GOVERNMENT OF WESTERN AUSTRALIA

PHILLIPS RIVER ACTION PLAN

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PHILLIPS RIVER ACTION PLAN

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Cover photograph: Andy Chapman testing the salinity of the Phillips River [taken by Kaylene Parker]

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Purpose of this plan

The purpose of this plan is to provide information on the state of the Phillips River. It also provides management recommendations to address the major processes threatening the health of the river.

In summary, the Action Plan provides:

- a record of river condition;
- water quality information;
- ecological information;
- management guidance; and
- a tool to apply for funding opportunities.

How to use this plan

The Phillips River Action Plan was prepared for the Water and Rivers Commission, community groups and the landholders in the Phillips River catchment.

Section 1 lists the projects aims and objectives and outlines relevant background information.

Section 2 describes catchment information including the natural resources, heritage and land tenure within the catchment.

Section 3 provides information on the Phillips River and Culham Inlet including water quality information, flora and fauna, macroinvertebrates and native fish.

Section 4 This chapter also describes the state of the Phillips River.

Section 5 provides general management recommendations needed to protect the Phillips River. It also includes detailed summaries of each section of the Phillips River and specific management recommendations for them.

Values of the Phillips River

- Culham Inlet is listed in 'A Directory of Important Wetlands in Australia' (Australian Nature Conservation Agency 1996). It is recognized for its scenic, and amenity value, black bream fishing and as a waterbird habitat.
- The Phillips River corridor is one of the four major linkages to the Fitzgerald River National Park Biosphere Reserve. It links to the Fitzgerald River corridor, the Ravensthorpe Range corridor, Mount Madden and a coastal corridor that runs almost continuously from the temperate forests in the west to the Nullabor Plain in the east.
- The entire Phillips River catchment is found within the Fitzgerald Biosphere Reserve, a part tenured management concept recognised by United Nations Educational Scientific and Cultural Organisation (UNESCO) as well as State and Commonwealth governments.
- The vegetative corridor of the Phillips River contributes to its high ecological value with 77% graded as A grade condition.

Executive summary

The Phillips River is located on the South Coast of Western Australia. It originates near Mount Madden in the Shire of Lake Grace and drains 120 km, discharging into the Culham Inlet near Hopetoun.

This report provides a summary of the values,condition and management recommendations for future management of the Phillips River. The current condition of the river was determined through a foreshore survey assessment and water quality sampling, in addition to an assessment of results of other environmental projects conducted on the river.

The Phillips River is in good-excellent condition, with a wide corridor of foreshore vegetation running the entire length of the river. Seventy-seven percent of this vegetation is in excellent condition (A grade). The river is largely protected from stock and weed infestations are restricted to a few areas. There are no major areas of erosion or sedimentation of river pools compared to many other rivers in the South Coast. Considerable work has been undertaken by landholders to protect the upper area of the river corridor, with those areas of the river in private ownership being fenced and revegetated. Many landholders are also fencing their tributaries, which is helping protect the tributaries that drain to the Phillips River.

The major threatening processes for the long-term health of the river include invasive weeds, which mainly occur in the south of the river and salinisation and/or waterlogging, which mainly occurs in the north. The worst degradation by weeds occurs at three well-defined, relatively small nodes where historical agricultural practices including grazing and movement of sheep has occurred and resulted in the understorey being partially replaced by weeds. There have been few water quality samples taken on the Phillips River, however there is a concern that the salinity levels have increased in the river.

The vegetative corridor has protected the river in most cases from impacts of surrounding land uses. There are early stages of system degradation however some of these can be managed on a local scale. Catchment wide issues such as salinity and waterlogging need to be addressed at a catchment scale.

Andy Chapman on the Phillips River (photograph Kaylene Parker)

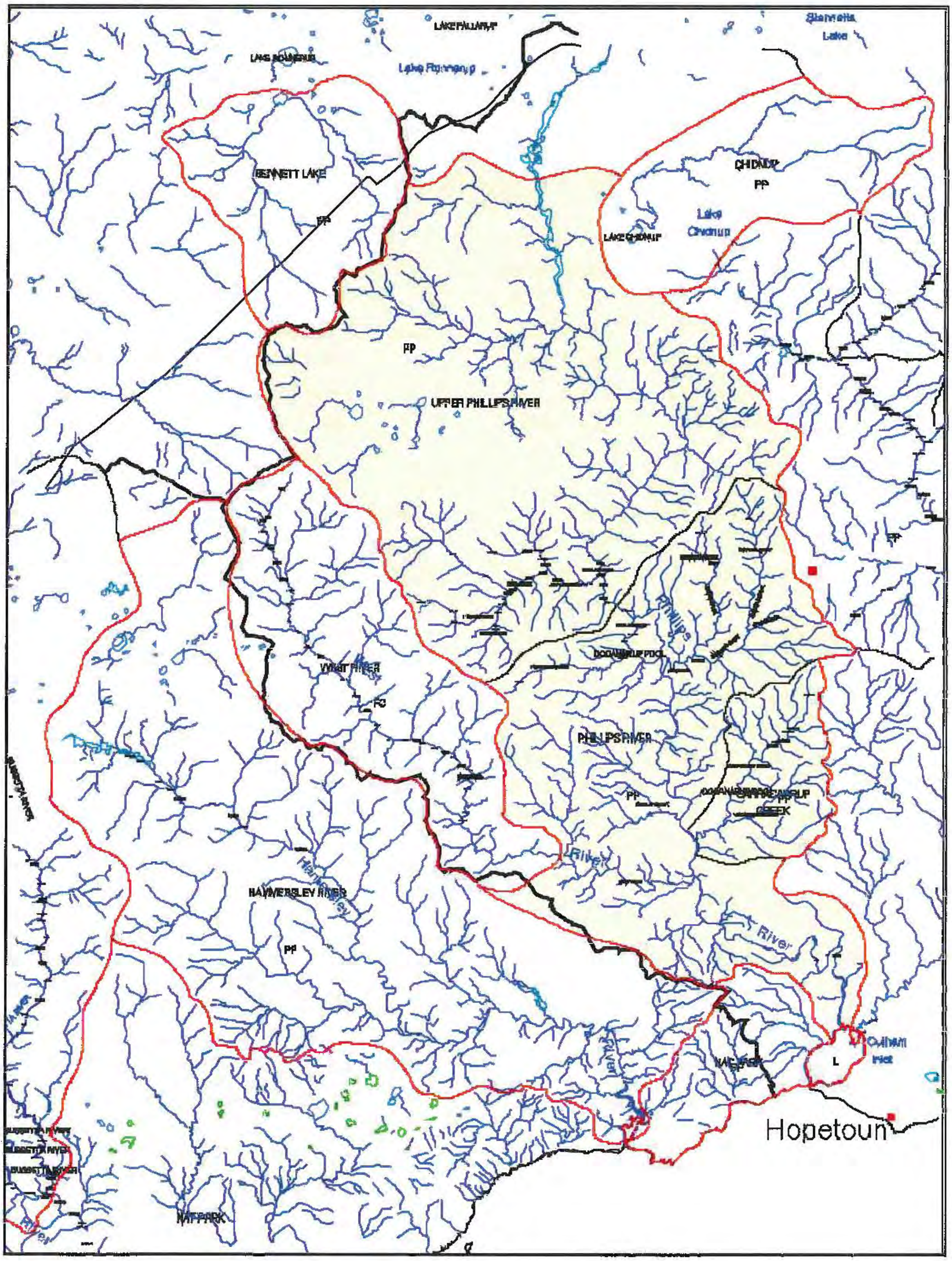


Figure 1. Location of the Phillips River catchment

1 Introduction

1.1 The issue

Waterways in Western Australia are a significant asset with important ecological, economical and ecological values. Ecologically, river channels and their riparian vegetation provide habitat for birds, frogs, native fish, and macroinvertebrates and form important wildlife corridors. They are often refuges for fauna during dry seasons, and form corridors linking micro and macro-corridors from coastal reserves to inland reserves between remnant bush habitats on private property. Estuaries link the catchment to the oceans with a corresponding unique array of aquatic and terrestrial flora and fauna. Economically waterways are important for tourism and recreation. Culturally they are spiritually significant to Aboriginals and formed part of European history for early explorers and settlers.

Many Western Australian rivers are becoming degraded as a result of human activity within and along waterways, and through the off-site effects of catchment and land uses. The erosion of foreshores and invasion of weeds and feral animals are some of the more pressing problems. Water quality in our rivers is declining with many carrying excessive loads of nutrients and sediment, and in some cases contaminated with synthetic chemicals and other pollutants (Water and Rivers Commission, 1999). Important river pools are being filled with sediment and receiving estuaries are showing signs of eutrophication. Secondary salinity is threatening the health and viability of many of our waterways across the State.

1.2 Background

The Phillips River and its protection is of considerable interest to the Ravensthorpe Land Conservation District Committee (LCDC), RAIN (Ravensthorpe Agricultural Initiative Network) and the informal Phillips River sub-catchment group. The Ravensthorpe LCDC felt that little was known about the Phillips River. They requested further information on water quality, historical information and ecological information on the rivers. This information has been incorporated into this report. An Envirogrant has recently been submitted by the Ravensthorpe LCDC, which plans to protect tributaries draining to the Phillips River. The final unfenced section of the Phillips River is currently being fenced - funded by the landholder, Water and Rivers Commission and the Natural Heritage Trust.

The Ravensthorpe LCDC has also been successful in obtaining NHT funding for a catchment survey supported by the Department of Agriculture and the Shire of Ravensthorpe. A report titled 'Phillips River Catchment' includes an assessment of natural resources in the catchment including secondary salinity risk, wind erosion risk and so on – with relevant management recommendations. Protection of the Phillips River ultimately depends on looking after the catchment. Issues such as waterlogging, secondary salinity and paddock erosion will have considerable impacts on the health of the river, therefore working together at a catchment and farm scale is needed.

1.3 Methodology

The Phillips River Foreshore Survey was done using the Stream Foreshore Assessment and Survey Technique developed by Pen and Scott as a guide (WRC, 1999). The approach to the survey is determined in part by the functional definition of a riparian zone as '*any land which adjoins, directly influences, or is influenced by a body of water*'. This is the definition adopted by the River Restoration Program (Boulton & Brock 1999). Riparian zones have four main functions: geomorphic influences ie. bank stability; shading; litter inputs and regulating nutrient fluxes (Cummins 1974). Awareness of this definition as well as the functions of riparian zones are fundamental to undertaking the assessment of foreshore condition.

The assessment technique classifies the condition of the foreshore as being in A, B, C or D grade. This technique breaks these grades down further, ie. A1, A2, A3, B1, B2 and so on, to provide a more detailed assessment, but for this survey a broader picture was required.

Prior to fieldwork both black and white aerial photography and custom prepared color mapping at a scale of 1: 50 000 were examined to identify sections that could be readily walked in the time available, adjacent land uses and if possible general condition and nature of riparian vegetation. As it was desirable to walk the entire river from the Fitzgerald River National Park boundary to Mt Madden, planning to define achievable portions of the river, invite appropriate assistance and organise vehicles at either end of walk was needed. Assessments took place over 8 days or part days between 21 September and 8 December 2000. The portion between Highway One and Aerodrome Road, conducted as a community walk, had 16 participants and finished with a social barbecue.

A total of 30 sections were used for the 85 km of river walked. A road or track intersection, a prominent bend or a change in landuse defined each section. In addition to the data required for the foreshore assessment form the following data were recorded:

- waterfowl presence on pools;
- land birds and other fauna that were using the riparian vegetation;
- water quality parameters, particularly electrical conductivity and dissolved oxygen, were measured *in situ* with a WTW Multiline P4 meter;
- presence/absence of fishes:- the spotted minnow(*Galaxias maculates)* and the blue-spotted oby (*Pseudogobius olorum)* as well as the introduced yabby *(Cherax destructor)*that was washed into the river from farm dams following the January 2000 flood; and
- aquatic macrophytes were collected and identified and weeds were noted.

A Grade vegetation of the Phillips River – pristine to near pristine condition

B Grade condition – note the weeds, although this is probably largely influenced by the 2000 flood event

C Grade – note the overstorey remains however the understorey is sparse and weed dominated. This site has since been fenced

D Grade – note the erosion and lack of understorey species. This is a tributary of the Phillips as there were no sections on the Phillips that were D grade condition

2 Catchment and community context

2.1 The catchment

The Phillips River catchment and its tributary the West River occupy an area of 2307 km^2 in the Shire of Ravensthorpe. The Phillips River catchment is 35% cleared (Pen 1999), mainly cleared in the late 1950s early 1960s. The Phillips River headwaters are in lands largely cleared for agriculture between Ravensthorpe and Mount Madden. The southern third of the river is within Fitzgerald River National Park, a large (329 000 ha) national park recognized internationally for its scenic values, extremely high plant species diversity and rare and endangered fauna.

2.2 Hydrogeology

Generally, in the catchment most groundwater is confined to weathered and fractured granitoid and greenstone rocks. There are between 5-20 metres to the saline watertable and the TDS of the water is between 14 000 and 30 000 mg/l. The lower salinity is usually found in upper catchment valley slopes where there is greater infiltration of rainwater. The watertable is closer to the surface in the north where it overlies granitoid rocks (Dodson 1999).

The replacement of deep-rooted, native, perennial plants with annual crops has resulted in less water evaporating or being retained by the vegetation – resulting in increased catchment runoff. This is causing groundwater levels to rise, resulting in secondary salinisation and/or waterlogging. At present 11.2% of cleared land is affected, this is expected to increase to 18.3% by 2010-2020 and to 22.7% when equilibrium is reached (Ferdowsian 1996).

2.3 Climate

The climate of the catchment is Dry Mediterranean according to the system of Bagnouls & Gaussen (1957). At Ravensthorpe, the nearest official recording station, the mean annual rainfall is 424.2 mm and the median is 415.2 mm. The wettest and driest years on record are 734.5 mm (1951) and 234.1 mm (1940) respectively. There are on average 109 rain days per annum. Temperature varies seasonally with warm-hot summers and cool-cold winters. The average summer temperature range is from 14°C to29°C and the average winter temperature range is 7°C-17°C. Frosts are recorded in winter though frequent cloud cover diminishes the frequency. Evaporation ranges from 1500 mm pa in the south to 2000 mm pa in the north.

