					
	1 #	Halosarcia halocnemoides		•			
	1	Halosarcia lepidosperma		•			
	1	Halosarcia pergranulata		•			
	1	Sarcocornia quinqueflora		•			
		Cyperaceae					
	3	Baumea juncea		•			
	3	Bolboschoenus caldwellii		•			
	3	Carex appressa		•			
	3	Carex tereticaulis		•			
	3	Chorizandra enodis		•			
	1	Cyperus polystachyos		•			
	2	Isolepis cernua		•			
	3	Lepidosperma longitudinale		•			•
		Dasypogonaceae					
	3 #	Lomandra micrantha			•		
		Droseraceae					
	3 #	Drosera erythrorhiza			•		
		Frankeniaceae					
	1 #	Frankenia pauciflora		?•			
		Gentianaceae					
	2 *	Centaurium sp.		•			
		Goodeniaceae					
	3 #	Dampiera alata					•
		Haemodoraceae					
	3 #	Haemodorm simplex			•		
	#						
		Iridaceae					
	3 *	Babiana disticha		•			
	3 *	Gladiolus undulatus		•			
	3 *	Hesperantha falcata		•			
	3 *	Romulea rosea		•			
	3 *	Sparaxis bulbifera		•			
		Juncaceae					
	2 *	Juncus bufonius		•			
	3 #	Juncus kraussii		•			
	3 ?	Juncus pauciflorus		•			
		Juncaginaceae					
	2	Triglochin centrocarpum		•			
	2	Triglochin mucronatum		•			
	3 ?	Triglochin procerum		•			
		Lemnaceae					
	#	Lemna disperma (aquatic)	•				

	W	WF	Us	Uc	D
Lobeliaceae					
3 Lobelia alata		•			
Lythraceae					
2 * Lythrum hyssopifolia		•			
Menyanthaceae					
3 # Villarsia sp	•				
Myrtaceae					
1/4 # Eucalyptus calophylla			•	•	•
1/4 Eucalyptus rudis		•		•	
1/4 Melaleuca preissiana					•
1/4 Melaleuca rhaphiophylla	•	•			
1/4 Melaleuca viminea		•			
1 # Verticordia densiflora				•	
Mimosaceae					
1 # Acacia dentifera		•			
1 # Acacia pulchella			•	•	
1 # Acacia saligna		•	•	•	
Onagraceae					
1 Epilobium billardierianum		•			
Orchidaceae					
3 # Microtis unifolia			•		
3 # Thelymitra campanulata			•		
Papilionaceae					
3 # Gompholobium marginatum					
3 # Hardenbegia comptoniana			•		
2 * Lotus angustissimus		•			
1 # Viminaria juncea		•	•		
Poaceae					
2 Agrostis sp.		•			
2 * Briza minor		•			
3 * Cynodon dactylon		•			
1? Danthonia caespitosa		•			
2 * Hordeum geniculatum		•			
2 * Lolium rigidum		•			
1? # Neurachne aleopecuroidea				•	
3 * Paspalum dilatatum		•			
2 * Polypogon monspeliensis		•			
2 # Stipa tenuifolia			•		
Polygonaceae					
2 * Rumex crispus		•			
Primulaceae					
3 Samolus junceus		•			
Proteaceae					
1/4 # Hakea prostrata					•

	W	WF	Us	Uc	D
Stylidiaceae					
1 # Stylidium bulbiferum				•	
1 # Stylidium piliferum			•		
Typhaceae					
3 Typha domingensis	•	•			
3#* Typha orientalis	•				

THE WESTERN AUSTRALIAN NATURALIST

Vol. 22 No. 3
June 30 1999

ISSN 0726 9609

12.8 BENNETT BROOK

12.8.1 GENERAL INFORMATION

LOCAL AUTHORITY: Shire of Swan
MRS ZONE: Parks and Recreation
SYSTEM 6 RECOMMENDATION: M41
WAC CLASSIFICATION: LE/Lo.f.1.se.c.
DRAINAGE: Affected by rural drains

12.8.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Bennett Brook is a seasonal tributary of the Swan River. The wetland of especial interest is the river terrace and floodplain in Pyrton and south of Benara Road in Caversham.

