GORDON-FRANKLAND CATCHMENT COMPENDIUM

Department of Environment

Natural Heritage Trust

DEPARTMENT OF ENVIRONMENT
WATER RESOURCE MANAGEMENT SERIES
REPORT NO WRM 44
SEPTEMBER 2004

Acknowledgments

Catherine MacCallum prepared this report, for the Department of Environment (then the Water and Rivers Commission), the Gillamii Landcare Centre and landholders in the Gordon-Frankland River catchment. Benson Todd and John Bryant completed the document and ensured publication. The Department of Environment and the Natural Heritage Trust provided the funding.

The following people are acknowledged for their input, advice and feedback; Kaylene Parker, Andrew Maughan, Kevin Hopkinson, Steve Janicke and Ben Boardman (Department of Environment), Kelly Hill (Department of Agriculture, WA), Tom Atkinson and Alex Growden (Gillamii Landcare Centre) and Anthony Witham (Broomehill and Tambellup LCDCs). A special thanks is extended to Kelly Flugge for his assistance in locating the Indigenous Heritage information.

Donna Lutz (Department of Environment) edited the draft copy and provided feedback. Marg Wilke edited the final copy and desktop published the report.

Thank you to those landholders who have completed works to protect the waterways in the catchment, and those who have taken up fencing grants to further protect the Gordon-Frankland River. The time taken for landholders to assist with site visits is also greatly appreciated.

This compendium is a synthesis of information and all sources of input are much appreciated.

Reference details

The recommended reference for this publication is: Department of Environment, *Gordon-Frankland catchment,* Department of Environment, Water Resource Management Series, No WRM 44.

ISBN 1-920947-39-6

ISSN 1326-6934

Cover photograph: Fankland River, Cranbrook Transport Road [taken by Kaylene Parker]

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Introduction

The Gordon-Frankland River system is located in the South West of Western Australia. It includes two major rivers; the Gordon River and the Frankland River. The upper catchment Gordon River feeds into the lower catchment Frankland River. Both are fed by many creeks and streams collected from across the catchment.

The Frankland River winds its way through picturesque countryside characterised by the tall tingle and karri forests of the South Coast and eventually discharges into the Walpole-Nornalup Inlet. The South Coast forests are unique, being located in the high rainfall area of the South West of Western Australia, one of the few places where the forests meet the sea. The beautiful Walpole-Nornalup Inlet, surrounded by the pristine forests of the National Park, is a popular tourist destination for recreational and aesthetic reasons. As a consequence, the community recognise the river, inlet and forests as high value areas in need of protection.

Like many other Western Australian rivers, the Gordon-Frankland is becoming degraded as a result of human activity within and along the waterways and catchment. The upper catchment is the more degraded part of the system, suffering from increases in salinity, degradation of foreshore vegetation, sedimentation and erosion of the river channel. The lower catchment is at risk from eutrophication from surrounding landuses. The tributaries of the Gordon-Frankland are also becoming degraded, with tributaries in the upper catchment already having an impact on the main river channel.

Lack of knowledge in terms of the pressures and threats to river systems can result in degradation that might otherwise be avoidable. It is difficult to know how to look after or restore and rehabilitate an area if there is insufficient information available on how the system works and if community values have not been determined. Therefore it is imperative to be aware of the biological and physical parameters, landuses practices, community concerns, natural fluctuations of the systems and how they all interact.

Some restoration work has already been implemented and it is vital that those groups involved in the rehabilitation of the Gordon-Frankland continue to be supported. An increased knowledge base provides opportunity for better management practices to be adopted and better action plans to be developed. Stakeholders are able to work together to rehabilitate and protect the Gordon-Frankland River and its catchment into the future.

This compendium is a synthesis of the information that is known about the Gordon-Frankland River system. It is designed to provide information to community groups, landholders, land managers, local government, other government agencies and people with a general interest in the system. The information is from a variety of sources and has been collated into one for ease of access and use. The format ensures that it is easily updated and links through the 'more information icon' guides the reader to where more information can be found.

 More information icon

The compendium can be used to:

- increase community knowledge of waterways management issues;
- facilitate the prioritisation of on-ground works and future research;
- aid community groups in funding applications;
- indicate where problem areas are; and
- provide details of what work is being done in the catchment and how people can become involved.

The compendium is also a record of the current condition of the Gordon-Frankland River and can be used as a benchmark to monitor change. It is divided into the following sections:

Section 1. Catchment – details the physical and biological resources of the area, heritage and landuses within the catchment.

Section 2. Waterways – details the physical and biological background of the Gordon-Frankland River.

Section 3. State of the Waterways of the Gordon-Frankland and key issues – details the current state of the waterways, threatening processes and pressures and recommended management responses.

Section 4. Estuaries – details the physical and biological aspects of the Walpole-Nornalup Inlet and heritage of the area.

Section 5. Wetlands – provides information on wetlands of regional and national significance within the Gordon-Frankland catchment and hreats facing them.

Section 6. Foreshore vegetation and surveys – details the status of the riparian vegetation of the Gordon-Frankland River, some tributaries and the Walpole-Nornalup Inlet.

Section 7. Demonstration sites – details projects that promote river restoration initiatives.

Section 8. Community action and vision – details the work being completed by the subcatchment groups of the Gordon-Frankland catchment and maps of each subcatchment. The community values, visions and issues of the Gordon-Frankland catchment.

References – resources used.

Web sites of relevance – useful links.

Other information – contact directory.

Upper Catchment, (photo by Kaylene Parker)

1 Gordon-Frankland catchment

1.1 The catchment at a glance

Location:	South West Western Australia
Main river channel:	Gordon-Frankland River
Inlet/estuary:	Walpole-Nornalup Inlet
Catchment area:	5990 square Kilometres
Number of shires:	7
Number of subcatchments:	19
Area cleared:	85%
Annual rainfall:	500–1400 millimetres (mm)
National parks:	2
Major wetland suites:	8

1.2 General

The Gordon-Frankland catchment is located in the South West of Western Australia and comprises the Gordon-Frankland River and its tributaries, which drain into the Walpole-Nornalup Inlet (Figure 1.1). The Gordon-Frankland catchment is also known as the Frankland River Basin. The total catchment area is 5990 Square kilometres and extends from the South Coast east of Walpole, in a north-east direction towards Broomehill. The catchment is bounded by the Kent River catchment to the east, and the Shannon catchment to the west. The neighbouring rivers are the Kent River to the east and the smaller Walpole River and larger Deep River to the west. There are seven shires within the catchment: Broomehill, Kojonup, Tambellup, Cranbrook, Plantagenet, Manjimup and Denmark.

The lower catchment is surrounded by pristine wilderness encompassing two national parks –Mount Frankland and Walpole-Nornalup. The majority of the upper catchment consists of alienated agricultural land that is used for cropping and grazing. It represents the majority of the 85% of cleared land within the entire Gordon-Frankland catchment. A variety of landuses exist within the catchment including agriculture, viticulture, grazing and conservation reserves. There are eight regionally significant wetland suites within the catchment. The Balicup Suite is located within the North Stirlings Wetland Group, which is part of the Pallinup catchment. This includes large areas of internal drainage in the South West corner of the Pallinup catchment. However in times of high flow the most westerly lakes are thought to drain to the Gordon-Frankland catchment. Some of the wetlands in the Balicup Suite are registered as being of national significance.

Signage on the major roadways outlines the Catchment boundaries (photo by Catherine MacCallum)

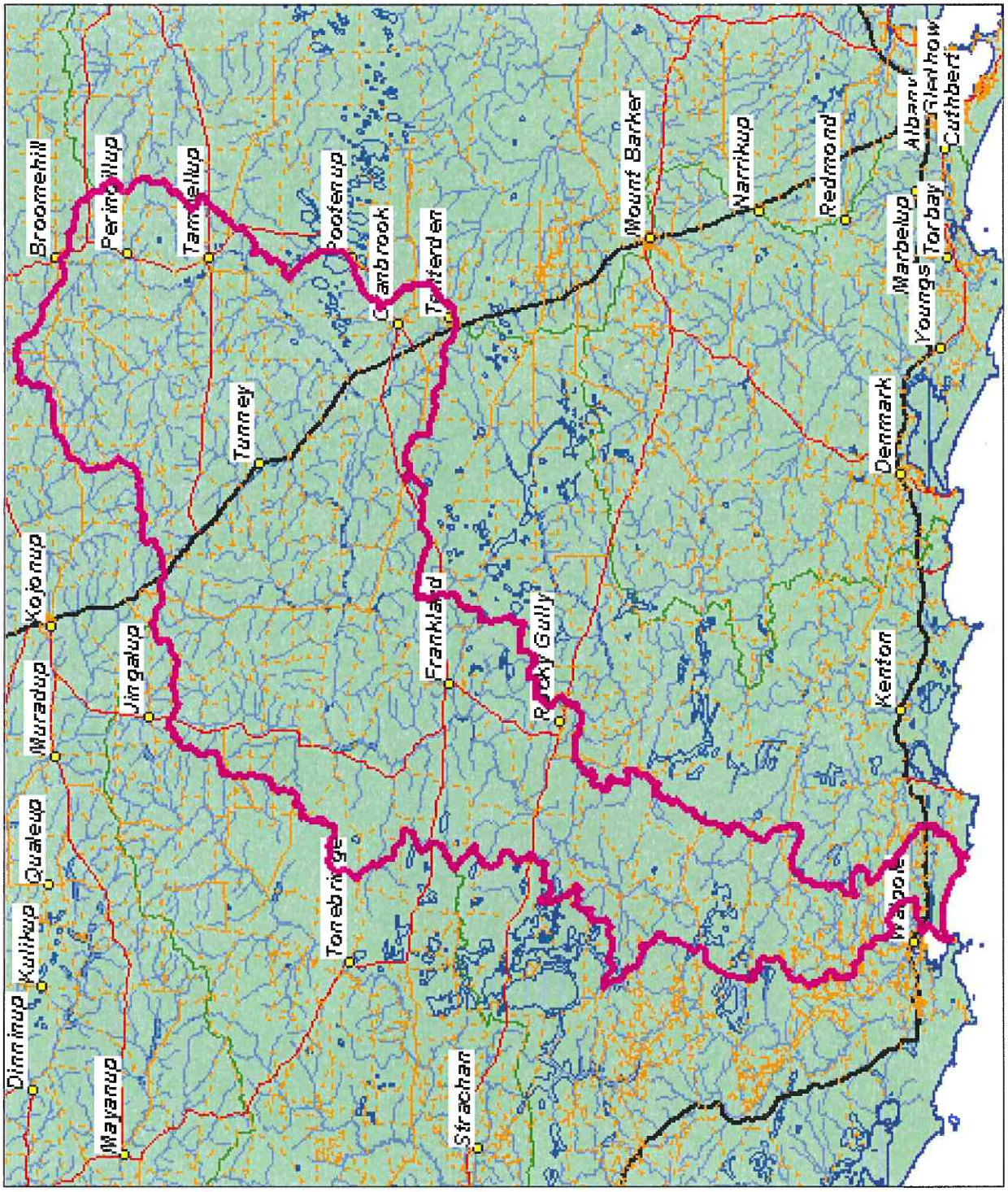


Figure 1.1. The Gordon-Frankland catchment

1.3 Climate and weather

Climate

The Gordon-Frankland catchment has a typical Mediterranean climate consisting of mild, wet winters and warm to hot, dry summers. The following information is sourced from the Commonwealth Bureau of Meteorology, 2002.

Table 1.1. Average temperatures in the Gordon-Frankland catchment

	Lower catchment °C	Upper catchment °C
Average annual maximum temperatures	18	21
Average summer temperature range	12–24	9–27
Average winter temperature range	6–15	3–12

Rainfall

Rainfall decreases progressively inland from the coast, with nearly 1400 mm a year near the coast, and less than 500 mm a year in the north-eastern part of the catchment. The majority of the rainfall occurs in winter with some occasional summer storms. Since the 1950s there has been a gradual decrease in rainfall in the lower catchment (approx. 200 mm a year). Figure 1.2 shows the rainfall isohyets across the Gordon-Frankland catchment.

Both the Bureau of Meteorology and the Department of Environment operate a number of rainfall gauges at different sites throughout the Gordon-Frankland Catchment. The amount of information available from each gauging station is varied, where some stations have collected one-off data sets and others continuous monitoring data for a period of several years.

Rainfall data can be obtained from the Bureau of Meteorology and the Department of Environment's Stream Gauging Network.

More climate and weather information is available through the Bureau of Meteorology's website. Information available includes up-to-date forecasts and predictions for different areas throughout Australia. General information is available free-of-charge including the SILO website that is particularly relevant to agricultural areas. Fees for more detailed and specific information vary depending on the service.

1.4 Geology, landforms and topography

Geology

The regional geology has a strong influence over the topography and landforms of the area, hence

The lower catchment consists of an undulating landscape in the high rainfall zone of Western Australia and is surrounded by tall karri forest (photo by Catherine MacCallum)

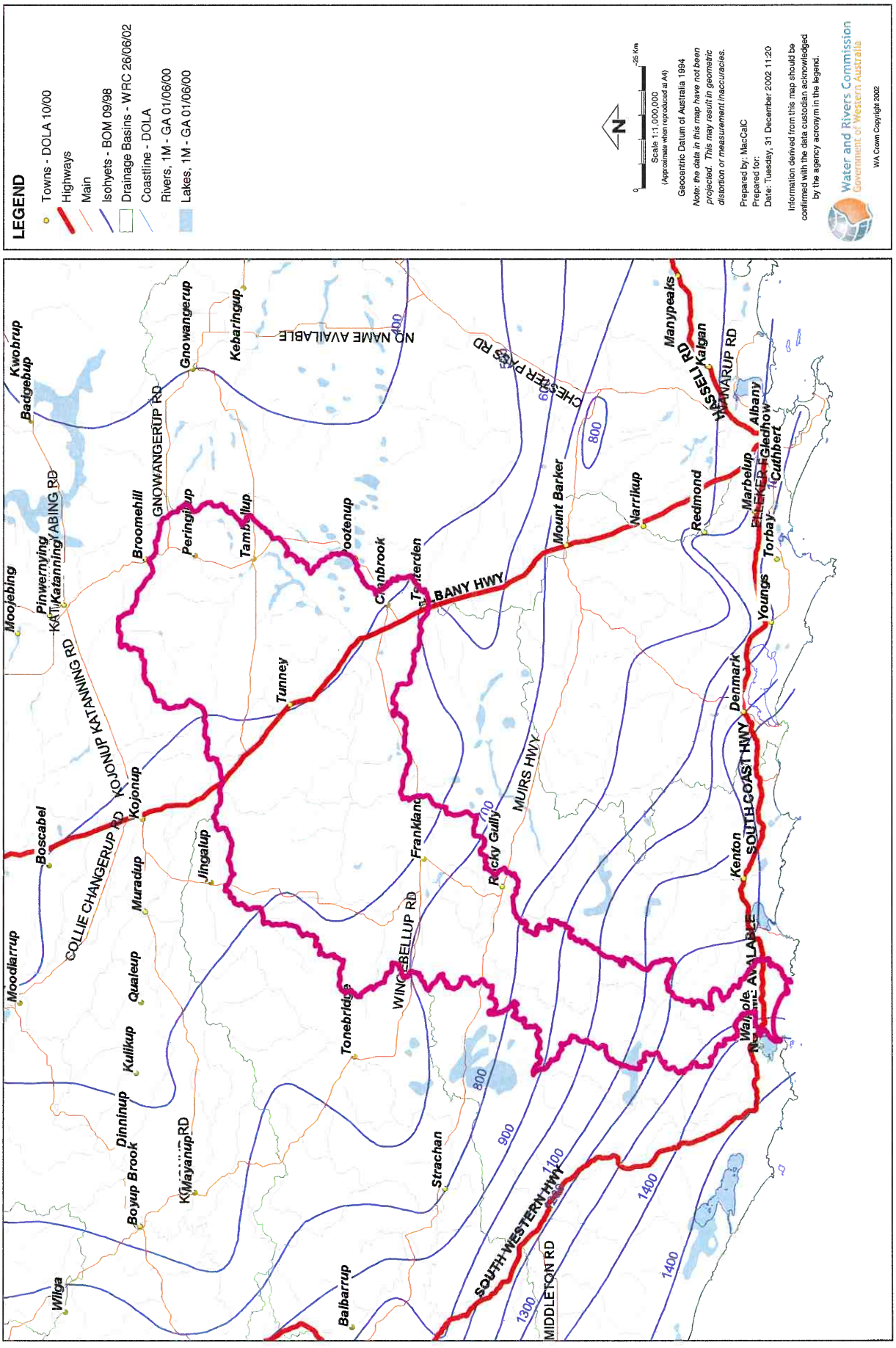


Figure 1.2 Rainfall in the Gordon-Frankland catchment – the lower catchment is in the high rainfall zone and rainfall decreases into the upper catchment

researchers have used a geological framework as the basis of primary classification of soil and landform units (Semeniuk, 1999). In the Gordon-Frankland catchment the main geological units are the old rocks of the Yilgarn Craton and the Albany-Fraser Orogen. The Yilgarn Craton and Albany-Fraser Orogen contact along an east-west oriented interface (Semeniuk, 1999). An east-west series of dolerite dykes has intruded into the rocks of the Yilgarn Craton to the north of the contact zone with the Albany-Fraser Orogen (SCRIPT, 1996; Smith, 1997).

About 100 mybp the South Coast slumped after Antarctica began to separate from Australia and was then covered by sea to the south-west of the region during the Eocene (50 mybp). The land was then raised which resulted in faulting and shearing of the basement rocks. Laterisation occurred in the region during the Tertiary (30 mybp) (SCRIPT, 1996).

Southerly flowing rivers have removed some of the laterite, however poor drainage in the upper Gordon River, has resulted in rain-borne salt accumulating in the deep soil profile (SCRIPT, 1996). The Gordon River is an older system than the Frankland River which has cut a nicely formed valley to capture the flat sediment filled valley of the Gordon River (Pen, 1999).

Further information about the geological history of the region can be found in Smith (1997) and in Hodgkin & Clark (1999).

Landforms and topography

The catchment lies on the southern edge of the Western Shield Plateau, where the land north of Muirs Highway is gently undulating open country about 300 m above sea level with granite outcrops and laterite residuals (Hodgkin & Clark, 1999). The area south of Muirs Highway slopes towards the coast and is hilly with deeply incised valleys (Hodgkin & Clark, 1999).

The major river system is the Gordon-Frankland River. Below Muirs Highway the river is known as the Frankland River and above the Highway as the Gordon River – the major tributary of the Frankland River. The Gordon River catchment extends east into salt lake country surrounded by cleared agricultural land (Hodgkin & Clark, 1999). Forested National Park surrounds the Frankland River.

Coastal setting

The Gordon-Frankland River flows into the Walpole-Nornalup Inlet, which is located on the south coast of Western Australia. Before entering the inlet, the river flows almost parallel to the coast near Bellanger Beach. There are steep granite cliffs to the west of Nornalup Inlet and Rocky Head (Hodgkin & Clark, 1999). A Pleistocene limestone dune system exists to the east of Rocky Head and stretches along Bellanger Beach. (Hodgkin & Clark, 1999).

1.5 Soils

In the cleared upper catchment the soil type is largely sand or loam yellow duplex. The lower catchment is mostly forested with leached sandy and gravelly soils

thin laterite cover.

For more information contact the Department of Agriculture, WA or refer to the following references:

McArthur, W.M., 1991, *Reference soils of south-western Australia*. Australian Soil Society of Australia Inc. (WA Branch), Perth Western Australia.

Schoknect, N., 1997, *Soil Groups of Western Australia*. A guide to the main soil groups of Western Australia. Agriculture Western Australia, Resource Management Technical Report No. 171.

1.6 Hydrogeology

The following information is summarised from (Smith, 1997).

There are five hydrological units found within the Gordon-Frankland catchment all with minor groundwater potential. The aquifers contain both confined and unconfined groundwater resources and tend to drain in a south-easterly direction toward the coast. The groundwater movement is extremely slow and is governed by the topography of the area, with most groundwater discharging into dissecting drainages from local shallow flow systems.

The surficial sediments containing groundwater consist mainly of limestone, sand, silt and clay, with small proportion of gravel and gypsum. These have been formed from tertiary sediments and occur along drainage lines in inland depressions and near the coast.

The surficial sediments are generally less than ten metres thick within the inland depressions, but are substantially thicker in the coastal dunes. Recharge of the surficial sediments is by rainfall, river flow, occasional flooding, and from upward groundwater leakage from underlying aquifers. The groundwater salinity in most areas is generally to high for stock use.

The Stirling Range Formation comprises sandstone, quartzite, and shale and there is a small intrusion of this hydrological unit near the town of Frankland in an east-west orientation. It rests unconformably on, Archean bedrock to the north and is faulted against Proterozoic rocks to the south. The rocks are substantially faulted and form a fractured rock aquifer recharged by rainfall and runoff from streams.

In some places there is an overlain weathered profile generally less than five metres thick and may include laterite at the surface. Regional faults and local joints, quartz veins and dolerite dykes cut into the bedrock.

Where there is laterized bedrock the weathered profile is up to 10–20 metres thick. Here the weathered granitoid rocks are the most prospective for minor aquifers. Gneissic rock generally forms poor aquifers as it weathers to clay. The quartz veins can form fractured rock aquifers and can transmit groundwater along the fractured zones. However the dolerite dykes are generally impermeable to groundwater flow and so form barriers when they are perpendicular to groundwater flow. When dolerite dykes form barriers they contribute to the rise in groundwater, which has the potential to cause land salinisation up gradient from the dyke. Groundwater recharge is from rainfall and runoff, however groundwater flow is very slow, except locally where there are preferred flow paths provided by fractures. Generally the groundwater in these hydrological units discharge into seeps, drainages or sediments. The groundwater is predominantly saline, with some poor quality stock water (3000–10 000 milligrams per litre). Fresh to brackish groundwater is limited and localised, and is restricted to higher ground along groundwater divides (Smith, 1997).

1.7 Flora and vegetation

Flora

The Walpole-Nornalup National Park is an area of considerable diversity reflecting the range of landforms and soils of the area. At least 698 native species of plants occur in the Park, including 42% of the known plant species within the Warren Botanical subdistrict, 17 of which are endemic to this subdistrict. The Park also contains a number of geographically restricted high rainfall species. The native flora within the Park consists of four families of ferns and 82 families of flowering plants. The major families represented include the Orchidaceae (104 species), Fabaceae (50 species), Myrtaceae (52), Cyperaceae (36), and Proteaceae (43 species) .The Park is also one of the richest reserves of Orchids in Australia. This information has been obtained from the Department of Conservation and Land Management, 1992.

Many plants and animals that were once plentiful are now rare and endangered, due to the reduction of vegetative cover. There are a number of plants that are rare, threatened or poorly documented within the Gordon-Frankland catchment (SCRIPT, 1996). For more details about these species please contact the Department of Conservation and Land Management.

Vegetation

The Gordon-Frankland catchment is located in the South West Botanical Province and covers the botanical districts of Avon and Darling, sub-districts of Warren, Menzies and Dale (Blackall & Grieve, 1988). Beard (1981) describes the botanical districts and vegetation systems. Figure 1.3 shows the location of the botanical districts and vegetation systems across the Gordon-Frankland catchment (note: the Kent River catchment is included in the map). The following information has been taken from SCRIPT (1996).

Nornalup System

Karri forms tall forest in this area. It is the Karri forest system near Walpole that grades into the Torndirrup system along the coast.

Bridgetown System

Consists of Jarrah–Marri forest.

Kwornicup System

This system is a poorly drained swampy area between the headwaters of the Kent, Hay and Gordon Rivers. It is covered with small lakes and swamps (Lakes Muir, Kwornicup and Poorarecup are in this vegetation system). It is dominated by Jarrah-Marri forest with numerous patches of low Jarrah forest, low Paperbark

forest and Sedge swamps. Yate (*Eucalyptus cornuta*), Swamp Yate (*E. occidentalis*) and Wandoo (*E. wandoo*) are often present in the Jarrah-Marri forest.

Jingalup System

The Jingalup System is found in the North West area of the catchment on undulating country with Jarrah-Marri forest on the lateritic ridge tops and ironstone gravels with woodlands of Marri and Wandoo (no Jarrah) on the slopes. Major creeks are lined with flooded gum (*Eucalyptus rudis*), *Melaleuca cuticularis* and *M. viminea*. The woodland can also have Jam (*Acacia acuminata*) or Sheoak as small trees with a scattered understorey, unlike the true Jarrah forest.

Kendenup System

This system is very much a transitional zone. The Kendenup System is basically a plain below the 635 mm isohyet. The forest opens out to woodland of Jarrah, Marri and Wandoo on the upper slopes with Yate and Wandoo dominating the lower slopes. Teatree is present along creeks and in the saline areas, samphire can be present.

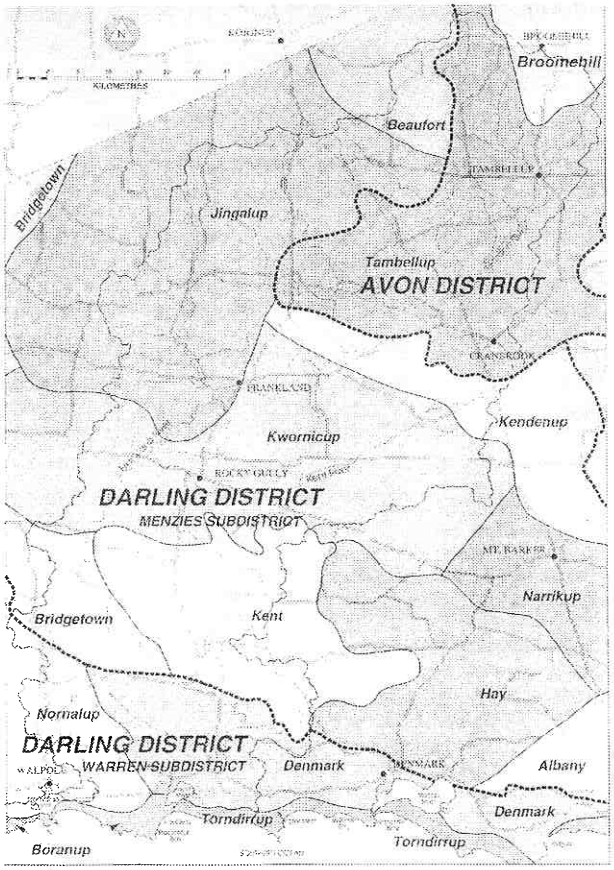


Figure 1.3. The Botanical Districts of the Kent-Frankland area (the Gordon-Frankland catchment is on the left (SCRIPT, 1996)

For more information about the vegetative systems in the Gordon-Frankland catchment contact the Department of Conservation and Land Management or the following reference:

Beard, J.S., 1981, *Explanatory memoir to the 1:250,000 map sheet – The vegetation of the Albany and Mt Barker areas*. Vegmap Publications. Perth, Western Australia Vegetation Survey (second edition).

1.8 Fauna

The Department of Conservation and Land Management have conducted fauna surveys within the Gordon-Frankland catchment with a focus on the national parks. Since European settlement the mammal fauna of the south coast has declined considerably (How *et al*, 1987) this is attributed to land clearing, changes in fire regimes, introduced pests and diseases (CALM, 1992).

Walpole-Nornalup National Park

The following information has been obtained from the Department of Conservation and Land Management (CALM), 1992.

The Walpole-Nornalup National Park has 19 species of native mammals, including the Southern Brown Bandicoot, Chuditch and Western Ringtail Possum, which are all, gazetted as threatened. Other species of interest that are known to reside in the park are Honey and Pygmy Possums, Quokkas and Brush-Tailed Phascogales.

There are 109 species of birds found within the park, including five species that are gazetted as threatened. This is a reasonably high number of species and is attributed to the wide range of habitats that exist within the park.

There are 22 species of reptiles that occur in the park, three of which are restricted to the southern dunes. Because the park receives high rainfall the number of reptile species is comparatively lower than parks of similar size in the arid zone of Western Australia. The greatest number of reptile species exist is in the coastal dunes followed by the swamps and the flats, where fallen and dead vegetation provide a variety of refuges.

The Walpole-Nornalup Park is one of the richest areas for frogs in Western Australia. All of the 12 species found within the Park are endemic to the South West, where swamps and drainage lines support large numbers of species. One species, *Geocrina lutea* is only found within a 12 kilometre radius of Walpole (Roberts *et al*, 1990).

Unallocated Crown land

A fauna survey was conducted by Liddelow & Ward (1981) for the then area of Unallocated Crown land directly east of the Frankland River and north of Roe Road, it includes the forest blocks of Hiker Gully, Karara and Northumberland (and is now part of State Forest 59). The area was surveyed for the possibility of it being dedicated as a flora and fauna reserve. The following information has been sourced from the survey. Details of the mammal fauna in the area are represented in Table 1.2. These species have been included if they were captured, sighted, evidence was present of their existence or there were previous museum records from the area.

Table 1.2. Mammal fauna found to occur in the Unallocated Crown land East of the Frankland River and north of Roe Road (1981)

Macropus fulinginosus	western grey kangaroo
Macropus irma	brush wallaby
Macropus eugenii	tammar wallaby
Setonix brachyurus	quokka
Trichosurus vulpecula	common brush-tailed possum
Phascogale tapoatafa	brush-tailed phascogale
Sminthopsis murina	common dunnart
Dasyurus geoffroii	western native cat
Hydromys chrysogaster	western water rat
Rattus fuscipes	southern bush rat
Pipistrellus tasmanienis	Tasmanian pipistrelle
Eptesicus regulus	little bat
Chalinolobus gouldii	Goulds wattled bat
Chalinolobus morio	chocolate bat
Nyctophilus geoffroyi	lesser long-eared bat
Tadarida australis	white-striped bat
Canis familiaris	dingo
*Vulpes vulpes**	European fox
*Felis cattus**	feral cat
*Oryctolagus cuniculus**	rabbit
*Rattus rattus**	rat
*Mus musculus**	house mouse
*Equus caballus**	horse

**** Introduced species***

Bird sightings and calls were recorded during the survey with a total of 55 species being noted. The limited permanent water available at the time of survey (being autumn, which is not the best time of year for bird records) is thought to have influenced the relatively short list of birds. The bird species were grouped according to the vegetation type in which they where found. A total of 44 species of birds were recorded in the Open Low Forest, the most common were the seed/ fruit eating Psittacifomes. There were a large number of Tawny Frogmouth and Australian Owlet-Nightjar recorded. These common forest species have previously never been recorded in such high numbers. Sightings of the Western Thornbill, Grey Fantail and Inland Thornbill suggest that the area is in the transition between the southern and northern assemblages of forest birds.

There were 30 species recorded in the Lowland vegetation (comprising Low Open Woodland, Heathland and Sedgeland), honeyeaters (particularly the western spinebill and the New Holland) being best represented group. Birds that were found at the Frankland River totalled ten, the most common were the Pacific Black Duck and the Dater. Limited time was spent observing the bird species in this area because much of the river is inaccessible. However the vegetation beside the river is thought to provide a food source for many species.

A total of 18 reptile species were collected from the area. These included one Goanna, one Gecko, ten Skinks and six Snakes, all typical of the southern forests. The Long-Necked Tortoise was not collected, however it is known to occur in the Frankland River. The collection of the Muellers snake (*Rhinhoplocephalus bicolor*) near Myalgalp Road further extends the range of this species, as it has not been recorded so far inland. The little brown snake (*Elapognathus minor*) was a noted find during the survey, as CALM had not previously recorded this species.

Nine species of frogs were collected from the area during the survey, the most common being the burrowing frog (*Heleioporus eyrei*). There were a total of six species of fish collected in the area, the most significant find was the mud minnow (*Lepidoglaxias salamandroides*), which extends the range of this species further inland from previous record.

1.9 Heritage

Indigenous heritage

The South West of Australia forms the distinct cultural block defined by the distribution of the Nyungar language (Goode, 2001). Before Nyungar was used as a group or linguistic name the South West people recognised themselves and their language as 'Bibbulman' (Bates, 1985, cited in Goode, 2001). The tribal boundaries were grouped into regions and form the Tindale Tribal Regions (Figure 1.4). The Frankland-River catchment encompasses three of the Tindale Tribal regions, Minang, Kaneang and Kalaako, and boarders the Wilman Region.

The following indigenous heritage information has been sourced from Dortch, 1999.

There is limited information available on the indigenous history of the Gordon-Frankland catchment. This is due to little documentation by early explorers and settlers on their encounters with indigenous people. However, there are a number of registered Aboriginal sites in the Gordon-Frankland catchment (see Figure 1.5). These vary from burial sites, archaeological sites, ceremonial sites, modified trees (possum trees), quarries and lizard and fish traps. The presence of these suggests that the area was frequented by indigenous people and holds historical value.

Some of the burial sites within the Frankland-Gordon region are listed on the Department of Indigenous Affairs (DIA) site register. The register suggests the names of the deceased at the Yeriminup Burials 2, and for others, such as the Lake Muir site, the site file gives reference to an early settler that helped bury the deceased. This evidence places the date of the burials in an historic period. The existence of local knowledge, such as the mention of people's names, suggests that the burials date back to the last one or two centuries. The presence of burials in the area, and in similar country indicates that indigenous people were living there in historic times, and that other burials may exist.

Other sites within the area include trees bearing footholds cut by stone axes, presumably by indigenous possum-hunters, such as the East Lynne Possum Tree. Other sites including Rocky Gully (near creek bank) and Lake Muir have kangaroo pit-traps which where documented by ethnographic observations at Albany and elsewhere (eg. Hammond, 1933, cited in Dortch, 1999). Lizard traps have also been encountered, for example at Glenerin, where artificial lizard habitats were constructed from granite slabs on outcrops. The slabs were supported by loose pebbles to create a narrow space where lizards can shelter and still be flushed out with a stick.

Gnamma holes are holes that are made in granite outcrops designed to hold water. These gnamma holes were important to any group traversing dry country and are uncommon in the high rainfall parts of the South West. There are several of these sites in the region including, Ashton, Glenerin and Tambellup gnamma holes, which are located in the Upper catchment where the rainfall is much less. The presence of gnamma holes in these areas suggests that people travelled inland at times when natural water sources were scarce, or rainfall was unpredictable.

Other sources of indigenous historical information come from archaeological survey reports. When construction or building is proposed an investigation for Aboriginal heritage significance or an archaeological survey must be completed to ensure there is no interference to any significant sites. This is required under the *Aboriginal Heritage Act* (1972) and usually involves a survey for archaeological evidence, a review of ethnographic history and interviews with indigenous groups who have interest in the specific area. There have been several such reports completed in the Gordon-Frankland catchment. Below is a summary of the information available from those reports.

There is very little ethnohistoric documents regarding the Upper Frankland catchment, however it is reasonable to assume that the traditional activities in this area were broadly similar to those recorded by early settlers in nearby regions, such as King George Sound and the Swan River catchment. The Frankland river valley may have been the path of Aboriginal trackways, as Nyungar people were reported to follow river valleys as they moved across the landscape (Ferguson, 1985; Hollam, 1975, both cited in Dortch, 1999). The banks of the Frankland River and the general area around Lake Muir are therefore expected to have attracted Aboriginal occupation (Dortch, 1999).

Indigenous groups using the Gordon-Frankland region probably made concurrent use of a very large range of aquatic and terrestrial foods. The small swamps and lakes scattered across the Upper Frankland region, and the Frankland River itself, would have provided fowl, turtles, frogs, crayfish and edible rhizomes (roots of sedges and rushes). Woodlands and open forests, like those found in the Gordon-Frankland catchment were the habitats of several mammals, birds and reptiles, and the source of many plant foods.

Observers such as Hammond (1933) and Nind (1831) saw that in forests and woodlands, Nyungar people typically travelled in small groups and camped for only one or two nights in a given location (cited in Dortch, 1999). This was due to the scattered resources of the inland forests and woodlands, thus a given location could not support long occupation or large numbers of people. Anderson (1984) further infers that people generally used the forests in the summer months because many of the small streams dry up (Cited in Dortch, 1999). Lack of water may have been a consideration in the upper catchment, which receives moderately high rainfall, but is markedly seasonal. Thus implying the relative difference in rainfall between winter and summer would have been important. The Upper Frankland River may not have always flowed throughout every summer, and perhaps, Aboriginal People would have more often travelled up the valley in winter.

Areas within the Gordon-Frankland catchment were important for meetings and corroborees.
(Goode, 1999). Laurie (1994) writes:

O.A Finlay, a well-known 'Cranbrook' resident, recalled that a gathering of Aborigines from the Salt River district [near the Pallinup River] *and other areas to the west was held annually in the Cranbrook township in the early years of the decade. Their corroboree was held on the site of today's bowling club, and between seventy and eighty adults generally arrived... There was also a big camp at a reserve on the Uannup Brook near Moriarty's 'Shamrock' homestead, and Aborigines would arrive from Kojonup and Yeriminup to join in the corroborees and sporting competitions held there.* (Laurie, 1994; pp72-75, cited in Goode, 1999).

Much of the information regarding indigenous heritage and stories are passed down from generation to generation within the indigenous community. The elders of groups impart the history of their people to the next generation. There is the potential for this oral history to be lost, not only to the indigenous community, but to the community as a whole if it is not recorded in some way.

European heritage

Early explorers of the South West deemed it suitable for farming and settlement. The earliest settlers who claimed large pastoral holdings were those who wished to establish large scale enterprises and employ many workers, similar to what was done in England. Unsuccessful farmers and convicts gained work shepherding sheep over large holdings, the pastoralists being able to claim areas of feed and water until the Government introduced Conditional Purchase Agreement to encourage farming. The freshwater river pools were often used as watering points for sheep. Gold discoveries and Government Acts assisting land availability and ownership gave tremendous boosts to the population of the Great Southern Region. The opening of the railway from Albany to Perth transported people, produce, stock, machinery and truly opened the region for settlement (SCRIPT, 1996).

There are a variety of information sources regarding the European history of the Gordon-Frankland catchment. These are summarised and presented as a timeline at the end of this section. The different boxes represent the source of the information as indicated in the 'key to references used' box below.

Key to references used in European history timeline:

1. Summarised from Mrs Jan Pope, "Homebush", Cranbrook in McFarlane (ed) (1994).
2. http://www.albanygateway.com.au.Town/Walpole/default.asp?sw=747
3. http://www.albanygateway.com.au/Town/Frankland/Local_History
4. http://www.albanygateway.com.au/Town/Cranbrook
5. SCRIPT (1996)
6. http://www.albanygateway.com.au/town/broomehill/Local_History
7. http://www.albanygateway.com.au/Town/Tambellup
8. Hodgkin & Clark (1999)
9. http://wwww.albanygateway.com.au/Town/Rocky_Gully/default.asp?sw=747

1.10 Landuse and tenure

Approximately 85% of the land in the Gordon-Frankland catchment is cleared agricultural land. There are two national parks that are vested in the Conservation Commission and classified as A Class Reserves.

Agricultural landuse across the region is predominantly cereal cropping and sheep grazing. The past few years has seen a shift towards fewer, larger farms in the broad-acre farming areas (upper catchment) and increasing numbers of small holdings in the shires of Denmark and Plantagenet (lower catchment) (SCRIPT, 1996). The agricultural practices of the area have become more diverse in recent years to include viticulture, olive groves, dairying and agroforestry.

Viticulture and the establishment of quality wineries in the areas is a growing industry. The Frankland area within the Shire of Cranbrook has long been associated with premium wine production and is currently undergoing huge developments. The establishment of an olive industry is also set to have an impact in the Frankland area.

National Parks

Within the Gordon-Frankland catchment there are two national parks which are managed by the Department of Conservation and Land Management. The Walpole-Nornalup National Park occupies a unique area of the South Coast with high average rainfall. The 20 000 ha park contains a diverse range of vegetation types, from the tall tingle and karri forest to low coastal heath. The park is well known for its tall tingle trees, rugged coastline, peaceful inlets and rivers, which together make beautiful scenic surroundings. There are a variety of different sight seeing locations to visit including, the Frankland River Circular Pool, Coalmine Beach, the Knoll, Valley of the Giants and Conspicuous Cliffs.

The Mount Frankland National Park covers an area of 30 830 ha with a rich array of forest bird life. There is thought to be over 50 different species of birds found in the Park. Birds that are found in the Park include Parrots, Birds of Prey, nocturnal birds, Cockatoos, Kingfishers, Robins, Swallows, Martins, Fairy-Wrens, Ravens, Butcherbirds and Currawongs. From the Mt Frankland peak there is a spectacular view that stretches across the national parks along the Frankland River and out to the Walpole-Nornalup Inlet and ocean.

For more details about the National Parks contact the Department of Conservation and Land Management or refer to their website.

European history of the Gordon-Frankland catchment – timeline

1826–1846

1. After traversing the country from Kelmscott to Walpole, Captain Tom Bannister's report to Governor Stirling fully realised the value of the area: "*That given forced labour to push an adequate road system through, the region would eventually support thousands of industrious settlers and townsmen.*"

1. JAN. Ensign Robert Dale climbed Mt Toolbrunup in the Koikeneruff Range (later renamed the Stirling Range). From his vantage point, and although his view was obscured by native fires, he observed that the surface of the plain was "*...diversified with open downs and extensive forests and with a great number of bare spots which were supposed to be salt lakes...*" (Dale, 1832).
Ref from Parnell (A History of the Town of Tambellup)

1. OCT. Governor James Stirling and Surveyor-General John Septimus Roe headed the Great Southern Expedition; the long term results of their work had significant and lasting implications for the growth and prosperity of the young colony.
A reported article written to celebrate its sesquicentenary, the Great Southern Expedition was of greater historical significance to the establishment of this region than any other event. One of the aims of the expedition was to determine a road route that linked the Swan River Colony with the Albany Colony.
Within a few years of the Central and Lower Great Southern hinterland being explored, vast areas of country with immense agricultural and grazing potential were being settled.
Comprehensive and favourable reports from Roe led to the founding of townships such as Wagin, Woodanilling, Katanning, Broomehill, Kojonup, and Mt Barker.

1826 — 1830-31 — 1832 — 1835

3. Western Australia's first European settlement began in Albany

1. Captain Banister was granted Plantagenet Location 31 for his service to the community, the first allocation made in Plantagenet Shire. The property was called "Capecup"; Bannister took little interest in it and did not develop it. The property was purchased by the Trent family, and members still farm the property today.