Wind is an important environmental factor in the catchment because most days are windy and the effects of light rains on plant growth are often militated by the evaporative effect of wind. Between May and October strong north westerly winds are associated with the passage of cold fronts along the south coast; the passage of the front is accompanied by a west-southwest change which, unlike elsewhere in the Wheatbelt, often delivers most winter rain. Summer winds are northerly or easterly associated with high-pressure systems in the Great Australian Bight and developing low pressure troughs off the west coast. Most of the catchment receives a regular sea breeze in summer, which is usually southeasterly. .

Despite being in a winter rainfall area, the most significant rainfall events are over summer and associated with either decaying tropical cyclones or complex upper atmosphere interactions. Usually these are not forecast and the associated flooding is a significant factor in agriculture, local river management, access and communications. A predicted increase in the severity of natural events such as cyclones, bushfires and particularly flooding due to enhanced greenhouse effect may have significant local implications (DEP 1998).

2.4 Vegetation

The vegetation of the catchment falls almost entirely within the Eyre botanical district of Beard (1990). The northern extremity, north and east of the Lake King-Ravensthorpe Road, is within the Roe district. Beard (1976) mapped three vegetation systems over the Phillips River catchment and are described below.

(i) Chidnup System. This system occupies the watershed between the southerly flowing coastal rivers and the Swan-Avon drainage. The dominant vegetation types are *Eucalyptus eremophila – E.oleosa* mallee on lateritic soils and *E.redunca- and E. uncinata* mallee on sandier soils lower in the landscape. Mallee heaths and woodlands with swamp yate(*E. occidentalis*) also present.

(ii) Jerramungup System. This system is south of the Chidnup system and occupies soils derived from and overlying granite, it has mallee associations similar to it but much better developed swamp yate woodlands in valleys and swamps. Other distinctive vegetation types are broombush (*Melaleuca uncinata*) thicket and sandplain heath.

(iii) Qualup System. This system is south of the Jerramungup system and occupies soils derived from marine sediments of the Albany – Fraser Orogen. Mallee heath with tallerack or blue mallee (*Eucalyptus pleurocarpa*) is particularly well represented. Other complex mallee associations as well as swamp yate woodlands are present.

2.5 Soils

Soils of the Phillips River catchment and elsewhere are determined by geology, landform and past climatic events. The boundary between the Archaen Yilgarn Shield and the Barrens Group has a dominant influence though most of the catchment. North of this boundary most soils are derived from the weathering of granite and re-working of the weathered material. A consequence of this is the abundance of duplex soils ie. those with a sandy A horizon and a clay B horizon. These are known locally as 'mallee' and 'sand over clay' soils. Laterisation of weathered material occurred extensively during wetter conditions in the Tertiary and sandy gravelly soils are present as a result. In between these two main soil types are small pockets of deeper sands usually referred to as 'sandplains'. They have characteristic vegetation including banksias and an array of sand-inhabiting lower shrubs. To the east of the catchment and south of Cocanarup are small pockets of hard red cracking clay or clay loams derived from weathering of Archaean greenstone rocks of the Ravensthorpe Range.

South of divide the soils are often derived from marine sediments; they include deep sands and sand over gravel. The soils of the riparian corridor and its main tributaries are often re-worked and transported; they are not indicative of the soils of the wider catchment.

2.6 Fauna of the Philips River riparian corridor

The only fauna survey work of any detail on the Phillips River is from two sites, Cocanarup Timber Reserve and Aerodrome Road Reserve, examined by Sanders (1996) as part of her study of Fitzgerald Biosphere Reserve. This study recorded 85 species of birds, 6 species of mammals, 7 species of frogs and 25 species of reptiles from the two sites.

The birds inhabiting the riparian vegetation of the river together with waterfowl are relatively well known due to the present survey. Several threatened species of terrestrial vertebrate are known including mallee fowl (*Leiopoa ocellata*), Western whipbird (*Psophodes nigrogularis oberon*), Carnaby's cockatoo (*Calyptorhynchus latirostris*) and carpet python (*Morelia imbricata*). Carnaby's cockatoo is considered to be most at risk, ranked as *endangered* under the Wildlife Conservation Act, 1975 . It is nomadic within the riparian corridor as opposed to the other species, which are resident and wholly dependent upon the ecological integrity of the corridor. Mallee fowl and Western whipbird are ranked as *vulnerable* and the carpet python as *specially protected.* The present survey recorded Western whipbird at 2 km south of Fitzgerald Road, a northerly extension of known range.

Frogs are a unique species that rely directly on water. Their health is invariably dependent upon the water in the environment. If the water is degraded or has pollutants, the frogs aren't likely to survive. 'Alcoa Frog Watch' is a community program to encourage monitoring of local frog species. The following frog species have been recorded on the Phillips River:

Table 1. Frogs recorded in the Phillips River catchment

Scientific name	Common name
Litoria cyclorhynchus	spotted-thighed tree frog
Ranidella pseudinsignifera	granite froglet
Limnodynastes dorsalis	banjo frog
Neobatrachus albipes	white–footed trilling frog
Heleioporus albopunctatus	spotted burrowing frog
Myobatrachus gouldii	turtle frog

Table 2. Reptiles recorded in the Phillips River catchment

Scientific name	Common name
Cenophorus ornatus	ornate dragon
Varanus rosenbergi	southern monitor
Ergernia kingii	King's skink
Morethia obsura	
Cryptoblepharus virgatus	
Notechis scutatus	tiger snake
Pseudonaja affinis	dugite
Morelia spilota imbricata	carpet python

2.7 Heritage values of the Phillips River

2.7.1 Aboriginal heritage

There is no doubt that the Phillips River featured prominently in the lives and economy of Aboriginal people prior to, and for a short period following, the European settlement of the Ravensthorpe district. There are 32 registered Aboriginal sites in the Shire of Ravensthorpe associated with the Phillips River (Shire of Ravensthorpe, 2000). As there has been no ethnographic survey of the River there is probably many others. The present survey located a possible stone arrangement and smooth rocks, perhaps used as a grinding site. Near the Phillips River bridge on Highway One is a patch of 'twice trodden ground'. This is nearby to a typical gnamma hole complete with stone cover. This freshwater spring was used by early settlers and travellers to obtain water.

The River and valley would have provided water, hunting and other food gathering opportunities on river flats, access from the coast to inland sites and were likely sites for ceremonial and religious activities.

2.7.2 European heritage

The Phillips River was named on 22 December 1848 by J. S. Roe after his son-in-law - Squire J. S. Phillips of 'Culham', who owned a horse breeding property located between Toodyay and Bolgart. Culham Inlet was later named after this property. The naming of the river occurred while Roe was returning to Perth from his expedition that started at York. During the expedition he also travelled to and named Mount Madden, Peak Charles, the Bremer and Russell ranges. After naming the Eyre Range he journeyed up the River from Culham Inlet and is reported to have discovered coal north of Hopetoun. This find no doubt was a factor in his much better known discovery of coal in the Fitzgerald River several days later.

'Cocanarup' on the Phillips River was the site of Ravensthorpe district's first European settlement. John Dunn applied for and was granted a lease at Cocanarup in 1868. He and his brothers over-landed sheep from Albany the following year. John Dunn was speared by an Aboriginal in 1880 and the recriminations from this event precipitated the demise of Aboriginal people in the district.

James Dunn discovered payable gold in 1899 and production began soon after at a number of mines. The population of Ravensthorpe grew from 500 in 1900 to 3000 in 1909. Thereafter, copper replaced gold as the principal mineral mined in the Phillips River Mineral Field. The ore was exported from Hopetoun first by wagon and then by rail. A fall in the price of copper in 1939 caused many mines to close. Small-scale mining began again in the late 1950s.

Other historical associations include the commencement of farming in 1905 by Max Moir at 'Kybalup' just north of the Phillips and West Rivers confluence. There is also an abandoned farm 'Cowerdup' on the River north of the Eyre Range, which was occupied by George and Bertha Parsons in 1925.

The Phillips River has lent its name to WA's smallest mineral field; the Phillips River Goldfield as well as Ravensthorpe's first newspaper 'The Phillips River Times'. The original local authority was the 'Phillips River Road Board' and the earliest vehicle number plates issued were pre-fixed by 'PR'.

Historical interview - *Phil Thomas (pers. comm. 2002)*

The Thomas family was one of the families occupying Cocanarup Springs, a property south of Ravensthorpe on the Phillips River, originally settled by the Dunn brothers in the 1860s. The property was bought from the Moirs in 1944. Phil left Cocanarup in 1957 to work in Katanning. Donald Thomas still owns Cocanarup Springs.

Phil Thomas spent his childhood at Cocanarup Springs, and spent many hours exploring the Phillips River. Snakes were common along the river, always a concern for their mother. The river was often a source of food and Mr Thomas remembers when food was a little short, taking a spade and the dogs down to the river to catch rabbits.

"If there was no meat, mum used to send us off to catch rabbit or duck on the river. If the dogs didn't flush them out, we had to dig them out".

Phil recalls that kangaroos were a source of food or the skins were sold to make money.

"We used to string wire across two trees to catch the kangaroos, or go spotlighting. This was sometimes our entertainment instead of dances. The kangaroo meat was fed to the pigs, and the skins were sold for money. This often used to be enough just to buy ammunition. Duck shooting was one of our sources of tucker".

Phil remembers Aboriginal graves near the Dunn grave, which was marked by sticks and bush posts sticking out of the ground. He thinks these will be gone now due to fires or would have rotted away.

"John Dunn was speared by Aboriginals, and the story goes that the police rounded up the local Aboriginals and speared these"

Phil's brother - Donald Thomas, built a spring in the Phillips River near Cocanarup Springs. Donald built the wall around the spring to help hold the water. He was careful not to build this too high so he didn't force water back elsewhere. The spring was used for stock water.

" It was called the bubbling spring, and it never once stopped bubbling. There is also some freshwater pools north of the highway called 'kangaroo soak', which are on the edge of the river. There also is a freshwater pool up Cocanarup Creek called 'Stoned up Soak', where stones were placed around the soak to help it hold water"

'Dunn's swimming pool' was a popular swimming spot in which Mr Thomas remembers swimming many times as a child.

"Dunn's swimming pool is down from the crossing - 400-500 m upstream from the grave site. I remember diving off a flat rock, but unfortunately I hadn't been taught to swim, and my brother saved me. The pool gradually silted up but I do remember that the floods cleaned it out".

The Thomas family used to go to Culham Inlet for picnics sometimes. There was good fishing. There was a corrugated track to get there. Culham Inlet never opened in Phil's memory. Phil does remember an event in 1955 when the school bus couldn't get across the River.

"Mum crossed the river in a horse and cart to pick them up from school. Our lunch boxes were floating in the back of the cart on the way back across".

Phil remembers a river crossing between the Highway and Cocanarup Road, a natural flat rock crossing.

Phil has seen little minnows in the river. Phil remembers a lot of dead fish in the Inlet once.

"We used to bend pins to act as a hook and a bit of cotton – we never caught them though".

Phil's memories of the area include two limestone kilns, one of which was on the river bank near the crossing, plus Dunn's making mortar to build their house from lime and sand and the horse yards built by Dunn's on the river from the top crossing before Cocanarup.

"There used to be wild horses between Hopetoun and Bremer Bay, along the sandplain. Dad found the mob once as he lost his horse into the pack, but the stallion wouldn't let him into the mob".

Phil remembers dingoes coming in at night and the river becoming very salty in the upper catchment over summer, such that they used to bag the salt up for the horses.

2.8 Land tenure

Of the approximately 120 km of the Phillips River over 60% is held in reserves. Thirty kilometres is within Fitzgerald River National Park; 13.5 km is within Cocanarup Timber Reserve, (both managed by the Department of Conservation and Land Management) and 29.7 km is within Reserve No. 34410 'Parklands and Recreation'. These reserves offer differing degrees of protection to the River. The upper 10.2 km of the Phillips River north-east of the Lake King-Ravensthorpe Road is privately held freehold currently used for farming; re-vegetation and exclusion of grazing is currently practiced here.

Two sections of the Phillips River are in Unallocated Crown land. There is a 15 km-section between the Fitzgerald River National Park and the south boundary of Cocanarup Timber Reserve. Some of this section, ie. north of Kybalup farm, is in land proposed by the Department of Conservation and Land Management as a nature reserve. The other section, between the north boundary of the timber reserve and Aerodrome Road, is 5.5 km in length. This is the only section of River that has no protection and there is no protection proposed. Nominally the Department of Land Administration is responsible for management of Unallocated Crown land.

Pitchie Ritchie, Phillips River (photograph Shane Lawrence and Kaylene Parker)

3 Environs of the Phillips River and Culham Inlet

3.1 Phillips River

The Phillips River is approximately 120 km in length, draining from North East of Mount Madden to Culham Inlet on the South Coast. The headwaters of the river are in lands largely cleared for agriculture between Mount Madden and Ravensthorpe. This northern section of the river is in a poorly drained area, and the river forms a sequence of salty pools. Because of the river's poorly defined nature, the actual catchment boundary is not officially delineated.

Further south, the Phillips River drains along a fault line through the Quartzite rocks of the Mount Barren Beds. The southern third of the river flows through the Fitzgerald River National Park before finally reaching Culham Inlet.

The Phillips River is naturally salty and flows only for a short period of the year, often after rainfall events. The river itself has considerable habitat values including overhanging vegetation, series of river pools and riffle zones that provide ecological niches for aquatic flora and fauna. The pools often have a dense growth of shrubs and trees between them. The smaller pools may be dry in summer but many larger pools, (often 1 km long), can be several metres deep and always hold water.