12.8.3 AREAS

Total wetland	approx 93	ha
Paperbark/flooded gum	59.7	ha
Sedgeland	4.0	ha
Samphire/Halophytes	9.6	ha
Modified wetland	approx 15.6	ha
Open water	4.4	ha

12.8.4 HYDROLOGY (Figure 12.16)

The water supply of this wetland is complex, including discharge from Bennett Brook, surface runoff from the flood plain, flood events in the Swan River system and groundwater seepage. The presence of samphire and Casuarina obesa woodland on the eastern side of the swamp indicates relatively high salinity levels. Flows in Bennett Brook would be expected to be fresh, largely originating as groundwater discharge in the headwaters of the brook. Reduced discharge could lead to the swamp becoming smaller and more saline.

12.8.5 WATER QUALITY - Refer to Section 12.8.4

12.8.6 LAND USE - Refer to Figure 12.15

12.8.7 VEGETATION (Figure 12.15)

The Bennett Brook wetland encompasses a range of wetland plant communities including flooded gum/swamp paperbark, closed swamp paperbark, samphire and casuarina woodland. It is thus a rather complex area.

12.8.8 FAUNA

The author is unaware of any systematic study of the fauna. It appears to offer a rich range of habitats for waterbirds.

A DESCRIPTION OF REMNANT VEGETATION OF BENNETT BROOK (SYSTEM 6 AREA M41)

B.J. Keighery April 1996
Department of Environmental Protection

INTRODUCTION

Bennett Brook (M41) was identified in the original System 6 study (Department of Environmental Protection 1983). As a consequence, an assessment of the vegetation of the area was part of the the 1994 -1996 System 6 Update (Department of Environmental Protection). This assessment involves placing the plant communities of the area in a regional perspective by comparing set area study sites to reference study sites on the Swan Coastal Plain according to the procedures used in Gibson *et al.* (1994). As a local group, the Success Hill Action Group, was embarking on a flora and fauna survey of the Bennett Brook area, including the System 6 area, this work was done in cooperation with the Group.

METHODS

The Bennett Brook area was visited on two occasions. On the first trip (6/10/1994) the System 6 Update field group and members of the Success Hill Action Group traversed the area south of Benarra Road. Native plants observed on the traverses were noted and three permanent 10 m x 10 m study sites were located in the areas of bushland in good condition or better (Keighery 1994).

Within each site all vascular plants were recorded and specimens collected according to the procedures described in Keighery (1994). Data on slope, aspect, vegetation structure and condition were collected from each site. Slope was scored on a one to three scale from flat to steep. Aspect was recorded as one of 16 cardinal directions. Vegetation structure was recorded and described according to Table 1, Appendix 1. Vegetation condition was scored on a five point scale with a score of one indicating vegetation in near natural condition and five indicating highly disturbed sites with significant weed invasion (after Keighery 1994). All sites were permanently marked with four steel fence droppers and had their position fixed using a GPS unit.

Several identification sessions were held in the WA Herbarium with the Success Hill Action Group to identify the plant specimens from the study sites and to prepare a field herbarium.

On the second visit (5/12/94) the System 6 Update field group revisited the sites and observed a transect through the wet flats on the eastern side of the Brook.

While all native plant species observed during the field work were recorded this study is not a comprehensive treatment of the flora of the Bennett Brook area. It is expected that the flora recorded (Appendix 2) accounts for 70% of the flora present but this could be as low as 60%. Also, while all non-native taxa were recorded in the study sites no attempt was made to record non-native taxa in the cleared areas.

A list of plants suitable for direct seeding was also compiled in consultation with Robert Bropho (Appendix 3) for rehabilitation of roadside areas.

SOILS

The general soils of the study area are described by Gozzard (1986), Bennett Brook being located at the interface of the Bassendean Dune System and the Pinjarra Plain. As a

consequence the surface soils to the west of the Brook are sandy, being dunes of Bassendean sands of various depths over Pinjarra Plain (S8 and S10). The soils to the east are are pebbly silts (Mgs1). The banks and wet flats of the Brook are clayey silts (Mc1) deposited by the Brook. To the east in the areas with a high clay content are a series of clay mines. Clay also appears to have been mined in similar deposits on the western bank adjacent to study site 2.