1. NOV. The party had traversed the country from Perth southwards via Williams, and were travelling along the Pallinup River east of what is now, Tambellup. Here they saw the Koikeneruff Ranges, where Roe renamed them the Stirling Ranges in honour of Governor Stirling.
As they travelled west they climbed a small summit at the western end of the Stirling Range and from there they could see the northern chain of lakes "*...but all having the appearance of one extensive salt chain stretched along the northern base of the Stirling Range towards Warreup in a valley remarkable for sterility and comparative uselessness*" (Roe, 1835).
Governor Stirling parted from the Expedition at Albany and returned to the Swan River Colony via sea.
On his return, journey, Roe chose a more westerly route travelling through the western district of Tambellup. On December 18, Roe and his party crossed a large river (about 8 km west of the present Albany Hwy) referred to by the Aborigines as 'Pakeerup'. Roe renamed this river in the name of an English official, George Hamilton Gordon, the secretary of the State for the Colonies "*...finding it a much more considerable river than we first imagined and that it took an inland direction I called it the "Gordon" in honour of the Earl of Aberdeen*" (Roe, 1835).

2. William Preston and his party officially explored the Walpole-Nornalup area after hearing sealers and whalers speak in glowing terms of the sheltered inlets, huge trees and great deep rivers.

2. William Nairn Clark and his party rowed into Nornalup and his description of the areas around Deep River and the Frankland River were of high towering hills, luxuriant vegetation and trees of magnificent growth, enormous girth and straight as a pole.

1. The Hassell family was one of the pioneering families who made a significant mark on the development of the Great Southern Region. After moving from Tasmania, Captain John Hassell came to Albany and purchased a large holding of land at Kendenup from George Cheyne. The holding was for 19,872 acres of land and John Hassell had the goal of establishing a large-scale pastoral enterprise. He was among the first in the Great Southern to have sufficient capital for such an enterprise and leased vast areas of prime land cheaply for flocks.
Captain Hassell spent large amounts of time travelling on horse back throughout the South West from Blackwood River to Cape Riche. He was searching for good watering points and well-grassed country. As he travelled along the Gordon River he noted "*Country here good soil and grass...and...plenty of good water bed and excellent grassy flats on the banks*' (Parnell, 1983).

2. A group of Englishmen led by Dr Henry Landor settled on the Deep River. They planned to catch and salt fish for export, and to raze cattle and horses. The venture failed within a year and the men went their separate ways.

1840 — 1842 — 1845 — 1846

1. A group seeking good land for pastures makes further mention of the Gordon River.
William Clark returned to the Slab Hut Gully where he rested and grazed the sheep he was taking to Kojonup. He took the opportunity to carry out further exploration where he described the land to the east "*...a park of about 300 acres covered with rich grass and scarce a tree to impede the progress of the plow*" (Clark, 1840).
Another member of the group with two Aboriginals, travelled across country to the Gordon River half below Watergarrup (south of Tambellup off the Paul Valley Road) and described the river as "*...fresh water, in large pools on several of which were large covies of water fowl*".
From this and other descriptions it is apparent that the Gordon River has always retracted into pools during summer as it does now. It was never a continuous stretch of water because of the flat terrain along the catchment of the Gordon River Catchment.

1. Surveyor Angustus Charles Gregory had traced the Gordon River down to its junction with the Frankland River and then on to Nornalup.

1. Kendenup became the capital of a wool growing empire. Between 1840-1864 the Hassell's sheep numbers grew from 815 to 1900. Many shepherds were needed to graze this many sheep, each had his own herd of many hundred head. There are records of about 25 separate flocks, each with there own shepherd and some with a hut keeper. The sheep were pastured at Kendenup or one of the outstations.

European history of the Gordon-Frankland catchment – timeline (continued)

1849–1889

[1.] JAN. Roe made another journey through the district and travelled to the Kylobunnup Pools "*...across mostly forest country in plains well grassed and had abundance of good water, encamping at the end of 11 miles upon the Gordon River in large pools*". Again, mention is made of the grassy forest country intersected with many small tributaries of the Gordon River, "*...in some of which were pools of good water and in all of them good grass*" (Roe, 1848/49).
Gregory again passed through the district and gave a brief account of his stay on the "*sandy and indifferent banks of the Gordon River*" as he travelled southwards from the Kylobunnup Pool over lightly grasses white gum forest and re-crossed the Gordon River.

[3.] 'Yeriminup' was taken up by the Egerton-Warburtons who were the first family to settle in the Frankland area. They were followed by the Moirs of 'Wingebelup' and 'Glen Valley', shepherds for the Hassells of 'Mongetup', and the Mulins of 'Westfield'.

[5.] Some bagged salt was collected from north of Pootenup. Settlers followed the pastoralists where grass and water was available. Orchards were established, fruit and vegetables grown and cows milked for home requirements.

1849 1850 1857 1860 1861

[4.] In the 1850s farming leases were bought in the Cranbrook area after an overland route was established between the Swan River Colony (Perth) and the King George Sound (Albany) passing through Round Swamp near Tenterden.

[3.] John Hassell was responsible for opening up extensive areas in the south of the state due to the large number of sheep he owned that needed the constant attention of shepherds as the only fences were post and rail.
Many of the shepherds drove their flocks into the Frankland area, which had many small creeks surrounded by natural pasture that provided good food in the autumn, winter and spring. The permanent waters of the Frankland and Gordon Rivers, and lakes such as Nunijup and Poorarecup made the area attractive during summer.
Families followed the shepherds into the area looking for land.

[5.] During the 1860s the upper region of the Gordon River was well traversed by Sandalwood cutters and kangaroo hunters

[6.] The town of Broomehill was closely tied to the settlement of Eticup, 8.5 km west of the townsite of Broomehill. However, Eticup never prospered as a townsite. In the 1870s the town consisted of several stores, a hotel and several dwellings.

[4.] Work began on the railway line to connect Albany to Perth. As there was insufficient suitable water catchment area at Round Swamp for a dam to provide water for the steam trains, the centre of the district was moved to Cranbrook. England and Round Swamp were renamed Tenterden.

1870 1872 1886 1889

[7.] Joseph Norrish first settled the town of Tambellup when he took up property to the east of the original townsite. Joseph Norrish concentrated on cutting Sandalwood and then later was involved with sheep breeding.

[5.] Some water resources turned salty in the summer during the 1870s.

[6.] The railway bypassed Eticup; this was the demise of the town and the flourish of Broomehill. Broomehill originated from the 'Broomehill Railway Refreshment Room' under licence of Patrick Carmody.

[5.] The populations in the great southern increased with the opening of the Railway.

[1.] The opening of the Great Southern Railway, which was established by Anthony Hordern.

European history of the Gordon-Frankland catchment – timeline (continued)

1849–1889

[1] A map dated 1893 of the Gordon-Frankland catchment area showed the Hassell family held leases on land bordering the Gordon and Frankland River at Campup, Yeriminup and at Nornalup Inlet.
Other families that were on the map were J. Annice (Ettakup), G. Harper (Boycup), McKail & Co (south of Yeriminup, which was taken over by the Egerton-Warburton family in 1857,) and A Muir & Sons (Frankland area).
The National Bank also held considerable leases around the Tambellup area. The WA Land Corporation also held leases between Rocky Gully and Nornalup and there were large areas of crown land around the Mt Frankland are.
These agricultural enterprises were mainly sheep grazing for wool production with all the wool being shipped to London for sale.
Before he died in 1883 and succeeded by his son, John Hassell travelled to London to study the wool industry and ways to improve the quality of the wool coming form the colony, in particular his clip. He adopted the Aboriginal practice of burning the country to improve the grass; the considerable fortune he amassed was founded on the native grasses and the fire stick.

[1] John Hassell's son JFT Hassell maintained that: "*Fire run over the land does more good than irrigation All the natural grasses of Western Australia have a hard shell and this must be cracked by heat before it will germinate. One fire will last the country for five years. As the result of our long experience we go in for patch burning, out boundary rider dropping matches in those patches which have been longest without fire.*" (Hassell, 1907)
Many settlers throughout the region worked for the Hassells as boundary riders and this enabled them to establish their own properties.

[4] With the railway line open, Cranbrook became the central loading point for wool, sheep, Sandalwood and grain.

[1] The river had other uses than just watering stock. Sheep brushing against the blackened trees gave the wool of the southern region a distinctive colour and hence the name 'blue wools'. On many farms, before sheep were shorn, they were first washed in one of the pools of the river. A pole would be placed across the pool and the sheep were swum past, having to swim under the pole to get their heads wet.
There are a number of pools in the various sections of the river commonly known as the 'wash pool' – one at Tambellup, another on a tributary of the Gordon River a few miles west of Albany Hwy on the Cranbrook-Frankland Rd and another at Yeriminup.

[5] Severe drought and World War 1 caused acute labour shortages and a depressed market.

1893 1899 1910 1914

[4] With the discovery of gold at Coolgardie improved the market for farm produce.

[7] The town of Tambellup was declared in August.

[8] The first permanent settlers to arrive at Walpole-Nornalup were the Bellanger family. They took up land beside the Frankland River.

[1] The discovery of gold had a large impact on the economy. The population that flocked to the goldfields to seek fortunes required feeding and many farmers supplemented their incomes.
Fruit was sent to markets in Kalgoorlie via the new railway. Properties such as Yeriminup and Boyacup boasted very large orchards and usually vineyards – the forerunners of the wine industry, which is now well established today.

[5] By this time farming at Tambellup consisted of mixed farming, cropping, dairy, fruit and wool production with some still just grazing. Poison bush, dingoes, kangaroos, tammars and cockatoos caused problems and the land was infertile.

[5] During the 1920s super phosphate was manufactured in WA to combat poor soil nutrient content.

[5] Facilities and amenities improved in the towns. Droughts in 1969, 1972 and 1973 checked progress. The Gordon River had become too brackish for use by this time. Dams and bores were more frequently used with improved pumps.

[5] The Government extended the railway line to Nornalup for transport of produce to market and general freight and passenger service.

[2] New township gazetted as Nornalup. However, settlers wanted this name changed to Walpole (presumably after the river which was discovered by Captain Bannister in 1831 and named by Governor Stirling after Captain W. Walpole) and this was gazetted as the official name in August 1934. The original site of the town was part of what is now Pioneer Park.

[9] The town of rocky Gully began with "Tent Town" until houses were built by the war service.

1929 1930 1933 1949 1951 onwards

[2] The remainder of the Walpole district was opened for agriculture with the introduction of the Nornalup Land Settlement scheme.
Walpole was settled – farmers and timbermilling developed soon after.

[5] Settlers in the area of Rocky Gully grazed cattle on the well grown clover, but dingoes, Zamia palm poison and thefts of prize cattle made settlement impossible. Rocky Gully was abandoned until 1949 when rapid development occurred.

[5] Ninety-nine new Australian families transferred from the Northern Immigration Camp were placed in new blocks in the upper Gordon River region. Land clearing was done by the bulldozer, large crawler tractor, log and chains and the new chemicals for weed and insect controls were

[5] The Great Depression in the 1930s lead to groups of settlers walking off to seek work, most moving to Perth.

2 Waterways information – Gordon-Frankland River

The main waterways in the Frankland Basin are the Frankland and Gordon Rivers and their tributaries. Combined, the main channel is referred to as the Gordon-Frankland River throughout this compendium.

2.1 The river at a glance

Total river length:	~ 400 km
Estimated Mean Annual Flow:	390 Gigalitres
Major tributaries:	Boxhall, Bolbelup, Pinjalup and Jam creeks, Elsie, Wedding, Towerlup, Cowenup and Uannup brooks, Slab Hut and Ettakup gullies, and Wadjekanup River.
Discharge point:	Nornalup Inlet
Length that is estuarine:	For 12 km upstream from river mouth
Salinity:	Saline, increasing
Nutrients:	Low below Muir HighwayHigh above Muir Highway
pH:	Neutral-basic
Turbidity:	Low below Muir HighwayHigh above Muir Highway
Colour:	Stained

The Gordon-Frankland River is the longest river on the South Coast, measuring approximately 400 kilometres. The ancient Gordon River drains the flat Yilgarn Plateau through agricultural areas, with its headwaters south-west of Broomehill. North of Muir Highway the river becomes the Frankland River, and remains this for the duration of its meander towards the Walpole-Nornalup Inlet. The rainfall changes from 500 mm per annum in the upper reaches to 1400 mm per annum near the coast.

The upper catchment has ill-defined drainage lines that join and flow into salt lakes during years of exceptionally high rainfall (SCRIPT, 1996). Both rainfall and runoff decrease rapidly away from the coast and 80% of flow is generated from the high rainfall forested area (800–1400 mm) south of Muirs Highway.

The upper reaches of the river consist of a series of permanent river pools that are connected during times of high rainfall. In the lower reaches the main river channel is wider, deeper and continuous, and it flows all-year-round. There are several gauging stations that have recorded streamflow data in the lower reaches. There is no data relating to the amount of sediment moving down the river.

Upstream from the Nornalup Inlet the river winds for six kilometres in a well defined channel through steep sided, forest clad hills and for most of that distance it is navigable. For six kilometres downstream the river flows in a wide, shallow (less than 1 m) stretch, a navigation channel has been dredged. On the north shore near the inlet riverine flats, swamps, and rock border the river.

The Frankland River was dredged in 1954 near the opening into Nornalup Inlet. The channels were examined in 1956 and 1958 with no siltation observed, however in 1963, thirty cubic metres had to be dredged. During the 1982 flood the river banks were seen to be falling in near the Monastery and one of the dredged channels had silted up to almost half its depth (Marine and Harbours, cited in Hodgkin & Clark, 1999). This information was taken from Hodgkin and Clark, 1999.

2.2 Geology

The Geological history of the two rivers that make up the Gordon-Frankland are markedly different it is for this reason that the two have been separated for the purposes of this section. The following information has been sourced from Pen, 1999, unless cited otherwise.

The Gordon River is a mature river flowing from the geological unit known as the Yilgarn Craton. The Gordon River extends to the division between the zones of ancient drainage and the mature drainage, with the majority being the area of mature drainage. There are places within the Gordon-Frankland catchment where the channel forms part of the ancient drainage, near the catchment boundary with the upper Kent River. Today the broad deep valleys of these ancient rivers or palaeo channels are filled with 50–60 m of sediment and are host to long chains of shallow salt lakes.

The salt lakes of the North Stirlings, including the Boorokup, Wareenip, Milyunup, Racecourse and Munrillup lakes and the Balicup Lake System are thought to be ancient drainage from the Gordon River (Smith, 1951). The lakes lie between the Pallinup drainage basin and the upper Gordon catchment and extend south to the Stirling Ranges (Smith, 1951). Most of the lakes drain to the Pallinup River, however in unusually wet years the lakes are known to drain to the Gordon River (Smith, 1951).

The Frankland River is a younger rejuvenated river channel formed during the Tertiary Period (65 to 2 million years ago). The Darling Plateau was further elevated by successive uplifts of the south western portion of the Yilgarn Craton. Along the south coast the plateau was not so much raised but rather tilted, forming the Ravensthorpe Ramp. Causing the belt of land within 40–80 km of the coast to gently slope towards the sea. The new rivers of the south coast obliterated the old drainage lines, but in the case of the Frankland River, it captured the old drainage beyond the ramp on the edge of the Yilgarn Plateau, ie the Gordon River.

2.3 Flow rates and flooding

Streamflow

The Gordon River is primarily a series of pools that connect to form a flowing continuous river at times of high rainfall, such as in winter. The Frankland River flows continuously throughout the year.

The Water and Rivers Commission had two streamflow gauging sites on the Gordon-Frankland River, Mount Frankland (605012) and Trappers Road (605013), which monitored streamflow, water temperature and salinity (conductivity). Both of these sites are now inactive, the Mount Frankland gauge collected data from 1 January 1952 until 7 June 2000. The Trappers Road gauge collected streamflow data from 25 June 1997 until 7 May 1998 and monitored water temperature and salinity until 10 March 1998.

Data from both of these monitoring sites can be obtained from the Department of Environment.

The annual flow and rainfall from the Mt Frankland gauging station is presented in Figure 2.1. The annual flow is related to the annual catchment rainfall. In years with higher rainfall, there has been a higher flow. The median monthly flow from the Mount Frankland gauging station is shown in Figure 2.2. The months where there is highest rainfall, during winter and early spring corresponds to higher river flow. Salinity is also recorded in addition to flow rates at the Mount Frankland gauging station. Annual salinity from the Mount Frankland gauging station is represented in Figure 2.3. There has been an increasing trend in salinity of the Frankland River over the past few decades. The statistics on the hydrology of the Frankland River are represented in Table 2.1.

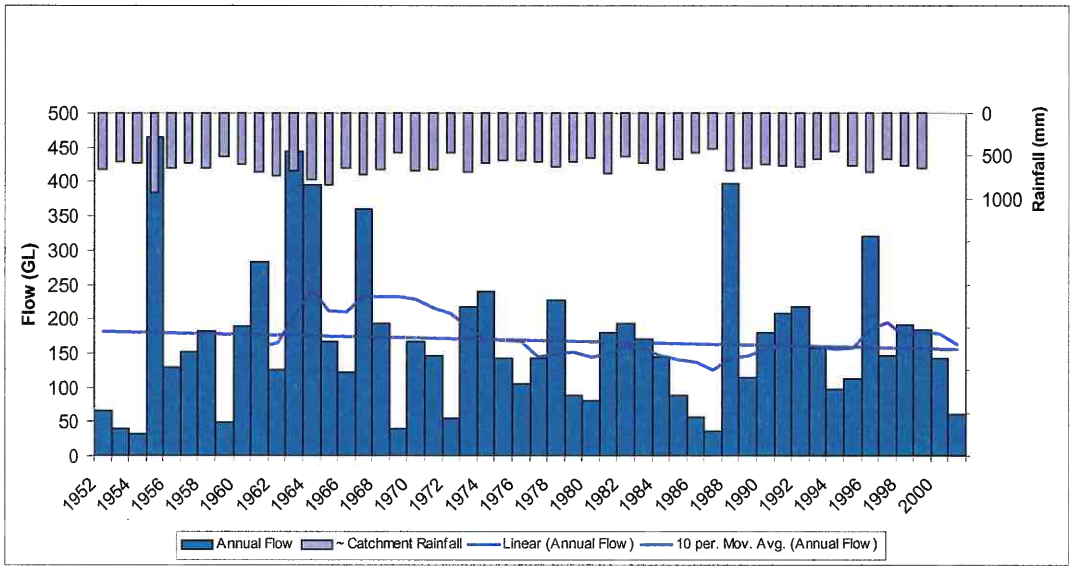


Figure 2.1. Rainfall and streamflow of the Frankland River at the Mount Frankland gauging station

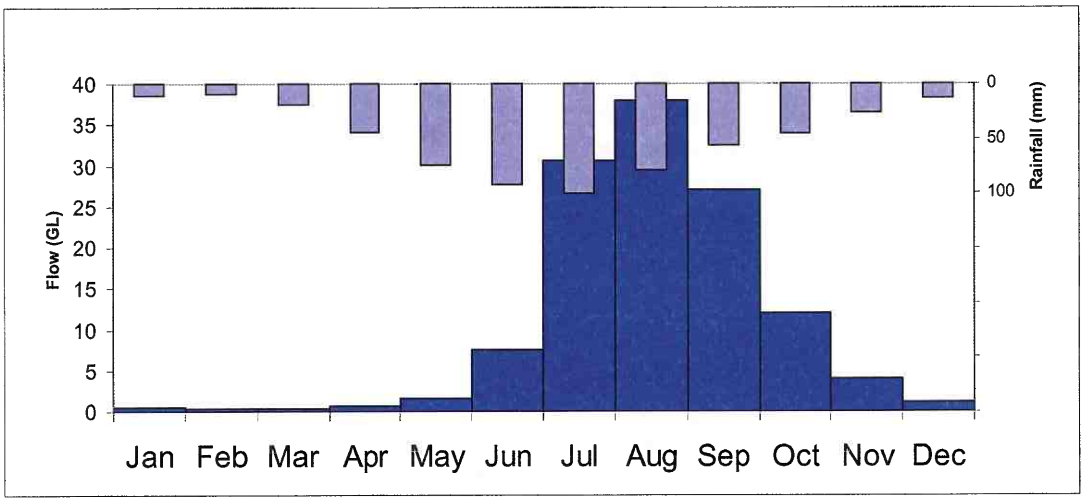


Figure 2.2. Median monthly streamflow of the Frankland River at the Mount Frankland gauging station

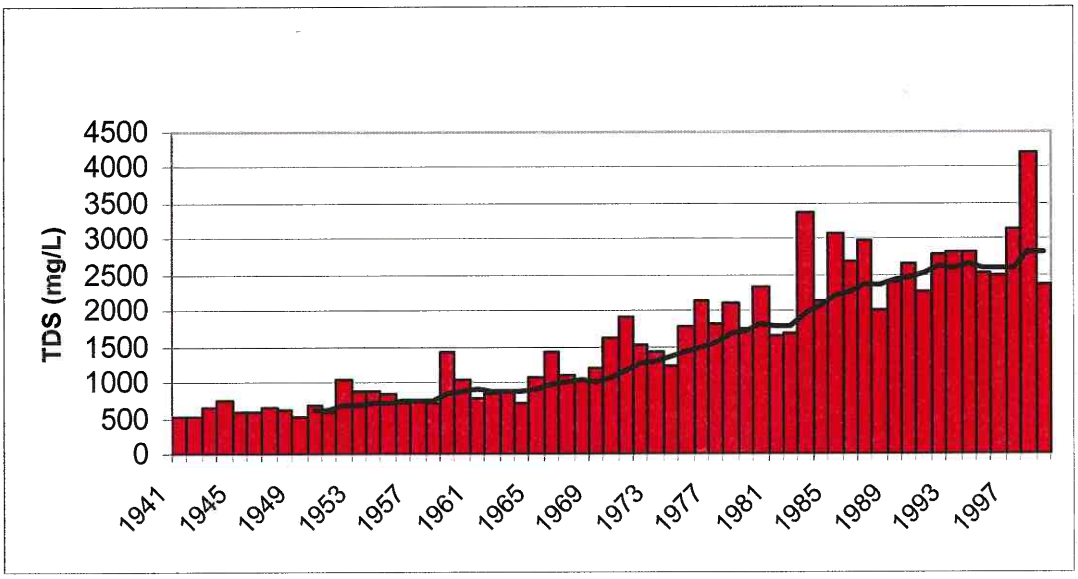


Figure 2.3. Annual salinity of the Frankland River measured at the Mount Frankland gauging station

Table 2.1. Hydrologic statistics of the Frankland River

	Mt Frankland	Trapper Rd	Comment
Mean Annual Flow, gigalitres	168	92	
Median Annual Flow, gigalitres	148	105	
Minimum Annual Flow, gigalitres	31	31	not corresponding years
Maximum Annual Flow, gigalitres	464	167	not corresponding years
Catchment area, square kilometres	5424	3850	above gauging stations (total catchment=4626)
Runoff (mm)	37	25	
Catchment Areal Rainfall (mm)	615	550	
Coefficient of Runoff (mm)	6%	4.50%	Proportion of rainfall converted to streamflow
Annual Salt load, tonnes	540000	480000	ave. last 10yrs Mt Frankland, 1997-2001 Trapper Rd
Mean Salinity, ppm	2800	7200	ave. last 10yrs Mt Frankland, 1997-2001 Trapper Rd
Maean Flow Weighted Salinity, ppm	3100	6000	salt load divided by flow volume

Flood events

Flooding is a likely occurrence in areas receiving high variations of flow and where the greatest proportion of flow occurs over brief periods. The upper catchment consists of broad flood plains and in some places the Gordon River forms a braided channel.* During heavy continuous rainfall events these areas are prone to flooding.

In January 1982 the Gordon-Frankland River flooded, caused by prolonged and intense cyclonic rains which brought flooding to a wide area of the state's South West (Sinclair Knight & Partners, 1983). The water rose 4.5 m in the Frankland River at Nornalup, which was over the handrail of the bridge (Hodgkin & Clark, 1999). This flood was the highest recorded and was well in excess of a 100-year flood (Sinclair Knight & Partners, 1983). The flooding at Tambellup is estimated to have an average recurrence of 300 years, whereby the recurrence interval is considerably higher for rainfall events with duration of 18 to 48 hours (Sinclair Knight & Partners, 1983).

The township of Tambellup is flood prone from the Gordon River and Jam Creek. Locals believe that the flood of 1982 was the largest since European settlement of the area although records are limited (Sinclair Knight & Partners, 1983). Many residences and premises were affected by the flood waters.

The Public Works Department of Western Australia commissioned Sinclair Knight & Partners (WA) Pty Ltd to undertake an investigation titled *Gordon River (Tambellup) Flood Study,* (1983). The study was to use recorded and simulated data to determine the degree of impact floods have on the Town of Tambellup and to propose different measures to avoid impacts such as those experienced after and during the flood of January 1982. Other significant floods have occurred in 1955 and 1964.

More information about this report is available at the Department of Environment's Albany Office.

Figure 2.4 depicts the annual accedence probability for stream discharge for the Frankland-Gordon River, ie the stream discharge for flood events and the probability of them occurring in any given year. This graph is produced using the peak stream discharge value for each year over the years of sampling at the Mount Frankland gauging station. These values are then represented so that the discharge can be calculated for a probable flood event. For example the stream discharge likely to occur for a 1 in 10-year-flood is

* A stream with multiple channels that diverge and reunite around unnumerable sand bars with complex geometry, characteristic of very heavy sediment loads debouching onto a plain (Stranger, 1994).

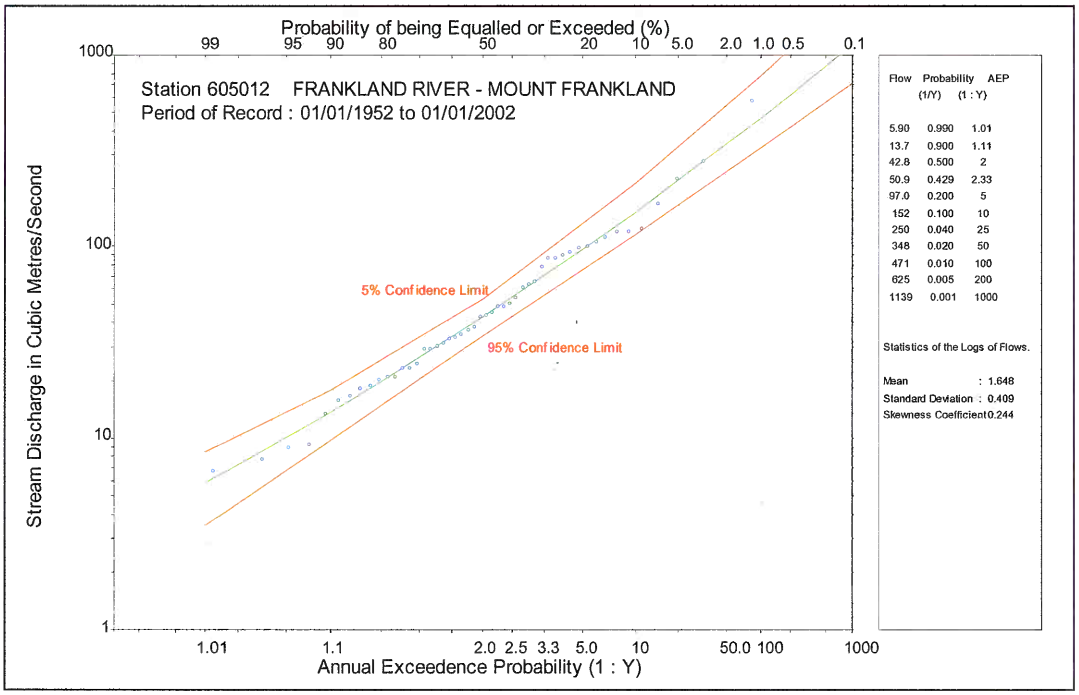


Figure 2.4. Annual exceedence probability for stream discharge for the Frankland-Gordon River calculated from the Mount Frankland gauging station

approximately 200 cubic metres per second and the probability of this discharge, to be equal or exceeded in any given year, is about a 10% chance. The period of record is from 1952 and represents one of the longest periods of record on the South Coast region.

River flood warning stations

The Department of Environment's Mount Frankland gauging station north of Bridge Road has been updated to include telemetry. This is accessed through the flood warning website, which details up-to-date salinity and water level information. For the Mount Frankland site there is the option to view several reports such as discharge rates and stage levels. A graph of river water levels is also available.

2.4 Water quality

A project titled, Water Resources Assessment and Enhancement, South Coast, was conducted in the upper catchment of the Gordon River over two years from October 1998 to September 2000. The project was funded by the Natural Heritage Trust and Water and Rivers Commission to assess the chemical and physical nature of the surface water in the streams of the upper catchment. Community members were trained in the appropriate skills needed to conduct water quality monitoring. An important objective of the project was to ensure the community had a continued means to determine the ongoing condition of their waterways.

Water quality parameters that were monitored include salinity, nutrients, oxygen and pH. Monitoring sites were identified across five subcatchments, Wadjekanup, Slab Hut Gully, Gordon River, Uannup and Towerlup. These subcatchments were chosen because they were adjoining catchments and of a comparable size. A stratified random sampling regime was used so that not all sites were sampled consistently, therefore there is varying degrees of data available from each site. Sampling sites are shown as Figure 2.5. (Note: not all these sites were sampled during the project). Results were summarised and presented to the community, the following Data Appendix contains the information gathered.

Snapshot sampling

A number of snapshot samples have been completed at various sites along the Gordon-Frankland River and its tributaries. Snapshot sampling of rivers tends to be ad hoc and one-off event, not linked to the normal rigorous monitoring programs established in the region. Snapshot sampling events do not generally take into account seasonal changes. The reasons for conducting this type of sampling can be varied, from just obtaining a general 'snapshot' of water quality in the river system at a particular time, to specifically looking for an indicator of river health, such as macroinvertebrates or macrophytes. It is important to remember that snapshot sampling is a useful tool for obtaining the general status of a system but is limited by its lack of rigour and trend analysis. Details of the snapshot sampling and the type of data that were collected are represented in the following Table 2.2.

Table 2.2 Snapshot sampling conducted in the Gordon-Frankland catchment

Date	Collectors	Data obtained
January 1999	Kaylene Parker (WRC) and Kathryn McMahon	The aim was to sample the macrophytes and other aquatic flora present in the upper catchment.Dissolved oxygen, nutrient, salinity, temperature, macroinvertebrates, macrophytes, phytoplankton, epiphytic algae and benthic algae data was obtained.
June 8 1999	Kaylene Parker (WRC), Ivan Evans (Walpole farmer) and Sharon Williams (Landcare trainee)	The aim of this sampling was to compare results of Total Nitrogen (TN) and Total Phosphorous (TP) obtained from the DoE and a Photometer 5000 used by Ivan Evans. Dissolved oxygen, temperature, salinity, pH, TN and TP data was obtained.
April 29 2002	Kaylene Parker and Catherine MacCallum (DoE)	The aim of this sampling was to obtain water quality data along the entire main channel from the Gordon-Frankland from the lower reaches up to the Upper reaches. Data was obtained from the South Coast Hwy crossing to Muirs Hwy. Temperature, salinity, pH, turbidity, TN, TP and macroinvertebrates data was obtained.
June 11 2002	Steve Janicke and Catherine MacCallum (DoE)	A continuation of 29 April sampling, continuing form Muirs Hwy upstream to Poonawirrup Pool, north of Tambellup. Dissolved oxygen, temperature, salinity, pH, turbidity, TN, TP and macroinvertebrates data was obtained.

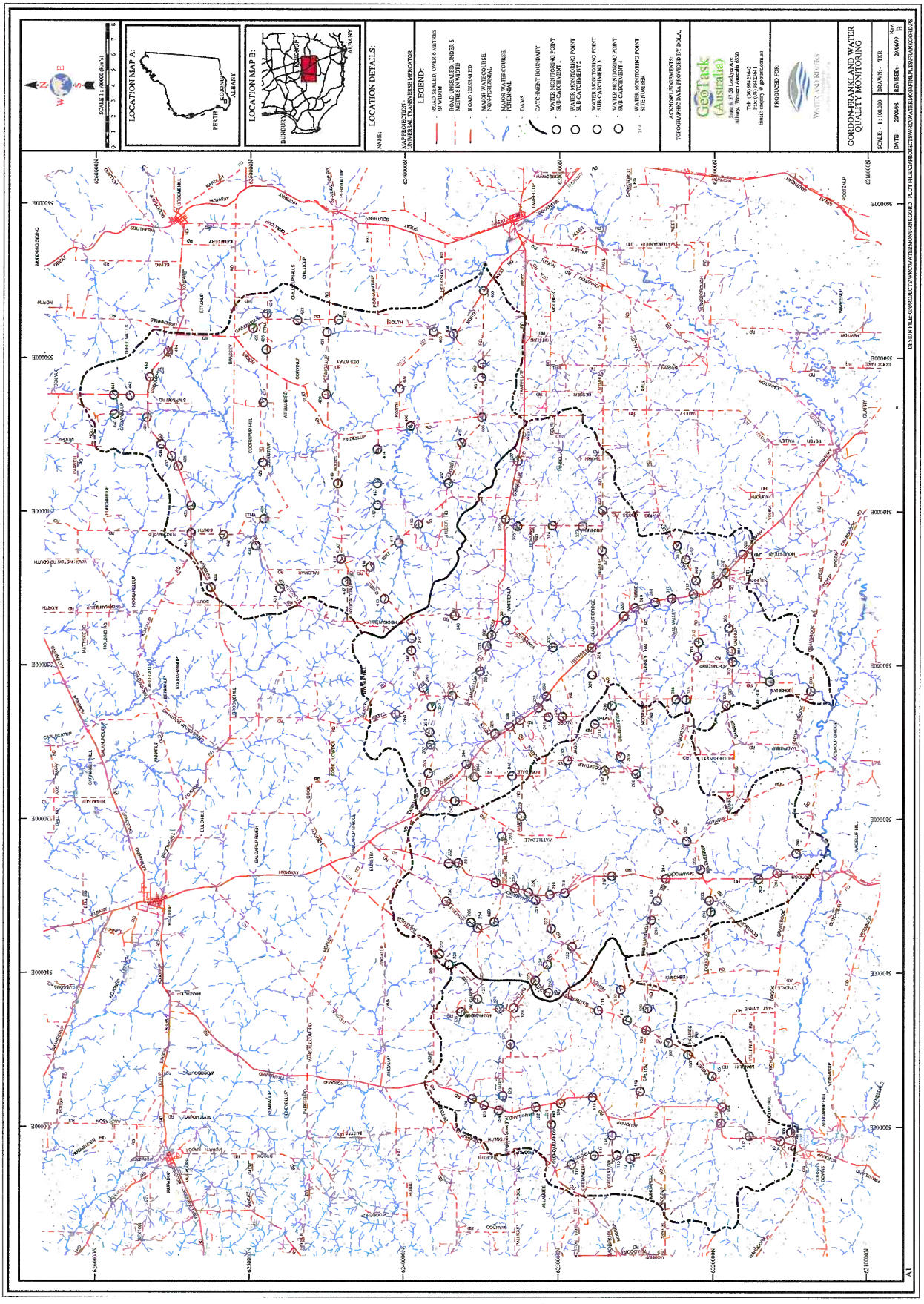
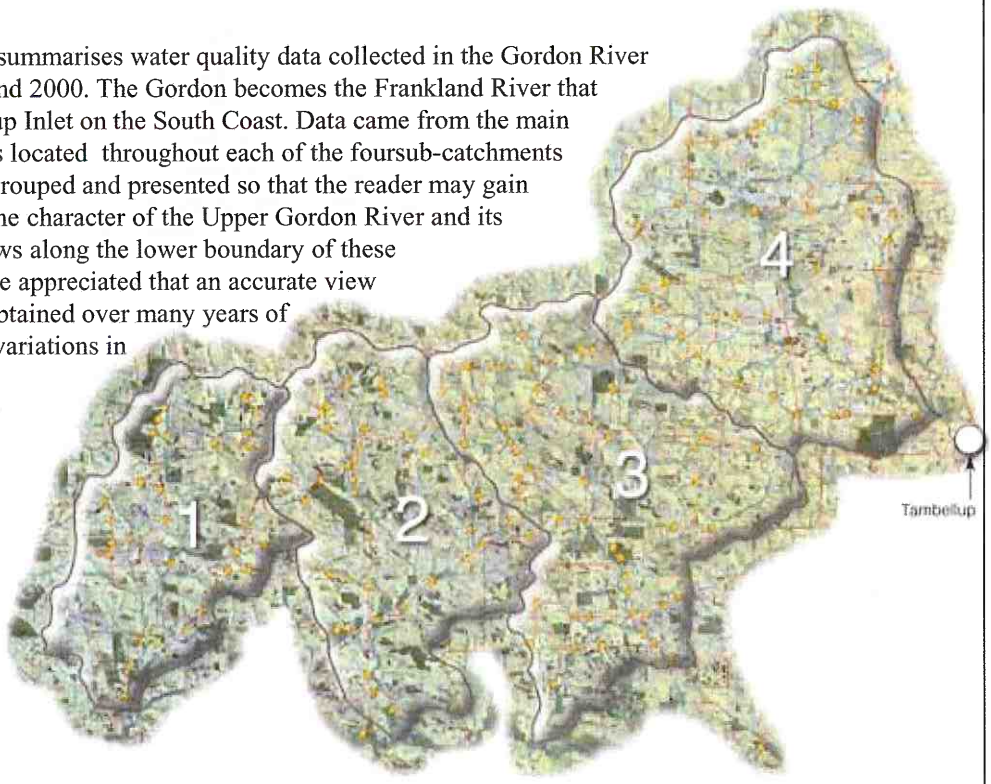


Figure 2.5. Sampling sites used in the water quality monitoring program conducted in the upper Gordon catchment as a part of the Water Resources Assessment and Enhancement Project

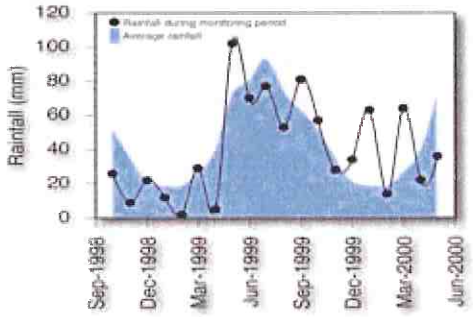
Data Appendix - Water quality in the Gordon River catchment

The following information summarises water quality data collected in the Gordon River Catchment between 1998 and 2000. The Gordon becomes the Frankland River that eventually flows in Nornalup Inlet on the South Coast. Data came from the main river channel and from sites located throughout each of the foursub-catchments shown. The data has been grouped and presented so that the reader may gain an overall appreciation of the character of the Upper Gordon River and its tributaries. The Gordon flows along the lower boundary of these sub-catchments. It should be appreciated that an accurate view of conditions can only be obtained over many years of monitoring, to account for variations in climate from year to year.

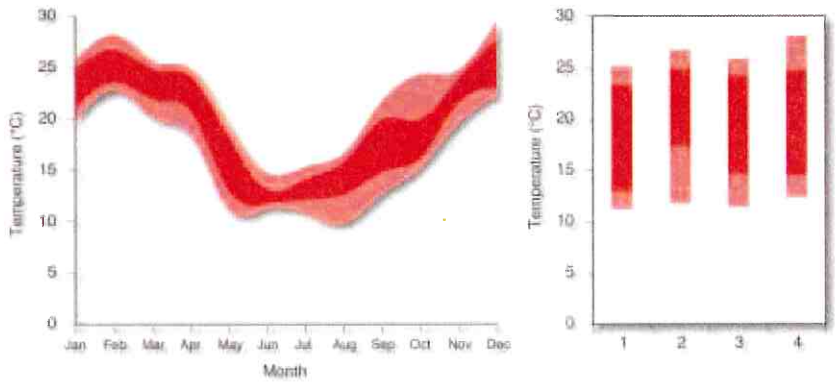


The graphs, with the shaded bands, show the range of values for the data. The darker inner band spans the middle 50% of values collected. The lighter outer band covers the middle 80% of values. Extreme high and low values are left out. The graphs therefore show what conditions were like for most of the time.

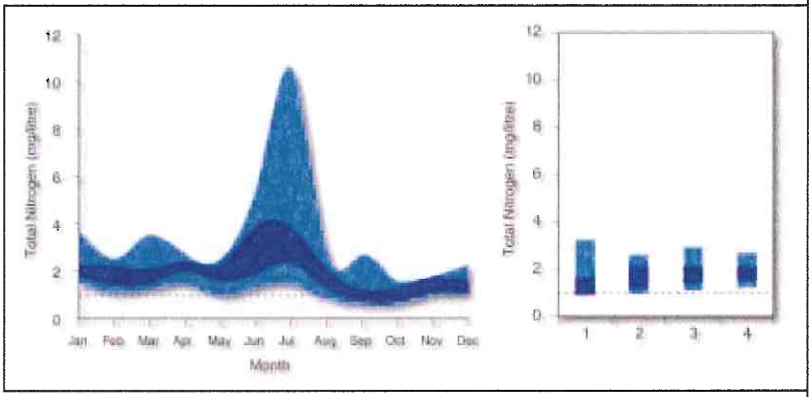
Average monthly rainfall for the monitoring period is shown in the graph opposite. Rainfall has a dominant influence on the quality of water in our streams.



Water temperature (graph below), shows the strong seasonal variation. Some high temperatures were recorded at some sites during the summer. The range was about 10 to 30° C. In 'warm' rivers such as the Gordon-Frankland, shading by the fringing vegetation is an important environmental factor for waterways health. The range is very similar to other South Coast Rivers as might be expected though there are suggestions that the higher temperatures are marginally cooler.