3.1.1 Geology of the Phillips River

To understand a river and its hydrology it is necessary to understand something of the geology and landscape processes that have formed it. This can be done at both the regional and local scale. The former is the big picture and includes the geological time component. This has been done elegantly by Mary White in her recent book 'Running Down – water in a changing land' (White 1999). Prior to Australia's separation from Antarctica *circa* 80 million years before present (mybp) the rivers of WA's central south coast originated in the mountains of Antarctica and flowed northward. Following separation, in the Eocene Period *circa* 40 mybp, a warm shallow sea covered much of the south coast and penetrated inland in these river valleys. Marine sediments were deposited which today are revealed as the well-known spongolite cliffs, mesas and buttes as seen in the Fitzgerald River National Park and elsewhere. As the Eocene Sea retreated there were major changes to local drainage; a divide called the Jarrahwood Axis developed parallel to the coast approximately 60–70 km inland. North of the divide the land was uplifted, south of it the land tilted away to the coast causing the local rivers, including the Phillips, to reverse their flow with increased energy. This process is called rejuvenation, occurring approximately 30 million years before present.

At the local geological scale the Phillips River originates in the vicinity of One Tree Rock, north east of Mt Madden, in a sandplain that has been re-worked in the Tertiary period. Between Muncaster Road and Fitzgerald Road the river traverses Quarternary gypsiferous sands and silts associated with the internally-drained Lake King playa lake system. The presence of this surface type here is indicative of the upper Phillips being at the drainage divide previously referred to. At Bridger Road there is a major geological change; south of which the Phillips River cuts through Archaean gneisses that extend south to Cocanarup Road. These are basement rocks, which provide for river pools and habitat for fish and aquatic invertebrates in comparison to the river north of Bridger Road, where the water is in very shallow, open clay-pans.

Between Cocanarup Road and its confluence with Manyutup Creek, the River traverses a complex Archaean greenstone belt that has been used for mineral prospecting with some exploration and mining having occurred, including the 'Pick and Shovel' mine. South of Manyutup Creek the Phillips River traverses a large area of Ravensthorpe quartz diorite that extends to Fitzgerald River National Park. Within the quartz diorite and adjacent to the river where the valley is well-developed, small pockets of alluvium and minor colluvium occurs.

3.1.2 Water quality of the Phillips River

The Phillips River catchment is in the Southwest Coast drainage division where, on average, only 1.7% of precipitation is runoff (figure 2.7 in Boulton & Brock 1999). Therefore over 98% of rainfall received is returned to the hydrologic cycle by other means. The Phillips River flows seasonally in response to rainfall events. A small proportion enters groundwater but by far the greater majority is normally returned to the atmosphere by evapo-transpiration from plants. There are some sections of the river where it is thought that groundwater flow occurs all year round.

Water and Rivers Commission operate a gauging station at Pitchie Ritchie, on the Phillips River. This has been recently upgraded to allow continuous flow recordings and measurements of electrical conductivity (salinity). Future monitoring results from this gauging station will be constantly telemetered, and results will be available on the Water and Rivers Commission web page. Prior to this, the Water and Rivers Commission and the Water Corporation (formally Water Authority of Western Australia) undertook spot sampling (Appendix 1), and through various other projects. This includes three snapshots conducted as part of this project in 1999, 2000 and 2001, and samples taken during the flood event (figure 2) , in January 2001 (Appendix 2.). These results are summarised in table 3.

Salinity

The Phillips River is naturally saline due to transport of soil-stored salts, mainly sodium chloride, which originated either from previous marine incursion, or from salt of marine origin, borne by wind and rain over thousands of years.

There is very little hard data to support the contention that the salt content of the River is increasing, however the observations of farmers and the changes to vegetation observed during this survey indicate that this may be happening. This is supported by limited data obtained from a pool on the Fitzgerald River National Park boundary. Twelve samples taken monthly between February 1983 and February 1984 had a mean conductivity of 22.8 mS/cm (Chapman 1985) (Appendix 2). Chapman has also sampled the same pool on 11 occasions between July 1997 and October 2000 to obtain a mean conductivity of Total Dissolved Solids of 43.7 mS/cm. These data, not being flow weighted, need to be interpreted with caution. However given that the samples show a doubling of mean conductivity over 15 years, do give cause for concern, particularly as some of the recent data were taken post flood when the River showed reduced salinity (*Andy Chapman, pers. comm., 2002).*

The Water and Rivers Commission conducted a 'snapshot' of river water quality in 1999, 2000 and 2001 and recorded salinity measurements (figure 2, table 3). This data does not enable any trend analysis, however indicates differing salinity levels in the river at different sites, and for different times. This data showed that the Phillips River is considerably more saline towards the north of the catchment, and becomes fresher towards the coast.

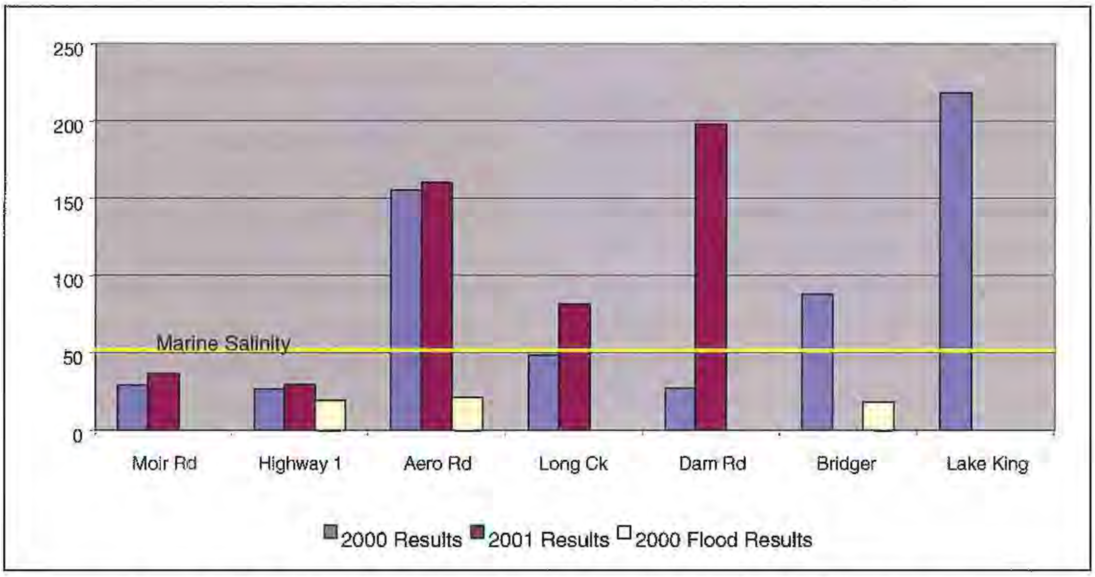


Figure 2. Conductivity levels (salinity) of various sites of the Phillips River (mS/cm)

Table 3. Water quality results of the Phillilps River for the 'Snapshot' – Andy Chapman

Site Description	Date	Salinity mS/cm	DO Mg/l	Temp	PH	Turbidity
Fitzgerald River Nat Park	18/01/1999	25.2	21.8		7.98	
(50773246H6260537)	17/10/2000	28.8	15.4	23.0	8.7	10
	16/01/2001	36.4	10.7	26.9	8.5	10
Cocanarup Rd	18/01/1999	27.9	19.8		6.97	
(51768765 H6274398)	17/01/2000 (flood)	18.03	7.04	23.9	7.14	60
Cocanarup Springs	18/01/1999	14.7	23		8.31	
Highway 1	18/01/1999	37.4	21.7		8.69	
(50767152H6277655)	17/10/2000	26.4	5.0	16.1	7.6	10
	17/01/2000 (flood)	19.04	7.25	23.8	7.14	60
	24/01/2000(flood)	1.30	8.97	18.6	7.29	300
	16/01/2001	29.2	11.5	32.8	7.9	30
Aerodrome Road	17/10/2000	155	6.9	16.3	8.0	60
	17/01/2000 (flood)	21.0	8.07	23.6	7.36	50
	16/01/2001	160	2.1	38.8	6.9	100
Long Creek	17/10/2000	48.5	8.4	16.7	8.1	15
	16/01/2001	81.4	7.9	31.9	7.8	40
Dam Road	17/10/2000	27.1	8.5	18.7	8.7	15
	16/01/2001	197.7	3.5	34.7	7.3	40
Bridger Road	17/10/2000	87.8	8.5	16.6	9.0	10
	17/01/2000 (flood)	18.18	7.07	22.5	7.07	10
	16/01/2001	NA	NA	NA	NA	NA
Fitgerald Road	17/01/2000 (flood)	13.34	7.93	21.8	7.22	10
Lake King	17/10/2000	218	5.9	20.3	7.4	15
	16/01/2001	NA	NA	NA	NA	NA

Notes: *The locality 'Fitzgerald River National Park' is where Moir Road crosses the national park boundary. Sampling sites on Bridger and Lake King roads were completely dry for the January sample. A Multiline WTW P4 meter was used to record electrical conductivity, dissolved oxygen, pH, temperature and turbidity*

The salinity of seawater is 51 mS/cm.

Nutrient information

Chapman (1985) found in 1983-84 that most records of total phosphorus from the Phillips River were between 0.01 and 0.03 in June and up to 0.06 mg/L in October. The levels recorded by the Waters and Rivers Commission staff in 1997-98 were, although most likely not in the same areas, very similar (Appendix 1). The measurements ranged from 0.02 and 0.03 in area 1 and between 0.06 and 0.09 in area two. This varied data would suggest that high concentrations of total phosphorus were short lived in the river system, and were either stored in river pools, consumed by plant matter or washed downstream into the Culham Inlet.

The level of total nitrogen is of larger concern due to the high readings recorded in 1997-98 in two sites along the Phillips River. The readings ranged from 1.63 mg/L down to 0.32 in the space of one month in site 2 and 1.41 to 1.37 over two weeks in site 1. These recordings far exceeded the recommended limit of 0.75mg/L set out by ANZECC (1992). The effect of these nutrients existing at high levels in the river for a short period of time could not be speculated, however if they persist, then there would be cause for further investigation into their sources.

Flood event January 2000

In January 2000 the Phillips River flooded due to above average and widespread rainfall in the catchment. Examination of rainfall figures for Ravensthorpe, the nearest official recording station, indicate that the official rainfall for January 2000 (224.4 mm) is the highest monthly figure since records began in 1902 and the only time that a monthly figure has exceeded 200 mm. The flood flow lasted until late April 2000.

Due to a malfunction at the official rain gauge on the 14 and 15 January, the official figure underestimates the actual rainfall. Another rain gauge in Ravensthorpe recorded 103 mm over these days compared to the official figure of 49.6 mm. Thus the actual rainfall for January 2000 in Ravensthorpe was 277.8 millimetres.

The previous highest monthly record was 163.3 mm in January 1939. The flood was initiated by 103 mm over 14/15 January and maintained by a second pulse of 137.2 mm over the period 22-26 January. The flood flow, as opposed to the base flow, which is often nil, lasted until late April 2000. Flood water quality data recorded by Multiline WTW P4 meter on 17 January at the Highway One bridge site are in Table 3.

The flooding caused widespread and prolonged disruption to the district including washing away the bridge embankment at the Highway One bridge and making the highway impassable for five weeks. The causeway across the mouth of the Culham Inlet, constructed in 1997 was washed away and not replaced for 12 months.

There was damage to local river crossings at Aerodrome, Bridger, and Long Creek roads as well as localised damage to creek crossings of most major sealed roads. The flood affected many aspects of the river itself including shifting sediment, causing erosion of river banks, invasion of weeds, destruction of some riparian vegetation, and chemical changes to physical and chemical characteristics of the water quality. In a short section of Carracarrup Creek, a major tributary, the dense in-stream growth of *Melaleuca cuticularis* restricted the peak flow to the extent that the creek re-defined its channel. This is a particularly graphic example of an effect of the flood. Following the second flood event on 24 January 2000, the greatest change was the decline in electrical conductivity between the first and second pulses with the first pulse flushing accumulated salts and with the second there was a brief and atypical period when the River was almost fresh. Twelve months post flood very high salt levels in the order of 150-190 mS/cm were recorded in the upper section of the river.

Flooding is a natural process for rivers and our plants and animals have often adapted to these events. Flora species such as swamp yates germinate after floodwaters have subsided. Many of our aquatic fauna such as our native fish species *Galaxias maculatus* breed in upstream pools left by receding floodwaters or significant flow events. Floods also scour pools out of the river bed and provide permanent river pools for future drought refuge.

3.1.3 Macroinvertebrates

Macroinvertebrates or aquatic bugs consist of worms, snails, crustaceans (prawns and marron) and insects (such as mayflies, stoneflies, beetles and bugs). Many macroinvertebrate species are found in the waterways throughout the Phillips River catchment.

Macroinvertebrates play an important role in the ecology of the river system. In the upper catchment, macroinvertebrates are responsible for shredding larger particles including bark, leaves and other detritus that falls into the waterway. Further downstream, macroinvertebrates such as worms, gilgies and marron take small particles of organic matter from the sediment and digest them further. Algae that grows on the rocks is 'scraped off' by snails and limpets. There are also predator species of macroinvertebrates including the dragon fly, adult beetles and stonefly larvae that prey on smaller animals.

The quality of the water is linked to the survival of macroinvertebrates and in turn larger animals such as fish. Macroinvertebrates are sensitive to changes in the physical and chemical conditions of the water, including salinity, flow and temperature.

The most important feature in a stream is vegetation – including logs, branches, bark and leaves. This forms the basis of a food web for macroinvertebrates in our waterways. Vegetation removal can impact on food availability, light penetration, water flow, sediment levels and temperature of the water. Protection of foreshore vegetation is vital to ensure the protection of the ecological attributes of our river system. Removal of riparian vegetation upstream can have serious consequence on downstream macroinvertebrates that rely on the input of organic matter to the system.

Macroinvertebrates have been sampled as part of the National Rivers Health Program. The Phillips River was sampled as a test site in 1997 (table 4). Only a few species of macroinvertebrates were sampled and further monitoring is likely to find more species.

Table 4. Macroinvertebrate species collected in the Phillips River as part of the National River Health Program 1997 (Aerodrome Road)

Scientific name	Common name
Hydrophilidae	beetle
Lestidae	damselfly larvae
Notonectidae	water backswimmer
Oniscidae	slaters
Orthocladiinae *	non-biting midge larvae
Staphylinidae	Beetle
Tanypodinae *	non-biting midge larvae
Oligochaete	aquatic worm

Source:CALM AUSRIV program (1997),site sampled Aerodrome Road.