VEGETATION

Much of the area encompassed in the System 6 boundary has been cleared of native vegetation. The areas of relatively intact vegetation occur along banks and wet flats associated with the Brook being confined to the clayey silts. There is insufficient remaining vegetation on the uplands associated with the Brook to give a description of the plant communities of this area but the remaining remnant individual native species and the soil maps of the area give some indications of the expected vegetation of the upland areas. There would have been quite different communities on the eastern and western uplands.

Uplands to the West of Bennett Brook

The Bassendean Sands on the west of Bennett Brook occurr as
(i) Dunes (S8): *Banksia* Woodland similar to that represented on Success Hill would have been typical of these soils.
(ii) Sandy flats, low relief dunes (S10): *Banksia* Woodland would also have been found on these soils but the underlying heavier soils and proximity to ground water would have resulted in Marri (*Eucalyptus calophylla*) and *Melaleuca preissianna* being important components of the vegetation as well as a series of understorey species characteristic of low lying *Banksia* Woodlands.

The Lightening Swamp area probably contains communities similar to those that would have been found in this area.

Bennett Brook banks and wet flats

Western side of Bennett Brook

The western wet flats contain a mosaic of communities which depend on the relief and degree of inundation, principally Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland with areas of *Casuarina obesa* and *Melaleuca rhaphiophylla* Woodland on the more extensive wet flats with patches of *Melaleuca viminea* Tall Shrubland *and Melaleuca rhaphiophylla* Low Woodland along the banks of the Brook. While these sites are broadly similar floristicaly different sedge species are dominant in sites one and two and shrubs are dominant in the understorey in site 3 (Appendix 1). Site 3 is apparently more saline than sites 1 and 2, the species present being typically associated with areas subject to salinity at some time in the year. In the past there were probably areas of *Casuarina obesa* Woodland along the Brook that had a fresh water understorey, as found elsewhere on the Plain, but these would have been selectively cleared.

Eastern side of Bennett Brook

The vegetation of the eastern flats ranges from *Casuarina obesa* Forest, *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland, *Melaleuca viminea* Tall Shrubland, Samphire Open Low Heath, *Bulboschoenus caldwellii* Closed Sedgeland and *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland on the margins of the Brook and extending into the area of shallow water. Zonation was more evident as the wetflats are broader on the eastern side of the Brook and the wetflats grade into similar soils rather than sands. The *Casuarina obesa* woodlands are more disturbed and less waterlogged than those on the west.

The area of *Bulboschenus caldwellii*. Sedgeland indicates that there are fresh water seepages associated with the wetflats, a typical feature of such areas.

Although limited in area the relatively intact vegetation of the banks and wetflats of the Bennett Brook provide significant habitat for the fauna associated with the wetland. This vegetation is also significant in that there are relatively few areas of vegetation along the river and creeklines of the Swan Coastal Plain.

Eastern Side of Bennett Brook

It is difficult to say what the vegetation was on the pebbly silts as there are apparently no significant remnants in the Swan Valley on these soils. Remnant trees in the area are Flooded Gum, Marri and Wandoo but these are rarely associated with other native vegetation. Marri and Flooded Gum are found in the Bennett Brook area.

Floristic Community Types

The plant communities sampled along the Bennett Brook (Department of Environmental Protection 1996) form a wetland grouping not represented in the regional study of the Swan Coastal Plain by Gibson *et al.* (1994). This is not unexpected as Gibson *et al.* (1994) did not generally sample communities associated with lakes, creeks or rivers This floristic group has been located at three other locations on the Swan Coastal Plain all are small areas associated with lakes, creeks or rivers. Of these locations the greatest development of the floristic group is along Bennett Brook.