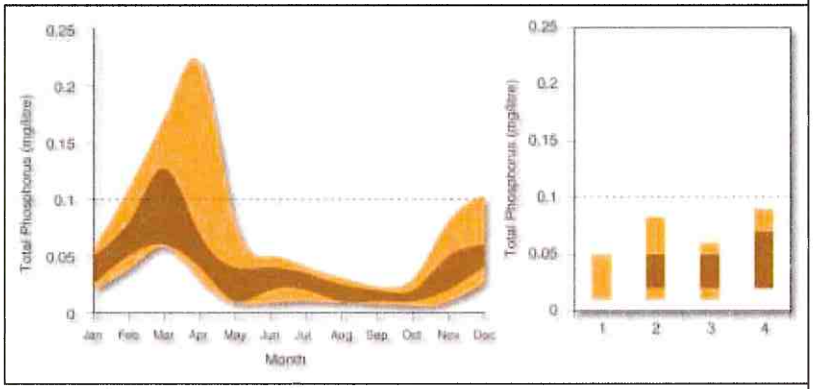


Nutrients



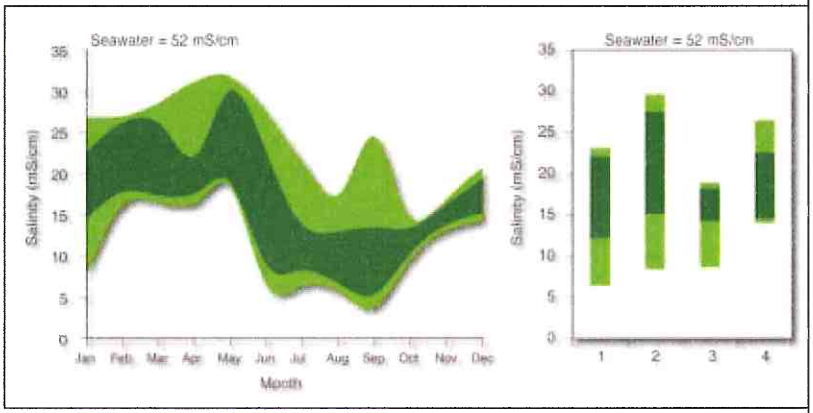
The The next two graphs show the average monthly levels of the nutrients nitrogen (TN) and phosphorus (TP). These were obtained by laboratory analysis of water samples. The samples were taken in flow and no-flow conditions. The higher summer values occur in stagnant pools in summer, and show how other local conditions vary considerably compared with the winter and spring months. Prior to land clearing, nitrogen and phosphorus levels in South Coast streams are thought to have been quite low. The values for the Gordon catchment are similar to those for other South Coast rivers. A winter TN peak however is particularly distinct compared with other rivers monitored in the eastern parts of the South Coast. Based on earlier suggested upper limits for healthy streams (TN of 1 mg/L), levels in many South Coast rivers are of concern and this concern is probably justified. For Total Phosphorus the limit was about 0.1 mg/L. The graph shows that Phosphorus levels are by and large below this limit except for late summer when internal processes in river pools are expected to dominate the water quality and there is little or no flow in the river.

Salinity



Some rivers on the South Coast showed an increase in salinities as winter proceeded. The Gordon shows high summer values consistent with conditions in pools where evaporation is concentrating the salt, but over winter salinities decreased strongly in response to increasing rainfall. The system may once have experienced regular quite fresh discharges. Salinity levels were on average noticeably lower than rivers to the east, such as the Pallinup, Gairdner and Oldfield, at least at comparable times of the year.

Oxygen & pH



Dissolved oxygen were quite adequate with less than 2% of readings at levels of concern to aquatic life. 84% were in the range 5 - 12.5 mg/L. The remainder were quite high suggesting active oxygen production which is in keeping with aquatic plant and algae growth. High nutrient levels will of course stimulate such growth.

On the other hand when some populations of microscopic organisms rapidly increase (bloom) they can quickly reduce DO levels in the water. Low DO due to these processes accounts for many of the fish deaths that have occurred in South Coast inlets, wetlands and river pools.

pH values for all the monitored rivers were consistently alkaline, between 7 and 9. About 90% of the measurements from the Gordon catchment were in this range and 4% slightly acidic to neutral. These make for interesting comparisons with other catchments, however since many factors can affect pH it is difficult to determine what this might imply about how the catchment is changing.

Results

Results from the macrophyte snapshot conducted in January 1999 revealed there are two main species of macrophytes present. These were the angiosperm, *Ruppia magacarpa* and the Charophyte, *Chorea*.

From the snapshot conducted on 8 June 1999 the nutrient levels were relatively high and the monitoring detected nutrient hotspots. There was evidence to suggest that the tributaries of the lower catchment are becoming degraded, with high nutrient concentrations.

The snapshot sampling conducted on 29 May and 11 June 2002 was undertaken to provide an estimate of the water quality along the main channel of the Gordon-Frankland. Turbidity is a measure of water clarity, the units used are NTU, a low reading relates to clear water and a high reading relates to murky water. Turbidity was very low in the lower reaches and was measured less than10 NTU at all sites up to and including Yeriminup. Turbidity increased to less than 15 NTU at Campup Pool to less than 20 NTU at Albany Highway and Pooniwirrup Pool. This may be due to the increase in suspended sediment in the water from runoff in the upper catchment.

The salinity results are shown in Figure 2.6, as expected the salinity increases progressively up the river into the upper reaches. There is a dramatic increase between the Albany Highway and Pooniwirrup Pool sampling points. The salinity of seawater is 53 mS/cm, and the salinity at Pooniwirrup Pool is close to this. In summer it is most likely that the salinity would be greater than that of seawater. Sampling at closer intervals in the upper catchment would allow for a better understanding of the system.

The pH results are represented in Figure 2.7. The majority of pH values at the sampling sites are around neutral. The pH in the upper catchment is alkaline, which can suggest polluted conditions. However, the soil type and the amount of tannin* in the water can influence pH. The presence of limestone often results in higher pH values (more alkaline) and because there is no limestone in the upper catchment of the Gordon-Frankland, it is unlikely to be influencing the pH.

Nutrient results from the snapshot are represented in Figure 2.8. The total nitrogen (TN) levels are all above the one mg/L concentration, set by the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines in 1992. This suggests that the high nutrient levels may represent a risk to the system and cause eutrophic conditions (represented visually by excessive algal growth). Total phosphorous (TP) has a guideline maximum limit of 0.1 mg/L and as the majority of samples are below this, it does not appear to represent a risk at this time. However, because the Albany Highway sampling site was recorded as being above the TP maximum guideline level and some sites were close to the maximum recommended safe level, the river will need to be further monitored. To gain a better understanding of the nutrient levels and related processes within the system, a more rigorous and continued monitoring program is needed.

Steve Janicke Department of Environment, shows community member Jo Langford how to sample the Gordon River (photo by Kaylene Parker)

Kaylene Parker sampling the Frankland River at a crossing near Elsie Brook (photo by Catherine MacCallum)

* *Tannin is caused by organic matter staining the water, giving it a tea colour.*

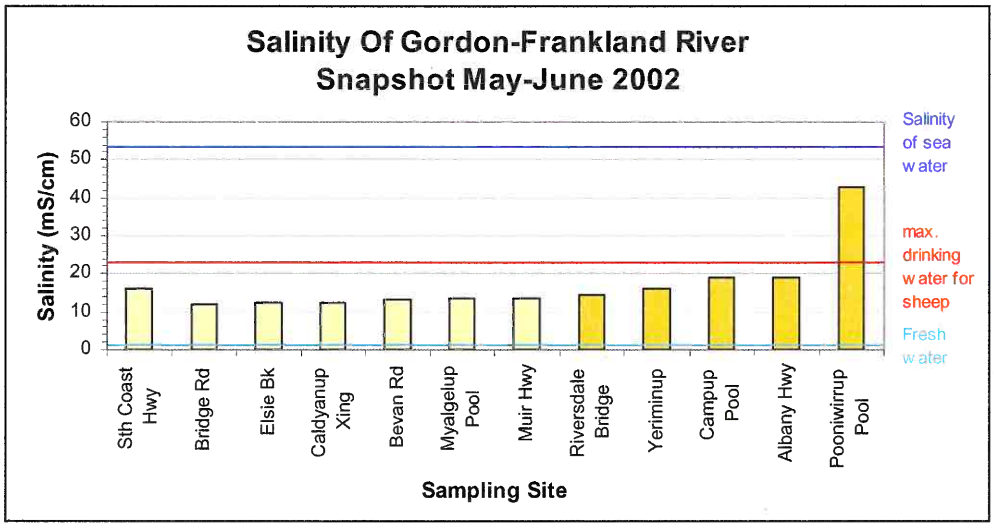


Figure 2.6. Salinity values for the Gordon-Frankland River from the snapshot sampling conducted in May and June 2002. Sampling sites range from the lower catchment on the left, up to the furthest site north in the upper catchment. The lighter values are those sites sampled on 29 May, and the darker values are those sampled on 11 June. The lines indicate the approximate salinity values for fresh water, maximum value for sheep consumption and seawater

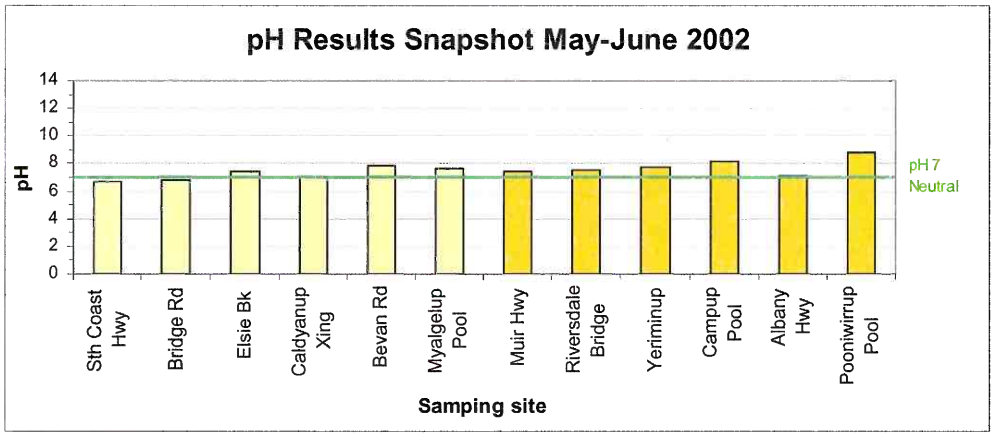


Figure 2.7. pH results for the Gordon-Frankland River from the snapshot sampling conducted in May and June 2002. Sampling sites range from the lower catchment on the left, up to the furthest site north in the upper catchment. The thick line represents a neutral pH, below that line are acidic (<pH7) conditions and above are alkaline (>pH7) conditions

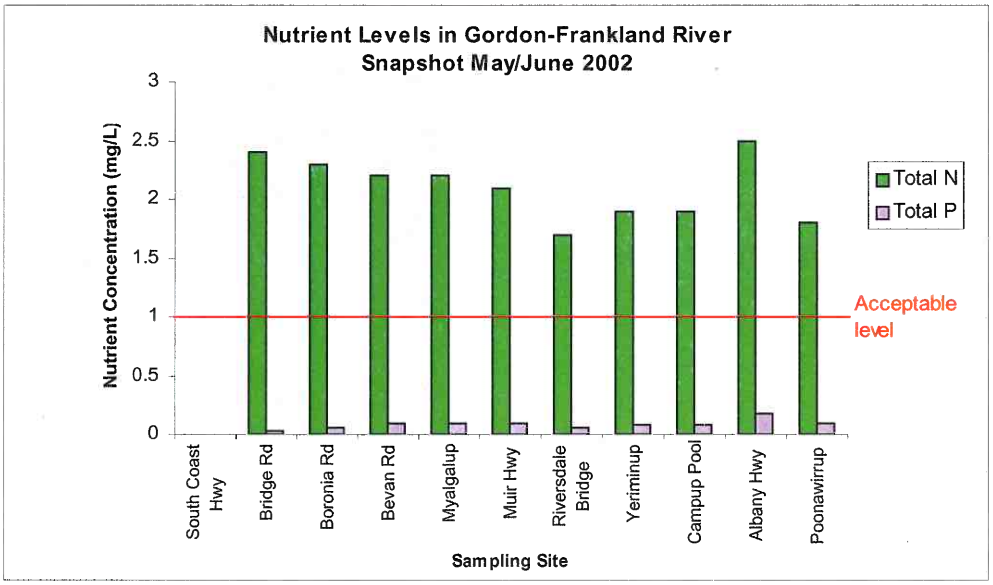


Figure 2.8. Nutrient results for the Gordon-Frankland River from snapshot sampling conducted in May and June 2002. Sampling sites range from the lower catchment on the left, up to the furthest site north in the upper catchment. Please note that there was no nutrient sample taken at the South Coast Hwy site

2.5 Aquatic fauna

Macroinvertebrates

There has not been any comprehensive sampling of aquatic fauna in the Gordon-Frankland River. Macroinvertebrates have been sampled as a part of the snapshot sampling conducted at several sights along the river. Benthic fauna was sampled by Shaw in 1987 (cited in Hodgkin & Clark, 1999) at a site in the lower reaches near the opening to Nornalup Inlet. The following table (Table 2.3) provides the results of the macroinvertebrate sampling that has occurred in the Gordon-Frankland River.

Previous research

Table 2.3. Benthic Invertebrate Fauna. Frankland River, April 1987

POLYCHAETA		
Phyllodocidae	*Phyllodoce* sp.	+
Nereididae	*Ceratonereis aequisetes*	+++
Orbiniidae	*Scolopolos simplex*	++
Paraonidae	*Polydora* sp.	+
Capitellidae	*Capitella capitata*	++
CRUSTACEA		
Cirripedia	*Balanus variegatus*	+
Amphipoda	*Corophium minor*	+
Decapoda	*Halicacinus ovatus*	+
	Palaemonetes australis	+
MOLLUSCA		
Gastopoda	*Diala* sp.	+
	Philine sp.	+
Bivalvia	*Xenostrobus securis*	+
	Musculus pauluccciae	++
	Arthritica semen	+++
	Spisula trigonella	++
	Irus crenata	+
	Theora lubrica	+
	Macamona deltoidalis	+
Depth (m)	1– 1.5	
Bottom type	Sand	

Source: J. Shaw, in Hodgkin & Clark, 1999

Note: + present; ++ abundant; +++ very abundant.

Snapshot results

The macroinvertebrate snapshot completed on 29 April and 11 June 2002 were not a comprehensive sampling event. Sampling time was approximately two minutes and sorting time was five to ten minutes – neither was completed quantitatively. Presence or absence was noted and when large numbers were present the most abundant species was noted. The object of these two snapshots was to gain a general idea of what macroinvertebrates were present. Also the time of the year the sampling was completed did not correspond with the lifecycle of the majority of macroinvertebrate species. Summer and spring are the most biologically productive seasons and sampling during this time will yield a wider species diversity than in winter (Davis and Christidis, 1997). Results are presented in Table 2.4.

Frogs

There has been no frog surveys conducted recently in the Gordon-Frankland River, however information from the Western Australian Museum suggests there are 13 species of frogs that should occur in the area. These species are:

Scientific name	Common name
Helioporus inornatus	whooping frog
Crinia georgiana	quacking frog
Pseudophryne guentheri	crawling frog
Heleiporu psammophilus	sand frog
Crinia pseudinsignifera	bleating Crinia
Litoria moorei	motorbike frog
Crinia glauerti	clicking Crinia
Metacrinia nichollsi	Nicholls' toadlet
Heleioporus eyrei	moaning frog
Limnodynastes dorsalis	Banjo frog
Crinia subinsignifera	South Coast Crinia
Geocrinia leai	Lea's frog
Litoria adelaidensis	slender tree frog

Fact sheets for the frogs listed above give details of their identification, distribution, habitat and biology and are available from the Western Australian Museum.

The Department of Conservation and Land Management notes the Walpole-Nornalup National Park as one of the richest areas for frogs in Western Australia. All 12 species that are found in the park are endemic to the South West. Swamps and drainage lines support the greatest number of species.

Frogs are an important part of the ecosystem and can be used as indicators of environmental health and the success of Landcare and Rivercare activities. The Western Australian Museum and Alcoa are partners in the Western Australian Museum's Alcoa *Frog Watch Program*, which is a community-based frog conservation program. To become involved in frog conservation and to receive a wealth of information on frogs, visit the Western Australian Museum website.

Table 2.4. Macroinvertebrate Results from Snapshots along the Main Channel of Gordon-Frankland River

		Site	Bridge Road	Caldyanup	Bevan Road	Myalgelup	Muir Hwy	Riversdale Bridge	Yeriminup	FRA 001 Campup Pool	FRA 002 Albany Hwy	Poonawirrup
		Date	29/05/02	29/05/02	29/05/02	29/05/02	29/05/02	11/06/02	11/06/02	11/06/02	11/06/02	11/06/02
Type	Common Name											
Arthropoda: Insecta												
Trichoptera	Caddisfly Larvae		✔									
Odonata	Damselfly larvae								✔		✔	
Corixidae	Water boatman			✔	✔	✔	✔	✔	✔	✔		
Dytiscidae	Diving beetles							✔	✔	✔	✔	
Culicidae	Mosquito larvae & pupae									✔	✔	✔
Chironomidae	Non-biting midge larvae		✔	✔	✔				✔	✔	++	✔
Collembola	Springtails			✔		✔		✔	✔			
Arthropoda: Crustacea												
Decapoda	Freshwater shrimp		✔	✔	✔		✔	✔	✔			
Amphipoda	Scuds		✔	✔	✔	✔	✔	✔	✔	+++	+++	+++
Ostracoda	Seed shrimps		✔		✔					✔		+++
Copepoda	Copepods									✔	+++	+++
Arthropoda: Class Arachnida												
Acarina	Water mite		✔			✔		✔		✔		
Mollusca												
Bivalva	Freshwater mussel		✔		✔					✔		

Note: ✔denotes presence; when a large number of individuals were captured (>100), abundance was estimated ie. ++ abundant, +++ very abundant

Fish

A survey of the distribution, identification and biology of fishes in South West Australia was completed by Morgan *et al* (1998) to update the Western Australian Museum records. These have been published in the Records of the Western Australian Museum Supplement No. 56. There were 20 sites sampled along or near the Gordon-Frankland River. This resource gives map references, distribution, abundance, habitat, reproduction, threats and conservation status and recommendations. The following is a summary of this information (Table 2.5 and 2.6).

2.6 Aquatic flora

There has been no continuous sampling program to monitor the flora in the Gordon-Frankland River. A snapshot sampling event conducted by Kathryn McMahon and Kaylene Parker in January 1999 focused on the aquatic fauna present at this time. Aquatic fauna includes macrophytes (submerged, floating or emergent plants in the water, usually attached to the bottom), algae, phytoplankton (microscopic algae living in the water column), epiphytic algae (algae attached to other organisms) and benthic algae (algae found on or in the sediment). Below is an excerpt from Kathryn McMahon and Kaylene Parker regarding the presence of aquatic fauna as indicators of nutrient enrichment.

Aquatic flora

Macrophytes and algae can be an indication of the health of a system. The type and density of species is influenced by several factors such as temperature, light, salinity, water flow and nutrient concentration. For this reason there is often a variation between seasons.

There are a number of symptoms that indicate excessive nutrients in a river or drainage system. These are dense blooms of filamentous algae such as *Cladophora* and *Stigeoclonium*, dense blooms of diatoms such as *Melosira* or Chlorophytes such as *Scenedemus* and dense blooms of blue-green algae such as *Nodularia*, *Anabaena*, *Microcystis* and occaionally *Oscillatoria* (Entwisle *et al*, 1997; Vas Hosja pers.comm.). Low species diversity is also an indication of excessive nutrients.

Kathryn McMahon and Kaylene Parker

Table 2.5. Locations of fish species in Gordon-Frankland River sampled by Morgan *et al* (1998)

		Species	*Lepidogalaxias salamandroides*	*Galaxias occidentalis*	*Galaxias nigrostriata*	*Galaxiella munda*	*Bostockia porosa*	*Edelia vittata*	*Lepatherina wallacei*	*Pseudogobius olorum*	*Gambusia holbrooki*
Site	**Latitude (S)**	**Longitude (E)**									
Frankland River-Muir Bridge	34°28.73'	116 54.00'		✔		✔	✔	✔			
Pool on Thomson Rd	34 45.70'	116 43.17'			✔						
Pool on Thomson Rd	34 46.89'	116 43.17'									
Pool on Thomson Rd	34 47.03'	116 43.20'									
Pool on Thomson Rd	34 47.22'	116 43.12'			✔		✔				
Pool on Thomson Rd	34 47.32'	116 42.84'			✔						
Pool on Thomson Rd	34 47.49'	116 42.97'	✔		✔						
Pool on Thomson Rd	34 47.65'	116 43.20'			✔		✔				
Pool on Thomson Rd	34 47.32'	116 42.84'					✔				
Wedding Bk Brook	34 50.78'	116 44.25'									
Elsie Brook	34 51.46'	116 43.43'		✔							

Table 2.5. Locations of fish species in Gordon-Frankland River sampled by Morgan *et al* (1998) (continued)

		Species	*Lepidogalaxias salamandroides*	*Galaxias occidentalis*	*Galaxias nigrostriata*	*Galaxiella munda*	*Bostockia porosa*	*Edelia vittata*	*Lepatherina wallacei*	*Pseudogobius olorum*	*Gambusia holbrooki*
Site	**Latitude (S)**	**Longitude (E)**									
Frankland River-Elsie Brook Rd	34 52.33'	116 44.14'									✔
Frankland River-Caldyanup Crossing	34 48.62'	116 48.57'		✔				✔	✔		
Frankland River-Mitchell Rd	34 45.80'	116 50.24'						✔			✔
Frankland River-Sappings Bridge	34 57.55'	116 49.40'							✔		
Boxhall Creek-Boxall Rd	34 58.55'	116 50.15'				✔					
Boxall Creek-East Flat Rd	34 58.53'	116 51.39'									
Frankland River-Monastery Rd	34 59.06'	116 48.93'							✔	✔	✔
Swamp-Blue Holes Rd	35 00.53'	116 49.72'									
Pool-Station Rd	34 59.96'	116 53.16'									

Note: ✔ located at that site

Table 2.6. Fish biology (modified from Morgan *et al* (1998)

Species Name	Common Name	Distribution	Abundance	Habitat	Ecology	Reproduction (breeding season)	Threats	Conservation Status and Actions	Conservation Recommendations
Lepidogalaxias salamandroides	Western Australian/Australian salamanderfish, salamanderfish, Shannon mud minnow, mud minnow			L Specially adapted eyes & neck for burrowing		(July-September)			
Galaxias occidentalis	Western minnow, Western galaxias					(June-September)		Not listed	
Galaxias nigrostriata	Black stripped minnow			A	L.C = 1 year	(June-September)			
Galaxiella munda	Western mud minnow			L A	L.C = 1 year	(July-October)			
Bostockia porosa	Night fish				A A's active at night, J's active in day	M F (late August-early September)		Not listed	
Edelia vittata	Western pygmy perch, pygmy perch					(July-November)		Not listed	
Lepatherina wallacei	Swan River hardy head, western hardyhead					(Protracted spawning period peaks late spring)		Not listed	No specific recommendations made
Pseudogobius olorum	Swan river goby, blue spot goby				L.C <1 year			Not listed	No specific recommendations made
Gambusia holbrooki	*Gambusia*, mosquito fish							NA	If captured do not return to water body

Key

Restricted		Highly abundant forming schools (rivers, streams, estuaries, lakes & coastal lakes)		Associated with riparian vegetation in stream/rivers & open water in pools	
Common & widespread		Abundant (pools, streams, rivers & lakes)		Large schools in open water	
Particular distribution		Rare, found in peat flats & ephemeral pools		Never caught in major channels rivers or lakes	
Introduced		Rare, found in pools & streams, sometimes headwaters & tributaries		Dark acidic conditions relying on moisture	
Fertilisation internal		Benthic species, consumes benthic species i.e. dipteran larvae, trichopterans, cladocerans & ostracods		Dark & acidic pools/streams exhibiting marked temperature fluctuations	
Reach sexual maturity at the end of first year of life		Consumes terrestrial fauna i.e. dipteran larvae & pupae, cladocerans & copepods		Under ledges, rocks, logs, inundated vegetation	
Reach sexual maturity at the end of 2 years of life		Consumes ostracods & dipteran larvae		Riparian vegetation & other forms of cover i.e. snags, algae, submerged macrophytes	
Move to creeks to spawn		Night feeding freshwater shrimp *Palamonetes australis*		Habitat alteration & exotic species introduction	
Multiple spawner		Calanoid copepods & some terrestrial fauna		Unlikely this species will become threatened due to high abundance	
Adults	A	Consumes different seasonal fauna i.e. summer & spring dipteran larvae & pupae, autumn cladocerans & copepods		Habitat alteration & exotic species introduction can pose a threat to some populations	
Larvae	L				
Life Cycle	L.C.	Consumes odonatan larvae, decapods, gastropods		Ensure suitable buffer zones	
Males	M	Consumes different seasonal fauna i.e. in winter collembolans, summer & autumn dipteran larvae & pupae, autumn diatoms		Classified as restricted in the Australian Society for Fish Biologist's list of Australian threatened fishes	
Females	F				
Not Applicable	NA	Consumes a variety of taxa		Preserve habitat	
		Maintain natural flow regimes to aid migration & spawning		Considered a pest and poses a threat to endemic species	

Note: habitat alterations are likely to occur with any changes to inflow and increases in salinisation, siltation and eutrophication caused by water point construction, road maintenance, mineral sand exploration and mining, groundwater extraction and agricultural and forestry practices in the uppermost catchment.

3 State of the waterways and key issues

The Gordon-Frankland River is in pristine condition in the lower catchment, flowing through the picturesque tall timber forests that rise across undulating hillsides. The national parks are well known for the karri and tingle trees and are a popular tourist attraction, especially the Valley of the Giants Tree Top Walk. The area attracts many visitors from Western Australia, as well as people from across Australia and around the world.

The scenic Walpole-Nornalup Inlet where the Frankland River discharges, is the only estuary on the South Coast permanently open to the ocean. The Inlet provides habitat for many fish species (estuarine and marine), bird life and macroinvertebrates. It is a popular spot for recreational activities such as fishing and boating.

The upper river reaches are severely degraded from the loss of fringing vegetation, bank erosion and sedimentation of pools. This is primarily caused from the clearing of native vegetation to make way for agriculture. The finer sediment, washed down from the agricultural areas, is transported the entire length of the channel and either settles in the Nornalup Inlet or is flushed out to sea (Hodgkin & Clark, 1999). The course sediment is most likely being trapped in river pools in the upper catchment and may be accumulating in the pools in the lower catchment. River pools are essential ecosystems and are thought to be the productive hub of the river, full of activity.

The Gordon-Frankland River and its tributaries are brackish to saline, caused by the hinterland salt lakes, saline groundwater and increased land clearing in the catchment. The land in the upper catchment has always had a high salt content caused by geological weathering and poor drainage, resulting in the accumulation of rain-borne salt in the deep soil profiles (SCRIPT, 1996). Waterlogging is also a problem in the upper catchment, where drainage is slow within the broad flat terrain. Waterlogging intensifies the impact of salinity on biological communities. The clearing of land has exacerbated the problem of both waterlogging and salinity.

In the summer months some of the river pools in the upper catchment can become very saline close to or exceeding the level of seawater. These hypasaline conditions result from the evaporation of water in the pools leaving a highly concentrated salt solution. Samples from the bottom of river pools often show higher salinity readings in comparison to surface readings. Despite the inflow of fresh water from the forested areas in the lower catchment, the water entering the Walpole-Nornalup Inlet is still brackish.

High nutrient concentrations are experienced in the upper reaches of the Gordon-Frankland River. These are characterised by high nitrogen levels, well above the suggested limits of healthy streams. The source of the nitrogen is thought to be surface runoff from agricultural areas. In summer high nutrient loads in streams and creeks can cause algal blooms, including some species of the blue-green algae *Nodularia* and *Microcystis*. These species are toxic and are a concern for recreational contact and watering of stock. Nutrient loads discharging into the Nornalup Inlet are low, due to the dilution as the river passes through the forested area. There is some clearing in the lower catchment near the coast but this appears to have had little effect on the main river channel in respect to nutrient levels.

The lower catchment faces different degradation issues to that of the upper catchment. In the lower catchment, eutrophication occurs from animal waste, particularly cattle and excessive fertilising of agricultural land. Although the main channel is in pristine condition, its tributaries are in poor condition. The banks of many are unfenced and used by landholders as summer pasture for their stock. These banks do not have native vegetation and are often over grown with Kikuyu grass, which chokes the river. Lack of vegetative cover and stock use, leads to channel slumping resulting in eroding banks and excessive sediment loads. The challenge in the lower catchment is to encourage landholders to fence and revegetate the degraded tributaries.

For the main channel in the lower catchment to remain in pristine condition, it is imperative that the issues and

pressures in the upper catchment and tributaries of the lower catchment are addressed. Because the catchment covers such a large area it is difficult to coordinate appropriate management strategies to address the issues and pressures.

There has been a concerted effort by many landholders to revegetate and fence areas of the river in an endeavour to reverse or prevent further degradation. As the Gordon-Frankland River is so large there is a lot of area to cover and more landholders need to be aware of the pressures on the river system. If this is done successfully the Gordon-Frankland River can remain in its pristine condition in the lower reaches, and the upper reaches can be improved and the decline in habitat reversed. This would ensure habitat for the wildlife that depend on the river and improve the river's aesthetic value. It will also help to control the problems of salinity and waterlogging that are affecting the land and preventing it from being used efficiently. The river must be safeguarded, as it is pivotal to the history of both Europeans and Indigenous Australians. This will also provide all landholders with a sustainable future.

Table 3.1 lists the current state, threats and pressures on the Gordon-Frankland River system, the recommended management responses that are needed to rehabilitate the river or prevent/control further degradation are also listed for each corresponding issue. There are many management techniques used to address the degradation of waterways including protecting foreshore vegetation, revegetation, channel stabilisation and the on-farm management of water. Management may also include erecting appropriate signs, building walk trails or increasing awareness of the river's value. Some management activities may require the approval of relevant management agencies. There are laws governing the management of river drainage, flood management, and the protection of wildlife and heritage, including indigenous heritage. For clarification of legal matters contact the Department of Environment in Albany.

Waterlogging near Cranbrook, the broad flat floodplain areas of the upper catchment create management issues in farming areas (photo Catherine MacCallum)

Fencing waterways is critical for their protection, enhancing vegetation regrowth, enabling the stabilisation of banks from erosion and sedimentation, and exclusion of stock (photo Catherine MacCallum)

In the upper catchment deep drains are used for removing saline water from the catchment and regaining farming land, where the Gordon River has been deepened and channelled in an attempt to enhance the flow of water. This often destabilises banks and results in sediment being transported down the river, which leads to the filling of river pools (photo Kaylene Parker)

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River

	Category	Waterway issue	Pressure/cause	Current State	Management response
Waterway condition	Ecological	Nutrient enrichment	Nutrients and organic matter draining from the catchment. Sewage and organic wastes, fertilisers use, intensive agriculture.	• Nutrient levels are high in the upper catchment and tributaries in the lower catchment. • Nutrients are low along the main channel in the forested lower catchment. • Nutrient levels are high in the Walpole Inlet, but low in the Nornalup Inlet.	• Monitor water quality to identify hotspots and determine long-term trends in nutrient levels. • Fencing and revegetation of the tributaries in the lower catchment. The use of sedge and rush species to act as nutrient strippers, thus decreasing the nutrient load entering the main channel. • Work with the Department of Agriculture to develop appropriate fertiliser regimes for soil types in the catchment.
		Foreshore vegetation	Livestock grazing, salinisation, waterlogging, weed invasion and inappropriate fire regimes.	• Foreshore vegetation condition (% area): Upper catchment – A grade 41%, B grade 37%, C grade 22%, D grade 0% (outlined in section six). • Lower catchment: generally A grade, some B grade. • The upper catchment is becoming severely degraded from clearing, grazing, weed infestation, flood damage and erosion. There are dieback infected areas within the National Park.	• Fence and revegetate those areas identified in the foreshore surveys (section six). • Obtain funding to help land managers implement on-ground works to protect waterways in the catchment. • Update the foreshore survey and enlarge the area it encompasses. • Develop a catalogue of species and methods used in successful revegetation projects in the catchment, particularly in saline areas.
		Exotic plant and animal invasion	Floods, livestock grazing, garden escapees, green waste dumping.	• Feral cats and foxes are impacting on the native fauna. Rabbits are impacting on the native vegetation and hindering rehabilitation. Pigs are causing soil and vegetation damage. • Weeds dominate areas that are cleared and disturbed by stock grazing. In particular kikuyu is dominant in the tributaries of the lower reaches.	• Coordinate fox, feral cats and rabbit control programs in the catchment. • Control and manage weeds in riparian zones, particularly invasive weeds and those as required under existing legislation. • Restrict stock access to riparian areas by erecting fences. Rehabilitate these areas.

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River (continued)

Category	Waterway issue	Pressure/cause	Current State	Management response
Hydrological	Stream salinisation	Altered catchment hydrology caused by land clearing.	• Upper reaches are saline and the water discharging into Nornalup Inlet is brackish.	• Monitor groundwater levels across the catchment to assess groundwater rise. • Revegetate saline river valleys with salt tolerant species, and increase the buffer width to allow for groundwater rise. • Increase water use throughout the catchment through the use of perennials, surface water management of waterlogged and water-repellent soils.
	Waterlogging and land inundation	Altered catchment hydrology caused by clearing, inadequate internal and external drainage, and sedimentation of waterways.	• Large flat low-lying areas in the upper reaches are susceptible to waterlogging and inundation, especially on the broad floodplain.	• Design and implement suitable water management options throughout the catchment, in particular appropriate surface water management options. • Increase water use throughout the catchment through the use of perennials, surface water management of waterlogged and water-repellent soils. • Increase community awareness of various water management options.
	Stream flow changes, flooding	Increased groundwater flows, increased catchment discharge due to catchment clearing. Inappropriate development of the floodplain.	• Increased susceptibility to flood damage in low-lying floodplains in the upper reaches by increased catchment flows and discharge. • There is the potential for loss or damage to property.	• Extend buffer widths of saline creeks to ensure they are adequate for flood events and floodplains. • Use flood proof fencing in areas where the river channel is unstable. • Encourage land managers to manage paddocks to minimise the risk of flood damage by planting perennial vegetation including woody species. • Main Roads and Shires to ensure that all culverts and bridges works consider changed catchment hydrology.

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River (continued)

	Category	Waterway issue	Pressure/cause	Current State	Management response
					• The weir at Tambellup be stabilised as this could wash out in a flood event.
	Geomorphological	Erosion and sedimentation	Altered catchment discharges and vegetation loss. Channel deepening and widening, instream erosion and sedimentation.	• It is estimated that there is high sediment loss from cleared land due to increased erosion and runoff. • As a result, this is causing the sedimentation of river pools. • The river is braided in some sections of the upper reaches causing damage to developed floodways.	• Increase water use throughout the catchment through the use of perennials, surface water management of waterlogged and water-repellent soils. • Redesign firebreaks, access tracks and crossing points to minimise the risk of erosion. • Protect and restore riparian vegetation identified in the vegetation survey to be at risk from erosion, helping to protect banks from further erosion. • Where channels are filled with sediment, encourage establishment of vegetation to help channels re-form naturally. Excavation of channels is not sustainable. • Conduct a study on sediment movement in the river system.
	Waterway pressures	Land development, residential and agricultural	Sub-divisions, developments, agriculture.	• Diversification of framing land in the catchment. • A move away from wool dominated agriculture towards more cropping. • Pressure from increased development near towns, particularly in the lower catchment.	• Ensure suitable advice is given to landholders about the impacts/improvements diversification can have on the river system. • Encourage the Shires to develop appropriate development guidelines in the catchment.
		Point source pollution	Piggeries, dairies, vineyards, horticulture and other industries are examples of potential point sources of pollution.	• Some point-source pollution in the catchment from cattle feedlots.	• Monitor areas where point-source pollution may impact on the river. • Promote waste treatment/ control methods that do not have an impact on the river system.
		Water development	Aquaculture, boating facilities.	• No water development along the river.	• Ensure no development occurs that may have a negative impact on the river system.

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River (continued)

Category	Waterway issue	Pressure/cause	Current State	Management response
	Recreation	Boating, jet/water skiing, fishing, swimming, camping, horse riding, picnicking, marroning and four wheel driving.	• Current levels of recreation are manageable. However if poorly managed will present significant pressure on the river.	• Management by appropriate agencies of recreational use to ensure limited pressure on the river system. • Controlled access points. • Community communication programs to raise appreciation for, and an awareness of human impacts on the natural environment.
	Commercial fishing	Over fishing decreases fish stock densities.	• No commercial fishing or recreational gill, haul or set netting is permitted in the river or estuary.	• Continue ban of commercial fishing.
	Water abstraction, industrial discharge	Industry development, irrigation.	• No industrial discharge or water abstraction.	• Not applicable.
	Refuse sites	Groundwater and surface water contamination, rubbish dumping.	• Groundwater contamination is unknown. • Refuge dumping in some areas.	• Refuge is disposed of safely in accordance with Shire regulations. • Refuge sites are not placed in areas where groundwater or surface water will be contaminated.
	Drainage (saline land drainage)	Changed catchment hydrology.	• Control of drainage is an important issue in the upper catchment. • Some drainage works are inappropriately designed and increases soil erosion and sedimentation of waterways. • There is likely to be increases in the amount of drainage used in the upper catchment.	• Develop appropriate design criteria for deep drainage and determine the most appropriate location for this in the catchment. • Design and implement suitable water management options throughout the catchment, in particular appropriate surface water management options.

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River (continued)

Category	Waterway issue	Pressure/cause	Current State	Management response
				• Increase water use throughout the catchment through the planting of perennials and surface water management of waterlogged and water-repellent soils. • Increase community awareness of various water management options.
Waterway values	Economic benefits	Increased farm values, loss of productive land.	• Possibly increased farm values with river frontage and waterways in good condition. • Loss of productive land due to increasing areas impacted by salinity and waterlogging. • The national parks and Walpole-Nornalup Inlet are major tourist attractions representing high economic value.	• Protection of riparian vegetation and restoration of waterways. • Control of salt affected land by revegetating affected land with salt tolerant species, providing appropriate buffer zones to allow for rising groundwater, use of perennial plants. • Diversification of farming to allow for more efficient landuse. • Protection of the river system to ensure sustainable tourism opportunities.
	Biodiversity	Rare and endangered animals.	• High biodiversity value of flora and fauna in national parks and conservation reserves	• Continued management by CALM and other appropriate management bodies for the conservation of lands and the protection of biodiversity.
	Recreation	Fishing, swimming, canoeing, camping, picnicking.	· High recreational values of the river, particularly in the lower catchment and the Walpole-Nornalup Inlet.	• Maintain the diversity of recreational use. • Ensure recreational use is managed in a sustainable manner.
	Aesthetics		• High aesthetic value in the lower catchment in the forested areas. • Low aesthetic value of upper catchment.	• Protection and enhancement of riparian lands through waterways restoration, fencing and revegetation. • Raising community awareness about the values of the river.

Table 3.1. Current state, threats and pressures, and recommended management responses for the Gordon-Frankland River (continued)

Category	Waterway issue Pressure/cause	Current State	Management response
	Spiritual and cultural values	• Little is known about the Indigenous values of the river. However, rivers play an important part of Indigenous history. • The river represents important social, cultural and historical values for European Australians.	• Raising awareness of indigenous heritage • Capture and record the European and Indigenous heritage of the river and the important social, cultural and historical values of the river.
	Conservation values	• High conservation value of national parks, Walpole-Nornalup Inlet and conservation reserves throughout the catchment.	• Awareness raising about the high conservation value of the area through community events and information presentations.

A river pool at Caldyanup surrounded by the Mount Frankland National Park (photo Catherine MacCallum)

Campup Pool on the Gordon River – the site of an old school house. The upper reaches of the Gordon-Frankland do not flow continuously throughout the year, in summer the river consists of a sequence of pools, which are a focal point for the community and where wildlife flock (photo Steve Janicke)

A river reach near Caldyanup – a river in a forest (photo Kaylene Parker)

4 Estuaries – Walpole-Nornalup Inlet

The Gordon-Frankland River drains into the Walpole-Nornalup Inlet that is located near the town of Walpole. The majority of information is sourced from Hodgkin & Clark (1999).

4.1 The Inlet at a glance

Total area:	14.8 km^2
Entrance channel and bar:	Permanently open
Number of rivers discharging to Inlet:	3; Frankland River, Walpole River and Deep River
Surrounding Landuse:	National Park, Town sites of Walpole and Nornalup, recreation
Salinity:	Estuarine
Nutrients:	Low in Nornalup Inlet, higher in Walpole Inlet
Colour:	Coloured – from river input, clearer in summer with greater sea water intrusion
Algae:	Chlorophyll *a* concentrations are not high enough for algal blooms
Fishing:	No commercial fishing or recreational gill, haul or set netting

The Walpole-Nornalup Inlet is located between 116°40' and 116° 45' East and 34°58' and 35°03' South, on Natmaps 2227 Ram Head and 2228 Deep River. The inlet is situated within the Shire of Manjimup.

The estuarine system consists of two coastal lagoons, Nornalup and Walpole Inlets and the tidal reaches of the Deep and Frankland rivers. A one kilometre channel, nestled between rocky headlands connects the small shallow Walpole Inlet with the larger and deeper Nornalup Inlet. The inlets are nestled between the steep granite hills and the high limestone dunes of the South Coast.

The Walpole-Nornalup Inlet system is typical of other estuarine systems in the South West in that it is highly susceptible to nutrient enrichment and experiences extreme variability in the patterns of runoff and salinity (Ecotones & Associates, 2000). However it is different to other estuarine systems because a large portion of the lower catchment is surrounded by forest. It is also one of the only estuaries that are permanently open to the ocean (including Oyster Harbour).

4.2 Indigenous and European heritage

European heritage

The Bellanger family were the first European settlers and arrived in 1910 by sea. They landed on the beach and ferried their belongings across the Nornalup Inlet to a site on the Frankland River at Nornalup. The Thompson family later settled 5 km up the Deep River at Tinglewood (Bellanger, 1980, cited in Hodgkin & Clark, 1999).

Indigenous heritage

There is little documented knowledge regarding the indigenous heritage of the Walpole-Nornalup Inlet. However, it is thought that the area holds value to Nyungar people. The use of the area was most likely similar to that of other estuaries along the south coast including Wilson Inlet, Princess Royal and Oyster harbours.

4.3 Geological history, geology and landforms

Information sourced from Hodgkin & Clarke, 1999.

The estuary is of a recent origin in comparison with the Deep and Frankland rivers that have cut valleys over millions of years. Early in the Pleistocene (the last two million years) the estuary would have been an open marine bay and Rocky Head would have been an island. It would have only been enclosed from the sea after development of the coastal dunes along Circus and Bellanger beaches. During the last glaciation, which was 18 000 years ago, the sea level was more than 100 metres lower than what it is today and Nornalup Inlet would have been an open valley with river channels through it many metres below its present level. The valley was later flooded due to sea level rise. The Walpole and Nornalup Inlets would have become estuaries about 6 000 years ago.

The landforms of the Walpole and Nornalup Inlets are represented in Figure 4.1. Both the Deep and the Frankland rivers discharge through extensive riverine

deposits and deltas and over the wide sandy shallows into Nornalup inlet, where navigation channels are dredged. Wave action has reworked the delta sands to form a series of beach ridges that are now fixed by vegetation. These are well developed in the Deep River delta.