3.1.4 Native fish

Murdoch University as part of its regional survey of native fish in inland waters - sampled three sites on the Phillips River - Highway One Bridge, West River Bridge and Aerodrome Road crossing. These form part of a national network of 605 sites at which river health is monitored by the collection of invertebrates as part of the River Health Project (AUSRIS). Four species of fish were recorded on the River including black bream (*Acanthopagrus butcheri*), spotted minnow (*Galaxias maculatus*), Swan River goby (*Pseudogobius olorum*) and hardyhead (*Atherinosoma?Leptatherina? wallacei*). A record of western pygmy perch (*Edelia vittata*) from the Phillips River is believed to be erroneous, (David Morgan *pers. comm., 2001*).

The Swan River goby grows to about 6 cm. It is brown to tan with numerous irregular dark blotches and spots. The most distinctive feature is that the eyes protrude and sit high on the head. The Swan River goby can tolerate extreme salinities and temperatures and is one of the few native fish found in highly eutrophic systems. It can be found in a range of waters from estuaries, rivers and streams and in both freshwater and hypersaline lakes. It is usually found in the muddy bottoms of still or slow moving water. The goby will feed on algae and mats of bacteria and fungi as well as insects and crustaceans.

Hardyhead *(Leptatherina wallacei)* – Allen records it as *Atherinosoma wallacei*

Wallace hardyhead (also known as Western hardyhead) are common at 4 cm but can grow up to 6 cm, silvery fish that tend to swim around in schools. It generally is an olive-green colour with silvery sheen on its sides and belly. Inhabits clear, flowing freshwater streams and upper estuaries with reduced salinities. It is

Swan River goby (photograph Kaylene Parker) normally seen in schools near the surface or around the shoreline vegetation and log debris. Spawning occurs during spring and summer months. The diet consists largely of insects and small crustaceans (Allen, 1989).

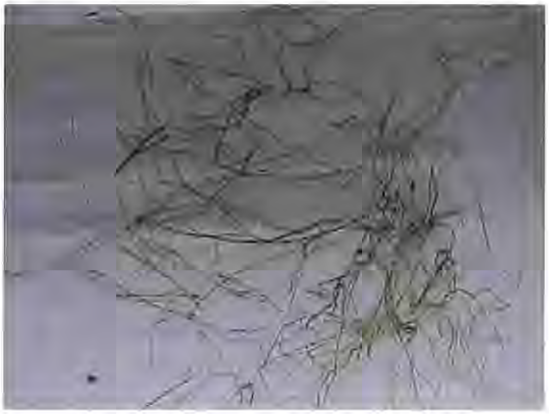
Spotted minnow

Spotted minnow *(Galaxias maculatus)* is a slightly larger fish, common at 10 cm but can grow to 17 cm, that is found in a variety of habitats, but is most common in still or slow-flowing waters, mainly in streams, rivers and lakes within a short distance of sea. They can survive in salinity up to 50 ppt. The diet includes a wide range of aquatic and terrestrial insects and crustaceans. Whether in landlocked water systems or in waterways with access to the sea, the spotted minnow lays its eggs on dense terrestrial vegetation and then relies on a series of flooding events to complete the spawn development life cycle (Allen, 1989).

3.1.5 Aquatic flora

The following aquatic flora was found in the water column of the Phillips River during a snapshot conducted in January 1999. Species sampled included macrophytes (rooted aquatic plants such as sea grasses and macroalgae visible to the naked eye), phytoplankton (small algae often single celled), benthic algae (feeding off the sediment) and epiphytic algae (small algae that grow on aquatic plant surfaces and give it a furry appearance). The results of the snapshot are included in Table 5. Kathryn McMahon from the Water and Rivers Commission identified the macrophytes and some of the epiphytic algae.

Aquatic flora can be an indication of the health of a system. The type and density of species are influenced by a number of factors such as temperature, light availability, salinity, water flow and nutrient concentration. For this reason there is often variation between seasons. Prolific growth is often experienced in late spring and during summer.



Ruppia sp. *Collected on the Phillips River (photograph Kaylene Parker)*

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 *Scenedesmus* and dense blooms of blue-green algae such as *Nodularia, Anabaena, Microcystis* and occasionally *Oscillatoria* (Entwisle *et al.* 1997 & Vas Hosja pers. comm.) Low species diversity is also an indication of excessive nutrients.

The two main species of macrophytes identified in the Phillips River were the angiosperm, *Ruppia megacarpa* and the Charophyte, *Chara.* The main epiphyte species were Chlorophytes, *Spirogyra*, *Zygnema* and *Cladaphora.* The sediment samples were composed of a number of species from the blue-green including *Lyngbya, Oscillatoria, Anabaena* and *Nodularia.* These also contained a mixture of species including Chlorophytes, *Mougetia, Enteromorpha, Botryococcus,Rhizoclonium, Cladophora and Oocystis,* diatoms such as *Melosira* and blue-green algae such as *Anabaena, Oscillatoria* and *Lyngbya.* There were many individual diatoms in the samples but these were not identified. Some estuarine species were found in the sediment samples, which is probably due to the saline characteristics of some of the rivers.

Table 5. Aquatic flora sampled in the Phillips River

Location	GPS	Date	Aquatic flora found
Fitzgerald River National Park	50 7 732 46 H 62 605 37	18/01/1999	No macrophytes, scum visible.
Cocanarup Road	51 7 687 65 H 62 743 98	18/01/1999	*Ruppia megacarpa,Chara,Cladophora, Botryococcus, Melosira, Anabaena, Lyngbya, Oscillatoria Spirogyra*
Highway One	50 7 671 52 H 62 776 55	18/01/1999	*Ruppia megacarpa, Rhizoclonium, Cladophora, Oscillatoria, Lyngbya*

3.2 Culham Inlet

(Information taken from Hodgkin and Clarke, 1988)

The Culham Inlet is located on the eastern flank of East Mount Barren, 7 km west of Hopetoun. It is recognized for its scenic and amenity value, black bream fishing and as a water bird habitat. The inlet is listed in 'A Directory of Important Wetlands in Australia' (Australian Nature Conservation Agency 1996).

The Phillips and Steere rivers discharge to the northern area of the inlet through a wide area of deltaic sand gravel about 2 m above the level of the lagoon bottom. This includes extensive shell beds of marine and estuarine species of molluscs.

The Inlet is shallow and often dries out in summer. It generally fills up from winter rainfall, and sometimes holds water for several years (as in 1988 and 1989). The Inlet is oval in shape and is approximately 11.3 km^2. In most areas the water level is less than 1 metre deep. There was about 4.5 m of water in the centre of the Inlet in August 1989. The Culham Inlet extends 7 km up the Phillips River, which always holds water and is deeper than the Inlet – 8 m or more near the cliff at 7 km. The smaller Steere River is estuarine for about 2 km.

3.2.1 Water quality

Culham Inlet is naturally saline and when it evaporates the little water that remains in the estuaries becomes too saline for all but a few marine or estuarine animals to survive. When the salinity levels in the inlet are favourable, there can be an abundance of the few species of fish and other estuarine fauna such as black bream, some hardyheads, gobies and their invertebrate prey. Populations of sea mullet and a few other species of fish are recruited from the sea when the bars break and may flourish for months or years until the water becomes too saline. Black bream and smaller native fish come down with the floodwaters from river pools and at times are very abundant. The salinity levels of the inlet water varies from 17mS/cm to 119mS/cm (seawater is 51mS/cm). Estimated flow to the Inlet varies from zero to >50 x 10 ^{6} m ^{3}, with most episodic events occuring over a few days following heavy rain (Hodgkin, 1997).

During the bar opening in 1993-1994, monitoring results indicated that levels of dissolved oxygen were uniform over the estuary system, with no evidence of stratification. The nutrient levels varied considerably pre and post bar opening, and also varied between the sampling sites. The nitrogen and phosphorous levels recorded are two or three times those recorded from estuaries with largely forested catchments. It is recommended that further samples of the river would enable an estimation of nutrient loads to the inlet.

3.2.2 History of Culham Inlet

Four thousand years ago Culham Inlet would have been a valley with a river flowing through it. The Inlet would have had a rich marine fauna similar to Princess Royal Harbour today (Hodgkin and Clarke, 1988). Today, Culham Inlet is cut off from the sea by a large foredune and is often referred to as a 'transient estuary' or 'fossil estuary' as it is seldom open to the sea. The bar is about 500 m long and 30-40m wide, and about 4-5 metres above sea level. It is subject to erosion and storm waves expose patches of hard limestone reef rock in the sea beach. The bar is reported to have been open in the 1870s after winters of very heavy rain (E. H. Dunn in Archer, 1979). Gregory (1849) records the bar breaking in April 1849 after continuous heavy rain. Accounts differ about attempts to break the bar. Varied dates from many sources include 1917, 1920, 1906, 1918 and 1955 (Hodgkin and Clarke, 1988). The Inlet has since opened naturally in 1993 and more recently in January flood event, 2000.

Flood event 2000

Culham Inlet opened 21/01/2000 (*Mark True, pers. comm.*) The culvert and road crossing Culham Inlet were damaged and closed for over a year. The inlet was estimated to be rising at 10 inches/year on the 21/01/2000 (Mark True, pers. comm., 2000). The inlet rose in January by 4.8 m, and an estimated 550 cubic metres of water per second poured out of the two rivers. Main Roads decided to dig an emergency channel across the west of the culverts to encourage the sacrificial section and to take the access water. The inlet level still rose, and 5 4.1 m above mean sea level, the causeway washed away – leaving a 300 m gap in the road embankment when estimated tidal flow was over two million cubic metres per tide (Ralph Cooper, *pers. comm., 2000*). The

Page 2 - COMMUNITY SPIRIT, Thursday February 3, 2000

Two floods hit Ravensthorpe

January has been a disastrous month for many parts of WA. A broad band of country stretching from Perth to Hopetoun had well over 100mm of rainfall concentrated in the two weekends 14-16 and 21-13 January.

Over the month to date (26 January), Ravensthorpe is the wettest place in the south of WA with an official 195mm. It has beaten its previous highest January total rainfall and suffered its wettest day since records began about 100 years ago. Areas just west of the town were even wetter.

All of this conspired to saturate paddocks, block many roads and generally upset communications over the whole district. The South Coast Highway was torn apart at the Phillips River Bridge in the first weekend and then some preliminary repair works were washed away in the second.

Roads to the north around Lake King and Lake Grace were also blocked by floods and so the district was effectively cut off from the west.

CULHAM INLET WAKES UP

At the turn of the millennium, Culham Inlet was a sleeping giant. It had not risen by more than a foot or two any time since 1993 and for some of that time it was just a puddle in the middle. But over the two January weekends it rose by 4.8m and, for a while, 550 cubic metres of water per second were pouring out of its two rivers.

But it had started off quite dry (0.7m below mean sea level) and even the 3m rise in the first weekend did not threaten the expensive new road access from Hopetoun into the National Park, completed in 1996. The six-year-old sand bar south of the road was still a metre higher than the Inlet and holding firm. Everything was working to plan.

But the Inlet, as usual, had other ideas. The next weekend it rose steadily upwards, despite the 12 full 1.8m culverts all pouring water towards the sand bar which soon opened to the sea. On the Sunday afternoon, Main Roads Department decided to dig an emergency channel across the road west of the culverts to encourage the planned sacrificial low section there to break open and take the excess. It did so in a minor way but didn't stop the level rising.

Again the Inlet laughed at the planners and three hours later when it was 4.1m above mean sea level, it burst out dramatically just east of the culverts. It followed exactly the same route as last time in 1993, leaving a 300m gap in the road embankment. This was the hardest section to build because it is over the deep and soft channel created when 1993 relief plans misfired—and no doubt it is now the most expensive to repair.

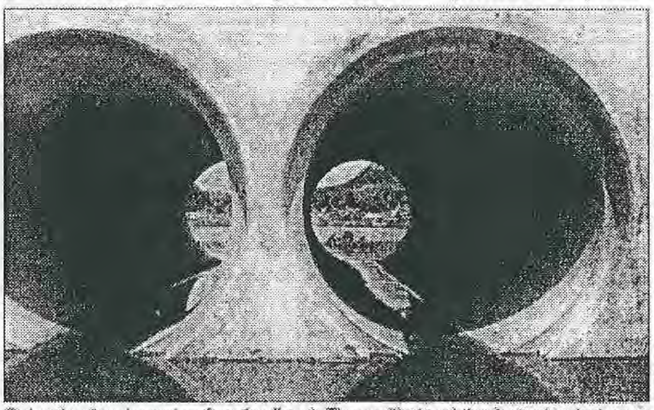
The next day was that time all over again. The spectacular display of water power attracted hundreds of spectators. More stretches of the old dunes were undermined and collapsed, trees and concrete structures were swept onto the new wide beach, and the sea turned from blue to brown.

The Inlet has once more had its say. Now again it is the turn of the local people.

More detail on p3.

—Ralph Cooper

STOP PRESS: Hammersley Inlet has also broken through. Sea shell fish and octopi are dying in the fresh water giving a great feast for the pelicans.



Culverts stand empty after the flood. They withstood the battering but were not very effective.

Figure 3. Newspaper article from 'Community Spirit' – Two floods hit Ravensthorpe

COMMUNITY SPIRIT, Thursday February 17, 2000 - Page 5

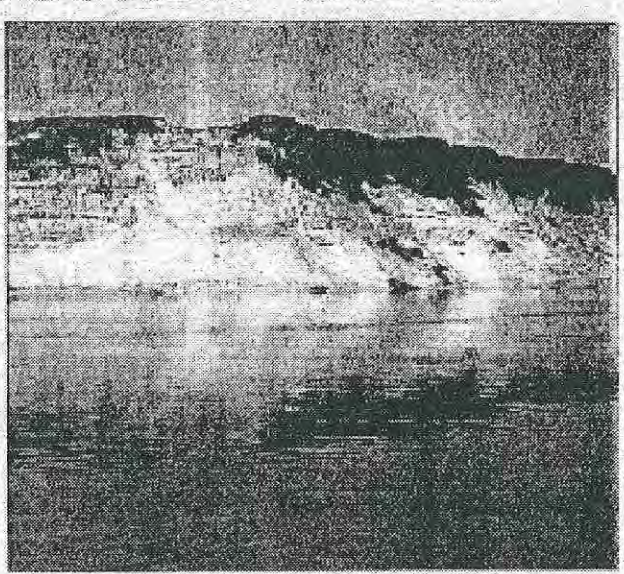
Culham settles down

The Inlet has now become a pleasant tidal estuary, as it was in 1993 after the breakout in May of that year. However the tidal range is greater than then, no doubt, because the channel to the sea is now wider and deeper. It makes a fine sight. The flow is over two million cubic metres per tide!