FLORA

Sixty one native taxa (species, subspecies and varieties) were recorded from the study area. This is a comparatively low diversity of taxa for an area on the Swan Coastal Plain, especially one that contains areas of heavy soil wetlands. This can be accounted for by the high degree of clearing of the area and the nature of heavy soil wetlands. On the Swan Coastal Plain the species diversity of wetlands drops with increasing salinity and the length of inundation. That is wetlands that are inundated through winter, spring and all or part of summer and/or are saline have limited species diversity. Both of these conditiona are present at Bennett Brook.

The co-occurence of *Halosarcia halocnemoides*, *H. lepidosperma*, *H. pergranulata* and *Sarcocornia quinqueflora* is significant being one of the few locations where these four samphires occurr together (L. Pen pers. comm.). Also it appears that *Sarcocornia blackiana* is also in the area and this taxon is currently known from only one other location on the Swan River (L. Pen pers. comm.).

The presence of *Juncus pauciflorus* is significant as this is not listed in the Flora of the Perth Region (Marchant et al. 1983) however it is recorded for the Serpentine River (Keighery, Keighery and Gibson 1994).

Vegetation Condition

As discussed previously most of the Bennett Brook area has been cleared, the remaining vegetation being confined to the wetflats and banks associated with the Brook. The condition of this vegetation ranges from degraded to excellent. There is significant weed invasion of these communities, 21 weeds being recorded for the three study sites (Appendix 1).

CONCLUSION

The vegetation of the Bennett Brook area is restricted to the banks and wet flats of the Brook. However considering that drainage line vegetation on the Swan Coastal Plain is predominantly cleared and/or highly modified the vegetation is significant. It also constitutes the largest remaining and most diverse relatively intact lagoonal system on the Swan - Canning River Estuary (L. Pen pers. comm.).

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Appendix 1: Vegetation Descriptions

The vegetation descriptions are made from a series of sites indicated on the maps. Each site is given a general unit based on the dominant overstorey species.

Keys to the terminology used for the vegetation descriptions and specific condition ratings.

Table 1: Key to vegetation description terminology

Table 2: Site condition scales

Vegetation Condition Scale (Keighery 1994)

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.

Permanent Sites - wet flats on western side of Bennett Brook

Site 1 - Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland

Flooded Gum Open Forest to Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Carex appressa* Closed Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous weeds.
Soil: grey brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 2 - Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Open Low Woodland

Flooded Gum Open Woodland over *Melaleuca rhaphiophylla* Low Woodland over Open Low Grassland and *Chorizandra enodis, Lepidosperma longnitudinale* and *Juncus pauciflorus* Closed Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Site 3 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Woodland
Casuarina obesa and *Melaleuca rhaphiophylla* Woodland over Samphire Open Low Heath and exotic Very Open Grassland, *Samolus juncea* and *Cotula corynopifolia* Herbland and *Juncus krausii* Very Open Sedgeland.
CONDITION Rating Very Good
Comments: The understorey contains significant herbaceous and grassy weeds.
Soil: brown clay (Mc1, Gozzard, 1986)
Drainage: poorly drained, waterlogged

Sites - wet flats on eastern side of Bennett Brook

Site 4 - *Casuarina obesa* and *Melaleuca rhaphiophylla* Forest to Woodland over exotic Grassland
CONDITION Rating Degraded
Comments: The understorey contains significant grassy weeds.
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged

Site 5 - Samphire Open Low Heath
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till December

Site 6 - *Bolboschoenus caldwellii* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till mid summer

Site 7 - *Melaleuca rhaphiophylla* Low Forest to Woodland over *Typha orientalis* Closed Sedgeland.
CONDITION Rating Excellent
Soil: brown clayey silt (Mc1, Gozzard, 1986)
Drainage: waterlogged, inundated till ?mid summer/all year

Appendix 2:
Flora from sites 1 -3 and opportunistic records made by the System 6 Update field team.

Key

Column 1 Family

Column 2 Taxon
Names follow Gibson *et al.* (1994). A * preceeding the name indicate a weed while # preseeding the name indicates an opprrtunistic record.