There are rocky shores on the southern and north-eastern sides of the Walpole Inlet, and the western shores are low-lying and sandy or swampy where the Walpole River and Coller Creek discharge into it. The channel between the two inlets is bordered by steep granite hills with rocky shores. The shoreline of the Nornalup Inlet either side of the channel entrance is granite. The south-eastern shore is composed of dunes that are truncated against the shoreline, sand which has eroded from the shore has formed wide shallow marginal shoals that continue north of the Frankland River mouth to Coalmine Beach. Swamps and beach ridges form the western shore either side of the Deep River delta and south of this, a sand spit is progressively enclosing a small bay. A shoal links the delta to the granite Newdegate Island (Snake Island), which rises to a height of 19 metres. For a short distance the south-western shore is interrupted by rocky outcrops on the floor of the Inlet.

4.4 Sediment

Information taken from Hodgkin & Clarke, 1999

The deltas and marginal shoals have clean, well sorted sands and due to a high water content they are generally firm. On the margins of the shoals (1– 2 metres deep) there are muddy sands with shells. In the deeper parts of Nornalup Inlet the sediment consists of sandy and clayey slits with a high water content of up to 80%. For an assessment of the mineralogical content of the sediments refer to Hassell (1962) who has examined them. The sediment of Walpole Inlet consists of mainly fine organic mud.

4.5 Entrance channel and bar

Information taken from Hodgkin & Clarke, 1999.

The bar at the mouth of the Nornalup Inlet does not close and remains open for the duration of the year. The entrance channel is variably shallow, and dangerous

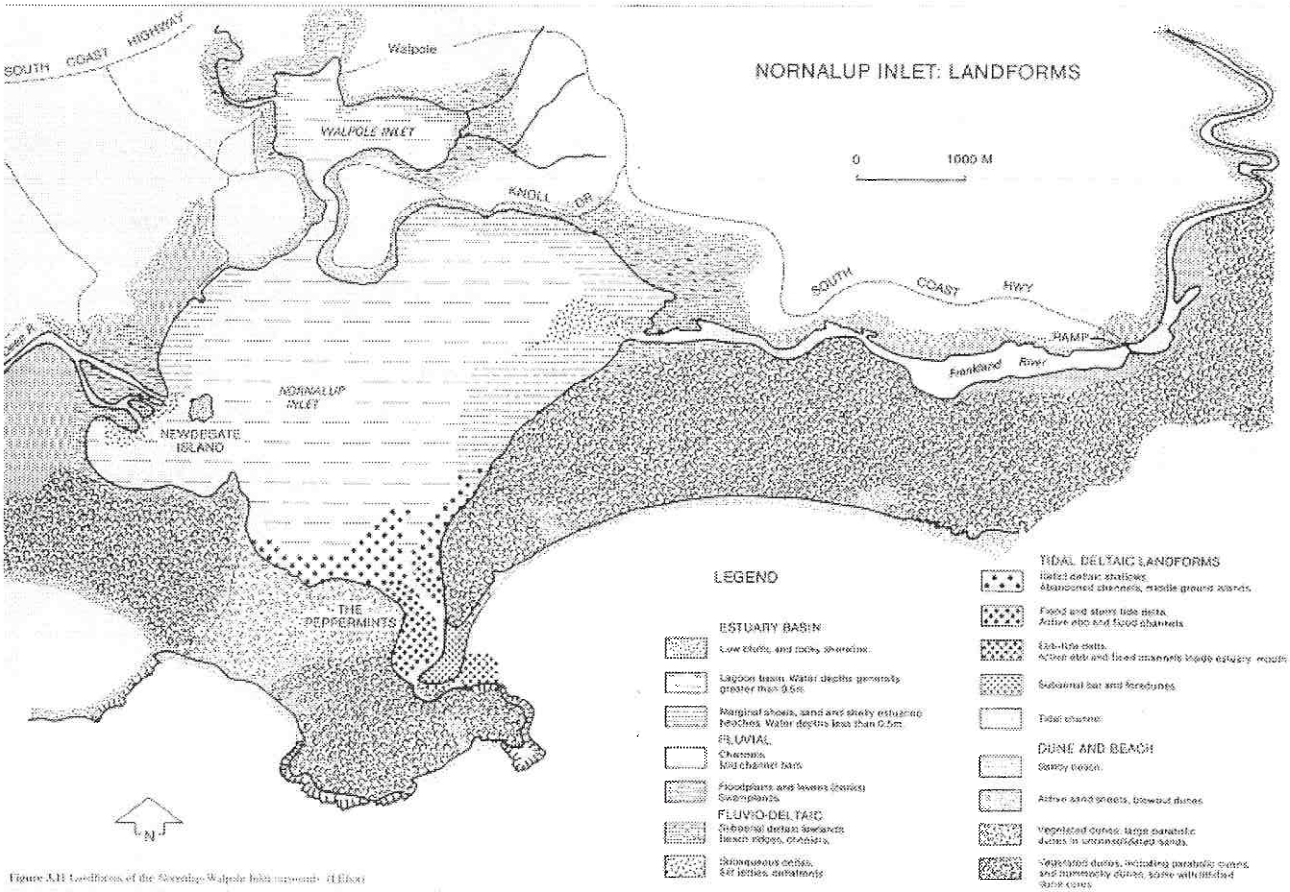


Figure 4.1. The landforms of Walpole-Nornalup Inlet (Hodgkin & Clark, 1999)

for navigation by small vessels due to the heavy swells that constantly roll into the bay even during periods of fine weather and light winds.

The channel takes different routes through the mobile sands of the flood delta where it is less than one metre deep. From the bar it swings south-west and then sharply eastward against a limestone cliff and the granite of rocky Head. The channel is constricted by the sand spit from the coastal dunes to the north-east and so narrows to about 20 metres.

4.6 Hydrology

Information sourced from Hodgkin & Clarke, 1999.

Due to the bar being open the water level in the inlets varies tidally, but the daily range is only 40% of the ocean range (at Albany) due to the small, shallow entrance (Marine and Harbours, cited in Hodgkin & Clark, 1999). There can be remarkable rises in water level in the riverine stretches during floods, with a smaller rise in the inlets.

The Public Works Department conducted a hydrographic survey of Nornalup Inlet in 1912 (Chart 16302) and surveyed the Walpole and Nornalup Inlets again in 1985. Walpole Inlet is shallow with a depth of less than one metre, with the exception of the dredged boat channels. The channel linking the two inlets has a maximum depth of about two metres. The marginal shoals of the Nornalup Inlet slope steeply to the deeper central area, which ranges from three to five metres. There is a defined channel at the mouth of the Frankland River that persists to the deep central part. The flood deltas are very shallow except where the narrow channels cut through.

4.7 Water quality

The CSIRO Division of Fisheries took water samples in the estuary at eight sites at roughly quarterly intervals from 1944 to 1955. This data is represented and discussed in Hodgkin & Clark (1999) and readers are directed to this resource for further information.

The Department of Environment has a sampling program to monitor water quality in the Inlets. The monitoring program was established in January 1999 as a response to community concern about the health status of the Inlets. The aims of the sampling program are to provide:

1. Information on seasonal and long-term changes in the water quality of the Inlets;
2. Baseline information on the nutrient levels in the waters of the Inlets;
3. A broad scale indication of nutrient sources to the Inlets;
4. Information on water circulation and flushing;
5. An understanding of the phytoplankton (single-celled algae) ecology; and
6. Data that will enable a comparison of the Walpole-Nornalup Inlets with other south coast estuaries.

Sampling is completed every three months. On a sampling run data is collected from eight standard sites (Sites WN01 to WN08) as shown in Appendix One. At sites WN01 to WN07 surface and bottom waters are collected and sent to the Australian Environmental Laboratories for the analysis of nutrient levels. The nutrients that are analysed are ammonia, oxides of nitrogen (nitrate and nitrite), total nitrogen, filterable reactive phosphorus, total phosphorus, colour,

The hydrolab used for the collection of data for the monitoring of the Inlet (photo Catherine MacCallum)

chlorophyll and phaeophytin pigments (more information on these terms can be obtained from the Department of Environment Albany). A hydrolab multiprobe is used at each site to collect temperature, salinity, specific conductivity and dissolved oxygen data at approximately 0.5 metre intervals. Secchi disk depths are also collected at each site. Phytoplankton samples are collected from sites WN01, WN02, WN04 and WN07 and sent to the Phytoplankton Ecology Unit of the Department of Environment for microscope identification.

There have been several reports written at varying stages of the monitoring. A detailed and current unpublished report by Boardman (2002)* includes results from monitoring between January 1999 to August 2002. The report is included as Appendix One. A previous version of this report (January 1999 – March 2000) was presented to the Walpole and Nornalup Inlet Systems Advisory Committee (WANISAC). It is proposed that the report will be updated, as results are available.

4.8 Aquatic flora

Aquatic Flora

Information taken from Hodgkin & Clark, 1999.
The aquatic vegetation has been found to be sparse on the two occasions it has been sampled, October 1976 (by M. Cambridge) and January 1987 (by J. Chambers).

* *This report has been edited for the purpose of this compendium, however the main information presented is without any changes.*

The seagrass *Ruppia megacarpa* grows in shallow water on sand flats near the Deep River delta and stunted plants occur on the south eastern shore. The marine species, *Heterozostera tasmanica* was also found on the south-eastern shore and towards the mouth in 1976. In 1987 the brown alga *Cystoseira trinodes* covered the sublitteral rocks near the mouth of the Walpole-Nornalup channel, both this and the *Ruppia* were heavily overgrown by the epiphytic filamentous alga *Chaetomorpha billarderi* and the fine red filamentous alga *Monosporus australis*.

Lananton (pers. comm.) reports the green algae *Chaetomorpha linum* and *C. aurea* were abundant in Walpole Inlet in 1973–1974 and Cladophora was reported to be growing on muddy sand in 1976. In 1987 occasional mats of floating green algae *Entermorpha intestinalis* and *Chaetomorpha billardierii* were noted to occur in the shallows on the eastern side. The small green alga *Acetabularia calyculus* was commonly attached to rocks and shells in the shallows. In 1976 a layer of live algae covered 10-20 cm of dead algae over black deoxygenated ooze in a water depth of 1–2 m in Walpole Inlet.

Marsh Plants and Terrestrial Vegetation

Information taken from Hodgkin & Clark 1999.
Figure 4.2 on the following page, details the marsh and terrestrial vegetation communities as noted by J. Chambers in 1987. Generally the rocky shores allow for little colonisation by fringing marsh. Elsewhere the rush *Juncus krausii* fringes the estuary in front of all

Geoff Bastyan undertaking the data collection and sampling of the Walpole-Nornalup Inlet (photo Catherine MacCallum)

vegetation types except for the coastal heath. In general the rush band is only one plant thick due to the steep slopes, however in slightly flatter areas the sedges and grasses *Baumea juncea*, *Ammophila arenaria**, *Lepidosperma gladiatum*, *Paspalum vaginatum** and *Isolepis nodosa* grow behind the rush community.

In the peaty swamps of the National Park scented boronia, *Boronia megastigma* and the insectivorous pitcher plant, *Cephalotus follicularis* grow.

The sand spit at the mouth is sparsely colonised by *Ammophila arenaria**, *Arthoeca populifolia** and *Isolepis nodosa* and marram grass has been planted on it. The nearby dunal vegetation is coastal heath, which includes the above plants but is dominated by the shrubs *Leucopogon paviflorus*, *Olearia axillaris*, *Acacia littorea* and the sedge *Lepidosperma gladiatum*. On the lea side of the dune, on the banks of the Inlet, this coastal heath gives way to a community dominated by Peppermint trees (*Agonis flexuosa*) with the shrubs *Spyridium globulosum*, *Olearia axillaris*, *Rhagodia baccata*, *Billardiera variifolia* and the sedge *Lepidosperma gladiatum*.

At the mouth of rivers, in low-lying areas and also near Walpole, a low scrub community is dominated by the yellow-flowered shrub *Oxylobium heterophyllum*. Other species that have also been identified in this vegetation community are: *Jacksonia horrida*, *Beaufortia* sp., *Acacia pulchella*, *Astartea fascularis*, *Anigozanthos* sp., *Macrozamia riedlei*, *Xanthorrhea preisii*, *Euphorbia* sp. and *Lepidosperma gladiatum*.

The steep forested hillsides that surround the Inlet have fine stands of Karri (*Eucalyptus diversicolor*), with Red Tingle (*E. jacksonii*) and Yellow Tingle (*E. guilfoylei*). On the headlands, the forest community is separated from the *Juncus* community by a narrow Peppermint-dominated community.

4.9 Aquatic fauna

Marcoinvertebrates

Information taken from Hodgkin & Clark 1999.

The benthic fauna of the Walpole-Nornalup Inlet has been surveyed twice by J. Wallace in 1976 and J. Shaw in 1987. The results of these are shown in the Tables 4.1 and 4.2 (adapted from Hodgkin & Clark, 1999). Due to the permanently open bar and marine salinity of the water, Nornalup Inlet permits the establishment and survival of more invertebrate species than other estuaries along the south coast, with the exception of Oyster Harbour.

Table 4.1. Benthic fauna (Hodgkin, Kendrick & Wallace; Wells, 1984) (Adapted from Hodgkin & Clark, 1999)

POLYCHEATA		*Arenicola* sp.
CRUSTACEA		*Metapenaeus dalli*
		Palaemonetes serenus
		Leander sp.
		Cyclograpsus audociuni
		Portunus pelagicus
MOLLUSCA	Gastropoda	*Haminoea* sp.
		Nerita atramentosa
		Tatea preissii
		Assiminea sp.
		Hydrococcus brazieri
		Salinator fragilis
	Bivalvia	*Mytilis edulis*
		Xenstrobus pulex
		Ostrea sp.
		Fulvia tenuicostata
		Paphies elongata
		Sanguinolaria biradiata
		Fluviolanatus subtorta
		Pholas australasiae
INSECTA		*Pontomyia cottoni*
	Chironomidae	Unnamed species

Fish

Information taken from Hodgkin & Clark 1999.

Table 4.3 lists the 37 species of fish that are found in the Walpole-Nornalup Inlet. Major species targeted by recreational anglers include Black Bream, King George Whiting and Trevally (Fisheries Western Australia, 2001).

In comparison with other estuaries along the south coast, there are more marine species captured in Walpole-Nornalup Inlet. This is because the bar is permanently open in the Walpole-Nornalup Inlet, whereas other estuaries such as Wilson Inlet, the bar is open seasonally. The marine species caught in the Walpole-Nornalup Inlet include five species of sharks and rays.

* *Introduced species*

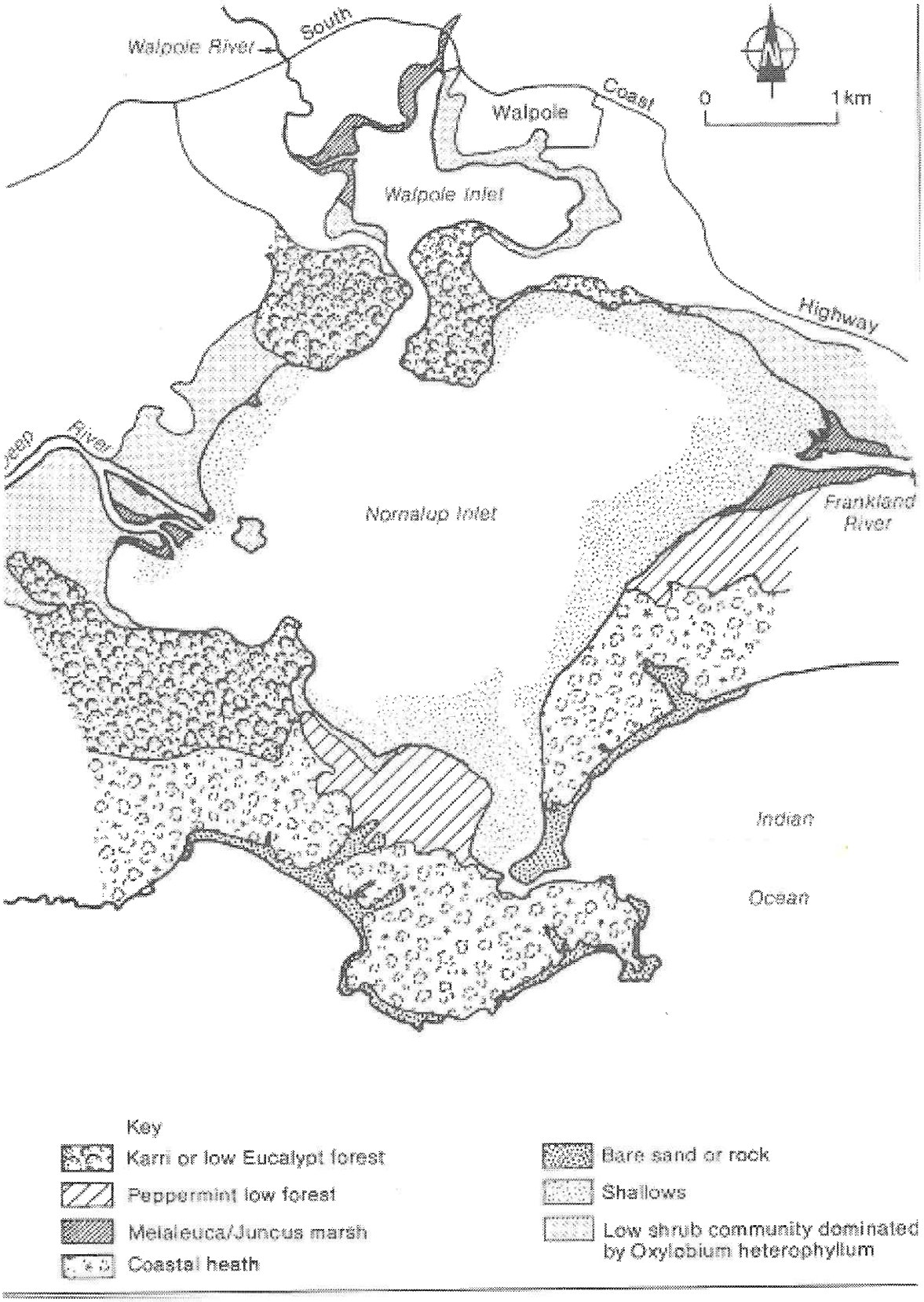


Figure 4.2. The Walpole-Nornalup marsh and terrestrial vegetation as depicted by Chambers (1987) (Hodgkin & Clark, 1999)

Table 4.2. Benthic invertebrate fauna found in the Walpole-Nornalup Inlet as sampled by Shaw (1987)

	Sample site	Walpole Inlet[1]	Newdegate Island[2]	Nornalup basin[3]	Coalmine Beach[4]	Frankland River[5]	Tidal delta[6]
POLYCHAETA:							
Phyllodocidae	- Phyllodoce sp.	+	+	—	+	+	—
Hesionidae	- Gyptis sp.	—	+	+	++	—	—
Nereididae	- Ceratonereis aequisetes	—	+	—	+	+++	—
	- Laconereis sp.	—	—	—	++	—	++
	- Neanthes sp.	—	—	—	—	—	++
Nephtyidae	- Nephtys inornata	++	++	++	—	—	—
Orbiniidae	- Scoloplos simplex	++	—	+	++	++	++
Paraonidae	- Polydora sp.	—	—	—	—	+	—
	- Prionospio sp.	+	+	+	—	—	—
	- Boccardia sp.	+	—	—	+	—	—
Opheliidae	- Armandia sp.	—	—	—	—	—	+
Capitellidae	- Capitella capitata	+++	+++	+++	+++	++	+++
Serpulidae	- Mercierella enigmatica	—	++	—	—	—	—
CRUSTACEA:							
Cirripedia	- Balanus variegatus	+	—	—	++	+	—
	- Eliminus modestus	—	—	—	+	—	—
Mysidacea	- Mysid sp.	+	—	—	+	—	+
Amphipoda	- Corophium minor	+++	+	—	—	+	+
	- Paracorophium sp.	—	—	—	++	—	—
	- Neomicrodeutopus sp.	+++	—	—	—	—	—
	- Melita sp.	+	—	—	—	—	—
Decapoda	- Halicarcinus ovatus	+	—	—	+	+	++
	- Pilumnus fissifrons (cf)	—	++	—	+	—	—
	- Ovalipes australiensis	—	—	—	—	—	+
	- Portunus pelagicus	—	—	—	—	—	+
	- Palaemonetes australis	+	—	—	+	+	+
	- Macrobrachium intermedium	—	—	—	—	—	+
MOLLUSCA:							
Gastropoda	- Diala sp.	—	—	—	—	+	—
	- Nassarius burchardi	+	—	—	++	—	++
	- Nassarius pauperatus	—	—	—	—	—	+
	- Liloa brevis	+	—	—	—	—	—
	- Philine sp.	+	++	—	++	+	+
Bivalvia	- Xenostrobus securis	—	—	—	—	++	—
	- Musculus paulucciae	—	—	—	+	+	+
	- Anomia trigonopsis	—	—	+	—	—	—
	- Wallucina assimilis	—	+	—	+	—	++
	- Arthritica semen	—	—	—	—	+++	—
	- Spisula trigonella	++	—	—	++	++	+
	- Soletellina donacioides	—	—	+	+	—	+++
	- Katelysia peroni	—	—	—	+	—	—
	- Katelysia scalarina	—	—	—	+	—	+
	- Irus crenata	—	—	—	—	+	—
	- Theora lubrica	++	+	++	—	+	—
	- Macomona deltoidalis	—	—	—	—	+	—
	Depth (m)	2.5	1-2.5	3	2	1-1.5	0.5-2
	Bottom type	Mud			Sand		

— not found
\+ present
++ abundant
+++ very abundant

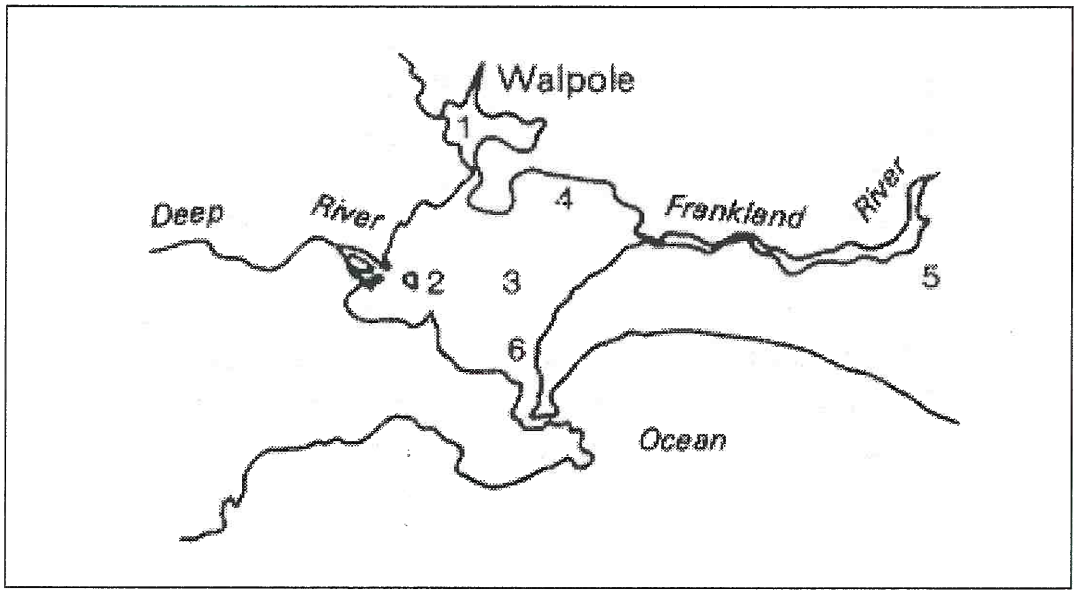


Figure 4.3. Sampling sites used to collect benthic invertebrates by Shaw (1987) (Hodgkin & Clark, 1999)

Table 4.3. Fish found in the Walpole-Nornalup Inlet (Lananton pers. comm., cited in Hodgkin & Clark, 1999)

Common Name	Scientific Name	Common Name	Scientific Name
Anadromous		**Predominantly marine**	
Wide mouthed lamprey	*Geotria australis*	Beardie	*Lotella rhacinus*
Estuarine		Southern school whiting	*Sillago bassensis*
Black bream	*Acanthopagrus butcheri*	Long-finned goby	*Favonigobius lateralis*
Blue spot goby	*Pseudogobius olorum*	Lemon tongue sole	*Paraplagusia unicolor*
Hardyhead	*Atherinisoma wallacei*	Spiny tailed leather jacket	*Bigener brownii*
Hardyhead	*Atherinisoma elongata*	Toothbrush leatherjacket	*Penicipetta vittiger*
Predominantly estuarine		Trevally	*Pseudocaranx dentex*
Sea mullet	*Mugil cephalus*	Banded toadfish	*Torguigener pleurgramma*
Tarwhine	*Rhabdosargus sarba*	Rosy weedfish	*Heteroclinus roseus*
Marine and inshore marine		Wirrah	*Acanthistius serratus*
Hardyhead	*Atherinosoma presbyteriodes*	Porcupine fish	*Dicotylichthys jaculiferus*
Yelloweye mullet	*Aldrichetta forsteri*	Serpent eel	*Ophisurus serpens*
King George whiting	*Sillaginodes punctata*	Gummy shark	*Mustelus antarcticus*
Southern blue spotted flathead	*Platycephalus speculator*	Southern shovelnose ray	*Aptychotrema vincentiana*
Striped trumpeter	*Pelates sexineatus*	Yellow-finned whiting	*Sillago schomburgkii*
Sand trevally	*Pseudocaranx wrighti*	Beaked salmon	*Gonorynchus greyi*
West Australian salmon	*Arripis truttaceus*	Red gurnard	*Cheilidonichthys kuma*
Pink snapper	*Chrysophrys auratus*		
Long snouted flounder	*Ammotretis rostratus*		
Cobbler	*Cnidoglanis macrocephalus*		
Herring	*Arripis georgianus*		
Tailor	*Pomatomus saltator*		
Southern anchovy	*Engraulis australis*		

Waterbirds

Various observers have recorded the different species of waterbirds that frequent the Walpole-Nornalup Inlet (Table 4.4).

Table 4.4. Waterbirds recorded at Walpole-Nornalup inlet by Ashby & LeSouef (1928), R. Clark, J.Lane, Munro, Peden, RAOU and P. Yewers (modified from Hodgkin & Clark, 1999)

Common Name	Scientific Name
Australian pelican	*Pelecanus conspicillatus*
Great cormorant	*Phalacrocorax carbo*
Little black cormorant	*Phalacrocorax sulcirostris*
Pied cormorant	*Phalacrocorax varius*
Little pied cormorant	*Phalacrocorax melanoleucos*
White-faced heron	*Ardea novaehollandiae*
Black swan	*Cygnus atratus*
Pacific black duck	*Anas superciliosa*
Silver gull	*Larus novaehollandiae*
Crested tern	*Sterna bergii*
Caspian tern	*Hydroprogne caspia*
Musk duck	*Biziura lobata*
Grey teal	*Anas gibberifrons*
Australian shelduck	*Tardorna tadornoides*
Eurasian coot	*Fulica atra*
Wood duck	*Chenonetta jubata*
Pacific gull	*Larus pacificus*
Sacred ibis	*Threskiornis aethiopicus*
Osprey	*Pandion haliaetus*
White breasted sea eagle	*Haliaeetus leucogaster*
Red capped plover	*Charadrius reficapillus*

4.10 Management

The Walpole-Nornalup Inlet is managed through the Walpole and Nornalup Inlet Systems Advisory Committee (WANISAC), which is part of the Shire of Manjimup. WANISAC has produced a number of reports guiding the future management of the area. The most relevant one is the Action Plan, which details the actions needed to be undertaken to address the concerns raised by the community. The community views are represented in the Subcatchment and Community section of this compendium.

Ecotones & Associates 2000, *An Action Plan for the Walpole and Nornalup Inlets and Catchment: Action Plan*. Walpole Nornalup Inlet Systems Advisory Committee, Shire of Manjimup.

Ecotones & Associates 2000, *An Action Plan for the Walpole and Nornalup Inlets and Catchment: Funding Options Report*. Walpole Nornalup Inlet Systems Advisory Committee, Shire of Manjimup.

Ecotones & Associates 2000, *An Action Plan for the Walpole and Nornalup Inlets and Catchment: Management Action Report*. Walpole Nornalup Inlet Systems Advisory Committee, Shire of Manjimup.

Ecotones & Associates 1999, *An Action Plan for the Walpole and Nornalup Inlets and Catchment: A Regional Assessment of the Ecological Health of the Walpole-Nornalup Inlet*. Walpole Nornalup Inlet Systems Advisory Committee, Shire of Manjimup.

Ecotones & Associates 1999, *An Action Plan for the Walpole and Nornalup Inlets and Catchment: Issues and Stakeholders Views Report*. Walpole Nornalup Inlet Systems Advisory Committee, Shire of Manjimup.

The Department of Conservation and Land Management manage the national parks surrounding the Walpole-Nornalup Inlet. For the management plans of these parks contact CALM or visit their website.

5 Wetlands in the Gordon-Frankland catchment

There has been no specific monitoring completed on wetlands within the Gordon-Frankland River catchment. There is also limited or no data concerning the bird, fish, frog and macroinvertebrate life that occupy the wetlands in the Gordon-Frankland catchment. However broader studies of wetland classification types and threatening processes, have been completed on the suites of wetlands between Walpole and Fitzgerald Inlet and in the Pallinup–North Stirling Region; these wetlands having been classified into groupings of a similar type. Despite the lack of detailed study it is known that there are seven suites of wetlands of regional significance occurring in the Gordon-Frankland catchment.

The National Directory of Important Wetlands identifies nationally important wetlands and provides information on their variety and dependent flora and fauna. The Directory is a cooperative project between the Commonwealth, State and Territory governments of Australia. The Balicup Lake system (Balicup suite) is included as nationally important. The Balicup suite is not technically within the Gordon-Frankland, however some of the wetlands within this network are located within Gordon-Frankland catchment. These salt lakes of the Balicup Suite function as part of the Gordon-Frankland catchment during years of high rainfall (Smith, 1951). The information about the Balicup Suite has been included in the compendium for interest as an example of a Nationally Important Wetland.

5.1 Wetland classification report

A broader survey of wetlands on the South Coast completed for wetland suites between Walpole and Fitzgerald Inlet and also the suites in the Pallinup–North Stirling Region was undertaken by Environmental Consultants Vic and Chris Semeniuk in 1997and 1998, on behalf of the then Water and Rivers Commission. Their assessment highlights the regional significance of wetlands on the South Coast and lists the threatening processes that are impacting on them.

The focus of these reports was the inland wetlands and estuaries that are semi-enclosed to closed. There were four major objectives to the study:

- Identification of wetlands regions;
- Classification of wetlands into groups having like natural attributes (ie. geological, hydrological, ecological);
- Identification of wetlands of regional significance – wetlands of outstanding importance by applying evaluation criteria identified by wetland scientists over the last two decades with the current scientific and social philosophy; and
- Identification of significant wetlands that are at risk due to poor management practices, inadequate reserves and for wetlands of importance, suggest general guidelines for improvements.

Wetlands at risk

The reports compiled by Semeniuk (1998, 1999) identified wetlands that were at risk from a number of factors. These factors are outlined below. Table 5.1 lists the regionally significant wetlands that are found in the Gordon-Frankland catchment and the factor/s from which they are at risk.

- *Lack of recognition of the wetland itself*
  These are those wetlands of a type that is hard to recognise and therefore are at worst risk of being cleared or inappropriately managed.
- *Lack of recognition of linked wetland systems and wetland catchment*
  The failure to recognise a linked wetland system is the cause of deleterious impacts on wetlands such as water level changes, changes to water salinity, nutrient enrichment, increases in siltation, aquatic weed invasion, decline in biodiversity of aquatic fauna and loss of habitat diversity.

- *Wetlands in areas of groundwater rise*
  These wetlands are, in essence, an example of linked wetland systems as all the wetlands are hydrologically linked to each other through the lateral and vertical movement of groundwater. The associated risks with increasing groundwater are deaths to the surrounding vegetation form both prolonged waterlogging, and dissolution and precipitation of salts.

- *Inadequate and inappropriate buffer zones*
  Buffer zones around wetlands enable the protection of the wetland and the associated processes. Therefore it is necessary to have buffers that are of an appropriate width.

Wetland biota

As previously mentioned there is very little information on the flora and fauna found at these wetlands, consequently no further details have been included in this compendium. For information regarding the vegetation types and hydrogeology, for some of the wetlands the reader is directed to the original Semeniuk reports, which are available at the Department of Environment's Albany office.

Outstanding wetlands

The Sememniuk report also suggested two wetlands had outstanding value (Semeniuk, 1998; 1999). They are:

- *Unicup Suite*
  Due to: the type of wetlands they are, wetland process and habitat diversity.

- *Balicup Suite*
  Due to: flora, research, water chemistry, natural history and sedimentary features.

It was recommended that the Madjenapurdap and Balicup wetlands be added to the National Conservation Estate. The Balicup Lake Wetland Suit has been added to the Register of the National Estate.

Further information about the Register is available on the Australian Heritage Commission web site.

Table 5.1. Wetlands found in the Gordon-Frankland catchment and the factors they are at risk from (modified from Semeniuk , 1998; 1999)

Wetland	Wetland Suite	Wetland risk
Bellanger Beach	Meerup Suite	• Lack of recognition of the wetland itself.
Bonhall Creek	Walpole Suite	• Lack of recognition of the wetland itself. • Inadequate and inappropriate buffer zones.
Bevan Rd/Roe Rd Sumplands	Bevan Rd Suite	• Inadequate and inappropriate buffer zones.
Hicker Rd Flats Turpin Rd Flats	Boronia Rd Suite	• Lack of recognition of linked wetland systems and wetland catchment.
Madjenapurdap Gordon River	Madjenapurdap Suite	• Inadequate and inappropriate buffer zones. • Wetlands in areas of groundwater rise.
Round Swamp	Unicup Suite	• Lack of recognition of linked wetland systems and wetland catchment. • Wetlands in area of groundwater rise. • Inadequate and inappropriate buffer zones.
Milyunup Lake Un-named wetland	Balicup Suite	• Lack of recognition of the wetland itself.

5.2 Directory of important wetlands

The Balicup Lake system (Balicup suite) is listed in the *Directory of Important Wetlands*. This specifically includes Balicup, Jebarjup Swan and Camel lakes, which are just outside the Gordon-Frankland catchment boundary. However, the Milyunup Lake and an unnamed wetland are within the catchment boundary and as they are part of the consanguineous suite should be noted.

The Balicup Lake system is significant because it is a good example of naturally saline, seasonal lakes that occur in south-western Australia, especially around the Stirling Range. The Criterion the Balicup Lake system meets for inclusion in the directory are:

- It is a good example of a wetland type occurring within a biogeographic region in Australia;
- The wetland supports 1% or more of the national populations of any native plant or animal; and
- The wetland supports native plant or animal taxa or communities that are considered endangered or vulnerable at the national level.

The Balicup Lake system has also been identified as meeting one of the Ramsar Criterion, for listing as a wetland of International Importance (Jaensch & Watkins, 1999,). Full details from the Directory follow.

For any further details refer to the Semeniuk reports, they are available from the Department of Environment in Albany.

Preliminary Delineation of Consanguineous Wetland Suites Between Walpole and Fitzgerald Inlet, Southern Western Australia, 1998, Report for Waters & Rivers Commission, V & C Semeniuk Research Group.

Preliminary Delineation of Consanguineous Wetland Suites in the Pallinup – North Stirling Region, South Western Australia, 1999, Report for Waters & Rivers Commission, V & C Semeniuk Research Group.

6 Foreshore vegetation and surveys

There has been four foreshore surveys conducted in the Gordon-Frankland catchment, the main channel from near Frankland to Tambellup, and the subcatchments, Lower Slab Hut Gully, Gordon River and Jam Creek (see maps for details).

6.1 Methods for the assessment of foreshores

Summarised from Pen & Greenskills (1998) & Alvarez de Toledo (2000abc)

The condition of a section of river foreshore or riparian zone was assessed using a simple system developed by Pen (1994) from observations of river system degradation throughout the South West of Western Australia. The methods, grades and system of assessment have been summarised in Pen and Scott (1995). The system consists of a number of stages or grades – A, B, C and D – starting from pristine through to completely degraded following the general process of degradation outlined in Pen & Greenskills (1998).

The foreshore survey of the main channel of the Gordon-Frankland River was assessed by landholders. The opposite sides of the banks of the river were assessed separately. Landholders were each given forms devised by Dr Luke Pen and they were taken into the field and annotated with relevant information on landscape, plant communities, foreshore conditions, points of severe erosion and fencing status. Remnant vegetation occurrence along the river foreshores was not mapped. The majority of this foreshore assessment was completed in 1995; however, Greenskills conducted follow-up survey work and completion of foreshore surveys in 1997. A report was produced (Pen & Greenskills, 1998) and is available from the Department of Environment's Albany office.

The assessment of Slab Hut Gully, Gordon River and Jam Creek was completed by Alvarez de Toledo with the landholder present on some occasions. Data on vegetation type, density and condition along the course of the tributary, the presence and standard of fencing, the types of declared weeds present, the severity of erosion and sedimentation processes, and how these parameters relate to the landholders overall attitude to conservation of riparian zones, were collected.

Further assessments of foreshore condition along the Gordon-Frankland River and the Walpole-Nornalup Inlet have used the methods described above.

Foreshore grades

Note: the foreshore grades have been modified to account for salinising landscapes. These changes are most significant in B and C grade foreshores. Refer to Pen & Scott (1995) for original descriptions of foreshore grades. Refer also to Figure 6.1, which depicts the original grades used by Pen & Scott (1995).

Plates 6.1-6.4 displays the foreshore grades (A, B, C & D) specifically found in the Gordon-Frankland River including vegetation in a salinising landscape.

A-Grade Foreshore

A1. Pristine

The river embankments and/or channel are entirely vegetated with native species and there is no evidence of human presence, including livestock damage. This category, if it exists at all, would be found only in the middle of large conservation reserves where the impact of human activities has been negligible.

A2. Near Pristine

Native vegetation dominant but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species. Otherwise there is no human impact. A river in this condition is about as good as can be found today.

A3. Slightly disturbed

There are areas of localised human disturbance where the soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks. Otherwise, native plants dominate and would quickly recolonise disturbed areas should human activity decline.

B-Grade Foreshore

B1. Good Condition – becoming degraded, weeds prevalent.

The general foreshore condition is good. In this stage, however weeds have become a significant component of the understorey vegetation. Although native species remain dominant, a few have probably been replaced or are being replaced by weeds. In a saline landscape salt tolerant species such as samphires (native) and *Puccinallia* (exotic) may accompany the native vegetation communities.

B2. Degraded – heavily weed infested

In the understorey, weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3. Degraded – weed dominated

Weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or have disappeared.

C-Grade Foreshore

C1. Erosion Prone or saline affected

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses. Most of the trees will be of only a few resilient or long-lived species and their regeneration will be mostly negligible. In this state, where short-lived weeds support the soil, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion. Disturbances could be caused by stock grazing the understorey or from salinity.

C2. Soil Exposed or saline affected

Here, the annual grasses and weeds have been removed through either of several processes: heavy livestock damage and grazing, a result of recreational activities or from the affects of salinity where the vegetation has died. Where salinity has affected the vegetation salt scalds begin to dominate. Low-level soil erosion caused by the action of either wind or water has begun.

C3. Eroded

Soil is being washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley. In a saline landscape this grade may depict by a bare salt scald with salt tolerant fringing vegetation.

D-Grade Foreshore

D1. Ditch – eroding

Fringing vegetation no longer acts to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots, but all are doomed to be undermined eventually.

D2. Ditch – freely eroding

No significant fringing vegetation remains and erosion is completely out of control. Undermined and subsided embankments are common, as are large sediment plumes along the river channel. In a saline landscape this grade may depict a bare salt scald.

D3. Drain – weed dominated

The highly eroded river valley has been fenced off, enabling the colonisation of perennial weeds. The river has become a simple drain, similar, if not identical, to the typical major urban drain.

6.2 Foreshore condition grades of the Gordon-Frankland catchment

A Grade condition – Pristine. Riverbanks near the South Coast Highway (photo Catherine MacCallum)

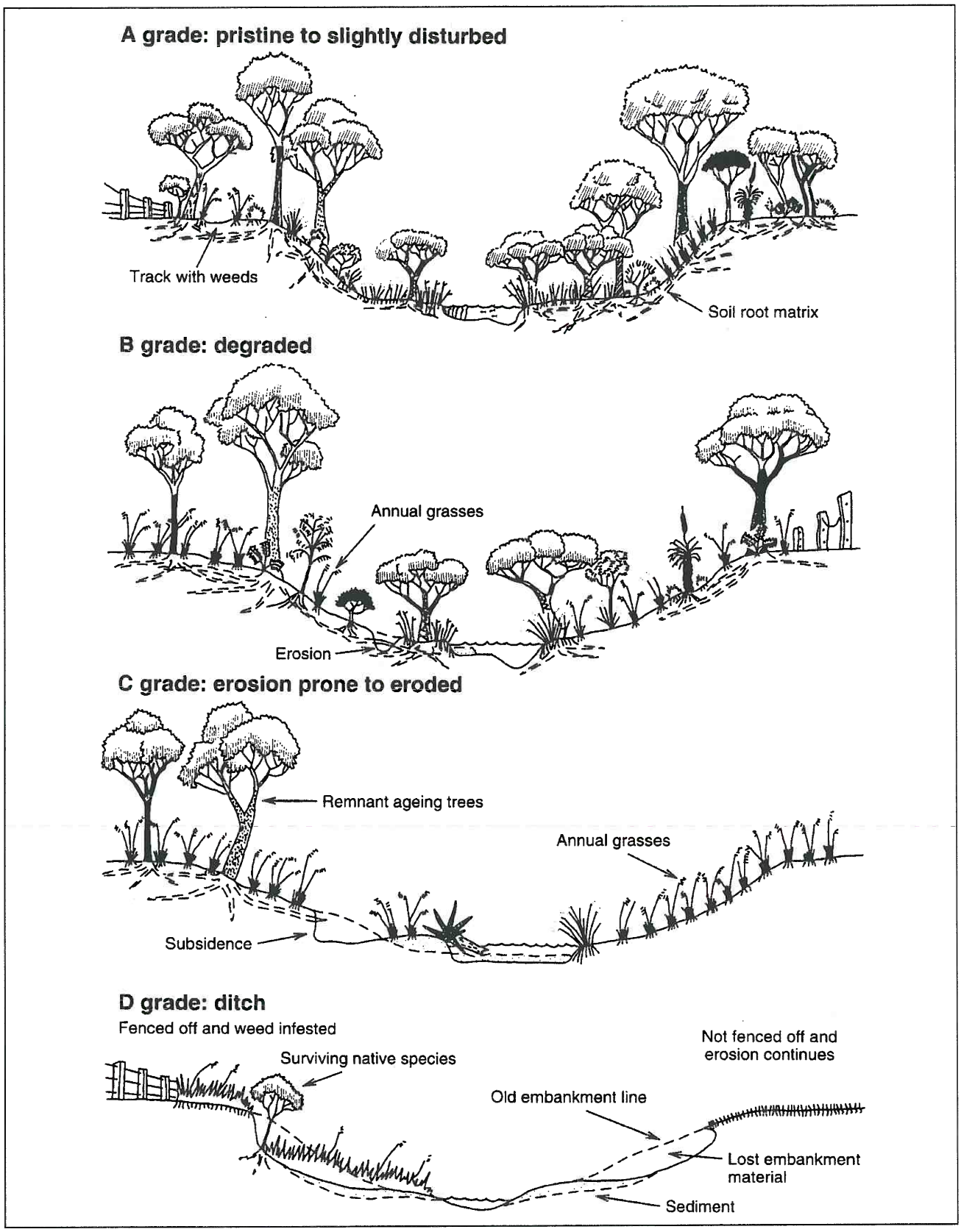


Figure 6.1. Pictorial depiction of foreshore grades as used by Pen & Scott (1995) and Alvarez de Toledo (2000abc)

B Grade condition – Good condition, becoming degraded. Foreshore vegetation upstream from the Muir Highway Bridge, note the presence of weeds in the understorey (photo Kaylene Parker)

B grade condition – Salinising landscape. Up stream from the Yeriminup Bridge note the vegetation is dominated by salt tolerant species of paperbark and samphire (photo Steve Janicke)

C Grade condition – Erosion prone. The upper reaches of the Gordon River near the Shamrock Road Bridge, note the exposed banks and lack of covering vegetation, where there is vegetation it is dominated by weed species. (photo Adele Alvarez de Toledo)

C Grade condition – Salinising landscape. The Gordon River upstream of Newton Road crossing, note the dominance of grasses with many dead trees and samphire (photo Catherine MacCallum)

D Grade condition – Ditch eroding. The Gordon River on the Cranbrook Transport Road, note the dead trees, exposed and eroding banks with a lack of fringing vegetation (photo Kaylene Parker)

D Grade condition – Saline landscape. The Gordon River along the Cranbrook Transport Road showing dead trees and bare and eroding banks due to salinisation. There is still some vegetation present, samphire but has limited erosion control (photo Kaylene Parker)

6.3 Walpole-Nornalup Inlet

The foreshore condition of the Walpole-Nornalup Inlet is represented in Figure 6.2. Water and Rivers Commission staff conducted the survey in 1998, and there are no accompanying details. The foreshore grades used are the same as those outlined earlier in this section.