This commencing water flow is still eroding the dune at the western edge of the sea opening, exposing a limestone cliff in places. In fact the large concrete culvert which was swept all the way from the road to the beach at this point is now almost engulfed by the channel and looks likely to sink out of sight under the sand. It will make an odd relic for future archaeologists.

The large masses of fresh and salt water are still mixing, but look likely to produce good water for the bream and mullet to multiply. But of course they will all be killed again when the bar closes the gap and then the water evaporates and goes hypersaline—unless the bar is periodically opened this time.

Readers have asked me to print our graph of Inlet levels over the years, so here it is (facing page). The recent record rapid rise above from the breakout and the present tidal range can all be seen—though rather squashed at the right of the graph because it all happened so quickly. It remains to be seen whether the water follows the same trend as in June–September 1993, rising mainly from high tides and waves flowing in over the rising bar. But the fish were dead by February 1995.—Ralph Cooper



The deep channel to the sea makes fine reflections of the new dune cliff.

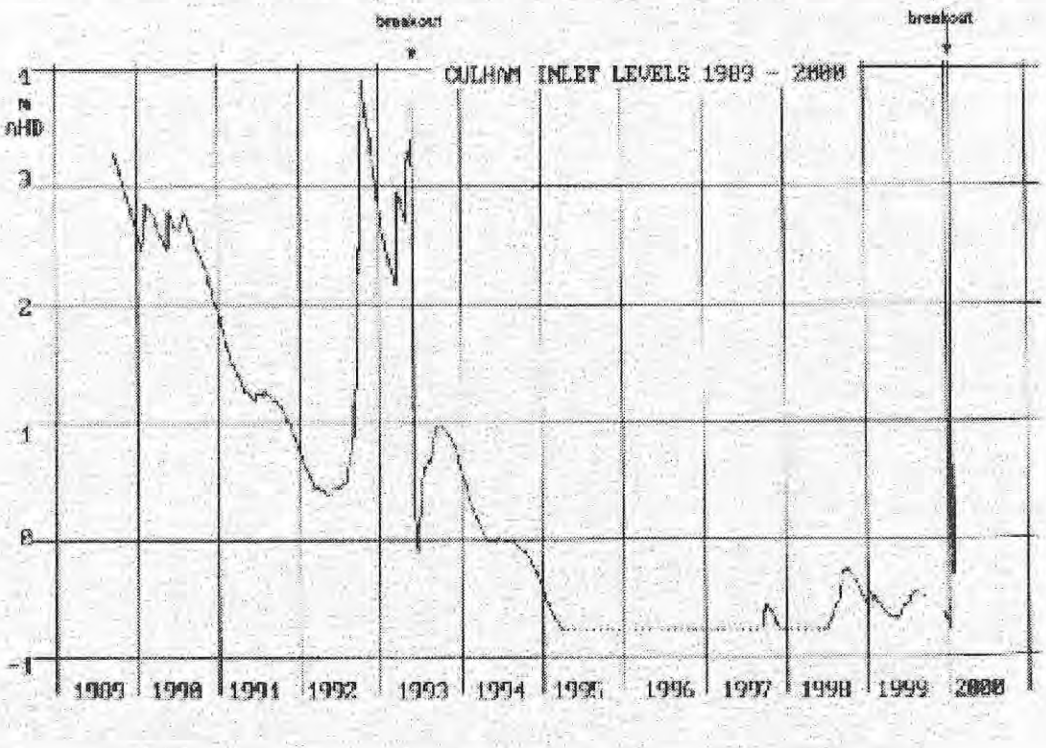


Figure 4. Newspaper article from 'Community Spirit' – Culham settles down

3.2.3 The biota

(information from Hodgkin 1997)

A biological study was completed on Culham Inlet (Bennett and George, 1994), Culham Inlet is periodically a highly productive ecosystem. Commercial fishers took large catches of black bream in seasons where the water level remained relatively high and salinity was < 76mS/cm. A goby (*Psudogobius olorum*) and two hardyheads (*Atherinosoma elongata* and *Leptatherina wallacei*) were common. There were waterbird populations with 25 recorded species. The few euryhaline estuarine species of macroinvertebrates were abundant including the encrusting tubeworm (*Ficopomatus enigmaticus*) and the false mussel, a few polychaete worms, two amphipods, and midge larvae (Hodkin and Clarke, 1990). After a period while the Inlet was titdal, additional estuarine-marine invertebrate species and a few opportunistic fish species, including sea mullet and herring (Bennett and George, 1994).

The Inlet has a narrow fringe of salt-tolerant flora dominated by the paperbark *Melaleuca cuticularis* backed by coastal moort and yate. *Acacia cyclops* and *Eucalyptus tetragona* on the higher ground. The paperbarks (*Melaleuca cuticularis*) and the coastal moorts (*E. occidentalis* var. *occidentalis*) along the eastern shore of the Inlet died following the prolonged 1989-90 flooding with saline water. The previously limited areas of samphire (*Sarcornia quinqueflora*) have expanded greatly while the water level has been low since 1993. The aquatic *Ruppia megacarpa* was present but not abundant.

Filamentous green algae *Chaeotomorpha indica* with traces of Cladophora were recorded in 1994 (Bennett and George, 1994).

Culham Inlet 1998

3.2.4 Research project

Impact of environmental changes on the biota of Western Australian south-coast estuaries.

Professor Ian Potter, Centre for Fish and Fisheries Research, school of Biological Sciences and Biotechnology, Murdoch University, South St. Murdoch WA 6150, Phone No. 9360 2524 Fax No. 9360 6303 Email i-potter@possum.murdoch.edu.au. Project schedule July, 2002 - June, 2005

Objectives

1. Determine, on a seasonal basis, the compositions of the fish fauna of the basin and riverine regions of Culham, Stokes and Hamersley inlets.
2. Attempt to relate any differences in the compositions of the fish faunas in the three estuaries to differences in the environmental characteristics within and between these estuaries, and in particular of salinity and dissolved oxygen.
3. Use age composition data for black bream to determine the years when there was strong recruitment and weak or no recruitment in Culham, Stokes and Hamersley inlets to determine the extent to which variations in recruitment of this species were related to environmental conditions, and particularly the relative estimated strength of freshwater discharge, the breaching of the bar at the estuary mouth and the relative levels of salinity.
4. Provide environmental and fisheries managers with an assessment of the levels at which salinity and dissolved oxygen influence the abundance of the main fish species and how those critical levels vary amongst those species.

Importance of South Coast Estuaries

Many of the estuaries in the large, central part of the south coast of Western Australia, such as the Hamersley, Culham and Stokes inlets, are atypical in that they are normally closed (Lenanton and Hodgkin, 1985). Some of these estuaries, which are located in a region that now constitutes a very important tourist destination, are fished extensively by recreational fishers, particularly during vacation periods. Indeed, estuaries such as Stokes Inlet provide the most important source of recreational fishing on the south coast for the communities in the Goldfields region, ie. Kalgoorlie, Coolgardie and Norseman. Furthermore, until recently, Culham Inlet supported not only a substantial recreational fishery for black bream, but also the largest commercial fishery for this species in Western Australia, yielding up to 70 tonnes of black bream per annum (R.C.J. Lenanton pers. comm.; WA Department of Fisheries' Catch and Effort System). The decline in the fishery for the black bream, *Acanthopagrus butcheri* in Culham Inlet can be attributed directly to the adverse changes to which this estuary has been subjected during recent years as a result of climatic and anthropogenic activities (see below). The types of extreme change that have occurred in Culham Inlet during recent years are likely to be manifested in other estuaries in the region in the future and thereby likewise have a deleterious impact on their fish faunas.

The type of biological information, that is required for managing the estuaries in the central part of the south coast of Western Australia and also their biota, is limited.

The results of this study will allow managers to understand the consequences of ongoing environmental perturbations in normally-closed estuaries in the central region of the south coast of Western Australia on the fish fauna of those estuaries and, in particular, on the abundance of recreational and commercial species. The data on black bream will enable Fisheries WA to develop appropriate plans for managing this important species in environments where marked seasonal and annual environmental changes have been shown to have major impacts on spawning and recruitment success and on the extent to which the recreational and commercial fish species enter and leave these systems. The findings of the study will assist the Waters and Rivers Commission in providing advice to relevant authorities of the effects of proposed changes to the catchment of the various tributary rivers and of the implications of the breaching of the bar at the mouth of estuaries.

Impacts of changes to south coast estuaries

There can be no doubt that, at least in Culham Inlet, degradation has now reached a point where, in many years, certain important members of its biota, including black bream, undergo massive mortality (G. Sarre, pers. obs.). Although the bar at the mouth of Culham Inlet was never breached naturally between 1850 and 1992, it was breached in the late summer-early autumn of

1993 and again in 2000 due to a significant flow event. Those periods of heavy discharge were caused by a greater runoff from surrounding land than used to occur during similar cyclonic rainfall, and which could be principally attributed to clearing of vegetation in the catchment (Hodgkin 1997, N. Arrowsmith pers. comm.). The breaching of the bar at the estuary mouth in 1993 and 2000 led to black bream being flushed out of Culham Inlet, thus reducing the numbers of this species in the basin of this estuary (N. Arrowsmith pers. comm.). In addition, the population of black bream in Culham Inlet sometimes experiences massive mortality in the warmer months of the year (G. Sarre, pers. com.). In this context, it is relevant that the dry winters, have resulted in low water levels during the summer, particularly when the bar had been breached in the preceding autumn, and this feature, together with an increase nutrient input from surrounding agricultural land, would have been likely to have produced exceptionally high salinities and/or reduced levels of dissolved oxygen. The fact that extreme conditions in Culham Inlet have led to such massive mortalities of black bream in this estuary, but not in the Wellstead Estuary, is almost certainly due to the presence of barriers which, at certain times, would prevent the upstream movement of fish into the refuges offered by the less saline and better oxygenated environments found further upstream.

Management plans were recently implemented for overcoming the damage that is caused by the breaching of the bar at the mouth of Culham Inlet to the coastal road that lay on top of that bar. These plans involved constructing, at a short distance inside the bar, a new coastal road that contained culverts (Hodgkin, 1997). Thus, in years of extreme freshwater discharge, water would not bank up on the inside of the coastal road and have the potential to result in its partial destruction. This management strategy will lead to a decline in the maximum height of water in Culham Inlet, which will inevitably have further impacts on the large basin of this estuary and its biota. The acquisition of comparable data for the impact of extreme conditions in previous years in Culham Inlet will be particularly valuable because it is possible to alter the water level of the inlet and thus inevitably change the environment in which black bream live. Furthermore, such information could be used as a predictive qualitative model to determine the fate of black bream in other estuaries in the region that are facing similar environmental changes.

Project Design and Methods

Samples of fish will be collected seasonally for 2½ years using gill nets and seine nets at three to five sites in Culham Inlet, Hamersley Estuary and Jerdacuttup Lake. Concomitant samples of benthic macroinvertebrates will be sampled using cores to provide data that can be used as indicators of the health of the biotic community. The densities of each species and macroinvertebrate will be determined and these data used to compare the fauna in the three estuaries, which vary in their physico-chemical characteristics. Comparisons between the compositions of the biotas within and between the three estuaries will be undertaken using multi-dimensional scaling ordination. The biotic results will be related to a set of environmental variables that will be recorded at each site at the time of sampling. The otoliths of samples of black bream obtained from each estuary will be used to determine the age composition of the stock of this species within each system. The resultant data on the age structures of the black bream in each estuary will be analysed in the context of previous recorded changes to the environment, such as those produced by the opening of the bar, and any periods of excessively high salinities or relatively low oxygen concentrations.

4 State of the Phillips River and management recommendations

The State of the Phillips River has been determined by collating information from other environmental projects and results from the survey conducted by Water and Rivers Commission. From these results, the Phillips River appears to be in excellent condition, however there are early stages of degradation with three relatively small nodes of advanced degradation (figure 5).

Using the Statewide Waterway Needs Assessment (WRC, 2002), the Phillips River is rated as having a medium value, a low-pressure response and a high condition, with an overall rating of medium – high value. Therefore the Culham Inlet is rated as having; a high value, low-pressure response and a medium-good condition.

Minimal activities and management responses are required to help ensure the long-term protection of the Phillips River. Some activities may require approval from relevant management agencies. There are laws covering management of river drainage, flood management, and for the protection of wildlife and heritage, including Aboriginal heritage.

Implications for management can be classified as either issues that operate at the catchment scale or at the individual landholder scale. This report should be read in context with the catchment report, to encourage adoption of a 'whole of catchment ' approach. The State of the Environment Report considered that land salinisation and salinisation of inland waters were two of only three issues of highest priority environmental status for WA (DEP, 1998). Both of these clearly pertain to the Phillips River and its catchment and place what may seem a local issue into its regional and national context. This survey has also identified three nodes of advanced degradation that can best be addressed at the local landholder level. It is recommended that owners of farmland adjacent to degraded portions of the river be approached to participate in remediation and management of riparian vegetation.

Specific management recommendations for individual sections of the rivers are provided further in section 5.

4.1 Foreshore vegetation condition

Foreshore vegetation (also termed riparian vegetation) is the vegetation found along waterways. Foreshore vegetation is responsible for maintaining the health of the river system. The vegetation provides habitat for a huge range of animals. It supports the soil that sustains it as the root systems form a matrix, which hold the riverbank together. The vegetation provides shade and habitat and leaves dropping into the water are a food source for aquatic animals. If the vegetation is removed erosion increases, weeds take over, rabbits become more plentiful and native aquatic animals such as fish start to decline.