Columns 3 - 7

Column 3 =	W =	Bennett Brook
Column 4 =	WF	Wet flats along Bennett Brook
Column 5 =	Us	Upland, sands
Column 6 =	Uc	Upland, clay
Column 7 =	D	Drainage line into Bennett Brook

	W	WF	Us	Uc	D
FERNS					
# Azolla filicoides	•				
FLOWERING PLANTS					
Anthericaceae					
# Caesia micrantha (blue flowered form GJK 10857)			•		
# Chamaescilla corymbosa			•	•	
# Thysanotus dichotomus			•		
# Tricoryne elatior			•	•	
Apiaceae					
Apium prostratum		•			
# Homalosciadium homalocarpum			•		
Araceae					
* Zantedeschia aethiopica		•			
Asteraceae					
* Aster subulatus		•			
Cotula coronopifolia		•			
* Lactuca serriola		•			
Pogonolepis stricta		•			
* Sonchus oleraceus		•			
Callitrichaceae					
* Callitriche stagnalis		•			
Casuarinaceae					
Casuarina obesa		•			
Chenopodiaceae					
# Halosarcia halocnemoides		•			
Halosarcia lepidosperma		•			
Halosarcia pergranulata		•			
Sarcocornia quinqueflora		•			

	W	WF	Us	Uc	D
Cyperaceae					
Baumea juncea		•			
Bolboschoenus caldwellii		•			
Carex appressa		•			
Carex tereticaulis		•			
Chorizandra enodis		•			
Cyperus polystachyos		•			
Isolepis cernua		•			
Lepidosperma longitudinale		•			•
Dasypogonaceae					
# Lomandra micrantha			•		
Droseraceae					
# Drosera erythrorhiza			•		
Frankeniaceae					
# Frankenia pauciflora		?•			
Gentianaceae					
* Centaurium sp.		•			
Goodeniaceae					
# Dampiera alata					•
Haemodoraceae					
# Haemodorm simplex			•		
Iridaceae					
* Babiana disticha		•			
* Gladiolus undulatus		•			
* Hesperantha falcata		•			
* Romulea rosea		•			
* Sparaxis bulbifera		•			
Juncaceae					
* Juncus bufonius		•			
Juncus kraussii		•			
Juncus pauciflorus		•			
Juncaginaceae					
Triglochin centrocarpum		•			
Triglochin mucronatum		•			
Triglochin procerum		•			
Lemnaceae					
# Lemna disperma	•				
Lobeliaceae					
Lobelia alata		•			
Lythraceae					
* Lythrum hyssopifolia		•			
Menyanthaceae					
# Villarsia sp	•				

	W	WF	Us	Uc	D
Myrtaceae					
# Eucalyptus calophylla			•	•	•
Eucalyptus rudis		•		•	
Melaleuca preissiana					•
Melaleuca rhaphiophylla	•	•			
Melaleuca viminea		•			
# Verticordia densiflora				•	
Mimosaceae					
# Acacia dentifera		•			
# Acacia pulchella			•	•	
# Acacia saligna		•	•	•	
Onagraceae					
Epilobium billardierianum		•			
Orchidaceae					
# Microtis unifolia			•		
# Thelymitra campanulata			•		
Papilionaceae					
# Gompholobium marginatum					
# Hardenbegia comptoniana			•		
* Lotus angustissimus		•			
# Viminaria juncea		•	•		
Poaceae					
Agrostis sp.		•			
* Briza minor		•			
* Cynodon dactylon		•			
Danthonia caespitosa		•			
* Hordeum geniculatum		•			
* Lolium rigidum		•			
# Neurachne aleopecuroidea				•	
* Paspalum dilatatum		•			
* Polypogon monspeliensis		•			
# Stipa tenuifolia			•		
Polygonaceae					
* Rumex crispus		•			
Primulaceae					
Samolus junceus		•			
Proteaceae					
# Hakea prostrata					•
Stylidiaceae					
# Stylidium bulbiferum				•	
# Stylidium piliferum			•		
Typhaceae					
Typha domingensis	•	•			
#* Typha orientalis	•				

BENN Ø1

BENN Ø2

BENN Ø3

BENNET BROOK.

5099 WA 3169(C) METRO REGIONAL AREA & EXT. RUN 13 (5082-5157) 1:20000 15-DEC-92 920676

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