6.4 Status of foreshore condition – Gordon-Frankland River

Main channel Gordon-Frankland

From the foreshore survey primarily conducted in 1995 by Pen & Greenskills (1998). See also Figure 6.3.

Total water-course length surveyed (km) – combined banks	**Foreshore condition by distance (km) and percentage**				**Section fenced (km) and percentage**	**Section requiring revegetation (km)**
	A	B	C	D		
257	104.75	95.9	56.35		143.25	112.65
100%	41 %	37%	22%		56%	44%

Note: This was conducted in 1995 and unfenced sections of river are likely to have degraded, and fenced areas improved. Landholders assessed the foreshore therefore no standardisation occurred. The survey needs to be updated and extended.

Lower Slab Hut Gully

(Alvarez de Toledo, 2000a)

From the foreshore condition survey conducted on the subcatchment lower Slab Hut Gully in 2000:

- The vegetation condition varied widely from **B1 to D3** Grade.
- About 10% of the area surveyed is now fenced.

See also Figure 6.4.

Jam Creek

(Alvarez de Toledo, 2000b)

From the foreshore condition survey conducted on the subcatchment Jam Creek in 2000:

- The overall vegetation condition is in **B1 to C2** Grade.
- Approximately 80% of the foreshore is fenced, of this approximately 70% is in B grade condition.

See also Figure 6.4.

Gordon River

(Alvarez de Toledo, 2000c)

From the foreshore condition survey conducted on the subcatchment Gordon River in 2000:

- Approximately 75% of the are in **C2 to D2** Grade condition.

See also Figure 6.5.

6.4 Snapshot results

As part of the snapshot monitoring that was completed in May and June 2002, a foreshore survey was completed at each of the monitoring sites. The results of these are given below. This was also a preliminary search to establish reference sites for pristine foreshore condition so that continued monitoring could ascertain any degradation in foreshore condition.

	Site	**Side of the river surveyed**	**Foreshore condition**
Lower reaches	South Coast Hwy	left	A2
	Bridge Road	left	A2
	Caldyanup Crossing	left	A3
	Bevan Road Crossing	left	B1
	Myalgalup Pool	right	A2
	Muir Highway	left	A3
	Riversdale Bridge	left	B1
	Yeriminup Road Crossing	right	B2-B3
	Campup Pool	left	B1-B2
Upper reaches	Albany Highway	left	B2-B3
	Poonawirrup Pool	left	C1-C3

Figure 6.2. Foreshore survey of Walpole Inlet conducted in 1998

? For more information about foreshore condition surveys refer to the River Restoration reports and Water Notes published by the Department of Environment, particularly:

Water and Rivers Commission 1999, *Planning and Management: Foreshore condition assessment in farming areas of south-west Western Australia.* Water and Rivers Commission River Restoration Report No. RR3.

Water and Rivers Commission 2000, *Protecting riparian vegetation.* Water and Rivers Commission Water Notes WN10.

Water and Rivers Commission 2000, *Identifying the riparian zone.* Water and Rivers Commission Water Notes WN11.

Water and Rivers Commission 2000, *The values of the riparian zone.* Water and Rivers Commission Water Notes WN12.

Water and Rivers Commission 2002, *Long term management of riparian vegetation.* Water and Rivers Commission Water Notes WN29.

7 Demonstration sites in the Gordon-Frankland catchment

What are demonstration sites?

The Department of Environment has allocated grant assistance for river restoration demonstration projects in priority waterways across the South Coast region. Demonstration sites promote innovative rivercare techniques used within catchments and specific waterways. They provide an avenue to encourage feedback about Landcare works completed within catchments, and a site that can be continually monitored and evaluated. Demonstration sites educate landholders about waterway restoration practices and can highlight how river restoration works can be improved. By using different sites and different techniques, demonstration sites provide an avenue to assess what types of restoration works are effective across many situations.

The demonstration projects were selected by the Gordon Frankland Catchment Management Group and the Tambellup Land Conservation District Committee (LCDC) to address some of their main concerns with protecting their waterways. The projects also involved the shires of Tambellup and Cranbrook to encourage Local Government involvement in Landcare. In addition, these towns are part of the Rural Towns Program*; hence hydrogeological examinations of the catchment have been conducted to ensure the overall sustainability of the works.

Flood plain management – Gordon River

Many sections of the Gordon-Frankland River in the upper catchment are not fenced and the vegetation is generally C–D grade condition. The Gordon-Frankland River is not clearly defined and there are extensive flood plain areas adjacent to the main channel. This creates a potential problem when fencing the river, as floods spill out into the floodplain, often damaging the fences. Many landholders in this catchment had previously fenced the river, however many fences were destroyed in the 1982 flood event. The foreshore survey completed in 1997 identified these flood prone areas as a priority requiring extensive fencing and revegetation to protect the river.

Managing the flood paddock is critical to looking after the Gordon Frankland River. The ideal is fencing and revegetation with native species, however often the flood plain is a very productive part of the farm. Planting of perennial trees or commercial tree varieties is an option to help stabilise the flood plain during flood events, and to enable productive use of the floodplain.

Two demonstration projects were established adjacent to the river to promote flood plain management to protect the Gordon River.

Ken Schlueter

Ken Schlueter fenced part of the river on his property and is planning to plant commercial options for the adjoining flood plain. The section of the Gordon River on his property is braided and the channel moves in times of high flow, depositing large amounts of sediment in small dunes on one side of the channel. If a suitable commercial species can be identified to grow on the flood plain, it will have the double benefit of stabilising the channel at the same time as becoming productive land. The site will be monitored over time to examine the re-establishment of native vegetation, success with different commercial species and the condition of the fence after flooding. A fence of seven single wires has been installed to minimise trapping of vegetation during flood events.

The fence erected by Ken Schlueter. Note the wires, which will minimise the trapping of vegetation during floods (photo Kaylene Parker)

* *Department of Agriculture's Rural Towns Program (Rural Rescue Towns), an initiative of the State Salinity Strategy, was established in 1997 to aid communities in combating townsite salinity. This includes bore pumping and groundwater monitoring.*

Tammar Farm Enterprises

The Tammar Farm Enterprises, in cooperation with the Department of Environment and the Indigenous Land Corporation, successfully fenced and revegetated considerable sections of the river.

Currently, most of the river on the Tammar Farm property is fenced at a distance from the river suitable for adequate flood plain management. As a consequence establishment and revegetation of the riparian zone has already begun. In addition to the works already completed, Tammar Farm Enterprises has planned the revegetation of 16 ha of flood plane in salt affected areas. This is intended to provide a vegetative riparian corridor and help further reduce the impact of salt across the farm. They also plan to use tall wheat grass as perennial pasture for the salt affected areas.

Channel Restoration Gordon River – Nardlah

The landholder completed a channel desilting and drainage project on a major tributary of the Gordon River. The Department of Environment funded a small component of this project.

The site was showing signs of secondary salinisation and the landholder constructed approximately 7.8 km of 'surface' drainage. The drain ranged from 1–1.5 m in depth. The site was fenced and revegetated to help stabilise the creekline and increase water use in the lower landscape.

This project has reflected similar drainage activities conducted in other catchments. The maintenance of existing channels is a common problem in the upper tributaries of the Gordon-Frankland catchment due to sedimentation from unstable channel banks.

Monitoring the drain is critical to determine its success in ameliorating secondary salinity. Water flow from the drain was measured for a short period (Alan Seymour Department of Agriculture, WA pers. comm.). The flow levels after completion of the drain were very high, but have since decreased markedly. Sedimentation of the main channel is also a major problem, with the sides of the banks slumping and filling the main channel.

Since construction, the channel has been stabilised with samphire established in the channel and covering much of the bare eroded areas adjacent to the channel. Considerable numbers of trees (flooded gums) have also naturally regenerated. The area has also been fenced to exclude stock access. The long-term success of the drain still needs to be monitored. If success is achieved it would meet the landholders main objective of minimising the further spread of the salt and regaining pasture productivity in adjacent salt affected land.

Site inspection of Nardlah before works were started in 1998 (photo Kaylene Parker)

The same site in 2002, post works showing the constructed drainage and the return of vegetation (photo Catherine MacCallum)

Revegetation of Pinjalup Creek – Cranbrook townsite

The Shire of Cranbrook has been identified as a rural rescue town and the Department of Agriculture, WA has conducted a detailed hydrogeological examination of the town site. Pinjalup Creek was identified as an area requiring surface drainage to minimise waterlogging and revegetation to lower the groundwater levels, stabilise banks and provide Pinjalup Creek with a buffer from the adjacent landuses. The Department of Environment funded the revegetation of Pinjalup Creek with native species adjacent to the main town.

Gordon River Restoration Project – Tambellup Town Pool

The Shire of Tambellup has constructed a pool on the Jam Creek tributary of the Gordon River near the Town of Tambellup. The Gordon River Restoration Project created a river pool with an island as a bird habitat. The project helped fund the construction of bird hides to encourage the local community to view the birds and gain an appreciation of the natural resources of their area.

For more information about demonstration sites refer to the Water Notes published by the Department of Environment, particularly:

Water and Rivers Commission 2002, *Demonstration sites of the waterways restoration in WA*. Water and Rivers Commission Water Note WN27.

Water and Rivers Commission 2002, *Monitoring and evaluating river restoration works*. Water and Rivers Commission Water Note WN28.

8 Community action and vision

This section summarises restoration and rehabilitation works carried out in the subcatchments. The different projects and the funds allocated to these groups are outlined in Appendix Two. The outputs from the RCA (Rapid Catchment Appraisal) process conducted by the Department of Agriculture WA is outlined – as well as some of the subcatchments that have also been involved. Following is a description of the community visions and values of the Gordon-Frankland catchment that have been captured by previous community liaison.

8.1 Subcatchments

There are 19 recognised subcatchments located within the Gordon-Frankland catchment:

- Wadjekanup
- Jam Creek
- Pindellup
- Gordon River
- Peringillup
- Pinjalup Creek
- Towerlup
- Upper Slab Hut Gully
- Lower Slab Hut Gully
- Peter Valley
- Ryans Brook
- Geekabee
- 18 Mile Creek
- Central Frankland
- Nardarup Creek
- Bokerup/Bolbellup Swamp
- Rocky Gully West
- Rocky Gully East
- Quindabellup

Some of the subcatchments have changed names over time. Each of the subcatchments has varying degrees of activity, with some involved in fencing, revegetation, groundwater monitoring, drainage and weed mapping. Appendix Two details the status of each subcatchment in regards to environmental condition, community input and funding allocation. Kelly Hill (Catchment Support Officer for the Kent Frankland sub-region) compiled the information using summaries of the catchment groups activities. The following subcatchment maps (Figures 8.2 – 8.16) show planned fencing and revegetation works. These maps also include the cadastre and some major roads to enable the easy location of individual properties. They were used in one of the Natural Heritage Trust funding applications and more fencing and revegetation has since been completed.

8.2 Rapid Catchment Appraisal (RCA)

Adapted from the Department of Agriculture, WA website. Rapid Catchment Appraisal (RCA) is a regionally-based approach for the delivery of information regarding salinity management to landholders. The approach emphasises Statewide coordination with delivery through regional catchment support teams comprising farming systems specialists, hydrologists, soils officers, spatial resource information specialists, revegetation specialists and local community support officers. The aim is to provide all landholders with access to the best available information for salinity management by 2005 and to establish a framework to enable on-going information access.

Priority actions will provide landholders in agricultural catchments, at risk from dryland salinity, with an assessment of the level of risk to their natural assets and the potential impact on and off-site. Final reports will be produced and summary sheets will cover key points. Information will be presented concerning:

- the assessment of risks to natural resources (soils, water, & vegetation) and options for managing those risks;
- links with regional and local strategies to provide the best chance for informed salinity management;
- technical information such as the latest interpretation of satellite images and analysis of agencies data using computer modelling tools; and
- results from computer modelling.

In 2001, a RCA report was completed for the South Broomehill Gnowangerup Area. This area covered some of the northern subcatchments of the Gordon-Frankland catchment. These subcatchments were grouped together with the Gnowangerup Area due to similar attributes within the area (eg. soil characteristics). However, the information in this report relates to the Pallinup River as the majority of the area is within the Pallinup catchment.

An RCA report has been written and compiled for the Gordon-Frankland Area, which covers all the subcatchments in the Gordon Frankland catchment, excluding those already in the South Broomehill Gnowangerup RCA report.


For more information contact the Department of Agriculture, WA or visit their website.

8.3 Projects

The projects listed below are an example of those that have been implemented within the Gordon-Frankland catchment. There are however, many more projects that have been implemented across the catchment.

1) Upper Frankland Gordon River Catchment Rehabilitation Project & Extension Project

1999–2001 Initial project

This is a very large project that has received over $650 000 from the Natural Heritage Trust (NHT) funds. The Frankland Gordon Catchment Management Group initiated the project. The project tackles the following four major issues across the upper catchment:

1. The loss of biodiversity in the catchment through increasing awareness and coordinating large-scale protection and re-establishment of local native vegetation.
2. Reducing the degradation of the Frankland-Gordon River through fencing and rehabilitating major tributaries.
3. Increasing the uptake of sustainable farming by promoting new and successful production initiative.
4. The implementation of works to reduce groundwater recharge and the spread of dryland salinity.

There are 79 participating landholders taking part in fencing, direct seeding, planting seedlings, awareness raising on biodiversity issues within the catchment, smoke water trials, monitoring and exploring sustainable farming practices. The project involves fencing 349.2 km enclosing 3703 ha of riparian and other strategic areas (including covenants and other managed areas) and revegetating 635 ha of land (including riparian land).

2001–2002 Extension Project

The second stage of funding was a grant for an extension of the initial project. The major aim of this project was to protect and restore headwater tributaries of the Upper Gordon-Frankland riverine ecosystem through revegetation, erosion control and stabilisation. A Green Corp team worked on some of the fencing and revegetation.

The work in this second stage will improve water quality and the ecological health of the main Frankland-Gordon River system. It involves approximately 78 farming families, construction of over 350 km of fencing, revegetating approximately 400 ha and protecting over 2500 ha of remnant vegetation and more than 150 km of waterways.

2) Planning and management strategies for Walpole & Nornalup Inlet systems

This project was a 1997/1998 NHT funded project proposed by WANISAC (Walpole and Nornalup Inlet Systems Advisory Committee). There were several components to this strategic project:

1. Community monitoring of the Inlets using piezometers, this section was combined with a Coastcare grant.
2. Production of an Action Plan, the consultancy group Ecotones has produced six individual reports covering data sources, community views and actions. More information is provided in the *Estuary* section of this compendium. The reports included:
   - Data Sources Report;
   - Issues and stakeholder views report;
   - Regional assessment of the ecological health of Walpole-Nornalup Inlet;
   - Management action report;
   - Funding options report; and
   - Action plan for the Walpole and Nornalup Inlets and catchments.
3. Production of a storm water management plan for the Town of Walpole.

3) Siphon Assisted Relief Wells

The Gordon River subcatchment group has been successful in attracting funding from NHT and the State Salinity Council for research and implementation of the use of siphon assisted relief wells as another tool for minimising the impacts of salinity. There are 3 projects in total.

8.4 Community values and visions

Ecotones & Associates (2000a) conducted community consultation to assess the current community concerns about the catchment for the Walpole-Nornalup Inlet Action Plan (written for WANISAC). There were several outcomes from this process; major themes were identified form community interviews, key community issues, threatening processes and actions to alleviate the problems. As many of the issues raised concern the whole catchment, not just the WANISAC area, they are included in the compendium. Figure 8.1 summarises the main issues raised as result of this report.

Community Consultation

The community was consulted to identify their concerns and a list of stakeholders formed. Consultation was completed using a variety of strategies that targeted different stakeholders. These were:

- Liaison with key groups such as WANISAC, local authorities and state agencies including the Ministry of Planning, the Department of Environment, the Department of Conservation and Land Management and Department of Agriculture, WA;
- Interviews with other interest groups, State government representatives, other agencies, farmers and community groups; and
- A public workshop held at the Department of Conservation and Land Management office in Walpole for the wider community.

In the interviews the respondents were asked questions to determine:

- Their assessment of the principle concerns or issues in the study area;
- Main geographical areas where these issues or concerns were (if any); and
- What actions they felt were necessary to address the concerns or issues.

The information was recorded during interviews or meetings and accounts made of all issues, where Ecotones & Associates grouped these into a number of major themes.

Major themes

The major themes from the interviews are represented in Table 8.1.

Table 8.1. Summary of major themes from interviews [modified from Ecotones and Associates (2000a)]

Theme	Major concern	% response
Preserve the inlets' naturalness	Preserve the inlets and surrounds in their current or better condition.	38
Waterways protection	Avoiding environmental degradation/damage to waterways (including more monitoring).	22
Catchment management	Ensuring good management in the catchment, including planning and strategic liaison, and impacts of catchment downstream.	16
Land degradation	Land degradation in the upper catchment, especially salinity/waterlogging	8
Other themes	Included: fire management, management of boating use, aboriginal interests, aquaculture and tourism industries.	16

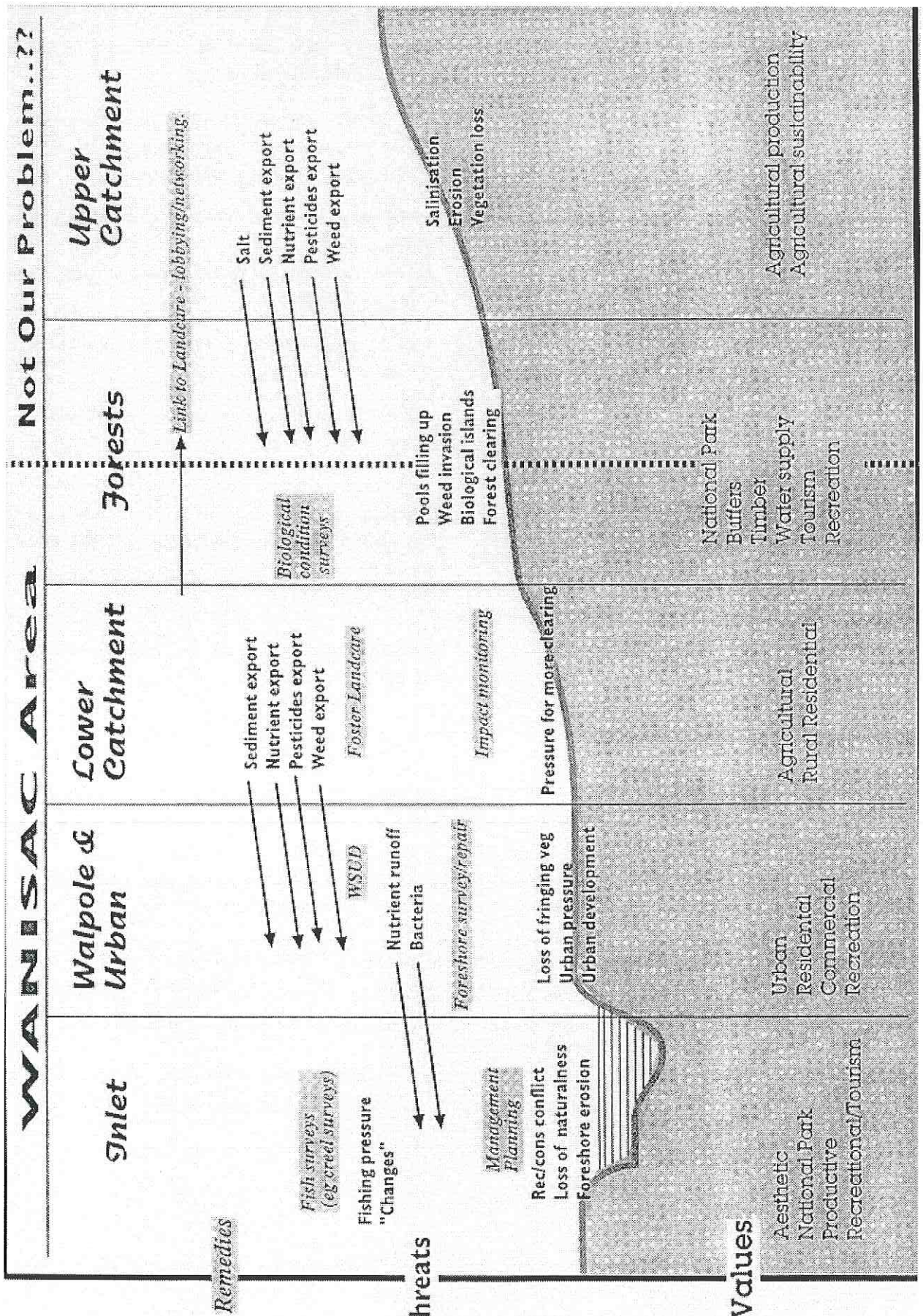


Figure 8.1. Values, threats and actions for the WANISAC area (Ecotones & Associates, 2000a)

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Appendix I
Walpole-Nornalup Inlets sampling program

Latest Update: September 2002 – Boardmen (2002)

Source data

Walpole and Nornalup Inlets were added to the Water and Rivers Commission's recently initiated sampling program for estuaries on the South Coat at the beginning of 1999. As such the Inlets have been sampled 14 times between January 1999 and August 2002. The data captures four summer periods, three early autumn periods, three winter periods and a spring period.

Background

The catchment of the Walpole-Nornalup estuarine system is poorly defined, especially in its northern reaches where there are areas of internal drainage that only flow to the coast in years of particularly high rainfall. The main rivers are the Frankland-Gordon, the Deep and the Walpole with approximate lengths of 400 km, 120 km and 20 km respectively. The catchment area is approximately 5990 km^2, except in high flow years when the catchment area is up to 2100 km^2 larger as areas of normally internal drainage contribute.

Mean annual rainfall at the coast is about 1300 mm decreasing to about 500 mm at the inland boundary of the catchment. Rainfall occurs predominantly in winter with summer storms that occur in some years capable of delivering a significant proportion of the annual total. The estimated mean annual flow to the estuary is about 390 000 ML (i.e. ten times the estuarine volume, which is more than any other south coast estuary) with 80% of that in the months June to October and negligible summer flow. About 40% of the flow comes from the Deep River and about 45% from the Frankland. There is significant interannual variation with up to 5 times the mean flow in a wet year and less than a third in a dry year. There has been a decrease in mean annual rainfall at the coast over some 200 mm in the last half century.

Eight monitoring sites have been established in the Walpole-Nornalup Inlet. Sites WN01 and WN02 are located in Walpole Inlet, site WN03 is located in the channel between Walpole and Nornalup. Site WN04 is located in the centre of Nornalup Inlet, sites WN05 and WN06 are located in Nornalup Inlet offshore of the Deep and Frankland river deltas respectively. Site WN07 is located in Nornalup Inlet just offshore of the flood tide delta and site WN08 is located in the ocean channel.

At each site profiles of dissolved oxygen, temperature and salinity are recorded at 0.5 metre intervals from the surface to the bottom using a Hydrolab H_2O instrument. Surface and bottom water samples are collected at selected sites and analysed for total nitrogen (TN) and total phosphorous (TP), chlorophyll pigments (chlorophylls a, b, c and phaeophytin), water colour and dissolved fractions of nitrogen and phosphorous (after 0.45 µm filtration): ammonium (NH_4-N), nitrate/nitrite (NO_x-N), filterable reactive phosphorus (FRP). Samples are also collected to identify the species of phytoplankton present.

River flow

Flows are tabulated below (Gigalitres per annum) for the main gauging stations in the catchment. Several hundred square kilometres of the lower catchment are ungauged.

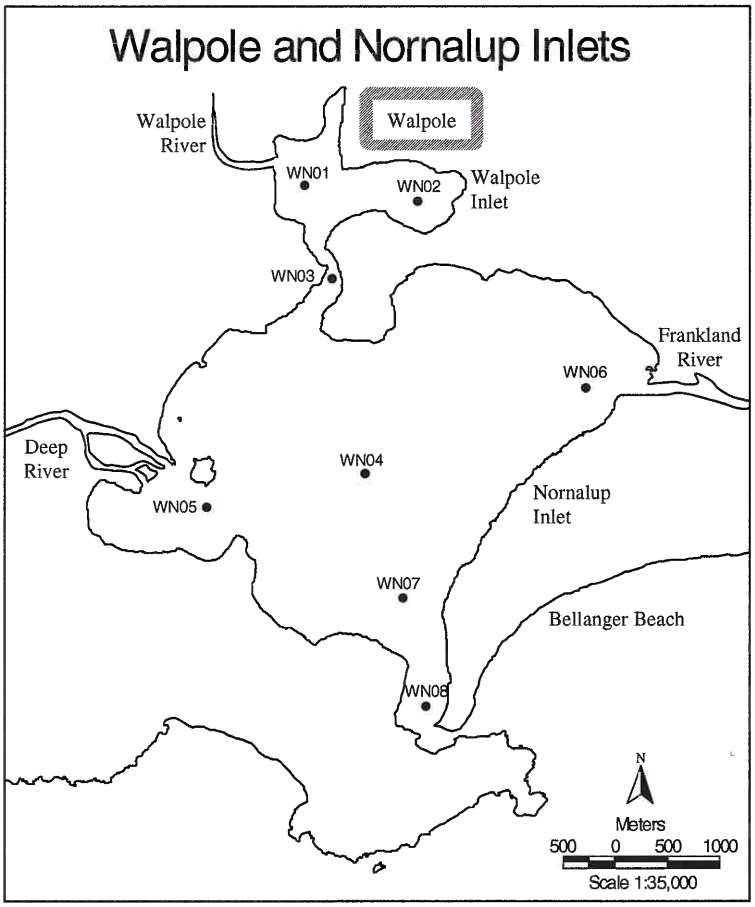
Year	Deep River (GL/a)	Weld River (GL/a)	Frankland River (GL/a)	Total (GL)
1998	40	30	190	260
1999	60	60	180	300
2000	30	40	140	210
2001	10	20	60	90

In addition to these gauged flows there are probably about another 50 Gigalitres per year in rainfall directly on the Inlet and from the ungauged catchment.

Flows in each of 1999, 2000 and 2001 were below the estimated long-term average. Specifically, the flow in 1999 was just below average, in 2000 it was quite a bit below average, while the flow in 2001, in particular, was significantly below average (average being about 390 Gigalitres).

Sand bar

The sand bar at the mouth of Nornalup Inlet is open throughout the year. However it is usually much shallower in the late summer months than in winter or spring. There were anecdotal reports that the sand bar at the mouth of the Inlet came very close to completely shoaling in late summer 2001; possibly the closest the Inlet has come to closing in recent years.

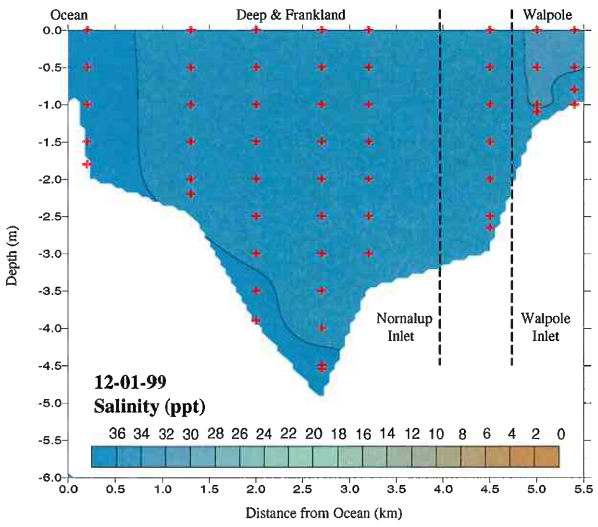


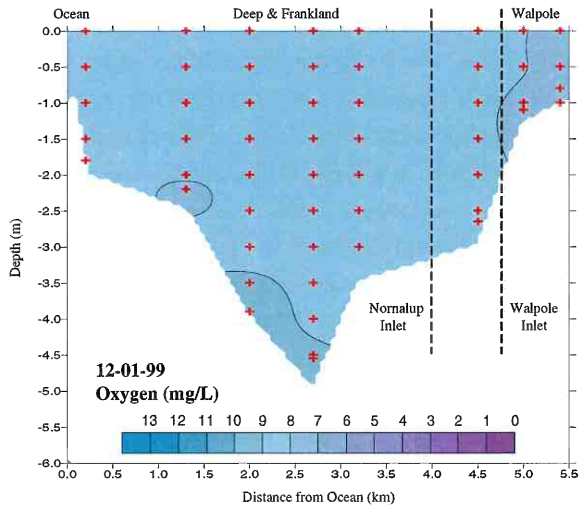
Salinity and dissolved oxygen

During the sampling program of approximately 3.5 years, the salinity of waters in the Inlets ranged from 36 ppt (essentially seawater salinity) down to less than 4 ppt. The maximum salinities were recorded in March when the Inlets were completely mixed and fully flushed with seawater. By July the situation had usually changed dramatically with strong vertical stratification present as fresh waters from the rivers poured into the Inlets, flushing Walpole Inlet and forming a buoyant plume over the seawater lying in Nornalup Inlet.

The following are cross sectional plots of CTD data through Walpole and Nornalup Inlets. The ocean is on the left hand side of the plots, Nornalup Inlet and Walpole Inlets are delineated with dotted lines, the Deep and Frankland rivers enter Nornalup Inlet in the middle of the plots and the Walpole River enters Walpole Inlet on the right of the plots.

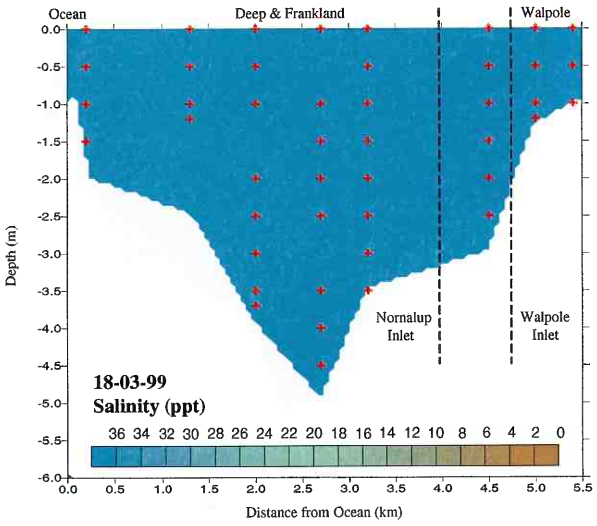
Summer 1999:

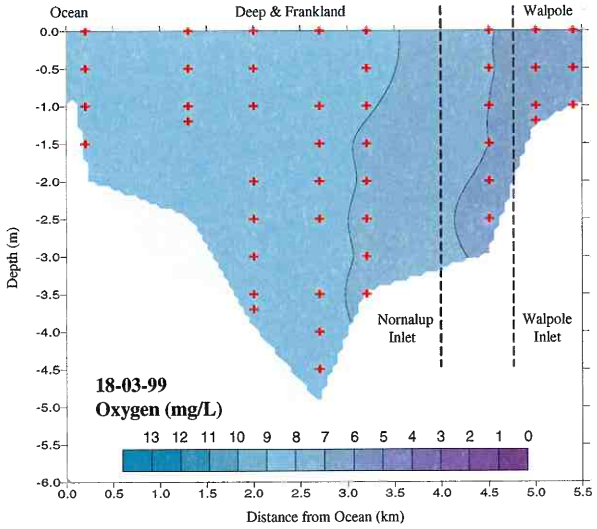




At this time of year there were no discernible effects of river flow on the Inlets. There was a slight horizontal gradient in salinity (4 ppt) from the ocean to Walpole Inlet with some intrusion of ocean water occurring but for the most part the Inlets were very well mixed. The average salinity of the system was just below that of seawater indicating that both seawater intrusion and mixing had been active. The maximum water temperatures were measured at this time (just over 24°C at the surface in Walpole Inlet and at site WN07).

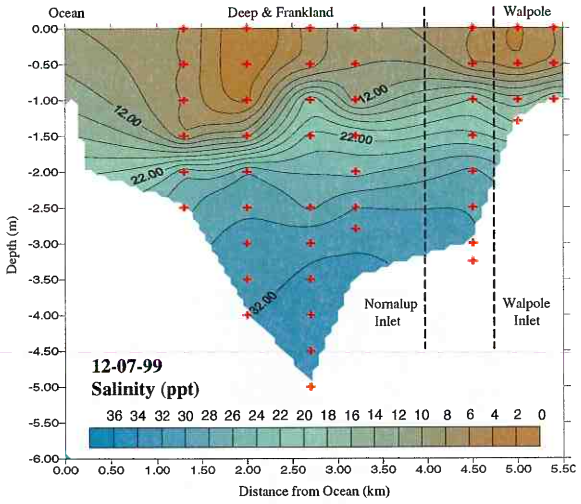
Late Summer 1999:

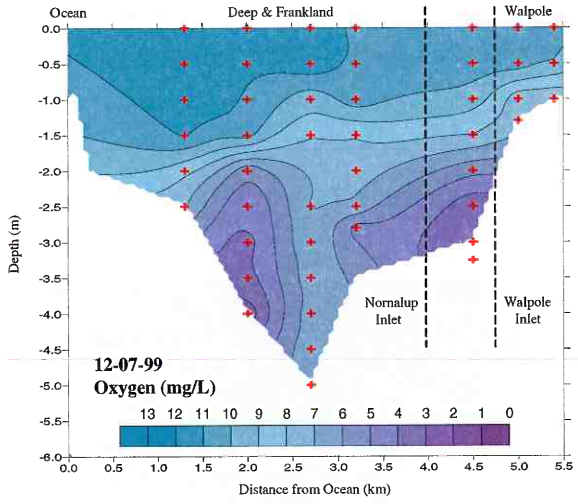




At this time of year there were no discernible effects of river flow on the Inlets. The system was completely mixed with a salinity equivalent to that of seawater. This indicates that there had been little recent freshwater input and active seawater intrusion. The water temperature in Walpole was about 1°C higher than in Nornalup, probably due to its shallower depth, and the lower dissolved oxygen concentrations in Walpole were probably a result of that warmer temperature.

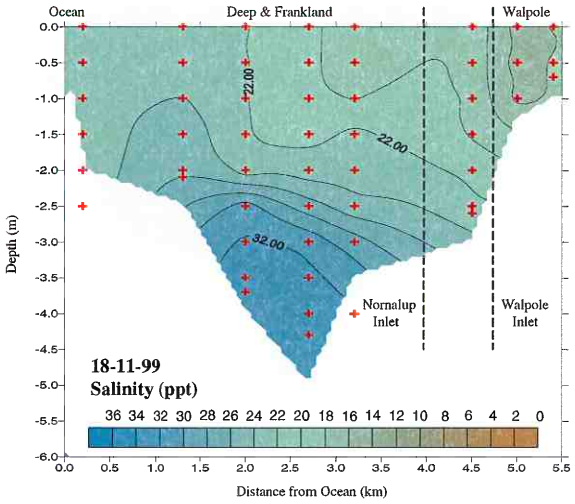
Winter 1999:

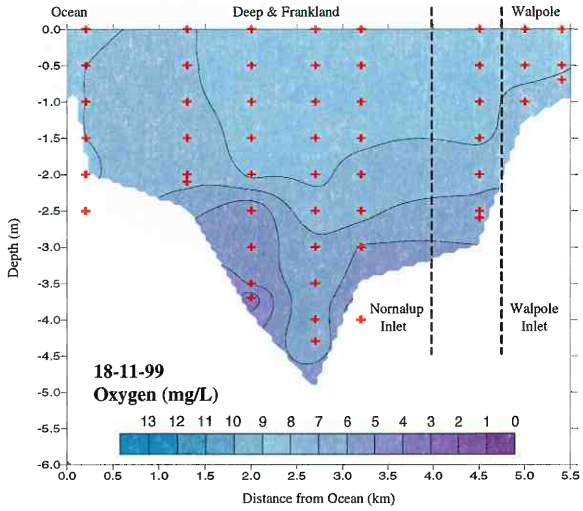




At this time of year there were very strong inflows of freshwater from all three rivers resulting in a buoyant plume of freshwater over the Inlets. Consequently the system was relatively strongly stratified, the freshwater surface layer was about 1–1.5 m deep and the saline water bottom layer was about 2 m in depth through Nornalup Inlet. A freshwater surface layer of that depth was probably completely blocking the inflow of seawater from the ocean over the shallow sill formed by the flood tide delta, so that the saline water layer in the basin of Nornalup Inlet was completely isolated. Walpole Inlet was almost completely flushed with freshwater. Although deoxygenated, the saline bottom layer in Nornalup was not anoxic (operationally defined as <0.2 mg/L and roughly the point where you would expect significant nutrient fluxes from bottom sediments to begin and the denitrification cycle to shut down) at the time of sampling. The saline layer may have become anoxic at a later time. However, because the layer was quite thick (approximately 2 m in depth), it therefore had considerable volume in the reasonably flat bottom contour of Nornalup Inlet. This suggests that it would have taken a lot longer for it to deoxygenate and become anoxic compared with the thin layers of salt water that occur in Wilson Inlet. Furthermore the salinity of the bottom layer was at most 32 ppt, a decrease from the 36 ppt seen in late summer. This indicates that there has been some mixing of the overlying fresh water into the saline bottom waters, with a consequent mixing of dissolved oxygen also into those bottom waters. The major mechanism of mixing is probably wind rather than processes like convection or entrainment on the interface of the inflowing river water and the more quiescent estuarine waters. The highly oxygenated waters at the surface were associated with cold water temperatures (just over 12°C to about 14°C).

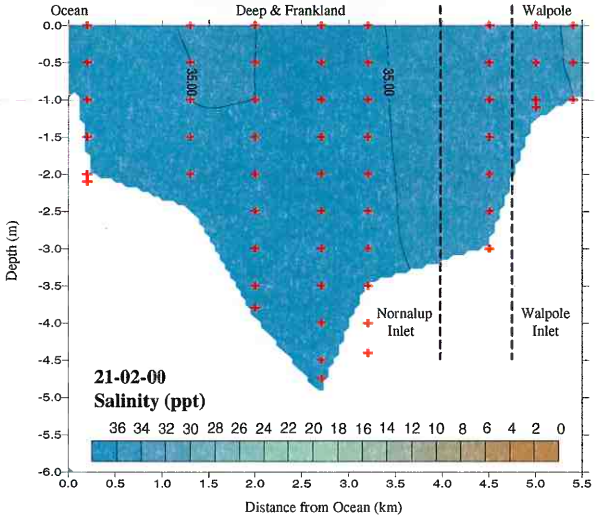
Early Summer 1999:

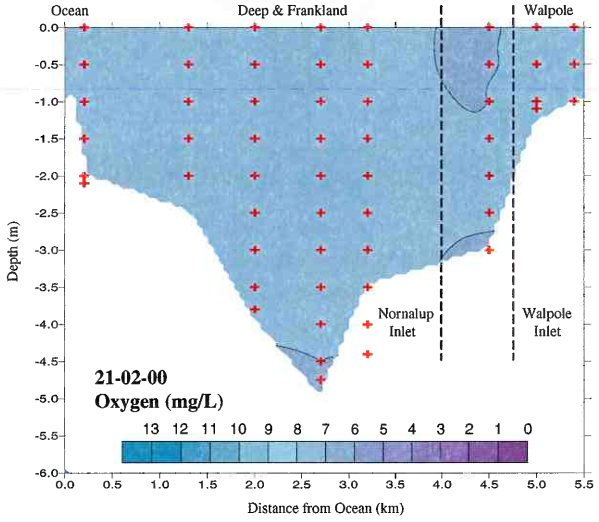




At this time of year some inflow of freshwater from the rivers was still occurring but a lot less than in July. Stratification was still present in Nornalup Inlet but much weaker than in July, deoxygenation in the saline bottom layer was also less than July. The maximum salinity was still slightly less than seawater, but the minimum salinity was now much saltier (16ppt) than the freshwater expected from the rivers so there is clearly active mixing between the more saline estuarine waters and the fresh river flow occurring. Walpole Inlet was on average fresher than Nornalup, probably due to the greater distance from the ocean.