The foreshore survey indicated that the foreshore vegetation is in excellent condition, with a remarkable 77% of the vegetation graded as excellent condition (A grade). A further 12% was recorded as in good condition (B grade) with only 4% in C grade condition (where the native shrub and understorey are replaced by annual grasses). There was no vegetation described as D grade condition. Considerable works had been undertaken by landholders to protect the upper area of the Phillips River – with 7% revegetated (figure 6). The river is almost entirely fenced from stock where it adjoins agricultural areas, with the final unfenced section currently being fenced.

The foreshore survey categories can be further broken down to A1, A2 and A3, B1, B2, B3 and so on – to provide a further classification of condition. The A3 classification for some sections of the river is due to the presence of African boxthorn, which is abundant. With the exception of a small pristine (A1 grading) section north of Bridger Road, the general best condition of the river is A2 (some 55% is of this condition which compares most favourably with other rivers assessed).

	Waterways issues	Comments
Waterway condition	Nutrient enrichment	• No long-term nutrient analysis completed. Preliminary results indicate high nutrient levels. • Algal mats have been noted in Culham Inlet.
	Foreshore vegetation	• Foreshore vegetation condition - 77% A grade, 12% B, 4% C. • Signs of degradation in three small nodes mainly from historical landuse and more recently effects from salinity.
	Exotic plant and animal invasion	• Feral cats, foxes, goats, rabbits and pigs have been recorded on the Phillips River. • Major weed species include bridal creeper and boxthorn.
	Waterlogging and inundation	• Waterlogging, inundation and salinity is causing loss of riparian vegetation, particularly yate trees and many understorey species, particularly in the valley floors in the upper catchment.
	Stream flow changes, flooding salinisation,	• It is estimated that catchment runoff has doubled since catchment clearing and this is likely to increase risk of flooding. • Increased volume of water discharging to the river, carrying inceased salt loads.
	Erosion and sedimentation	• There is some evidence of sediment in river pools along the Phillips River, however this is not significant.
Waterway pressures	Land development – residential, agriculture	• Increased size of broad acre farms. Increased subdivision around the estuary. • Increased tourism pressure, especially lower in the catchment.
	Pollution from point-sources	• Possibly pollutants include pesticides and herbicides. No studies undertaken.
	Water development	• No water development along the river.
	Recreation	• Small amount of recreational pressure in the lower catchment, particularly bream fishing in river pools.
	Commercial fishing	• Culham Inlet is commercially fished.
	Water abstraction, industrial discharge	• No industrial discharge or water abstraction.
	Drainage (saline land drainage)	• There may be increased pressure for deep drainage in the amount of drainage in the upper catchment. Surface water runoff directly into the rivers has increased.
Waterway values	Economic benefits	• 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. • Culham Inlet forms an important tourist drive.
	Biodiversity	• High biodiversity value – river corridor. Also Culham Inlet – National Estate Database.
	Recreation	• Increasing in the lower catchment.
	Aesthetics	• Some spectacular sites, forms important backdrop to some farms along the river.
	Uniqueness	• Unique in that the Phillips is almost entirely A grade, with a wide buffer.
	Spirituality and cultural values	• Little known about social and cultural values. • Social, ecological, cultural and historical values of the river not captured. Few studies completed in the area to determine the importance/connections to the river by indigenous Australians.
	Conservation values	• Culham Inlet – registered on the National Estate Database.
Overall condtion	Highlight lowlight	• The Phillips River is rated overall as in excellent condition.

Figure 5. Summary of waterways degradation issues for the Phillips River and Culham Inlet

The C1 classification for parts of sections 1-4 is where the natural shrub understorey has been completely replaced by annual grasses. The B2 classification for section 19 is due to native and introduced species being 50/50 present in the understorey. The A3 classification for sections 5-9 is due to the presence of African boxthorn which is abundant but has not entirely replaced native species. With the exception of a small stretch north of Bridger Road that is pristine, the general best condition of the River where it has not been influenced by stock is A2; some 55% is of this condition which compares most favourably with other rivers assessed. The effects of salinisation and/or waterlogging are most apparent in the north of section 24 and then in sections 26, 27 and 28 where extensive areas of melaleuca shrubland are being replaced by samphire flat. It is possible that the January 2000 flood has advanced the proliferation of *Halosarcia* spp.

4.2 Weeds

The major degradation issues include invasive weeds, which mainly occur to the south of the river and salinisation and/or waterlogging, occurring mainly in the north. The worst degradation by weeds occurs at three well-defined, relatively small nodes where historical agricultural practices including grazing and movement of sheep has occurred. This has resulted in the natural shrub understorey being completely replaced by annual grasses. There is also African boxthorn, which is starting to out-compete native vegetation in some sections.

4.3 Salinisation and waterlogging

With clearing of native vegetation in the catchment and its replacement with lower water using annual crops and pastures, more water passes into the groundwater aquifers causing the watertable to rise. This has mobilised the salt in the soil - bringing it to the surface. These changes have generated land degradation problems associated with surface and sub-surface water such as water erosion (sheet, rill and gully erosion), waterlogging, inundation, flooding and salinity.

Secondary salinity is currently having an impact on waterways and agricultural land in the catchment and has the potential to continue to degrade. Salinisation has an impact on the health of waterways by increasing the salinity of the waterway, loss of foreshore vegetation and increased erosion. Waterlogging is also impacting on many areas of the catchment (waterlogging often corresponds with salinity). Many areas along the waterways that would have ordinarily dried out immediately after rains, now remain waterlogged for longer periods (Pen, 1999). The effect of inundation and waterlogging, together with salinisation, explains the presence of dead and dying trees along many

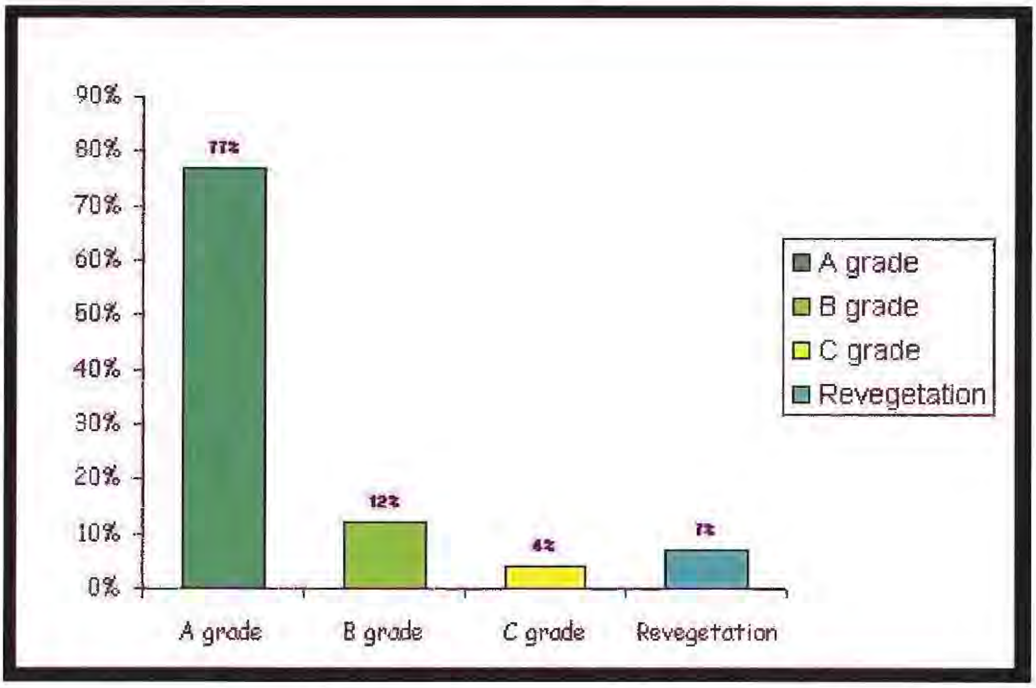


Figure 6. Foreshore vegetation condition Phillips River

waterways in the catchment. The yate tree (*Eucalyptus occidentalis*) is particularly sensitive to rising salinity and inundation.

The effects of salinisation and/or waterlogging are most apparent in the north where extensive areas of melaleuca shrubland are being replaced by samphire flat. Elsewhere along the river there are sporadic deaths of swamp yate trees, and further examination is required to determine whether salinisation and/or waterlogging, or for example insect attack is the cause of the decline.

4.4 Feral animals

The survey recorded that rabbits are present along the river however they were only abundant in section 2. This is in contrast to the situation on the Oldfield River where they are in relatively high numbers throughout due to the greater presence of deeper sands. No feral animals were recorded in the assessment although feral goats, sheep and pigs have been reported in sections of the river. Only one fox was recorded.

4.5 Sedimentation and erosion

The river channel is generally stable however it is likely that clearing has resulted in an increase in the volume and rate of river flow. Sedimentation of river pools is a concern as pools are important drought refuges for many aquatic flora and fauna. At this stage sedimentation does not appear a major issue however there is no hard data to show what effect it may have had on river pools or Culham Inlet. There is evidence that some sediment is entering the main channel from tributaries in the catchment.

4.6 Water quality

There have been few water quality samples taken on the Phillips River, but there is a concern that the salinity levels have increased in the river, even though the river is a naturally saline system. There are also rising groundwater levels and subsequent salinisation and/or waterlogging in the catchment. At present 11.2% of cleared land is affected, this is expected to increase to 18.3% by 2010–2020 and when equilibrium is reached, it is estimated that 22.7% of the catchment will be impacted by secondary salinity (Ferdowsian, 1996). This is likely to have significant impacts on the river in the future.

Richard Pepper showing his ideal fencing location for the Phillips River (photograph Kaylene Parker)

Table 6. Management recommendations to protect the Phillips River

Protect foreshore vegetation of the river	• Revegetate degraded sections of the river with local, indigenous species. • Develop a fire management strategy for the Phillips River in cooperation with The Department of Conservation and Land Management, Bushfires WA and local bushfire brigades that encourages natural regeneration and protection of riparian vegetation. • Examine the sporadic deaths of swamp yate to establish whether they are consistent with natural attrition or due to salinisation and/or waterlogging or insect attack. • Address the proliferation of tracks along the Phillips River through an appropriate management plan. • African boxthorn threat to the River be assessed and a removal program be initiated immediately.
Protect tributaries in the upper catchment	• Fence and revegetate tributaries in the upper catchment. • Revegetate saline river valleys with salt tolerant species, and increase the buffer width to allow for groundwater rise.
Improve water quality	• Conduct a routine water quality-monitoring program in the catchment, in particular examining nutrient levels and salinity levels. • Monitor ecological characteristics of the river – including macroinvertebrates, frogs, native fish and macrophytes. • Minimise sediment and nutrient transport to the river from paddocks – through minimum till farming, soil testing, contouring and retention of vegetative buffers adjacent to waterways.
Improve stability of river crossings	• Water and Rivers Commission provide the Shire of Ravensthorpe and landholders with technical advice on correct design and location of crossings. The design of these should take into account changed catchment hydrology.
Increase awareness of cultural and heritage values of the river	• Capture cultural and historical values of the Phillips River through interviews, stories and published articles. • Increase community understanding and awareness of the river through river walks and information evenings. • Capture the importance/connections to the Phillips River by indigenous Australians.
Catchment hydrology changes (salinity)	• Monitor groundwater levels to assess groundwater rise in the catchment. • Increase water use throughout the catchment by using perennials, surface water management, management of waterlogged and water-repellent soils (AgWest, 2001). • Design and implement suitable water management options throughout the catchment, in particular surface water management options.
Land use planning and development proposals	• Future subdivisions/developments in the upper catchment – request the vesting of the foreshore reserve with an appropriate agency. • That the portions of river corridor that are Unallocated Crown land ie. between the north boundary of Cocanarup Timber Reserve and Aerodrome Road and between Fitzgerald River National Park north boundary and MHL 140 be gazetted as reserve for 'protection of river'.

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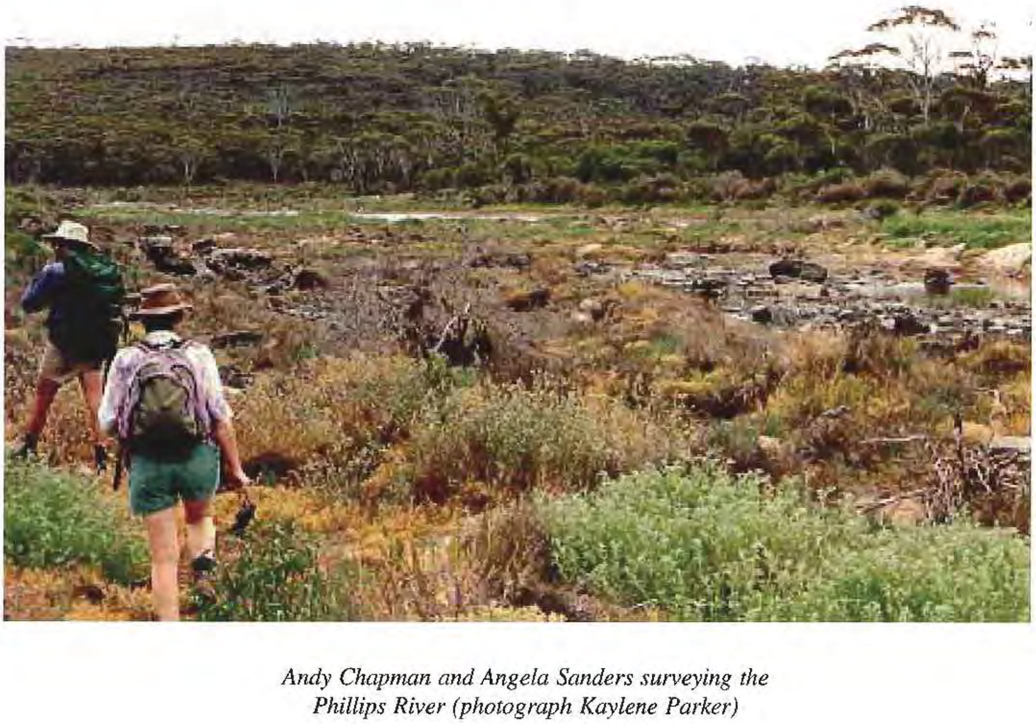
5 Foreshore survey results and specific management recommendations

The following sections describe in detail the vegetation condition (A-D grade), the vegetation communities, weeds, bank stability and other information for specific sections of the Phillips River. Specific management recommendations for each section of the river are also included in this section.