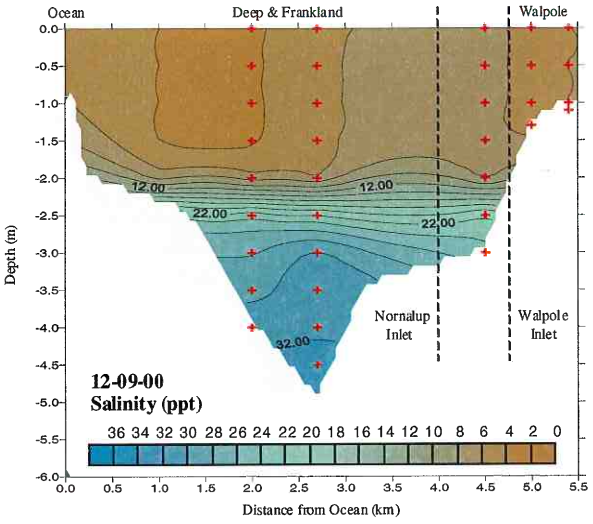
Late Summer 2000:

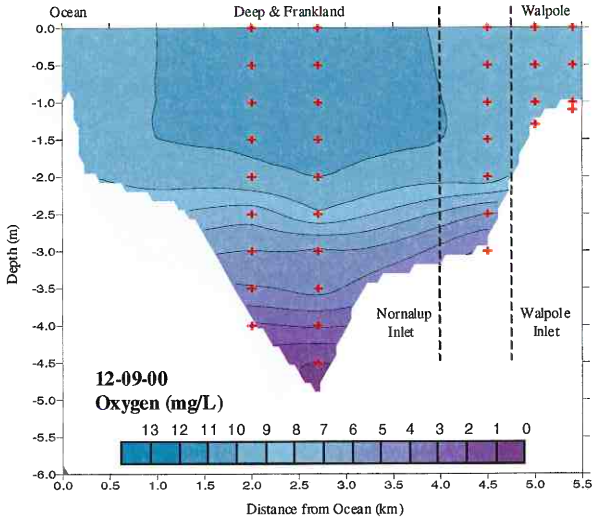




At this time of year the situation is similar to late summer 1999, the system has almost returned to a state of being completely marine.

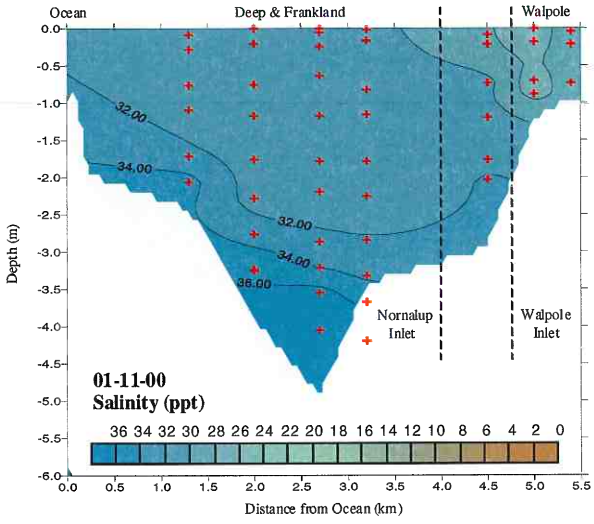
Spring 2000:

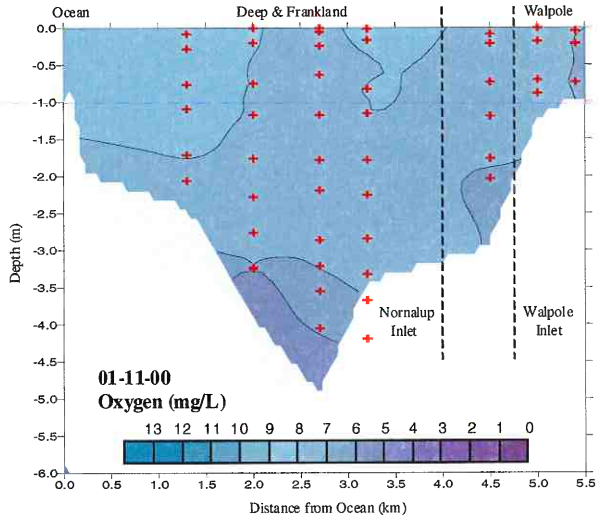




There is no winter data set for 2000. Although this spring data set is probably similar to what may be expected in winter with strong flow from the tributaries and a strong vertical stratification. Note that the upper 2 m of the water column is well mixed vertically and those isohalines present are vertical – there was very active mixing at the time of sampling with strong winds and the sampling had to abandoned before all sites could be tested. As in the winter of 2000 the dissolved oxygen concentration in the deep of Nornalup Inlet is very low, once again a function of the stratification.

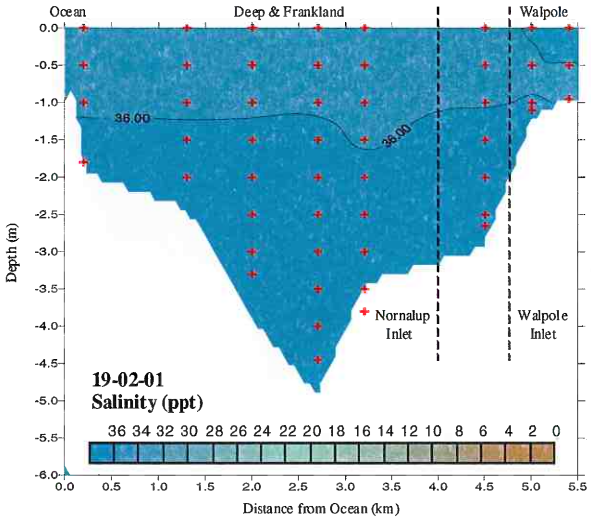
Early Summer 2000:

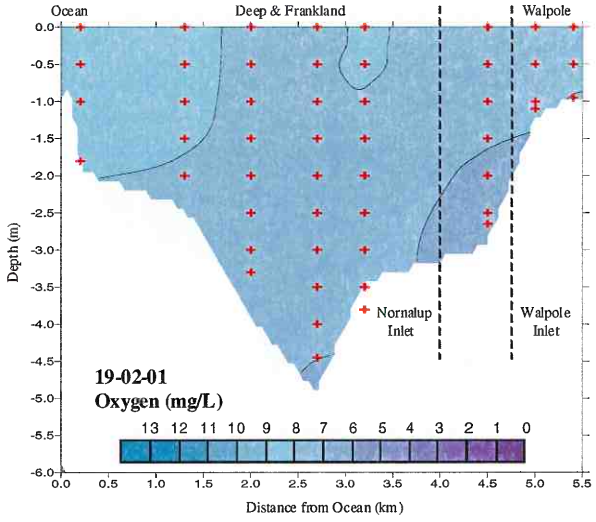




The early summer of 2000 was much more marine than that of 1999. This is probably a reflection of the smaller volume of fresh water flow to the Inlet and the earlier slowing of runoff from the catchment than in 1999. Broadly speaking slightly depressed dissolved oxygen levels track the salinity stratification.

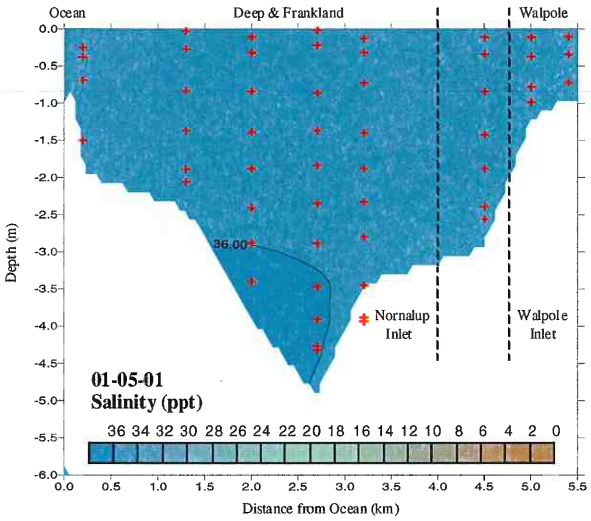
Late Summer 2001:

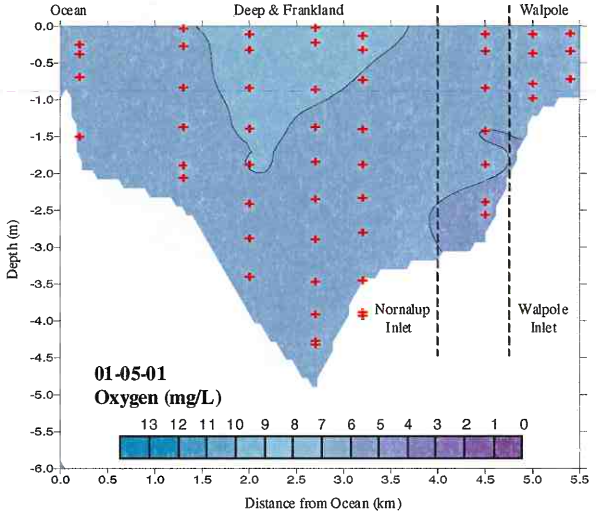




As in the previous summer the Inlet is largely marine in nature.

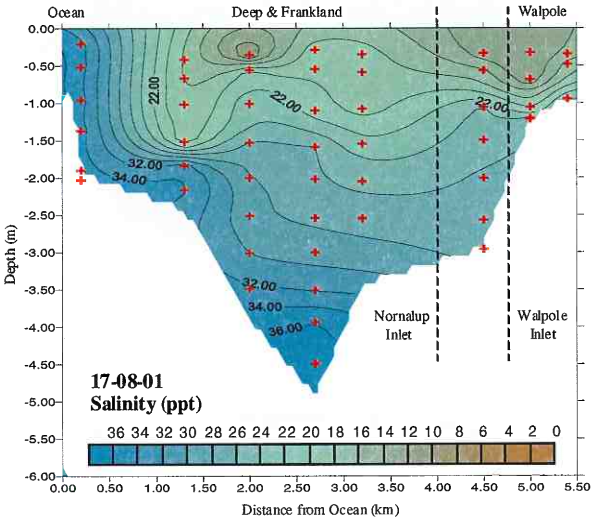
Autumn 2001:

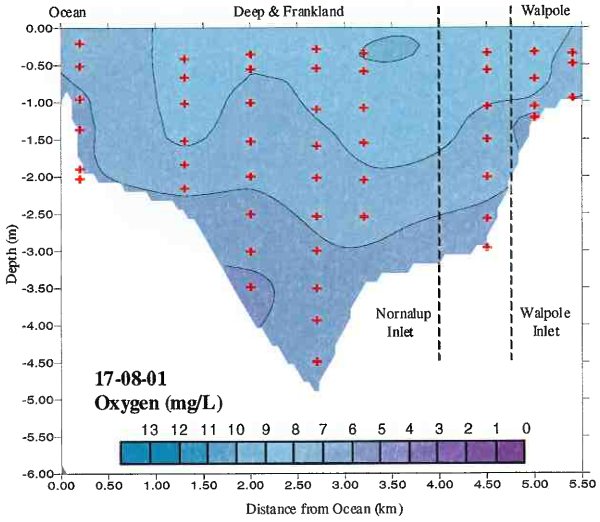




In mid to late autumn there is still no evidence of freshwater runoff. Moderately depressed dissolved oxygen concentrations reflect the still relatively high water temperatures.

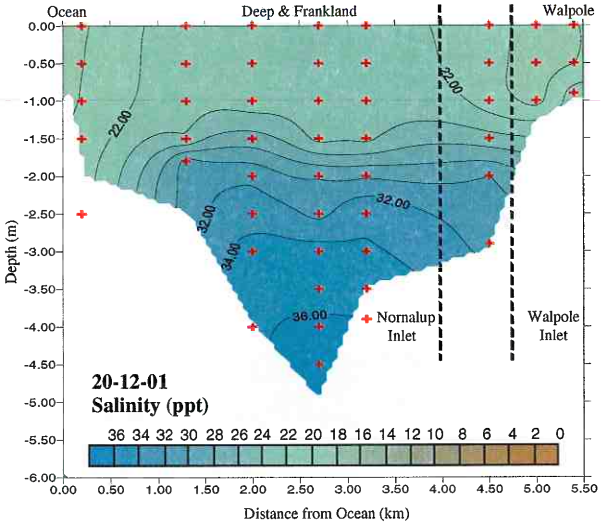
Winter 2001:

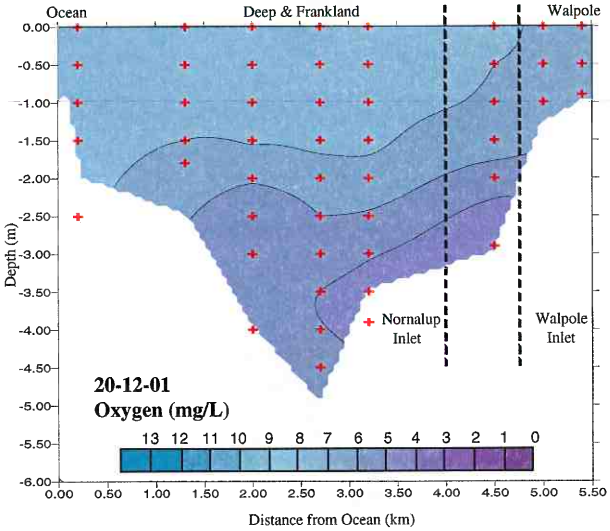




There was clearly an effect of inflow with depressed salinities in surface waters adjacent to river mouths. The Inlet was more saline than in 2000 or 1999 at this time of year though, probably reflecting the lower river flow. Again depressed oxygen concentrations broadly reflected stratification and salinity.

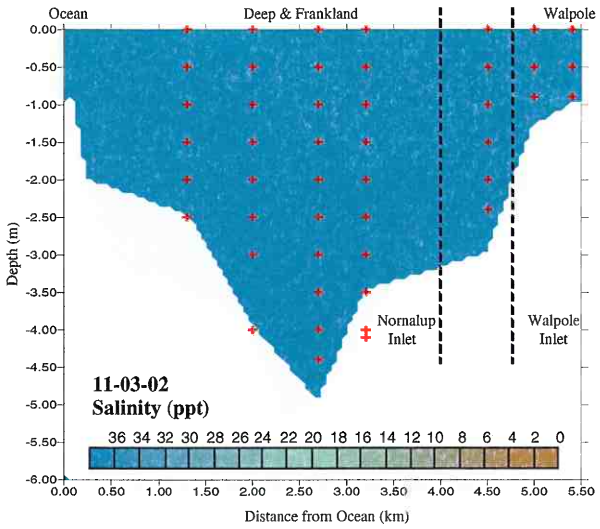
Summer 2001:

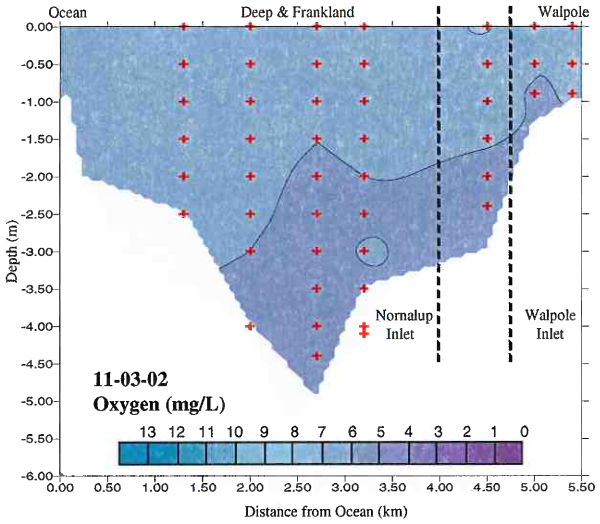




Appears to be slightly more fresh water in the Inlet at this time of year compared to previous years (this was because the majority of runoff in 2001 was much later in the year than it had been in previous years). Again depressed oxygen concentrations broadly reflected stratification and salinity.

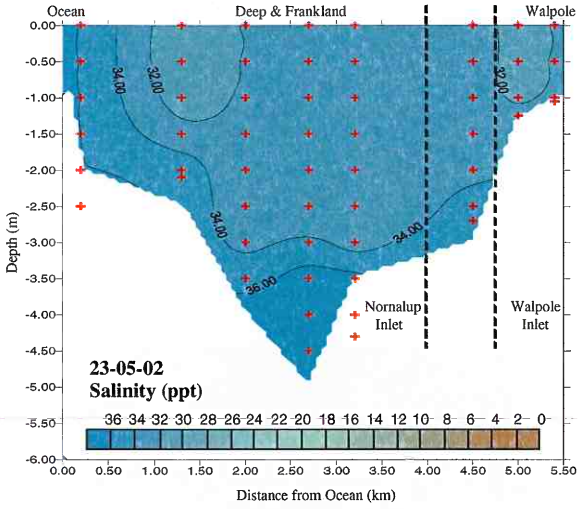
Late Summer 2002:

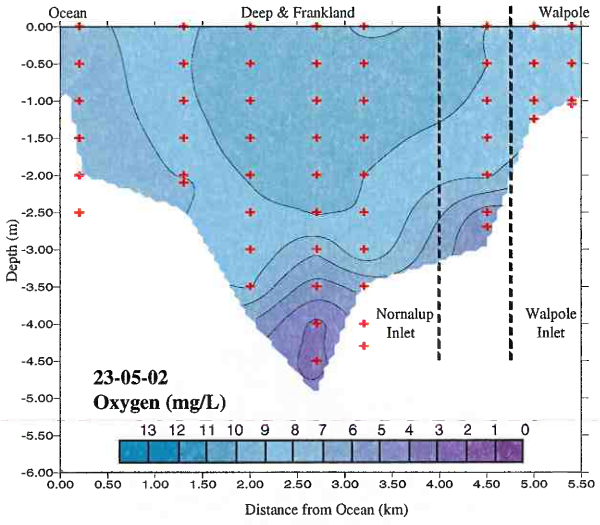




As in previous late summer periods, the Inlet appears to be completely flushed with marine water.

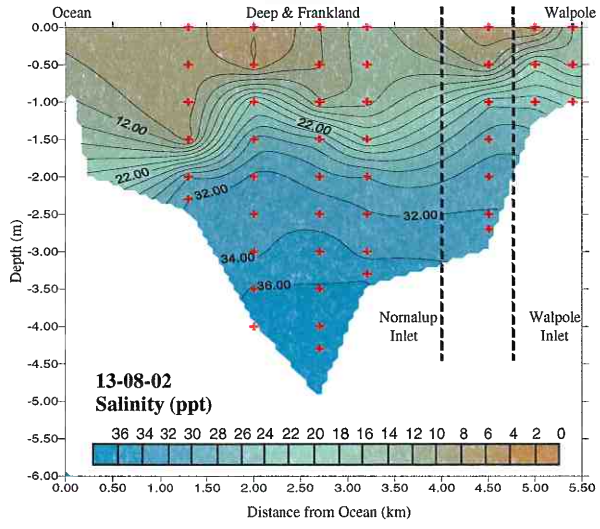
Autumn 2002:

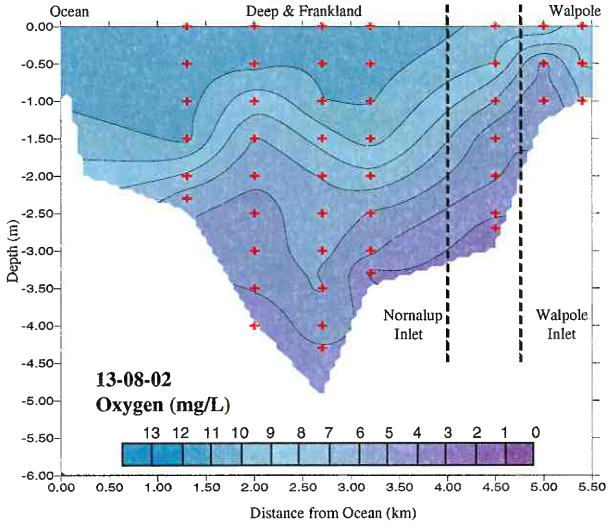




Freshwater appears to be mixing into the Inlet.

Winter 2002:

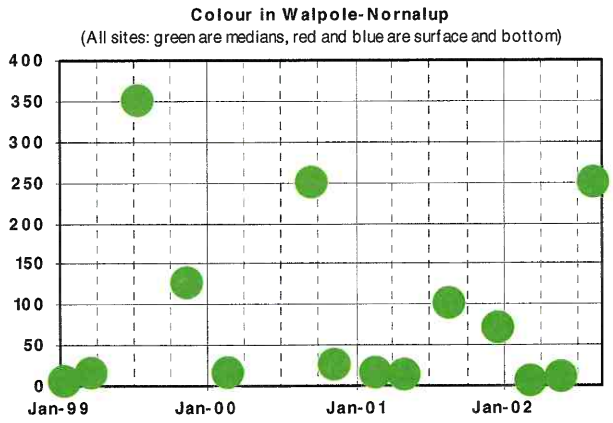




Nutrients, Chlorophyll and Water Colour

Water Colour

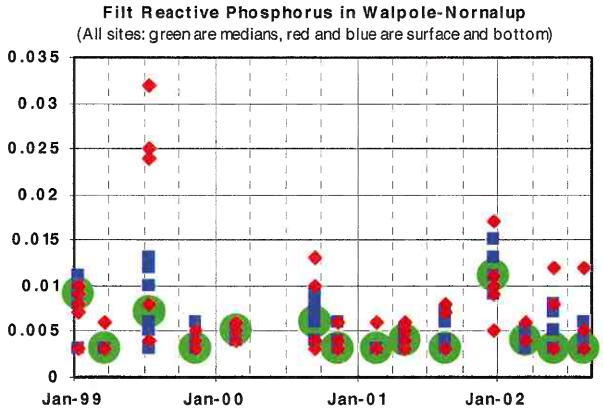
The water colour measured in the Inlet (against platinum-cobalt standards or 'pcu') ranged from an almost clear 5 pcu in summer, when the system contained seawater, to a very dark 400 pcu (i.e. tea coloured) in mid-winter when the surface waters of the system consisted of highly tannin stained freshwater runoff. The colour of the water in each year roughly reflected the volume of freshwater flow from the catchment.

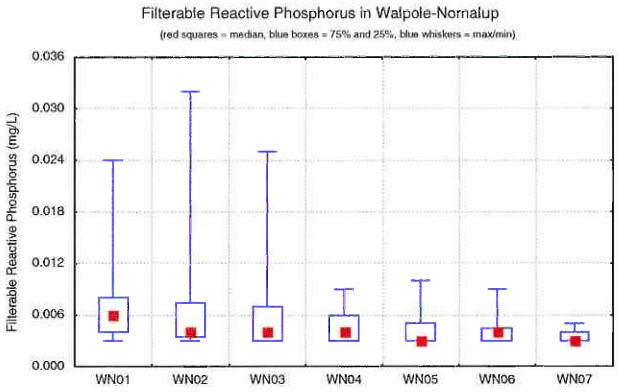


Nutrients

All of the nutrient concentrations measured in the inlets showed a seasonal response, except for the total phosphorus concentrations which were fairly constant throughout the year and for the most part, relatively low compared to most other south coast inlets at less than 50 µg/L on average. The load of nutrients delivered in 2001 and 2002 appears to be somewhat less than in 1999. It is difficult to compare the data that we have with 2000. Walpole Inlet consistently recorded higher nutrient concentrations than Nornalup, probably related to reduced flushing and increased re-suspension from the shallower bottom.

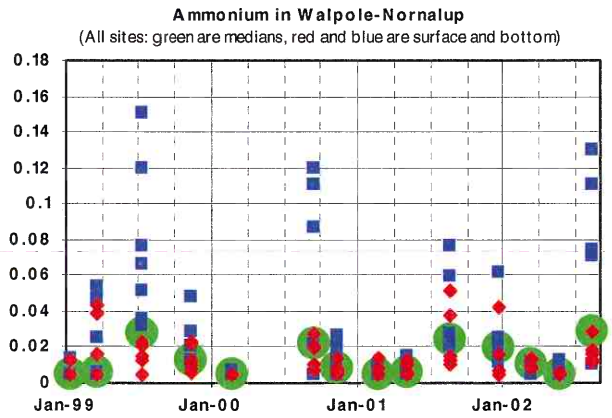
Filterable Reactive Phosphorus

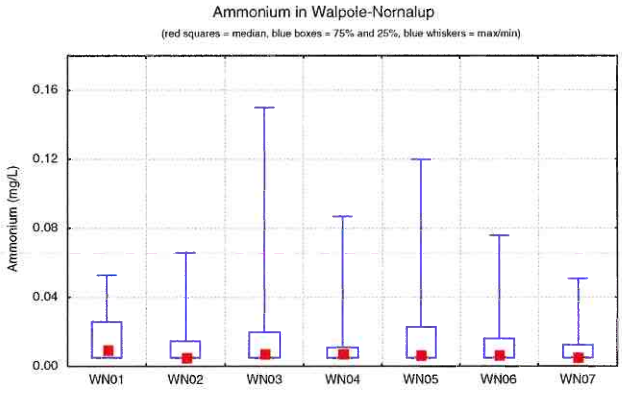




The filterable reactive phosphorus was relatively low with a range for most of the year between the detection limit and about 10µg/L. With the advent of freshwater inflows in winter, concentrations in excess of 10µg/L were measured in surface waters. Concentrations tend to be higher in Walpole Inlet, possibly due to less flushing of Walpole or maybe some wind stirring of bottom sediments in the shallow depths.

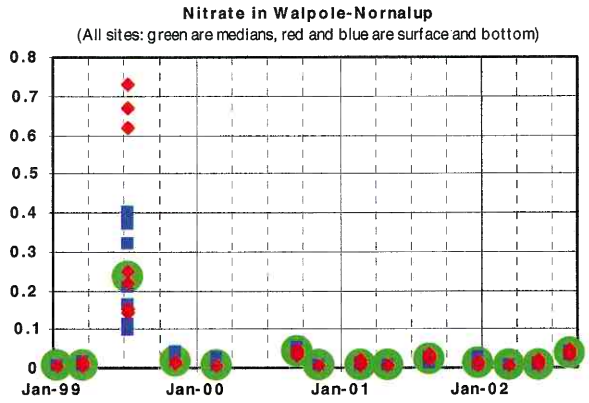
Total Phosphorus

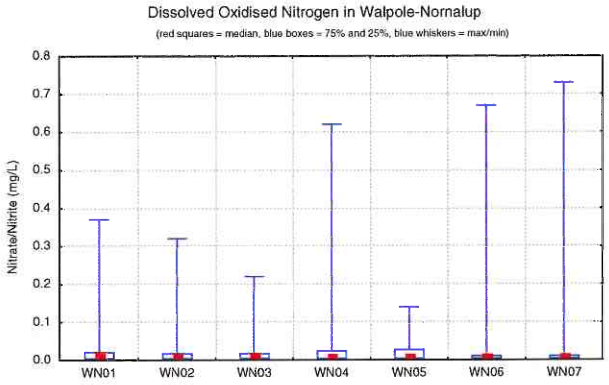




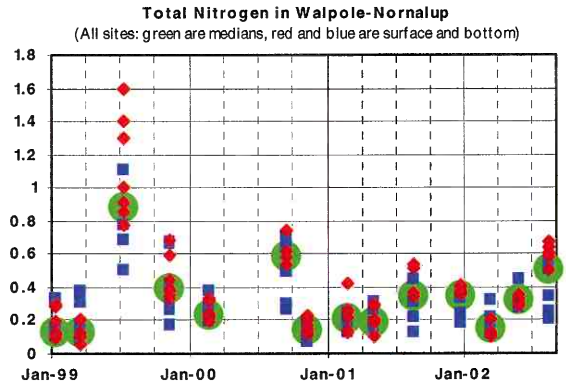
Total phosphorus was reasonably low, but interestingly does not have a strongly seasonal response as might be expected – especially given that there is a seasonal response in the filterable reactive phosphorus. Although a large increase in total phosphorus in winter with particulates from river flow might be expected this may not occur because there is limited phosphorus associated with any particulates/suspended sediments flowing into the Inlet – or perhaps because the sites aren't capturing any particulates/suspended sediments. Bear in mind that the values are quite small compared to the detection and analytic limits making it difficult to see any obvious pattern against the probable noise in the method. Walpole appears to have reliably higher concentrations than Nornalup.

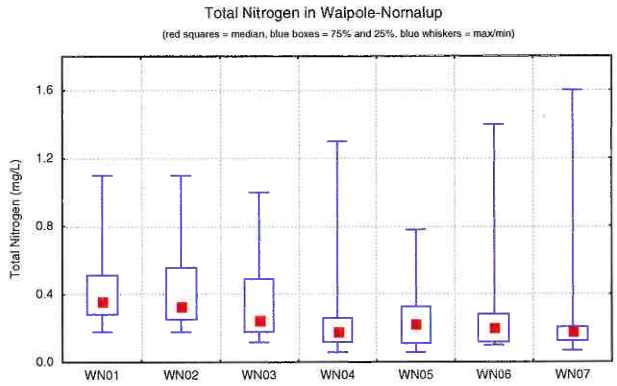
Ammonium





Nitrate

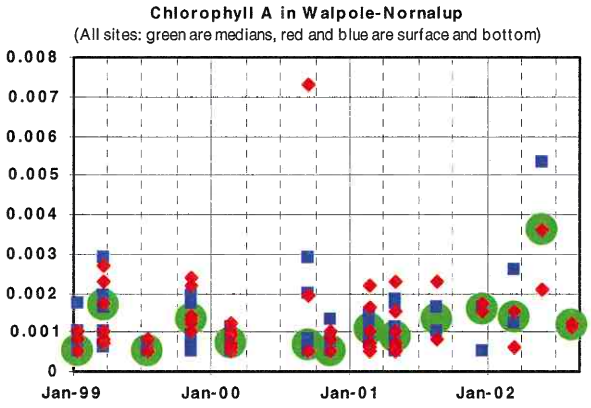


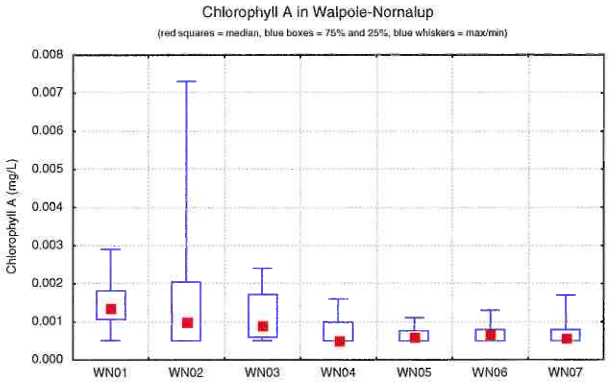


The dissolved inorganic nitrogen (ammonium and nitrate) concentrations were at a maximum in winter with the highest concentrations in surface waters associated with river inflows. In mid-winter and early summer most of the dissolved inorganic nitrogen consisted of nitrate. Through summer concentrations of ammonium and nitrate were very low, however by late summer some ammonium was present in the water column, possibly representing a small amount of regeneration from the sediments. The winter concentrations in 1999, at 100 µg/L to about 750 µg/L, were very high but the majority of this material probably flushed through the Inlets out to sea. Interestingly there was very little measured nitrate in the 2001 and 2002 winters compared with 1999, and there was proportionately more ammonium. This may be a reflection of the different flow patterns for those years.

The ratios of dissolved inorganic nitrogen to dissolved inorganic phosphorus demonstrated a strong seasonal pattern. Ratios ranged from an average of about 5:1 in the summer periods through to 100:1 in mid-winter. These ratios suggest that in summer the availability of dissolved inorganic nitrogen is more likely to be limiting primary production in the Inlet than phosphorus. In winter, when dissolved inorganic nitrogen is in excess of phosphorus, factors such as light, temperature and water flow or residence time are probably more important controls on primary production than nutrient availability.

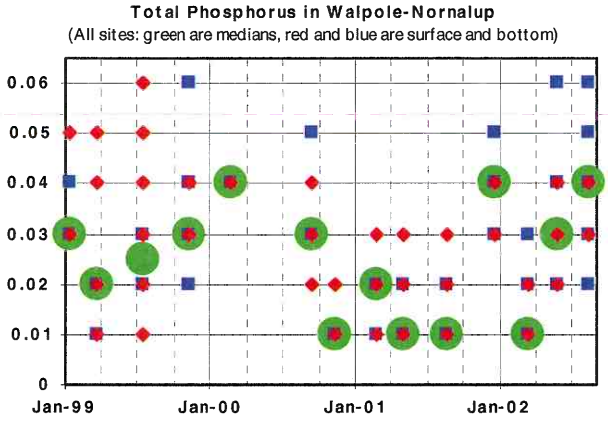
Total Nitrogen

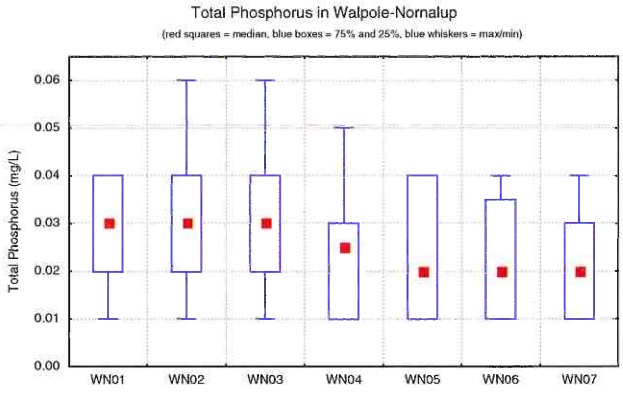




Total nitrogen concentrations showed a seasonal response, with higher concentrations measured in winter as a result of the freshwater inflows from the rivers. In winter the dissolved inorganic nitrogen constitutes up to 60% of the total nitrogen, however in summer that drops to some 5%, probably as biomass in the system take up the dissolved inorganic nitrogen. The difference in the total nitrogen concentrations most likely consists, for the most part, of relatively refractory organic nitrogen and particulates such as silt, bacteria and algae.

Chlorophyll A





Although its not a very clear picture it would seem that chlorophyll *a* concentrations were at their peak in spring, early summer and late summer and at their minimum in winter. The winter minimum is undoubtedly due to inflowing river water keeping the Inlets well flushed, lower concentrations in the mid-summer period compared to early and late summer probably reflect the lower availability of dissolved inorganic nitrogen at that time. Sites WN01, WN02 and WN03 (Walpole Inlet and the channel between the Inlets) had much higher chlorophyll *a* concentrations than the other sites; although none of the concentrations could be considered high enough to be a 'bloom'. The higher concentrations in Walpole Inlet probably reflect the slightly higher nutrient concentrations there and I would guess the reduced opportunities for mixing and flushing. In terms of composition the phytoplankton flora consisted of a fairly sparse population of estuarine diatoms, cryptophytes, chlorophytes and occasionally dinoflagellates.

Appendix II

Summary of subcatchment works and funding within the Gordon-Frankland catchment, as of January 2003

Subcatchment	Corresponding LCDC	Area (ha)	No. of farms	Group last met	Activities and funding
Wadjekanup	Broomehill	27349.5	24	Currently meeting	• This group is an amalgamation of West Wadjekanup , East Wadjekanup, Central Wadjekanup (CW), Peinellup Creek. • CW groups currently meeting as a TopCrop group and employ a consultant. • Have devised a salt map for whole catchment with $40 000 matching funds provided by the group, NLP & World Geoscience. • In 1996 installed 40 piezometers across the region with a $17 000 grant. • Group received a $50 000 revegetation grant with matching funds in 1995. • Success with a three year NHT application in 1997, in their first year received $85,000, $22,000 in their second year and $15,000 in their third year. • Received $42 000 for establishment of woody perennials and surface water management, through Southern Incentives One. • In 1998 held a drainage day and revegetation day. • Five families participated in the *Better Business Program* run by the Department of Agriculture. • This region has, in the past, been a border between cropping and wool, but due to economic pressures, more areas have been assigned to cropping. • Were successful in obtaining $30 000 through envirofund with Pindellup and Wadjekanup subcatchments (2003).
Peringillup	Broomehill	17969.5	15	Currently meeting	• In early 1990s the group received funds to install WISALT banks and trials on the revegetation of saltland. · Peringellup conducted a subcatchment tour of the stakeholders properties in 1999. • The group had a CALM field day in late spring in 2000, looking at lucerne and drainage. • The group undertook a tour of Ron Watkins property in early spring of 2000. • They are currently undertaking a major on-ground works program of fencing and revegetation as part of the Upper Frankland Gordon River Catchment Rehabilitation NHT extension project.
Gordon River	Tambellup	18949.5	17	Currently meeting	• The group has implemented a lot of Landcare in their catchment, which until 2001, was wholly funded by the landholders. From 2001, the group was successful in attracting NHT funds. • The catchment had a hydrology study conducted on four sites within the catchment. • Gordon River members Completed an Action Plan for their catchment with the Broomehill Tambellup LCDC in 1998. • In 1998 they also conducted a catchment tour. • In 1999, the Gordon River catchment was selected as a Department of Agriculture Focus Catchment. • As a Focus Catchment, the group identified its vision and major issues facing the catchment.

Subcatchment	Corresponding LCDC	Area (ha)	No. of farms	Group last met	Activities and funding
Gordon River *continued*					• In 2000, a NHT application was written to fund the installation and research of tracer piezometers and a biological component (fencing and revegetation). This was stage 1 of a 2-part relief well trial project. The NHT application was successful and provided ~$157,000 to the catchment. • In 2001, the catchment (in conjunction with the Kent Recovery catchment, Water and Rivers Commission and the Department of Agriculture, WA), was successful in receiving $150,000 from the State Salinity Council Community Support Scheme. This money was used to further research siphon assisted relief wells in the Gordon River and Kent Recovery catchments. • In 2001, a NHT extension project was written for part 2 of the relief well project. This application was successful and ~$143,000 has been used to finish the research into siphon assisted relief wells. The aim of the projects was to determine: if the relief wells have a role in reducing the impact of salinity, where in the landscape they should be sited and whether relief wells can be replicated into other catchments. • Currently the group is continuing with their siphon-assisted relief well trial work – collecting and interpreting data.
Pindellup	Tambellup	12351.6	9	Currently meeting	• In 1997 successful in receiving a ~$26 000 NHT funding for fencing and revegetation. • The group have planned and mapped the weeds in their catchment. • Participated in a catchment tour. • Over the recent years there has been an economically-driven trend away from grazing to cropping-based agricultural systems, however sheep are still the dominant enterprise in the catchment. • Currently undertaking a major fencing and revegetation program as part of the Upper Frankland Gordon River Catchment Rehabilitation NHT extension project. • Also currently in the throws of forming a Woolpro group based around the existing Pindellup subcatchment. • Were successful in obtaining $30 000 through envirofund with Jam Creek and Wadjekanup subcatchments (2003).
Upper Slab Hut Gully	Tambellup	25598.3	18	Currently meeting	• The group has provided matching funds for two remnant vegetation grants of $20 000. The group planned a third application in 1997 for the continuation of the Upper Slab Hut Gully revegetation plan and they were successful. From 1994 until December 1998 the group received a total of $64,590 of NHT funding. • In 1997 the group was selected to become a focus catchment under the 1996 State Salinity Action Plan. The group finished their planning and implementation phase was implemented in 1999. • In 1999 the group conducted a catchment tour and installation of more piezometers. • Group submitted an application for funding from NHT to help them fence remnant vegetation in their catchment for 1999/2000 round of funds – this was successful. • The group is currently undertaking major fencing and revegetation works as part of the Upper Frankland Gordon River Catchment Rehabilitation NHT extension project.

Subcatchment	Corresponding LCDC	Area (ha)	No. of farms	Group last met	Activities and funding
Jam Creek	Broomehill & Tambellup	8898.1	12	Currently meeting	• Most of the work carried out by this group has been self-funded. The majority of Jam Creek has been fenced and revegetated. • Were successful in obtaining $8 000 towards trees and the fencing of creek lines form NHT funds in 1998. • The group participated in a hydrology tour of the catchment. • In 1999, the Jam Creek catchment was selected as a focus catchment. The group identified their catchment vision and priority issues. • They have undertaken weed mapping of their catchment and attended a hydrology seminar. • Half the members are currently carrying out fencing and revegetation as part of the Upper Frankland Gordon River Catchment Rehabilitation NHT extension project. • Were successful in obtaining $30 000 through envirofund with Pindellup and Wadjekanup subcatchments (2003).
Ryans Brook	Kojonup	45314.1	~15	Currently meeting	• This group has submitted three funding applications for revegetation. • This group is keen to increase their revegetation and have installed many kilometres of drainage.
Towerlup	Kojonup	26423.9	~30	Currently meeting	• In 1995 this group had a successful catchment planning project, including air photo mosaic, salinity meter and funding for farm and a catchment planning workshop. • The group has developed a catchment vision, and plan on fencing entire creeklines across property boundaries for long-term preservation of remnant vegetation. • The long-term aim of the catchment is to involve all landholders and form corridors of vegetation, which link to the beautiful Jingalup Reserve. • Catchment members are presently implementing fencing and revegetation works as part of the Upper Frankland Gordon River Catchment Rehabilitation NHT extension project.
Peter Valley	Tunney	11511.7	9	Currently meeting	• In 1997 the Peter Valley Group were selected as a focus catchment group under the State Salinity Action Plan. The group completed the planning stage and moved into the implementation phase in 1999. • Involved in a self-funded piezometer project through out the catchment, which involved the placement of two nests of piezometers on each property within the catchment. • This group is continuing to fund work as necessary. • In 1998 the group submitted a NHT application for $37 525 and was successful. The group applied for continued funding over the following two years, totalling ~$116 000 for fencing and revegetation work. • The group has completed individual and catchment concept plans for the implementation of drainage and revegetation works. • In 1998 the group was presented with the focus catchment folder to help the group implement their plans. • Currently members of the catchment are sowing perennial pastures and intend to increase the area sown to perennials in the future. • The Tunney fox shoot is an annual event, which continues to involve the majority of catchment members. The group also continues with its annual baiting program.

Subcatchment	Corresponding LCDC	Area (ha)	No. of farms	Group last met	Activities and funding
Lower Slab Hut Gully	Tunney	22396.6	22	Currently meeting	• In 1998 the group held a catchment tour and had specific hydrology and earthworks information delivered to them at a series of hydrology days. The group also participated in the Tunney fox baiting program. • The Tunney fox shoot is an annual event that continues to involve the majority of catchment members. The group also continues with its annual baiting program. • The members of this group ran a crop competition with a private consultant to increase the productivity of their crops. • This group is very active and their Landcare work until 2001 was self-funded. In 2001, some members of the group received NHT funding as part of the Upper Frankland Gordon River Catchment Rehabilitation project. • The group has a combination of cropping and grazing based agricultural systems. Over recent years there has been an economic drive towards cropping systems. • In 1999, the group was selected as a Focus Catchment. The members developed a catchment vision and identified their priority issues. Workshops were held to address their priorities, from perennial pastures, to surface water earthworks, to vegetation management. In 2002 the group was presented with a catchment folder. • Members of the group continue to implement fencing and revegetation works as part of the Upper Frankland Gordon River Catchment Rehabilitation project and extension project. • Currently members of the catchment are sowing perennial pastures and intend to increase the area sown to perennials in the future.
Pinjalup Creek	North Stirling	16824.1	22	Currently meeting	• This group received a revegetation grant in 1995 for $12 000. Several other funding applications have been made between 1993 and 1995. • A series of farm planning workshops and a catchment tour were held in 1998. • In 1998 the group also had a successful NHT application for $19 710, which was to fund the Pinjalup Creek corridor plan. • In 1997/98 and1998/99 the group received $19 400 and $5 000 from NHT (respectively) for revegetation and conservation. • The group plan to develop a whole of catchment plan. • Currently the group is involved with the Department of Agriculture and the Rural Towns Program, as the town of Cranbrook (which is at threat from the rising watertable and salinity) is within the subcatchment boundaries. A consultant's report has been produced and the Shire of Cranbrook is currently implementing recommendations of the report.
Geekabee	Frankland Below Gordon	21140.4	~21	Currently meeting	• The group is interested in direct seeding. • Interested in fencing their creek lines, high water use farming systems and catchment drainage. • Some group members are interested in planting pine trees on their property (for commercial value and/or for revegetation of sandy soils). • In particular the group wish to address their salinity issues.

Subcatchment	Corresponding LCDC	Area (ha)	No. of farms	Group last met	Activities and funding
18 Mile Creek	Frankland Below Frankland		13	Currently meeting	• In 2001, members of the group worked with the Cranbrook LCDC and the Department of Agriculture to develop a surface water and riparian management plan for the catchment. This plan was delivered to the group in 2001.
Central Frankland	Frankland Below Gordon	25931.7	Un known	N/A	• This group has no known history of working together. No comment can be given in regards to the funding they have received.
Bokerup/ Bolbellup Swamp	Frankland Below Gordon	30104.6	~16	1997	• The group has made successful NLP funding application for $35 000 in 1996 with matching funds for fencing and revegetation work. • The potential exists to go into more intensive agricultural systems. • Historically this area has relied heavily on wool. There has been gradual shift to cropping and more intensive agricultural enterprises. • Some members of the group have implemented fencing and revegetation as part of the Upper Frankland Gordon River Catchment Rehabilitation project (NHT).
Nardarup Creek	Frankland Below Gordon	23753.9	18	1998	• The group has implemented fencing within the catchment and in 1995 was successful in NLP application. • The potential exists to go into more intensive agricultural systems. Historically this area has relied heavily on wool. • There has been gradual shift to cropping and more intensive agricultural enterprises. • Some members of the group are implementing fencing and revegetation work as part of the Upper Frankland Gordon River Catchment Rehabilitation project (NHT).
Rocky Gully East	Frankland Below Gordon	17400.1	Un known	N/A	• As this group has not worked together in the past, no comment can be made at this stage. • The potential exists to go into more intensive agricultural systems. Historically this area has relied heavily on wool. • There has been a gradual shift to cropping and more intensive agricultural enterprises. • Extensive planting of vineyards and tree crops now covers a large proportion of the catchment.
Rocky Gully West	Frankland Below Gordon	15982.1	Un known	N/A	• As this group has not worked together in the past, no comment can be made at this stage. • The potential exists to go into more intensive agricultural systems. Historically this area has relied heavily on wool. • There has been a gradual shift to cropping and more intensive agricultural enterprises. • Extensive planting of vineyards and tree crops now cover a large proportion of the catchment.

Note: NHT = Natural Heritage Trust, NLP = National Landcare Program
This table was based on the work of Kelly Hill from the Gillamii Community Agriculture Centre, Cranbrook.

Appendix III

Declared rare and priority flora list for WA

Source: K.J. Atkins, The Department of Conservation and Land Management, 2001

CONSERVATION CODES

R: Declared Rare Flora – Extant Taxa
Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

X: Declared Rare Flora – Presumed Extinct Taxa
Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.

1: Priority One – Poorly known Taxa
Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two – Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three – Poorly Known Taxa
Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four – Rare Taxa
Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Note: the need for further survey of poorly known taxa is prioritised into the three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on the current information.

* = species which also occur outside Western Australia
x = species presumed to be the result of hybridization

ms = manuscript names. These names have not been published and must be indicated as being manuscript names whenever used, either by the standard format of the addition of ms after the name, or the inclusion in inverted commas.

Recommendations for additions, deletions or changes to the Declared Rare and Priority Flora List should be forwarded to the Administrative Officer Flora or Principal Botanist, Wildlife Branch, CALM.

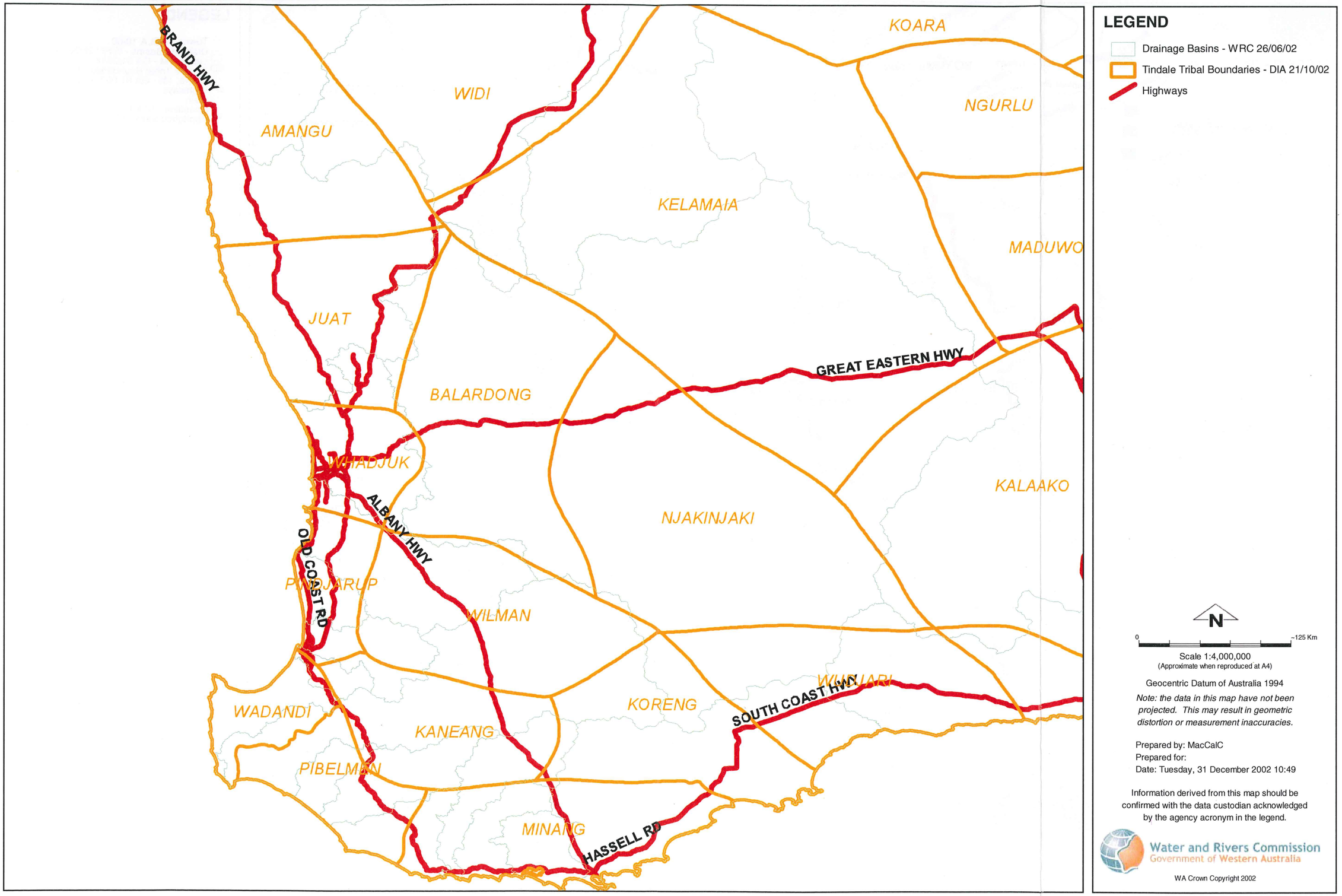
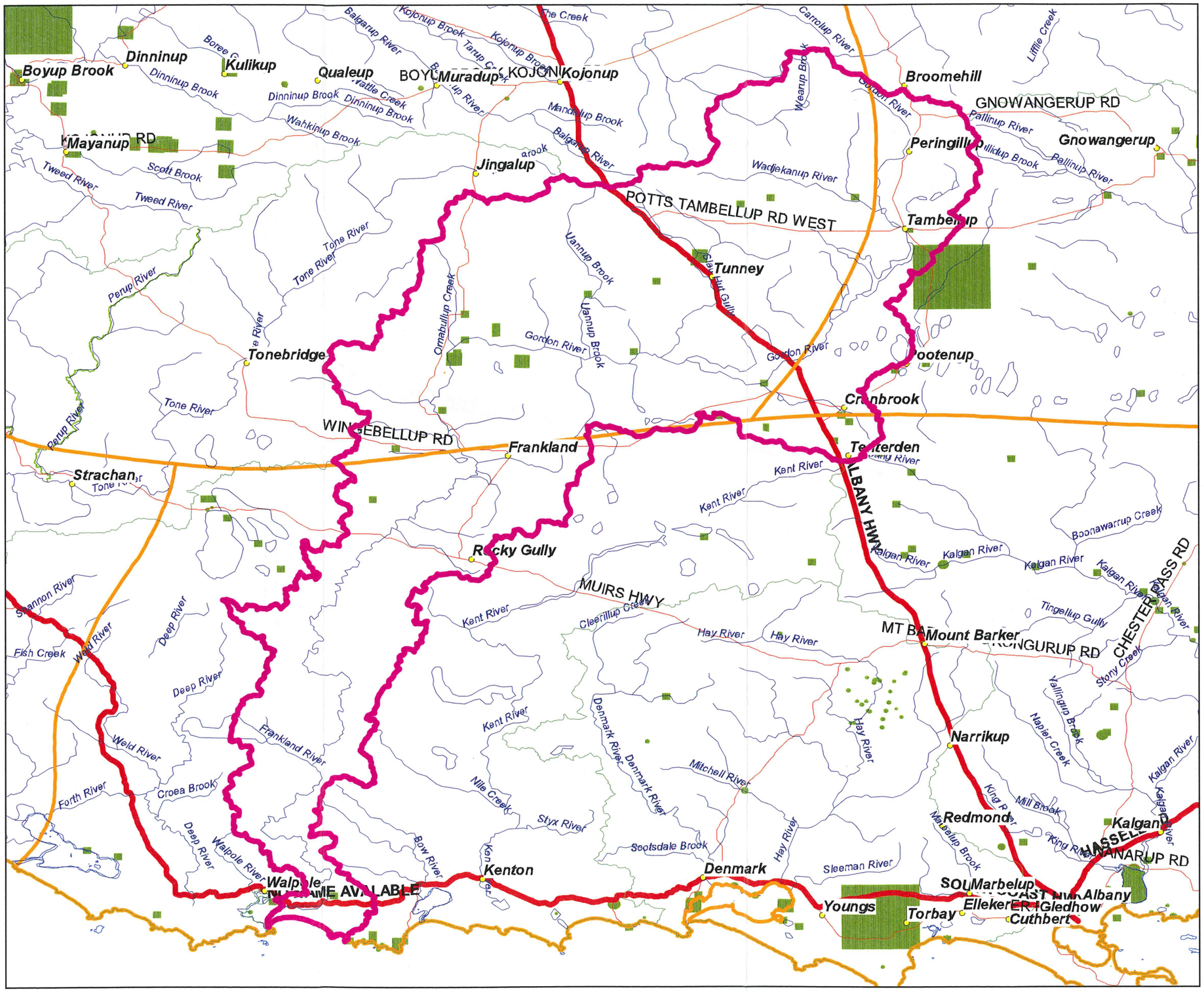


Figure 1.4. Tindale Tribal boundaries in the South West of Western Australia



LEGEND

- Towns - DOLA 10/00
- Drainage Basins - WRC 26/06/02
- Lakes, 1M - GA 01/06/00
- Tindale Tribal Boundaries - DIA 21/10/02
- Rivers, 1M - GA 01/06/00
- Highways
- Main
- Coastline - DOLA
- Aboriginal Sites of Significance - DIA 04/07/02

Geocentric Datum of Australia 1994

Note: the data in this map have not been projected. This may result in geometric distortion or measurement inaccuracies.

Prepared by: MacCalC
Prepared for:
Date: Tuesday, 31 December 2002 10:12

Information derived from this map should be confirmed with the data custodian acknowledged by the agency acronym in the legend.

Water and Rivers Commission
Government of Western Australia

Figure 1.5. Aboriginal-registered sites of significance found in the Gordon-Frankland catchment

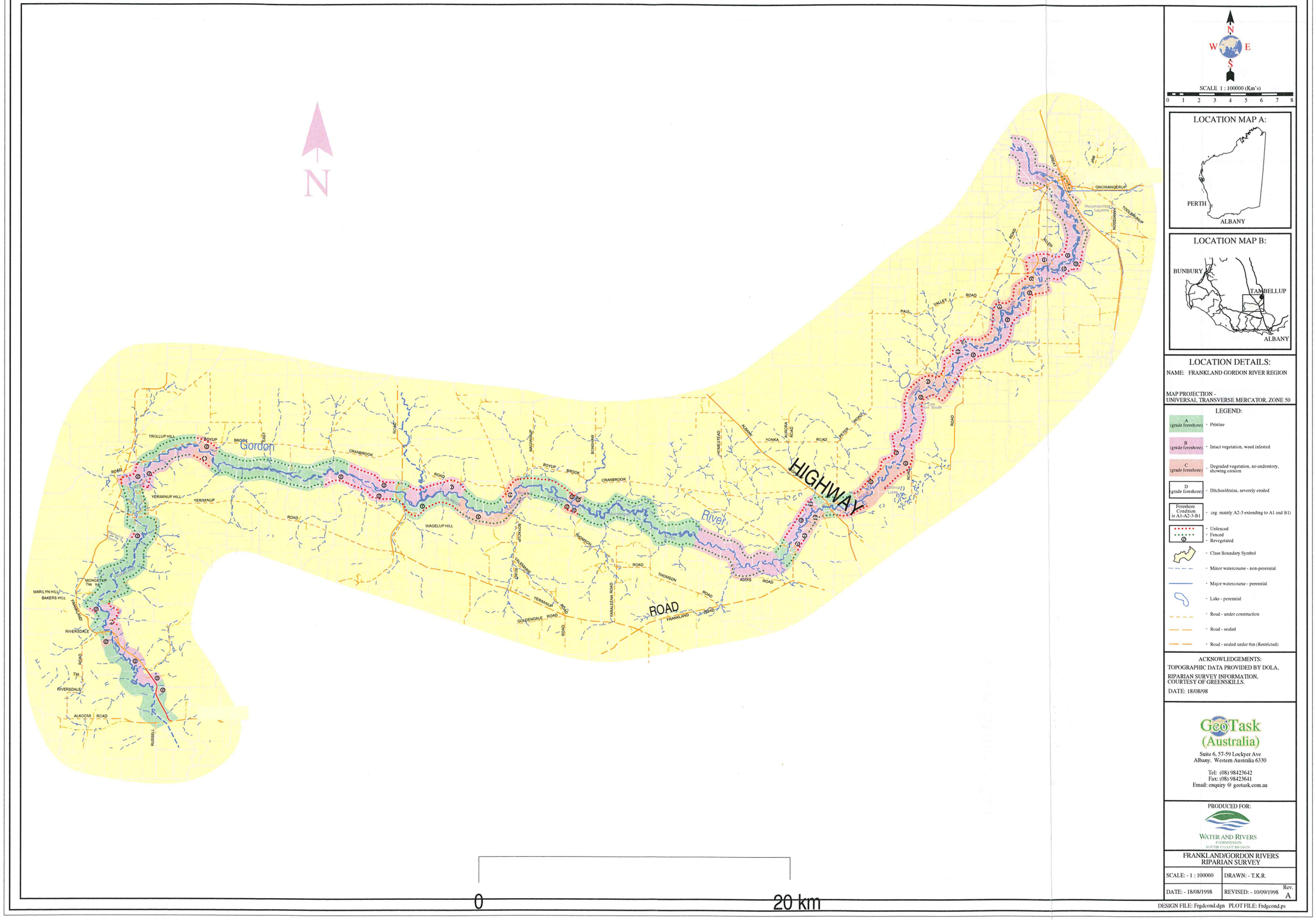


Figure 6.3. Foreshore grades from the Gordon River Foreshore survey conducted in 1995

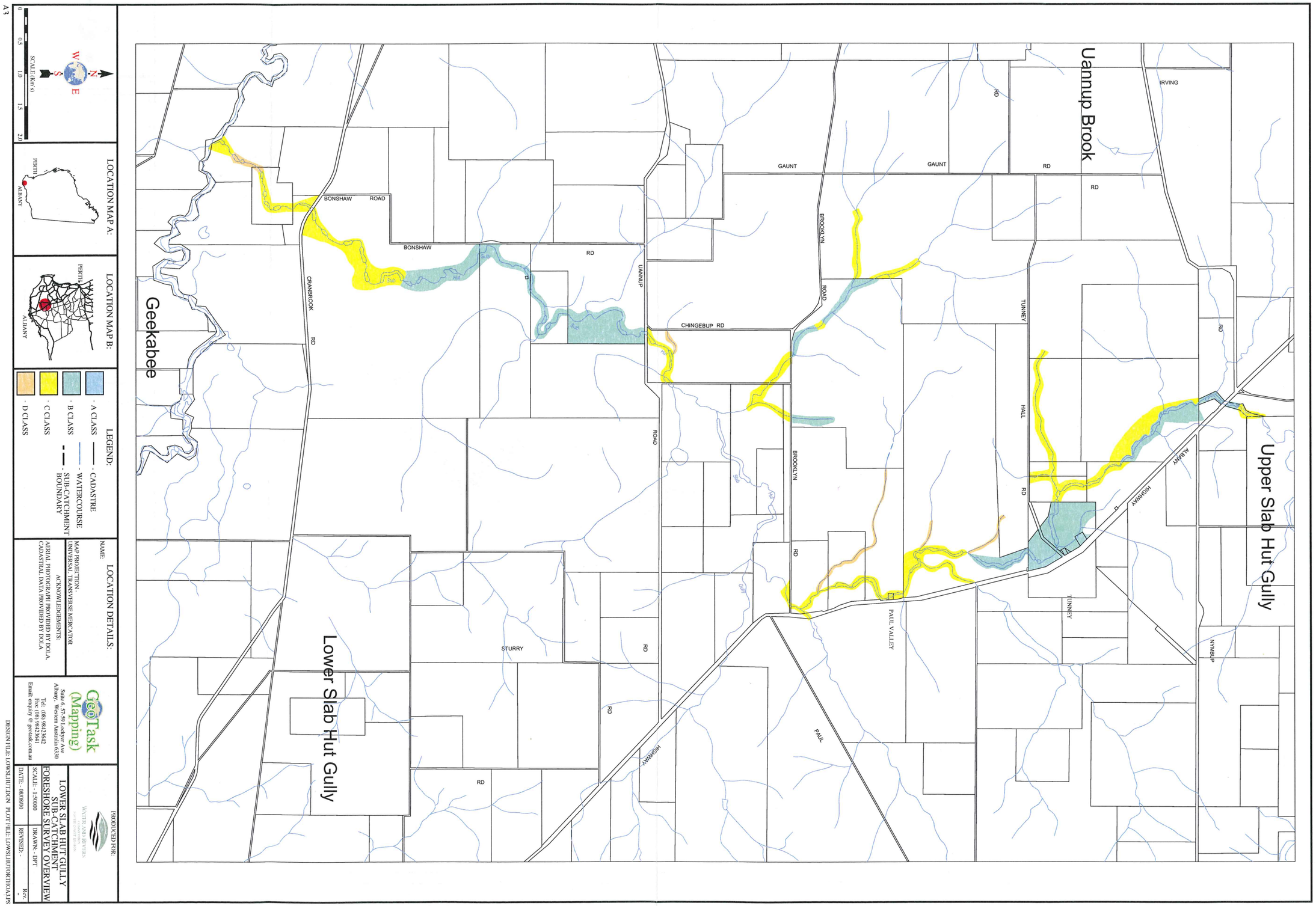


Figure 6.4 Foreshore survey of the sub catchment of Lower Slab Hut Gully conducted in 2000

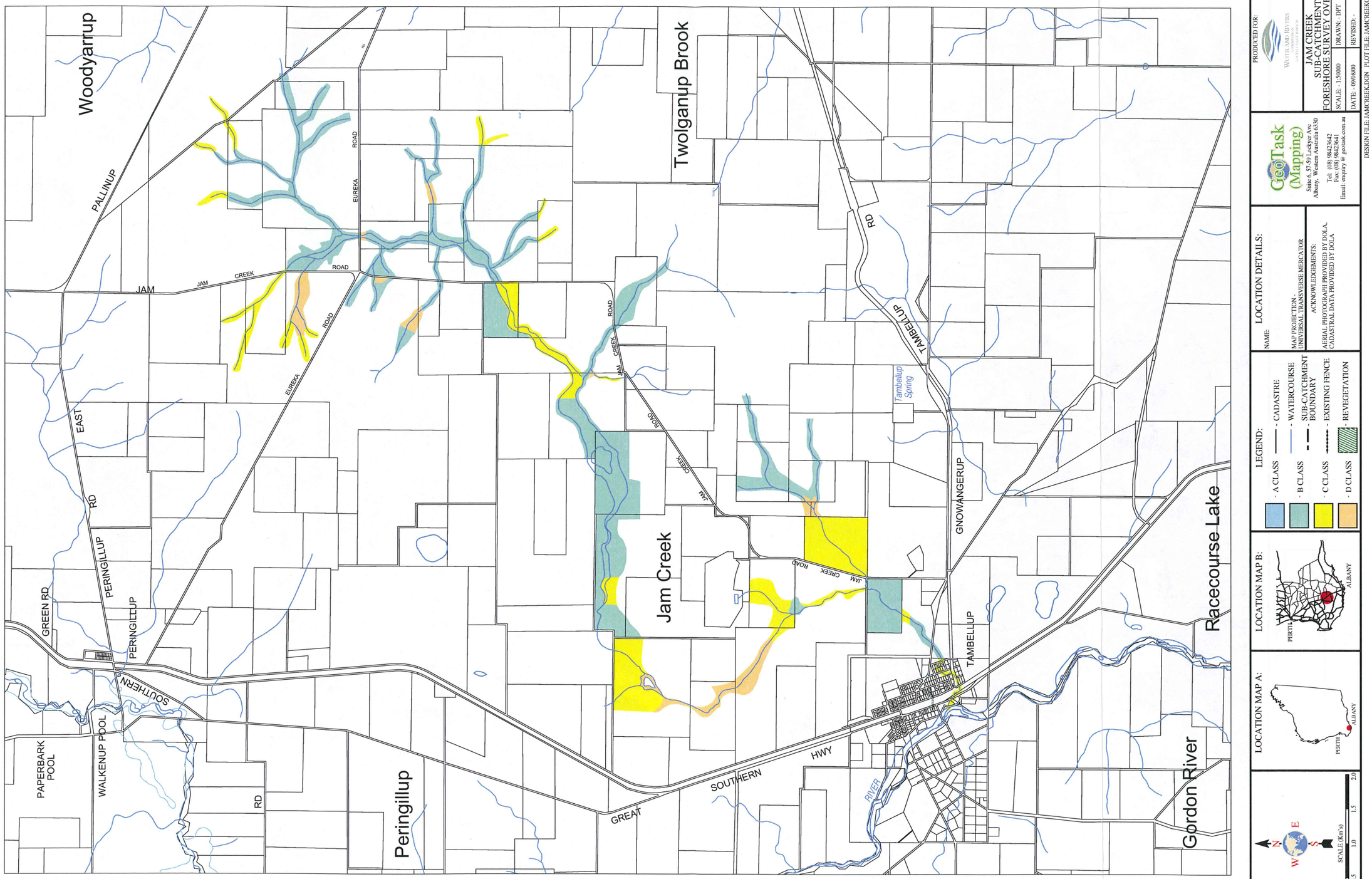


Figure 6.5 Foreshore survey of the sub catchment of Jam Creek conducted in 2000

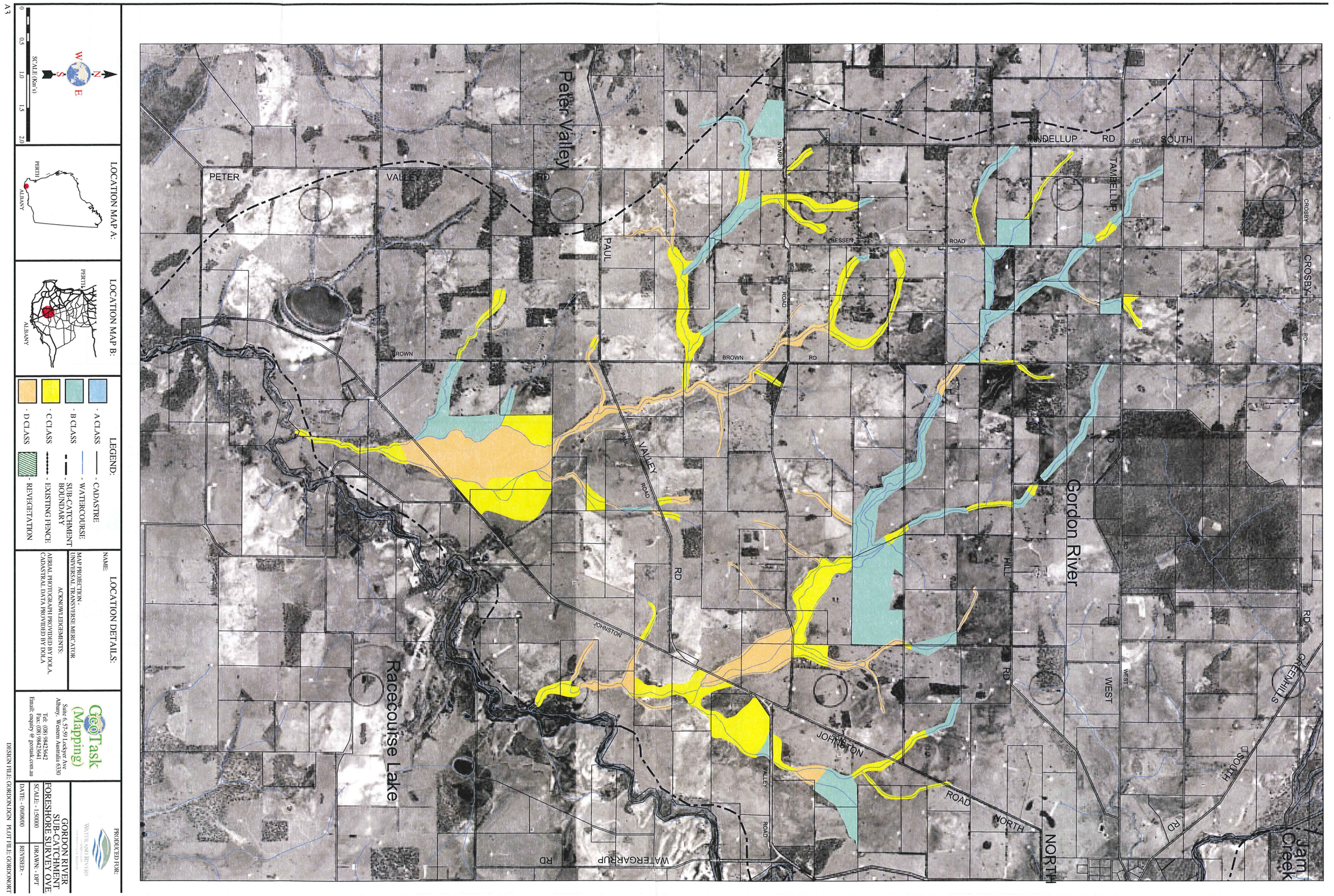


Figure 6.6 Foreshore survey of the sub catchment of Gordon River conducted in 2000