The foreshore condition is mapped over a vegetation change map, which shows vegetation change since 1988. The vegetation condition change map is provided by DOLA, as part of the Land Monitor Project. A copy of this map in addition to a satellite imagery map of the Phillips River Catchment is also provided in the front cover of this report.



Andy Chapman and Angela Sanders surveying the Phillips River (photograph Kaylene Parker)

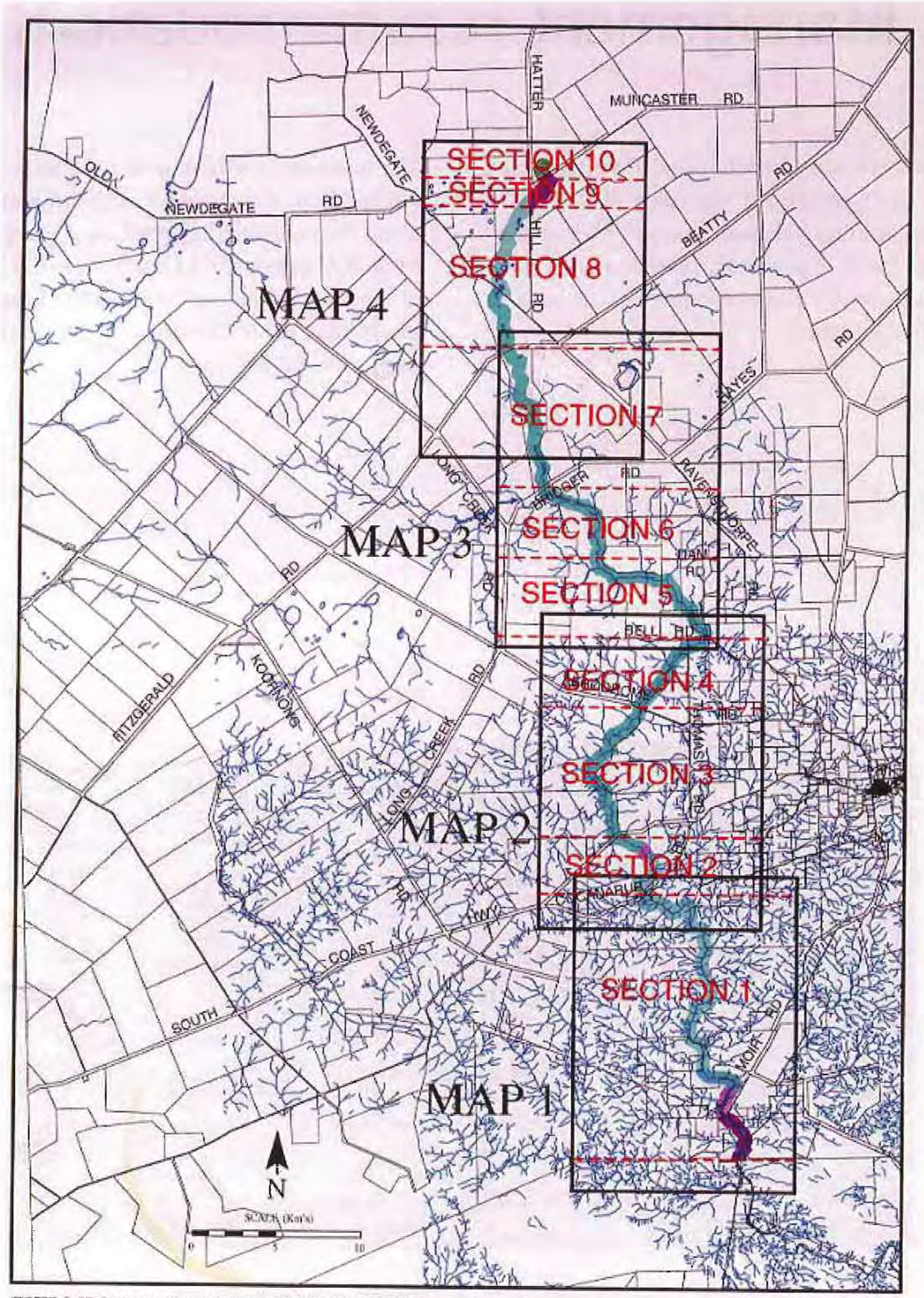


Figure.7. Overall foreshore survey map – showing section numbers

Table 7. Summary of foreshore vegetation condition for each section of the river

Section	Part section	Description	Length (km)	Condition	Comments
1	1	Fitzgerald River National Park –	3.0	A2/B1/C1	80% B1, 20% C1. A2 is east side of River.
	2	Cocanarup Road	1.4	B2/C1	50% B2, 50% C1
	3		0.8	A2/C1	A2 is east side of River
	4		1.3	A2/C1	A2 is north side of River
	5		2.0	A3	
	6		2.0	A3	
	7		2.3	A3	
	8		2.0	A3	Firebreak crossing
	9		2.3	A3	
	10		2.1	A3/B1	90% A3, 10% B1
2	11	Cocanarup Road to Highway One	4.3	A3/B1	80% A3, 20% B1
	12		0.8	B3	
	13		2.3	A2	
3	14	Highway One to Aerodrome Road	2.3	A2	
	15		2.1	A2	
	16		2.9	A2	Firebreak Crossing
4	17	Aerodrome Road to Belli Road Crossing	5.5	A2	
	18		4.0	A2	
5	19	Belli Road Crossing – Dam Road	2.5	A2/B2	80% A2, 20% B2
	20		3.0	A2/B3	90% A2, 10% B3
6	21	Dam Road to Bridger Road	2.5	A2	
	22		3.0	A2	
	23		4.6	A2	
7	24	Bridger Roadto Fitzgerald Road	3.5	A2	
	25		2.8	A1	
	26		2.8	A1/A2	50% A1, 50% A2
8	27	Fitzgerald Road to	3.0	A2	
	28	Lake King – Ravensthorpe Road	3.5	A3	
9	29 Road↓	Lake King – Ravensthorpe Road to Hatters Hill	5.0	B1	Private freehold farmland
10	30	Hatters Hill to Muncaster Road	5.2	NA	Private freehold farmland, revegetated.

5.1 Section 1 (part sections 1 – 10) Fitzgerald River National Park boundary to Cocanarup Road

Vegetation condition
A3 – C1

The entire western side of section 1 has been influenced by agriculture and for most of its length by the track into Fitzgerald River National Park. A previous practice was to graze sheep to the river resulting in some areas where the native understorey has been replaced by introduced grasses. A similar situation prevails in section 2 and on CG 217 where the riparian zone is not wide enough and the paddock extends into the riparian zone. Sections 3 and 4 are similarly influenced by agriculture on their western sides. Sections 5-10 are not directly disturbed.

The riparian corridor is 100-300 m wide. The in-stream vegetation is typically *Melaleuca cuticularis* and *M. viminea* shrubland. The former grows to 3 m ands is by far predominant. There is often a dense sward of sedges. Other plants, some of which increased in abundance due to flooding, are *Acacia saligna, Atriplex semilunaris,A. semibaccata* with the chenopods *Threlkeldia diffusa* and samphire. The river banks are lined with a narrow band of *Eucalyptus occidentalis* woodland with trees to 20 m that form woodlands where there are floodplains. Where the woodlands have been grazed in the past *Hakea preissei* to 5 m is a common tree. Beyond the tall woodlands are low woodlands of *Acacia acuminata* with occasional *Santalum acuminatum* and *S. spicatum.* Understorey species include; *Senna artemesioides, Disphyma crassifolium, Dodonaea ptarmicaefolia* and *Dianella revoluta* .

Distinctive features are a small patch of 'greenstone woodland' in section 5 with *Eucalyptus cylindroidea* and *E. extensa* to 10 m over dense *Atriplex* spp. with shrubs *Melaleuca acuminata, M .cucculata, Acacia erinacea* and *A. glaucoptera.*

The presence of old fences here suggest this vegetation was formerly grazed. At the north end of section 5 is a 2-3 ha-patch of mature salmon gum woodland that was the only one of two similar woodlands, and by far the least disturbed seen on this survey. It provides a distinct habitat for fauna, particularly birds. Some of the understorey plants here, *Alyxia buxifolia* and *Olearia muelleri* are more typically of an arid zone than are usually found in the district. In section 10 where the River traverses Archaen greenstone rocks there is an almost pure stand of *Eucalyptus extensa* woodland.

Weeds

African boxthorn (*Lycium ferocissimum*) and Maltese cockspur (*Centaurea melitensis*) were present throughout, the former is abundant and a conspicous element of the flora. Saffron thistle (*Carthamus lanatus*) is occasionally present. Bridal creeper (*Asparagus asparagoides)* was occasionally present in section 1. Grasses including couch (*Cynodon dactylon*), rye (*Lolium* sp.) and wild oats (*Avena barbata*) were particularly abundant downstream of Cocanarup settlement ie. the northern half of section 11. Wild oats and other annual grasses frequently colonised plumes of coarse sediment that had been mobilised by the flood. The upstream half of section 11 is under the influence of weeds originating from Cocanarup.

Erosion/sedimentation

A firebreak crosses the River in section 8.

Other

Rabbits were abundant in section 2 where they were more frequently recorded than anywhere else on the River. Management requirements are; to gazette a river reserve over VCL between FRNP boundary and the north-west corner of MHL 180; to assess the African boxthorn threat over sections 5 – 11; invite the owners of Kaybalup farm, Cocanarup and CG 217 and MHL 280 as well as the Ravensthorpe LCDC and the Department of Conservation and Land Management to participate in remediation and management of these degraded sections of river (noting that the routing of the access to FRNP is an issue here).

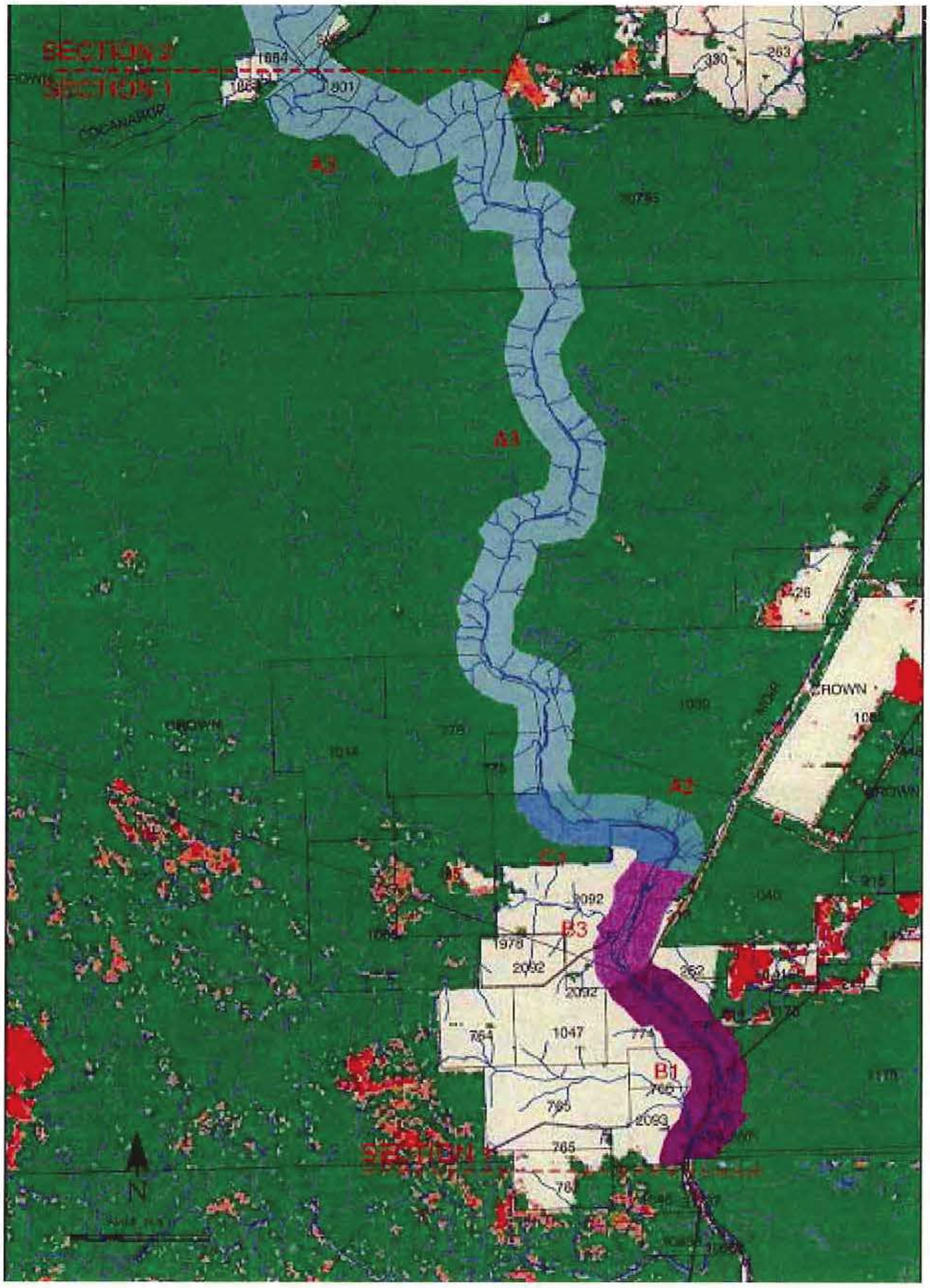


Figure 8. Foreshore survey results - Fitzgerald River National Park boundary to Cocanarup Road

5.2 Section 2 (part sections 11, 12 & 13) Cocanarup Road to Highway One

Vegetation condition

A2 - B3

North of Cocanarup Road the corridor is vegetated with swamp yate woodland with a jam and mallee understorey. At sections 13 & 14 there is a marked shallowing of soil and the swamp yate is replaced by a complex shrubland on coarse gritty soils with granite exposures. The following species are present; *Melaleuca elliptica, Acacia acuminata, A. lasiocalyx, Allocasuarina huegeliana,* and *Dodonaea* sp. The in-stream vegetation includes *Melaleuca cuticularis, M. thyoides* and *Callistemon phoeniceus.* Just south of the bridge the river bed has cut back to bare rock which is largely devoid of vegetation. A distinctive feature of section 14 south of the bridge on the east bank is a small, low woodland of *Allocasuarina huegeliana* with a pure understorey of *Leptospermum erubescens.*

Weeds

Weeds on these sections include; African boxthorn (noting that it does not occur north of Cocanarup), cape weed, pimpernel, wild oats and stinkwort (*Dittrichia graveolens*).