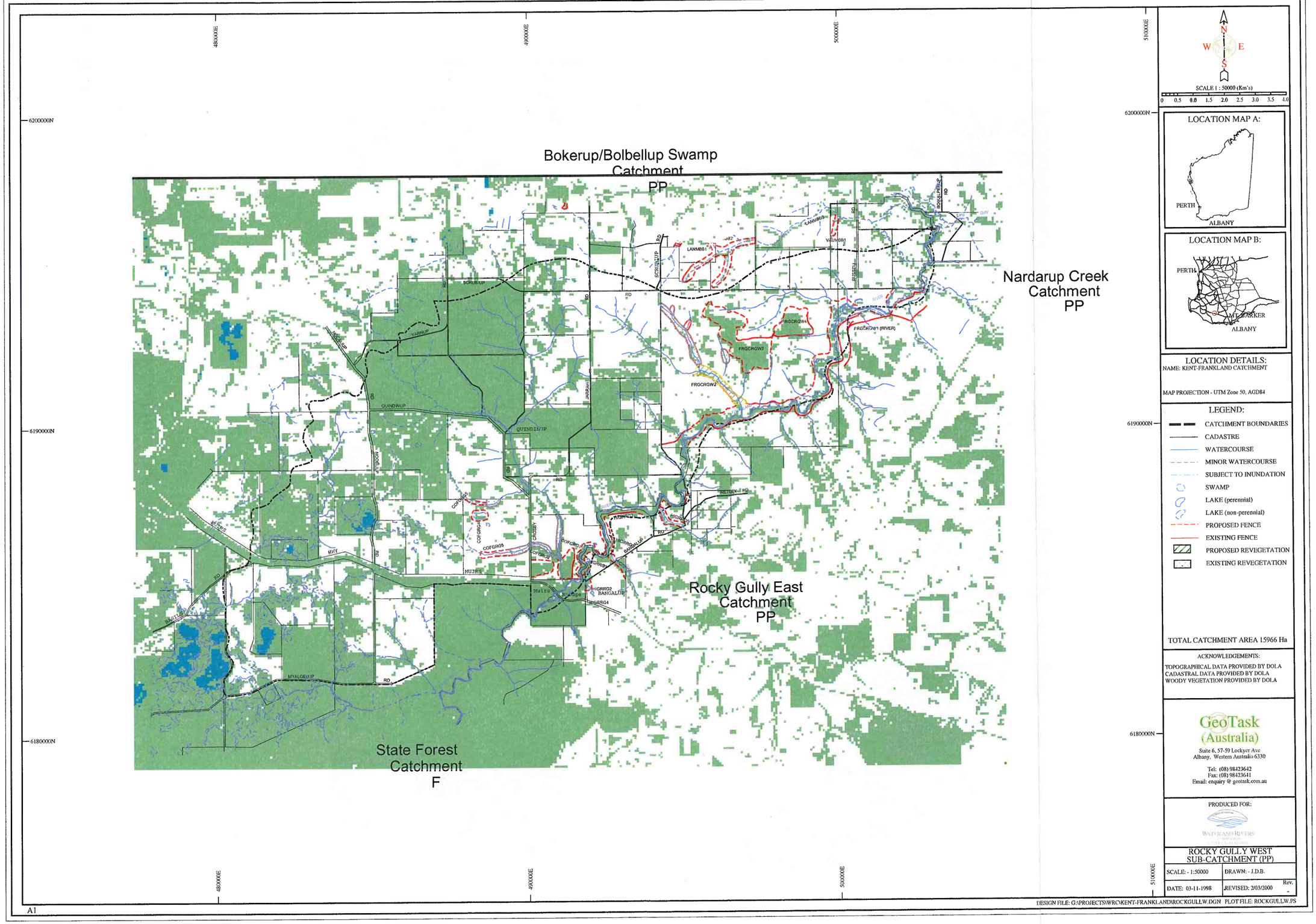


Figure 8.2. Rocky Gully West subcatchment

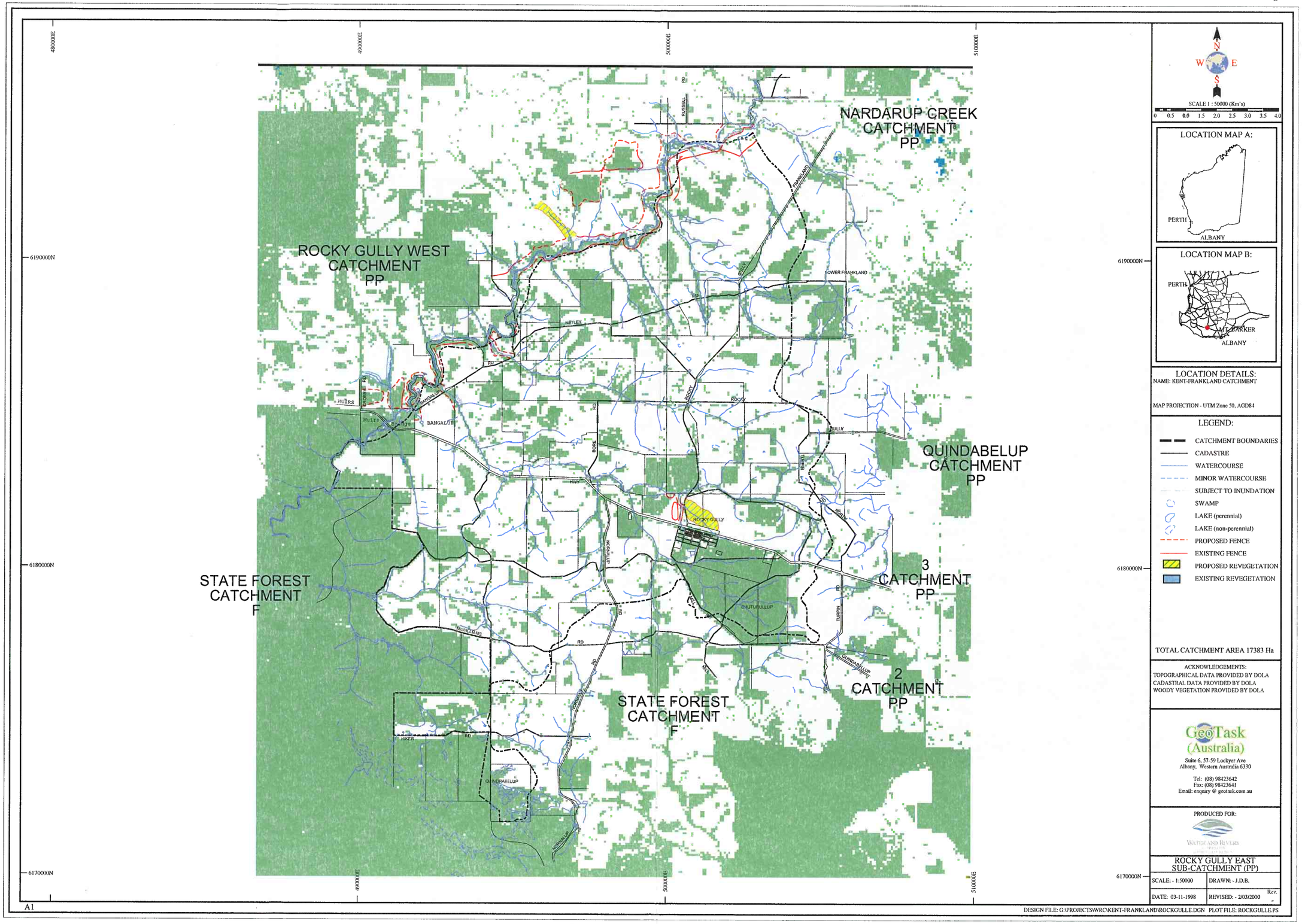


Figure 8.3. Rocky Gully West subcatchment

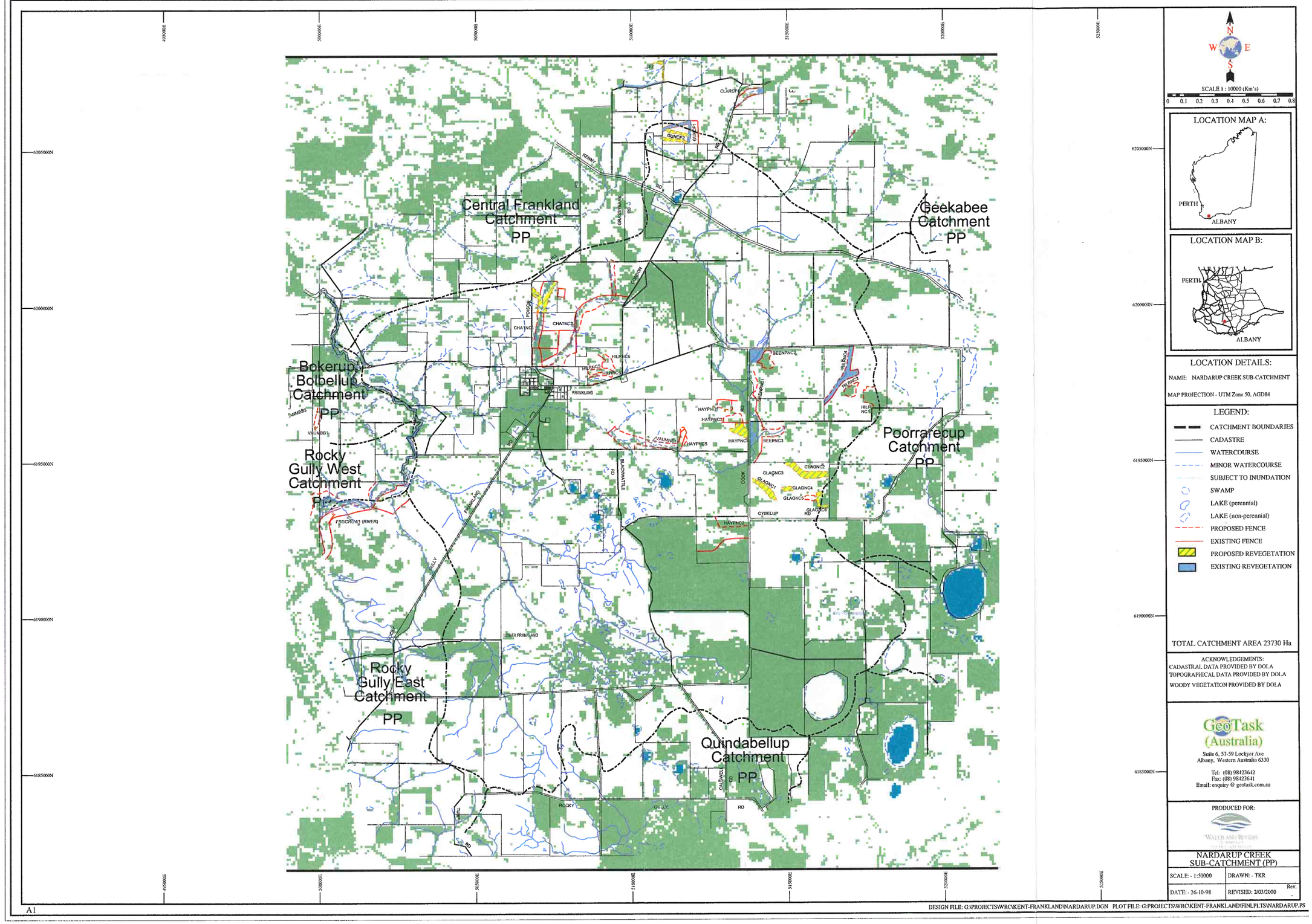


Figure 8.4. Nardarup Creek subcatchment

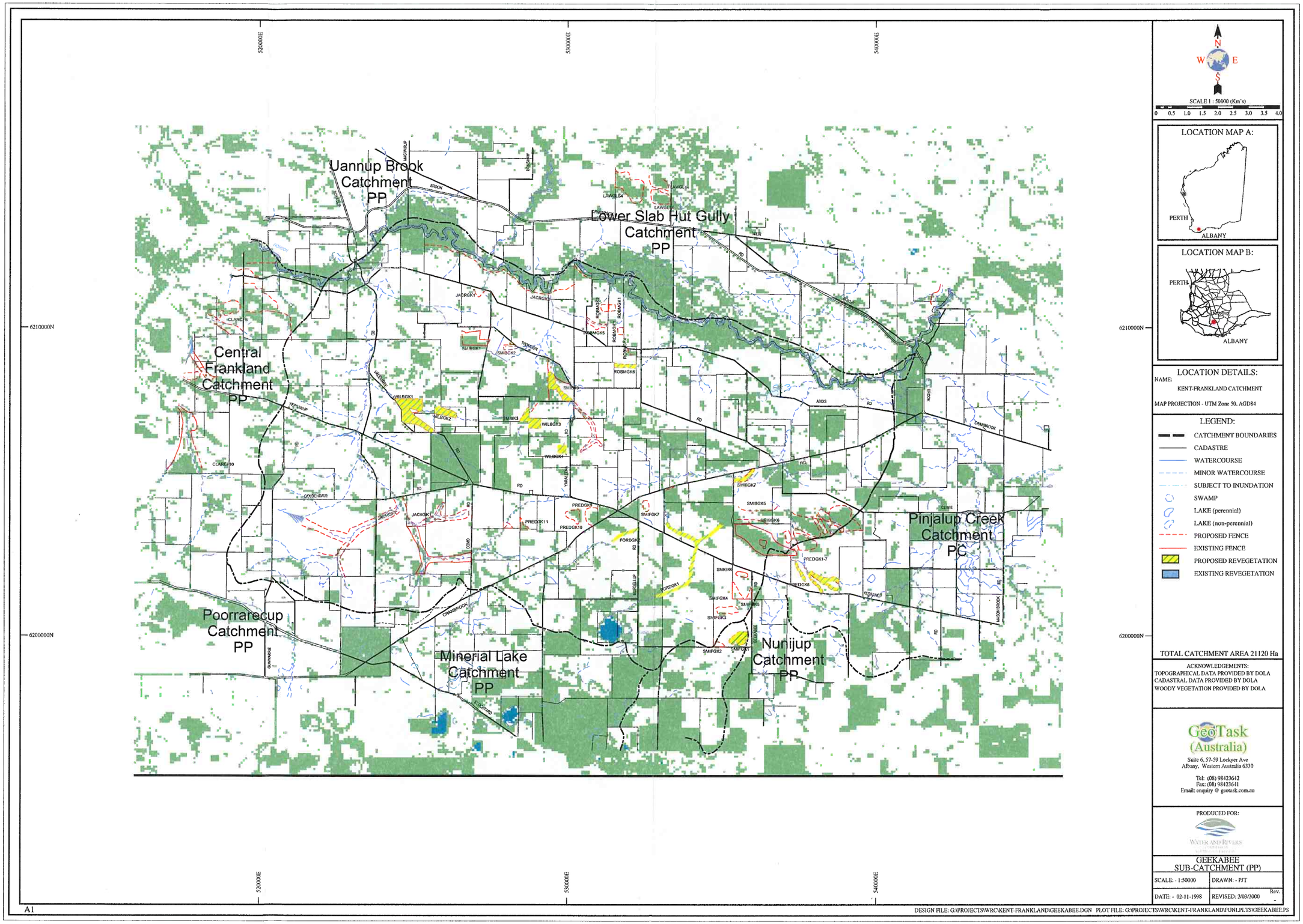


Figure 8.5. Geekabee subcatchment

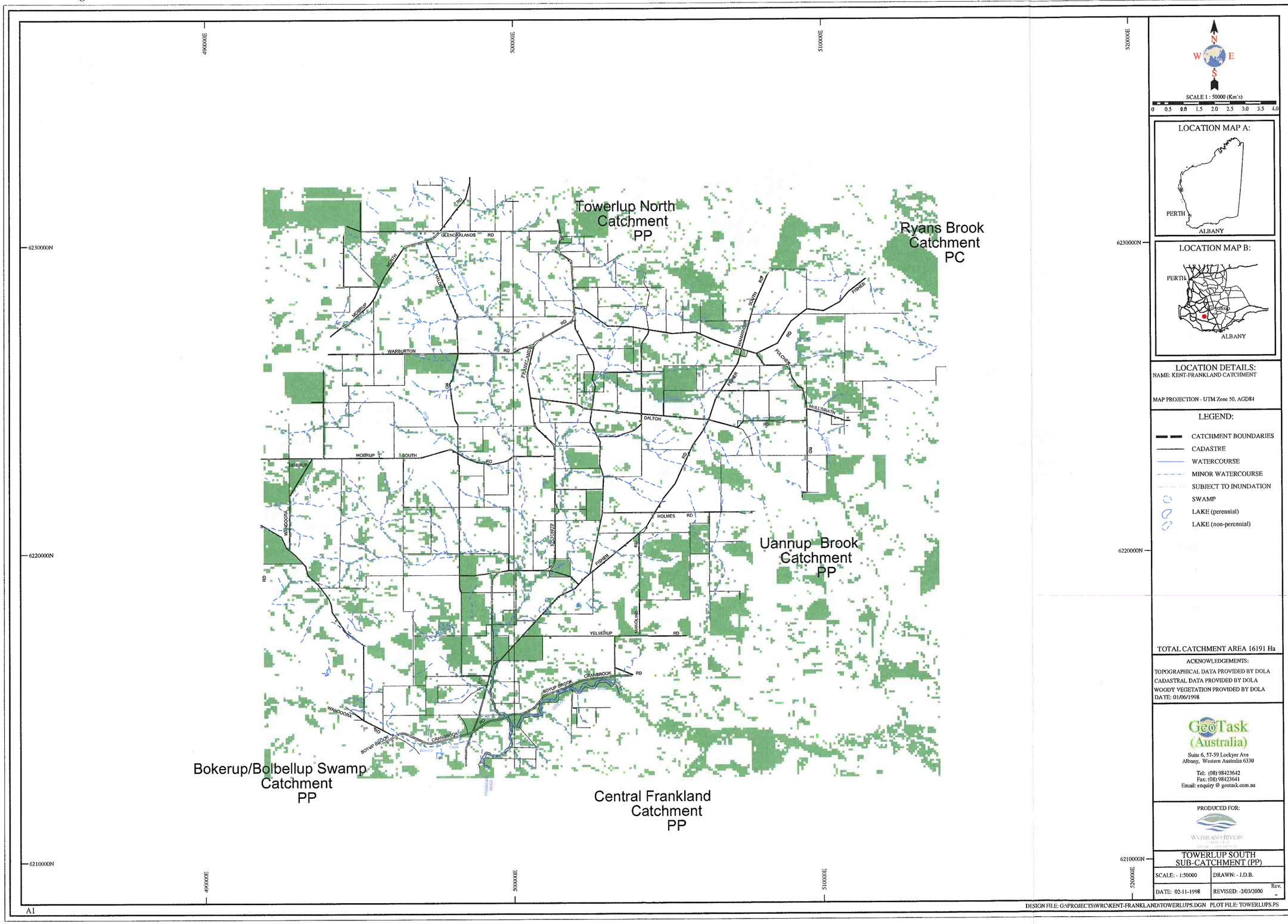


Figure 8.6. Towerlup South subcatchment

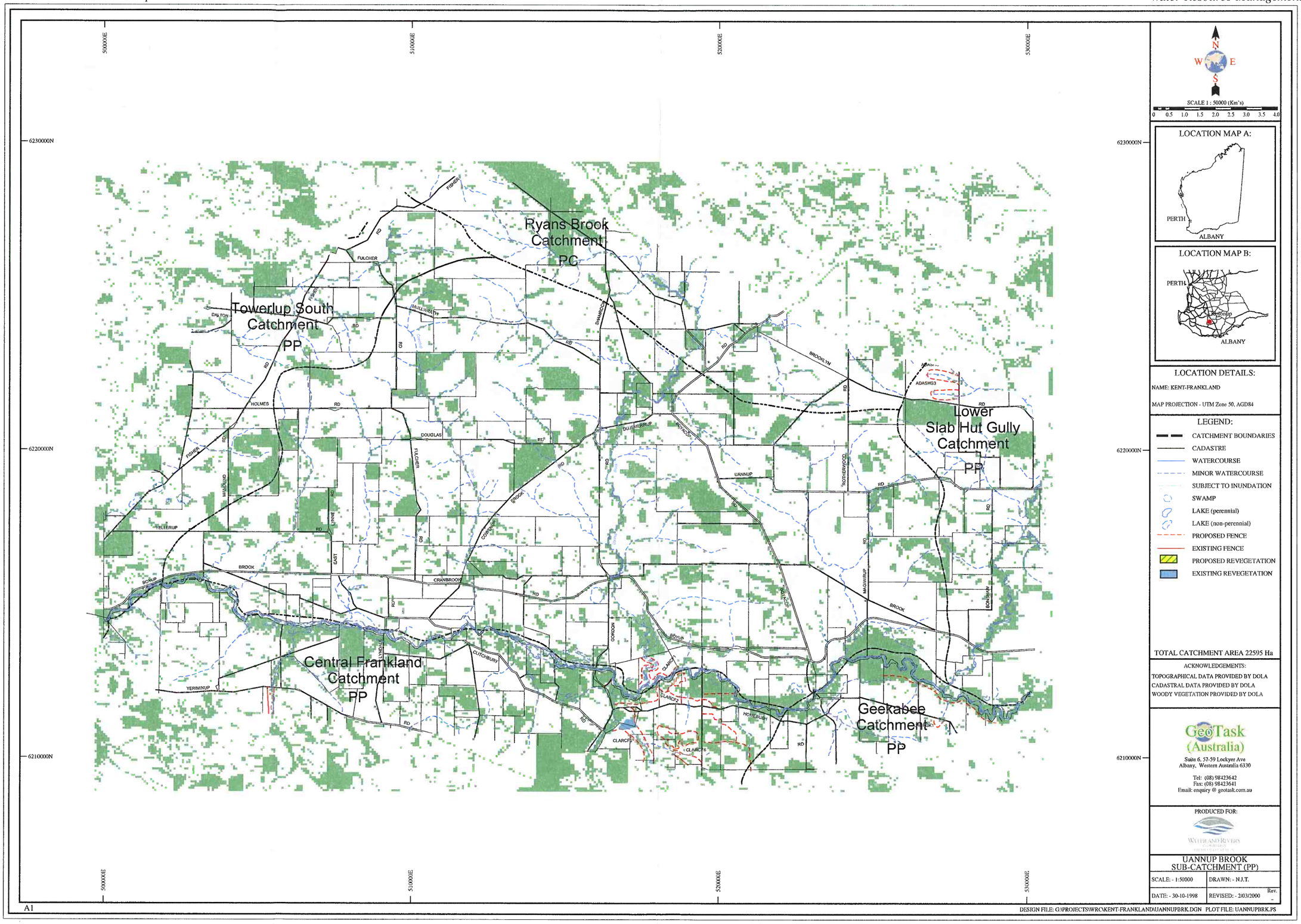


Figure 8.7. Uannup subcatchment

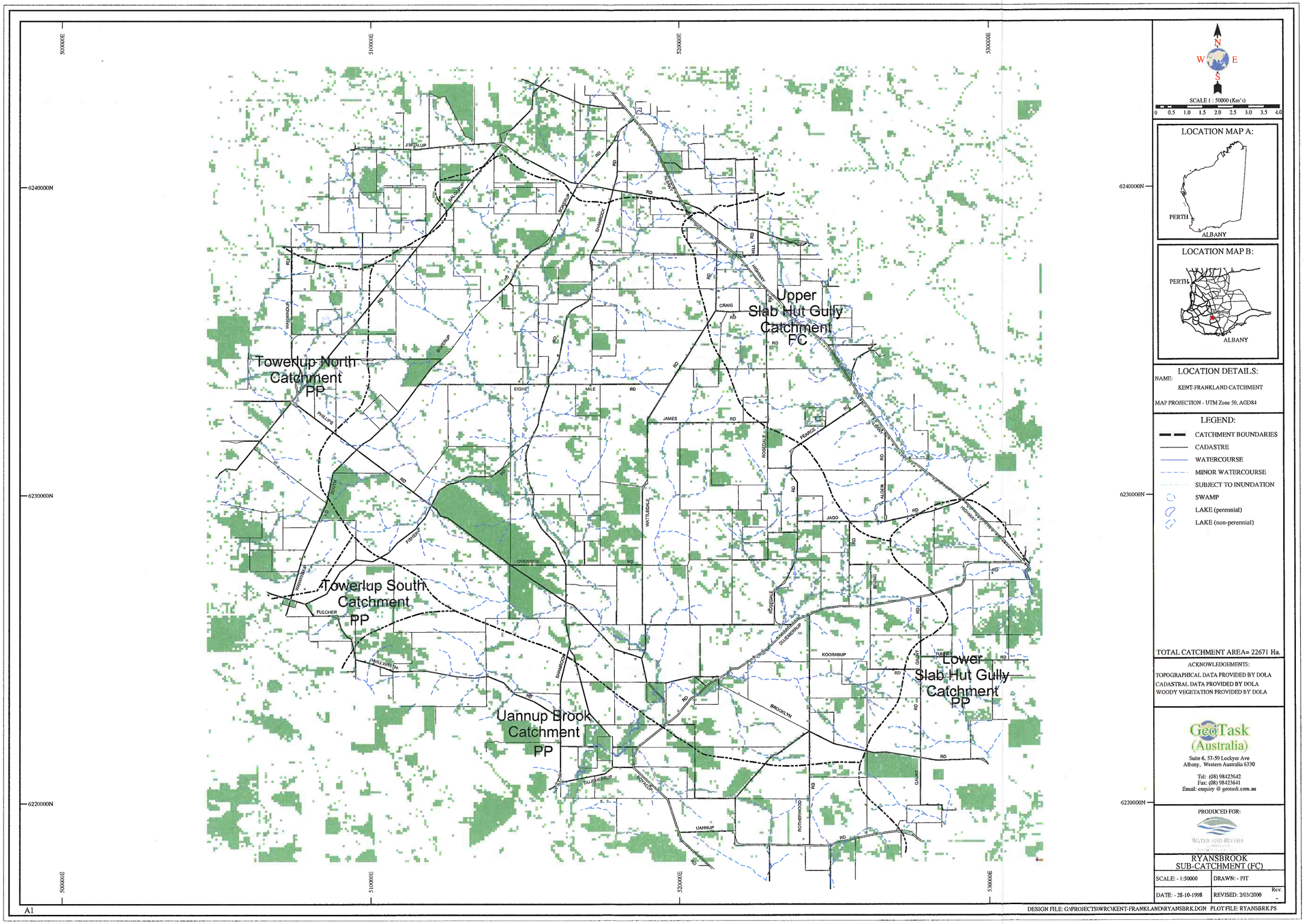


Figure 8.8. Ryans Brook subcatchment

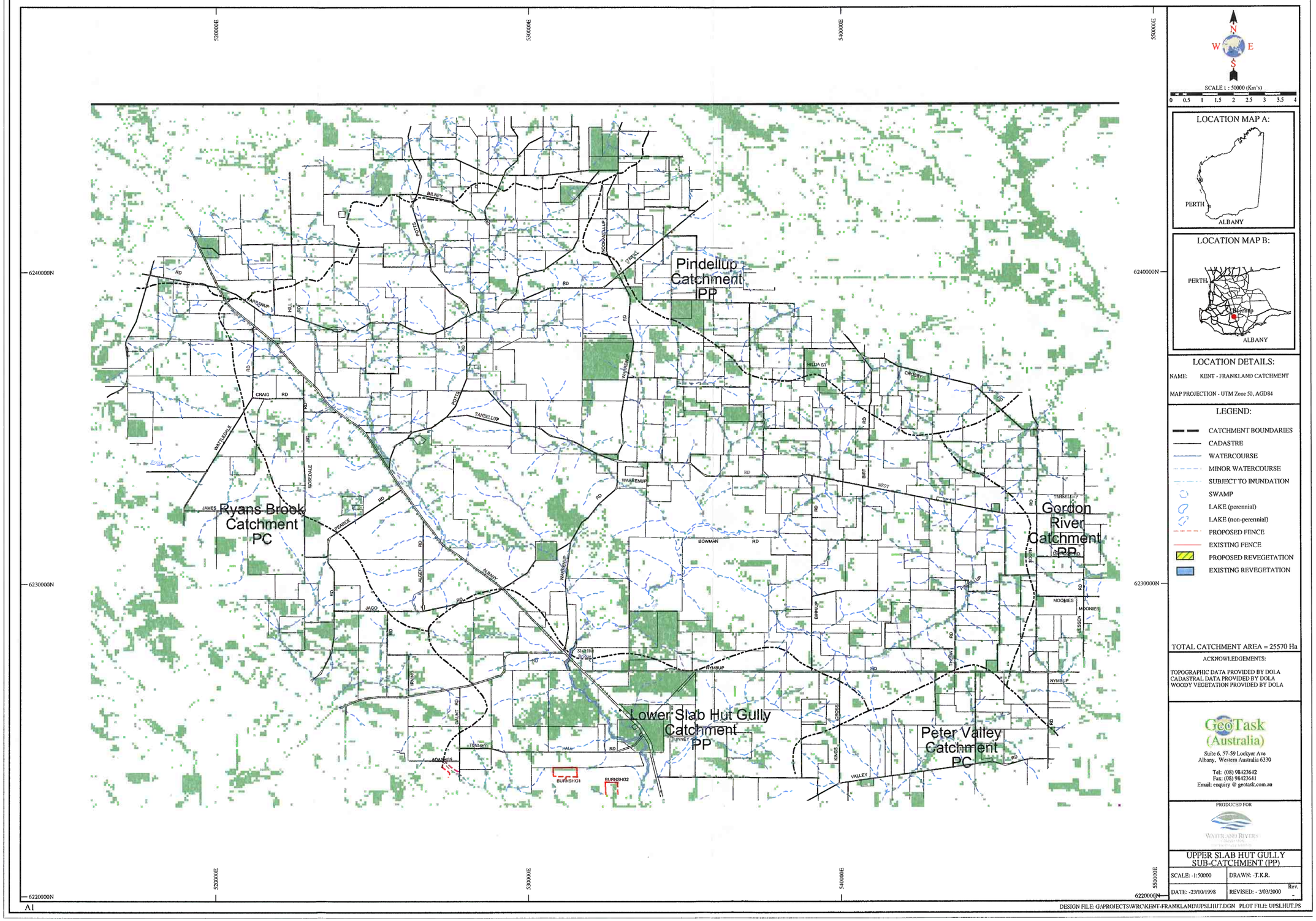


Figure 8.9. Upper Slab Hut Gully subcatchment

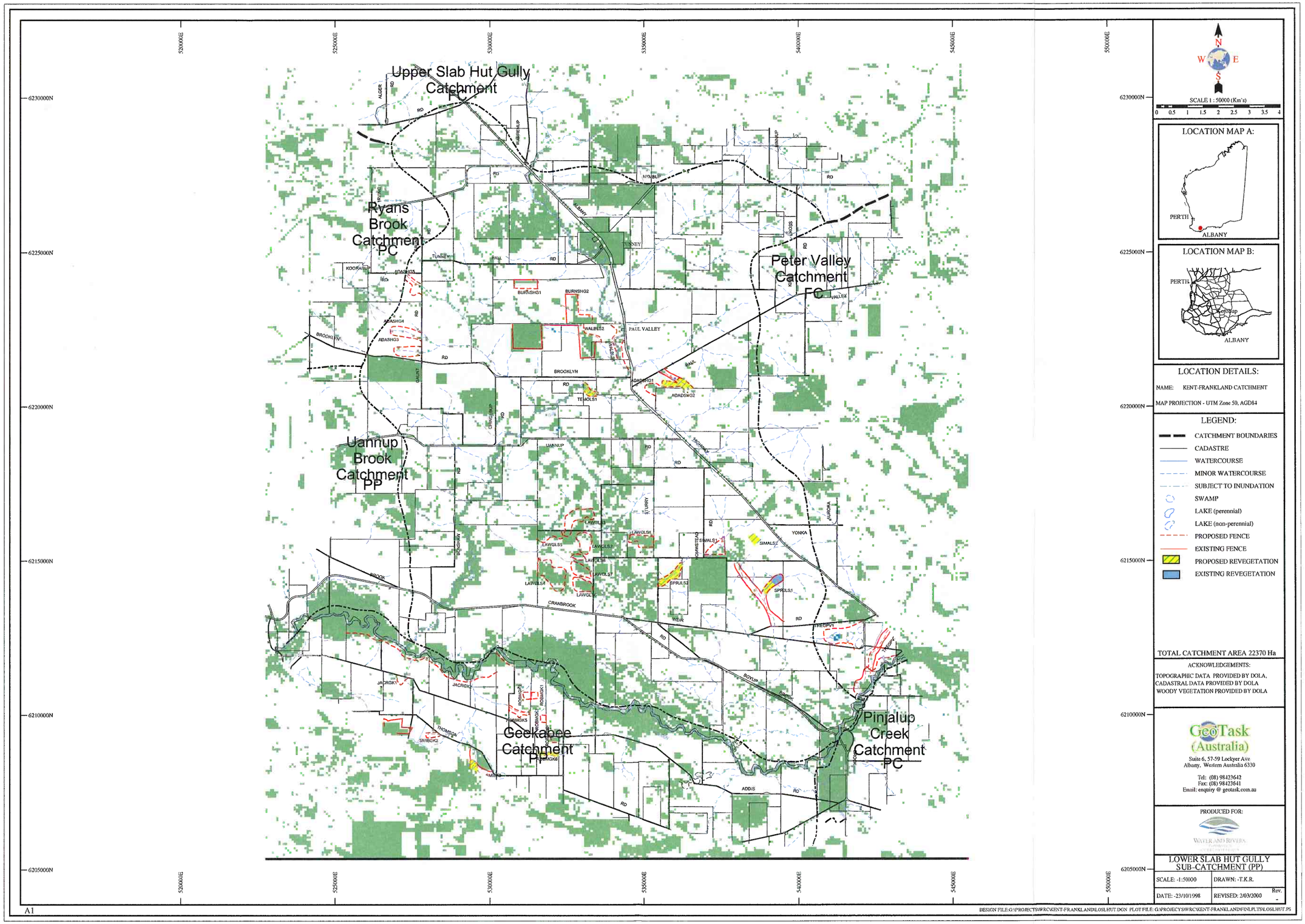


Figure 8.10. Lower Slab hut Gully subcatchment

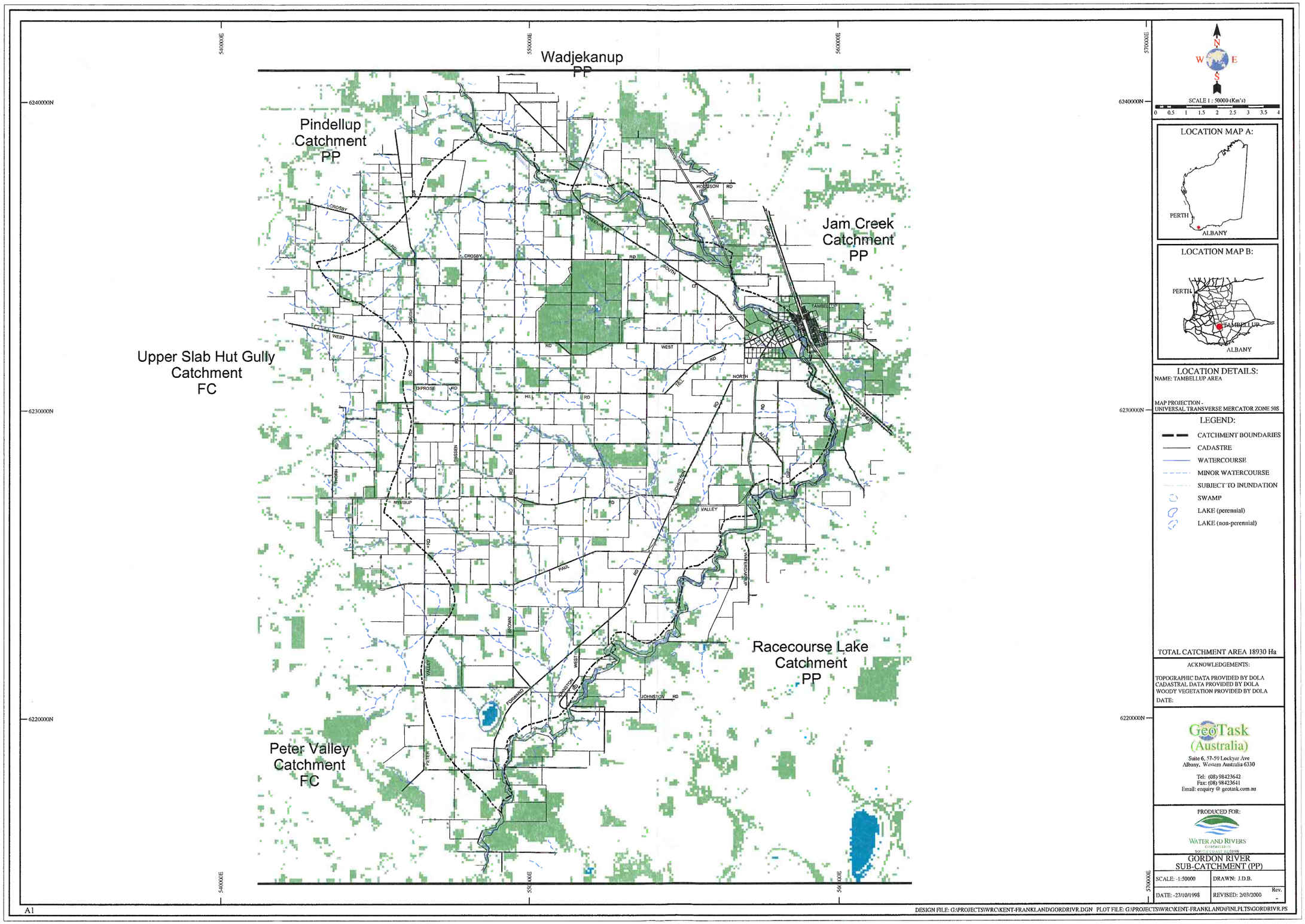


Figure 8.11. Gordon River subcatchment

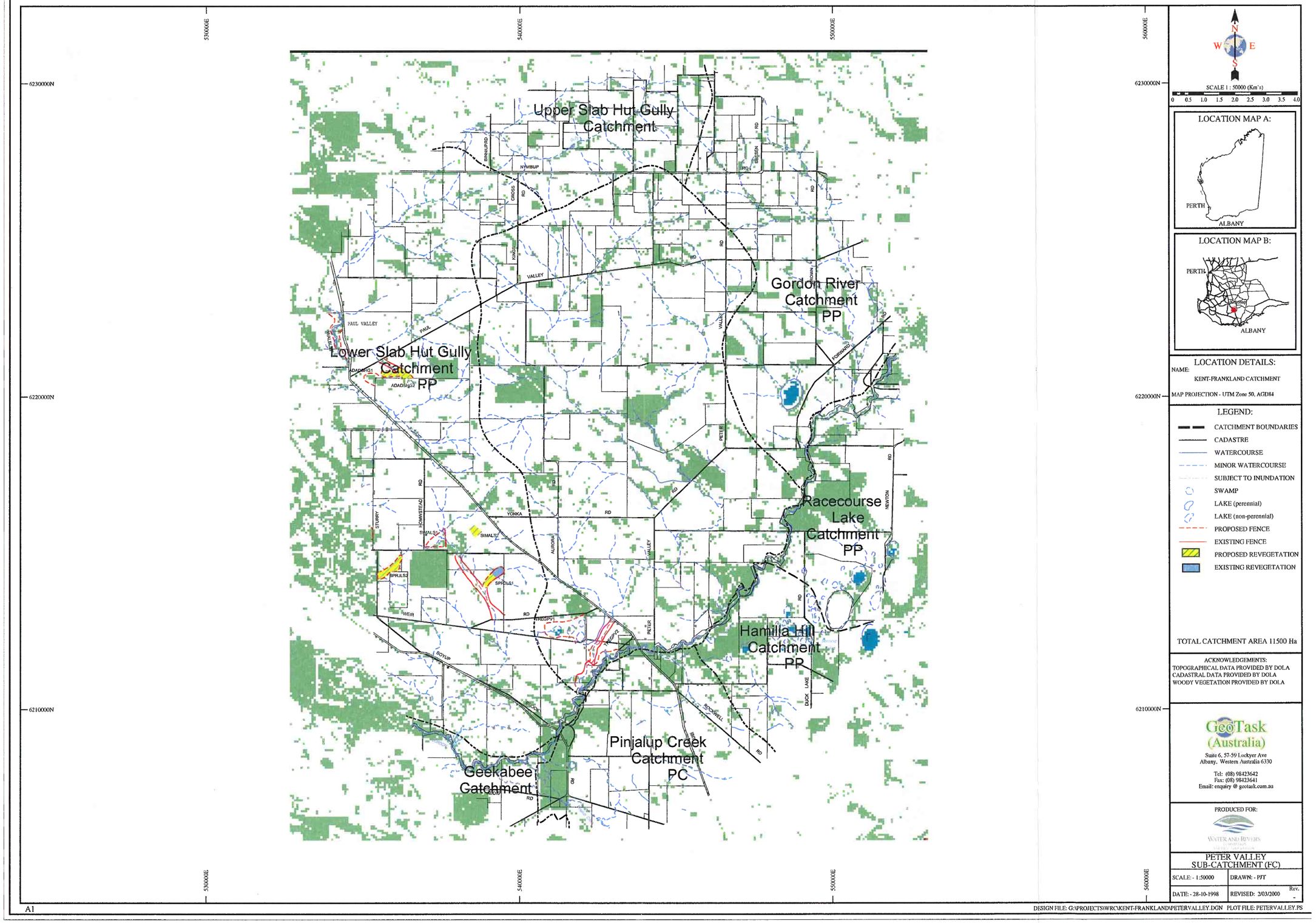


Figure 8.12. Peter Valley subcatchment

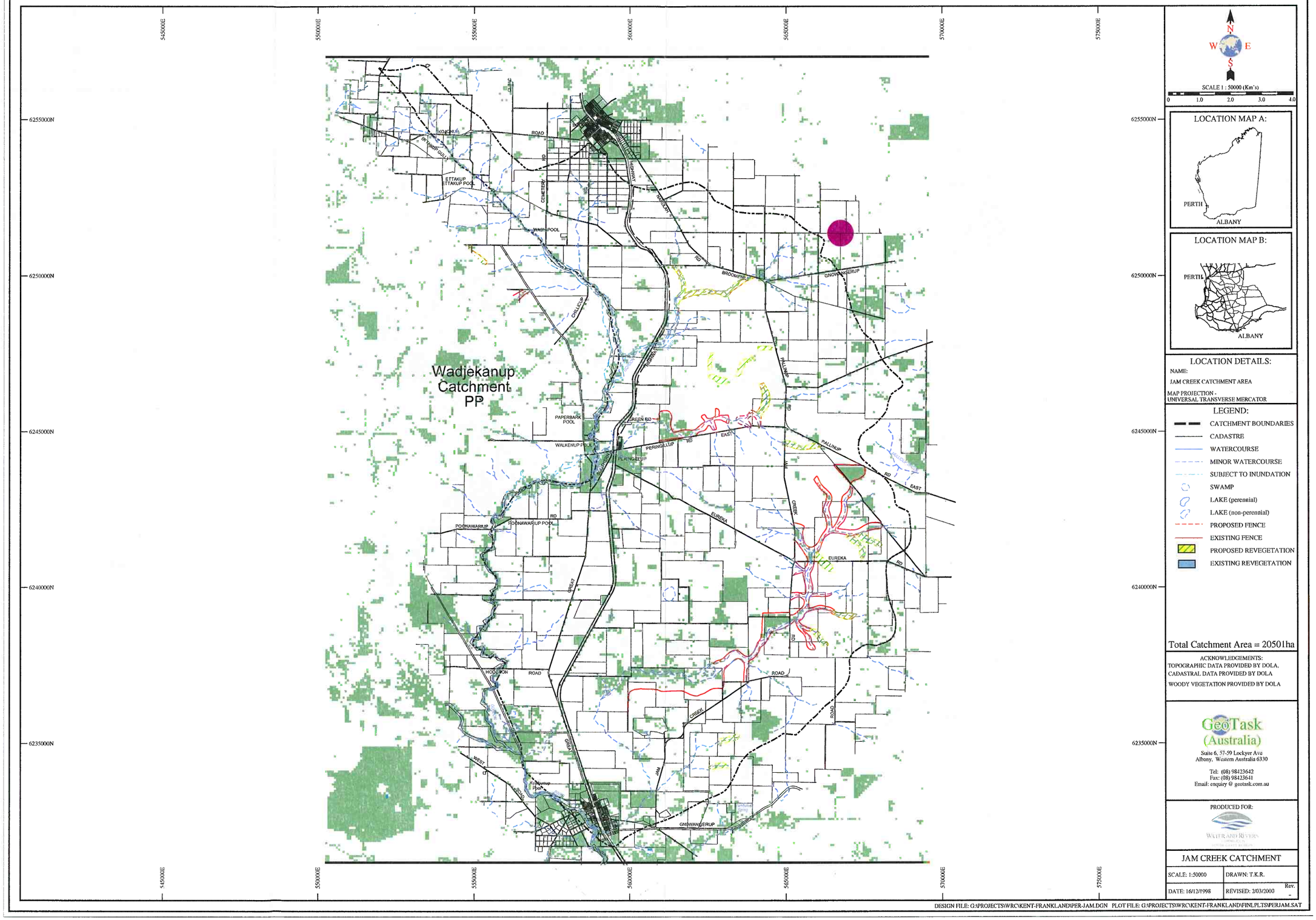


Figure 8.13. Jam Creek subcatchment

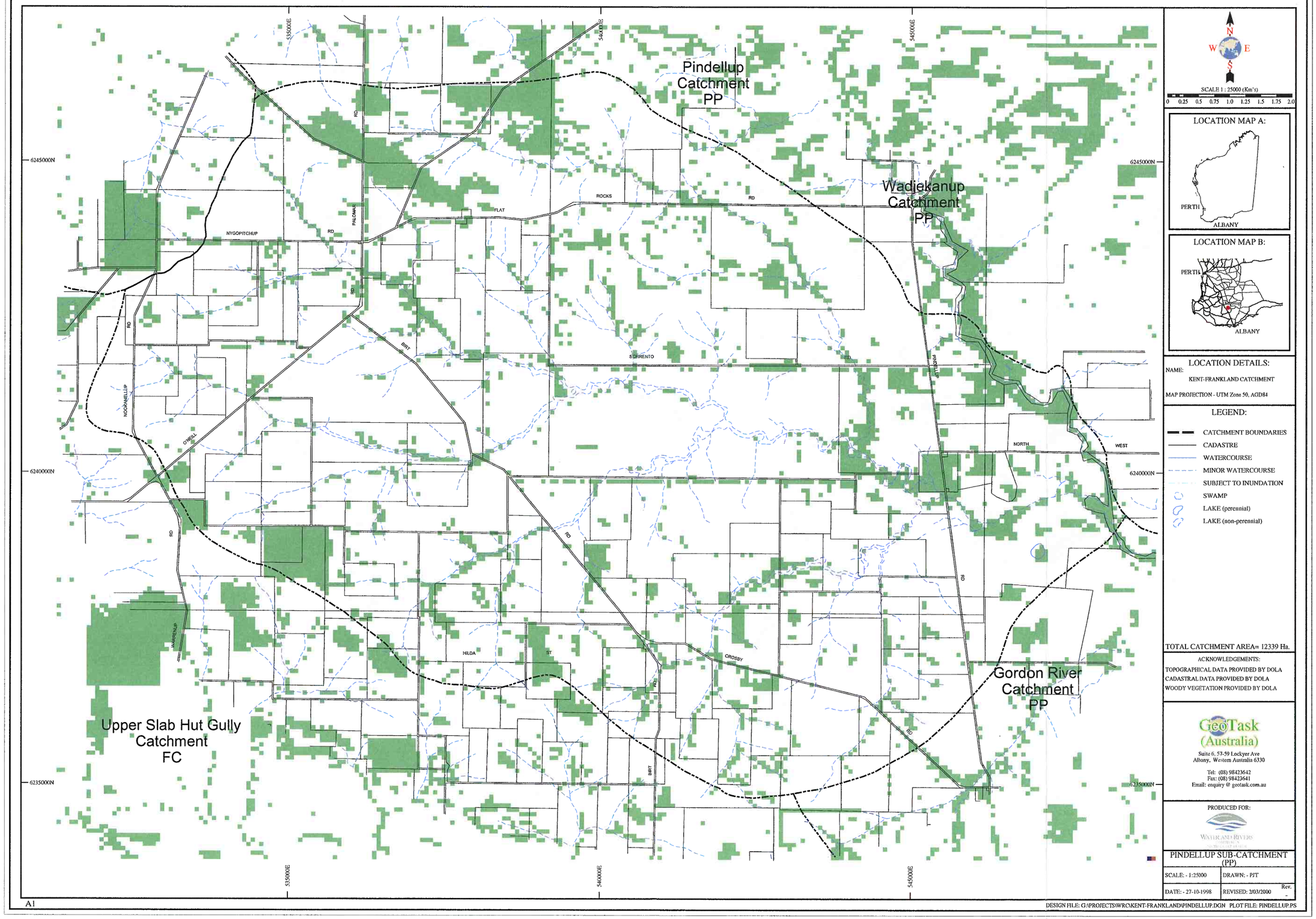


Figure 8.14. Pindellup subcatchment

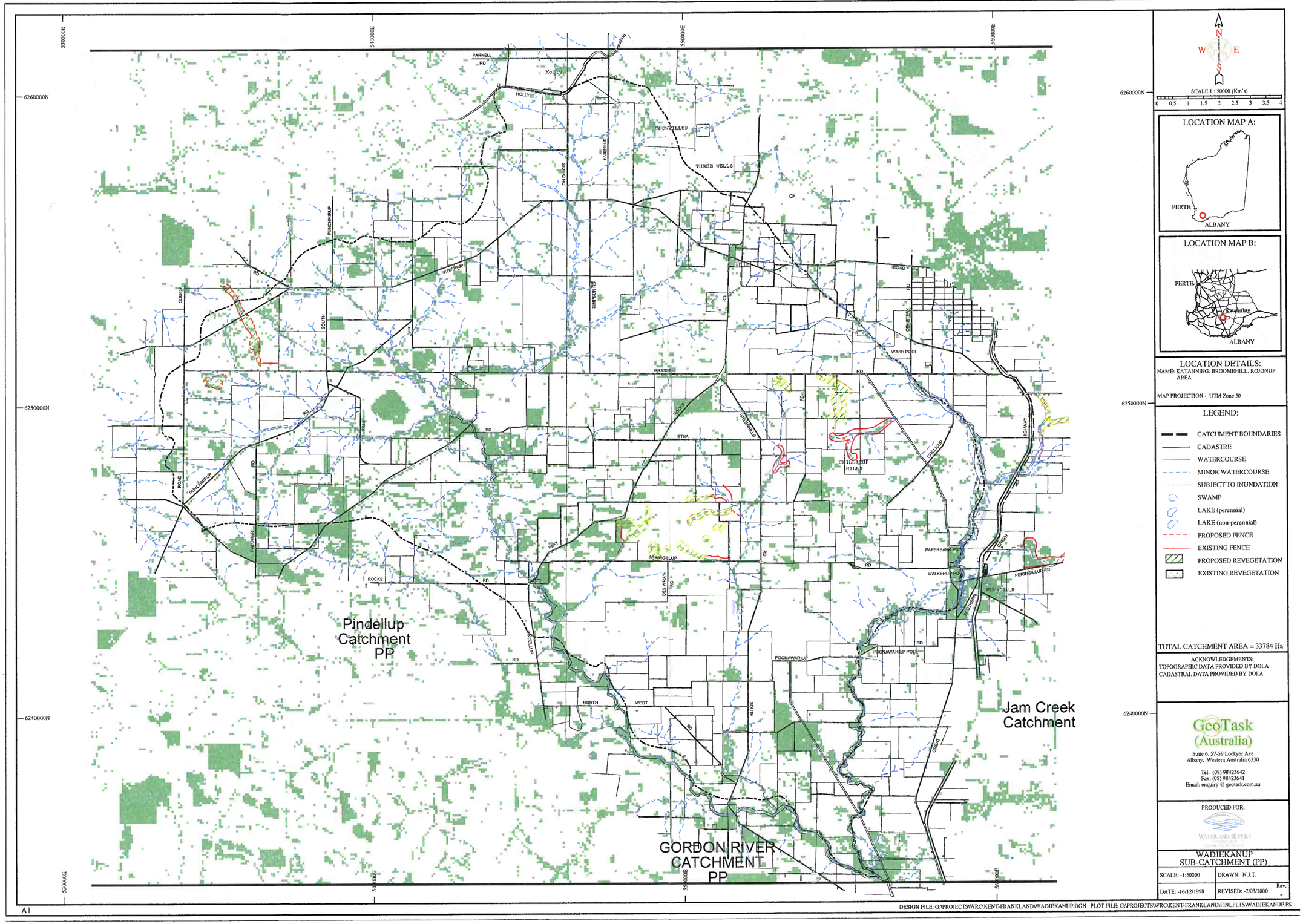


Figure 8.15. Wadjekanup subcatchment

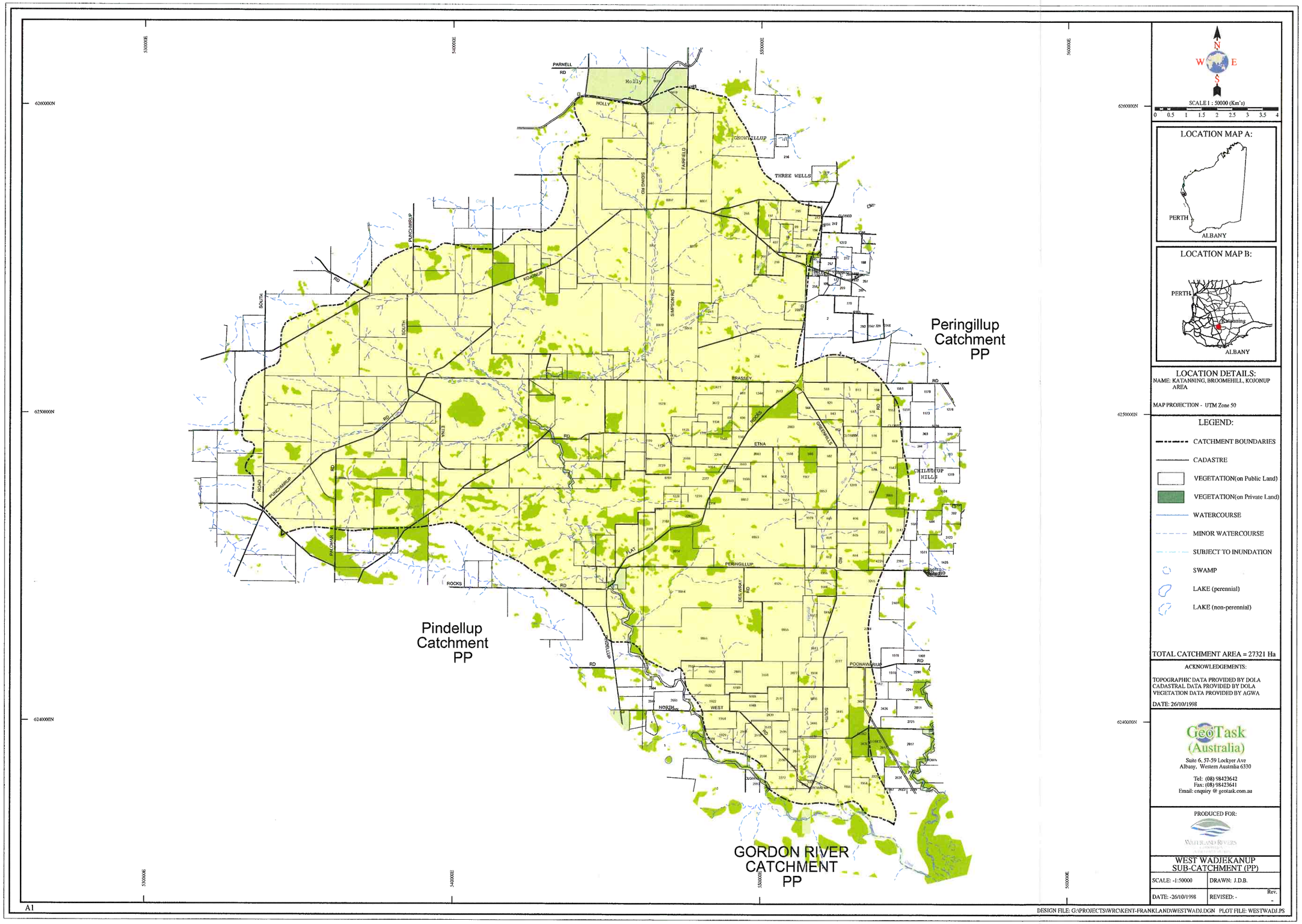


Figure 8.16. West Wadjekanup subcatchment