Erosion and sedimentation

There is minor erosion and sedimentation where the former road crossing crosses the River south of the Highway One Bridge.

Other

Management issues are to invite the owners of Cocanarup as well as the Ravensthorpe LCDC to participate in remediation and management of degraded parts section of section 12. This degradation is historical rather than current.

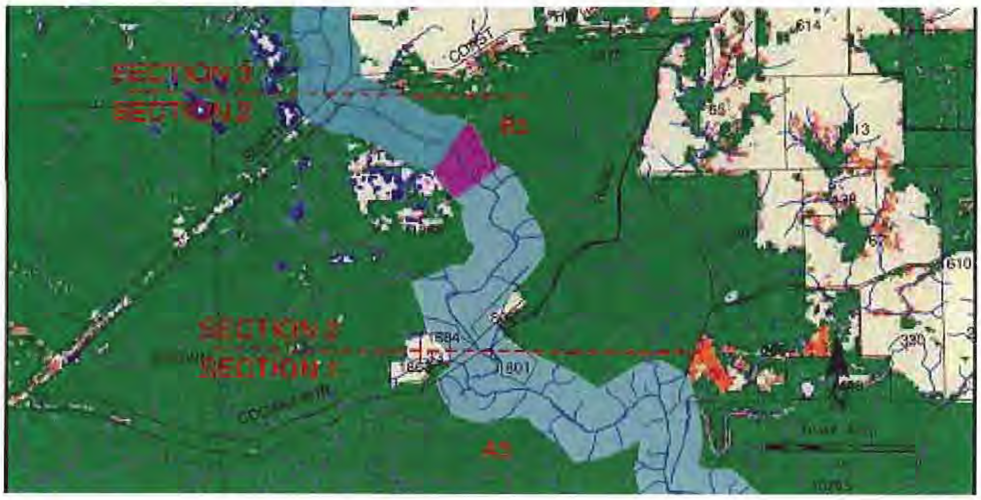


Figure 9. Foreshore survey results - Cocanarup Rd to Highway One

5.3 Section 3 (part sections 14, 15 & 16) Highway One to Aerodrome Road

Vegetation condition

A2

North of the bridge there is sufficient soil to sustain a riparian corridor of swamp yate woodland with a jam understorey for most of these sections. There is sufficient soil within the riverbed to sustain prolific growth of *Melaleuca cuticularis*; some of the more mature shrubs had been either up-rooted or smothered by sediment plume as a result of the flooding. There was in-stream regeneration of samphire, *Acacia saligna* and *M.cuticularis* along these sections.

In section 15 there were numerous fresh water soakages in deep sand in the river bed; these were not seen at any other point along the River. In section 16 the River traverses an area of extensive and massive granite outcropping where small rock holes also accumulate fresh water. Here the freshwater edible plant nardoo (*Marsilea* sp.) was found.

Weeds

Weeds on these sections were; cape weed, ruby dock (*Rumex vesicarius*), prickly paddy melon (*Cucumis myriocarpus*), pimpernel, couch grass, Marshmallow (*Malva parviflora*) and wild oats.

Erosion/Sedimentation

There is minor erosion and sedimentation just north of Highway One Bridge where a Telstra easement crosses the River. There is general sedimentation along much of section 15. There is a fire-break crossing in section 16.

Other

A management issue is to gazette a river reserve between the northern boundary of Cocanarup timber reserve and Aerodrome Road.

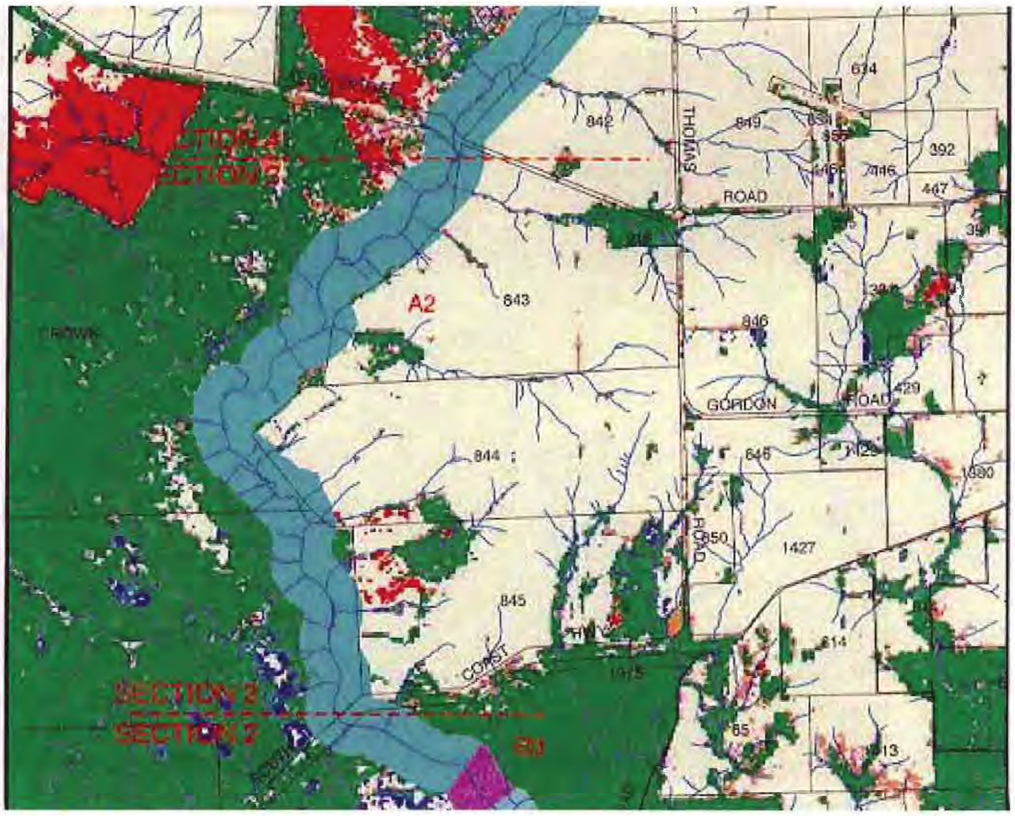


Figure 10. Foreshore survey results - Highway One to Aerodrome Road

5.4 Section 4 and 5 (part section 17,18, 20) Aerodrome Road to Dam Road

Vegetation condition

A2 - B3

Vegetation

North of Aerodrome Road swamp yate woodland is replaced by *Allocasuarina huegeliana* woodland as the soils become progressively coarser and more sandy. There is a jam and mallee association in section 19 at the approach to Belli Road and a slightly degraded salmon gum woodland to the east of the River here. Upstream of Belli Road crossing there is a return to swamp yate woodland.

Weeds

A stock crossing c. 0.5 km south of Belli Road has provided a source point for invasive weeds. The following weeds were recorded between here and the road crossing; prickly paddy melon, pimpernel, barley grass (*Hordeum* sp.), wild oats, milk thistle, ruby dock, storksbill (*Erodium botrys*), shepherd's lucerne (*Lepidium* africanum), blackberry nightshade, wireweed (*Polygonum aviculare*) and windmill grass (*Chloris* sp.). This represents more species of weed recorded than in any other relatively small stretch of the river.

Erosion/sedimentation

The crossing is not ideal as it is located too close to the river bend, which may result in further erosion of the river bank, and likely that flood waters may bypass the crossing, however it is designed relatively well in terms of the rock size.

Other

Management issues are in conjunction with the Shire of Ravensthorpe to re-design and re-construct the Belli Road crossing.

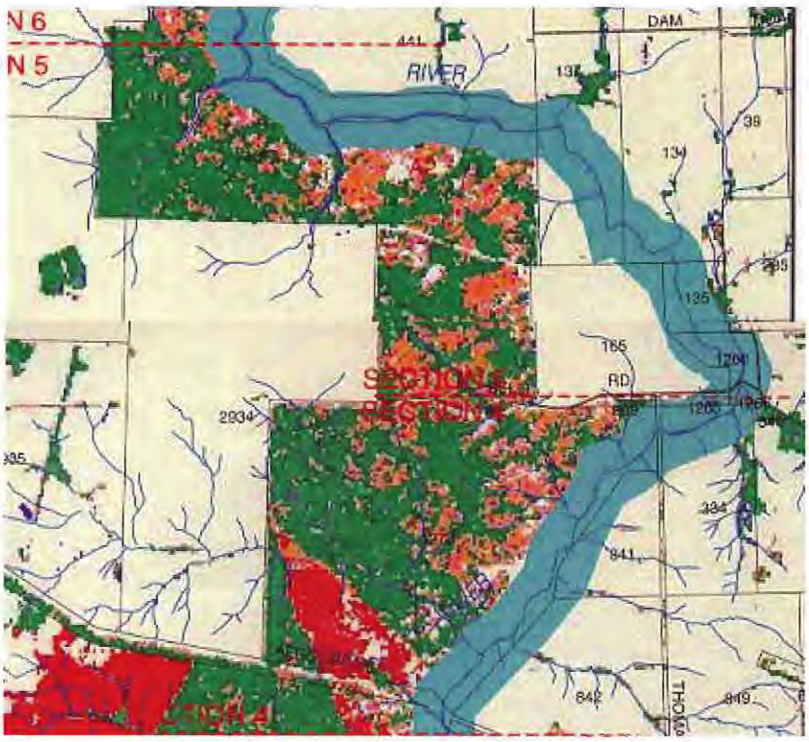


Figure 11. Foreshore survey results - Aerodrome Road to Dam Road

5.5 Section 6 (part sections 21,22 &23) Dam Road to Bridger Road

Vegetation condition

A2

Upstream of the Dam road crossing awamp yate woodland is replaced by a complex shrubland with *Melaleuca elliptica, M. urceolaris* and *Santalum acuminatum*. In section 23 the shrubland is replaced by extensive *Allocasuarina huegeliana* woodland that in turn is replaced by one of the two patches of true sandplain traversed by the River. Prominent species here are *Banksia media, Adenanthos cuneatus, Callitris* sp. and Christmas tree (*Nuytsia floribunda*). Towards Bridger Road, a melaleuca shrubland dominated by *Melaleuca urceolaris* has become well established.

Weeds

None noted

Erosion/sedimentation

None noted

Other

A distinctive feature of sections 22-23 is the presence of dolerite dykes in bare gneissic rocks of the riverbed. These dykes are the source of extensive hypersaline seepage. In places the combined effect of seepage is to produce a small but perceptible flow of highly saline water.

Vegetation condition

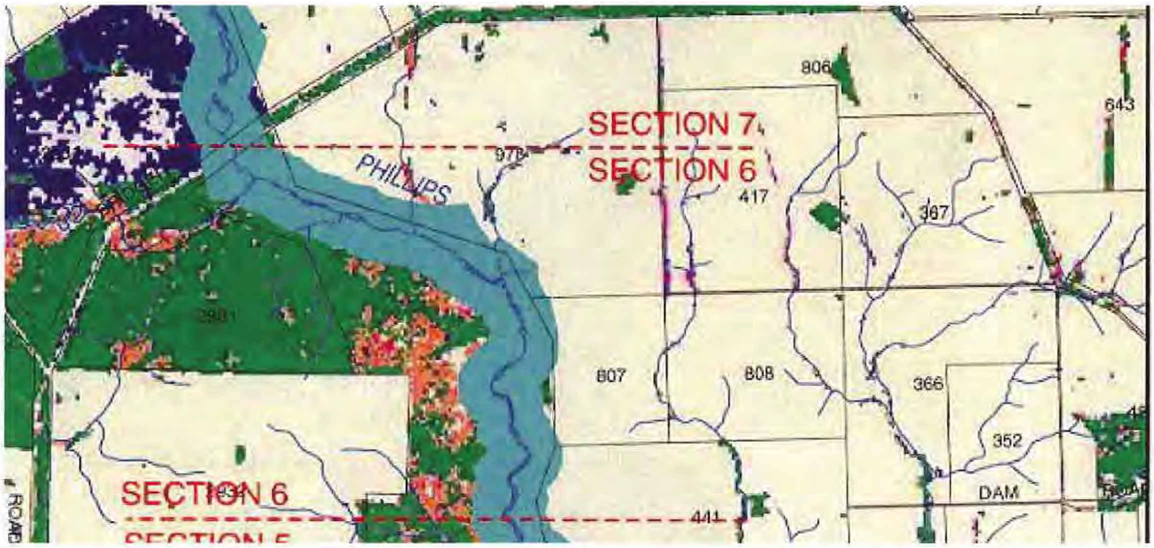


Figure 12. Foreshore survey results - Dam Road to Bridger Road

5.6 Section 7 (part sections 24, 25 & 26) Bridger Road to Fitzgerald Road

A1 -A2

North of the road the vegetation is a complex mallee and melaleuca shrubland which was burnt 10-15 years previously. In section 26 there is sandplain with *Banksia media*. Here, and in some of section 25, the riparian corridor is pristine due to the total absence of weeds, erosion or the effects of salinisation and/or waterlogging. However the pristine aspect is short-lived because in the upstream of section 26 and section 27 there are extensive melaleuca deaths and replacement with samphire. Here there is little or no defined channel but a braided watercourse through a samphire flat 50-100 m wide. No weeds or erosion and sedimentation were noted.

Other

At Bridger Road there is a major geological discontinuity between gneissic rocks to the south and gypsiferous sands and silts upstream. A consequence of this is that upstream there are no rock based river pools; the only water is very ephemeral and contained in shallow claypan depressions. Ecologically, Bridger Road defines the upper limit for fish and no doubt many aquatic invertebrates in the River. A management issue is to monitor the extent of melaleuca deaths due to salinisation and /or waterlogging in sections 26 and 27.

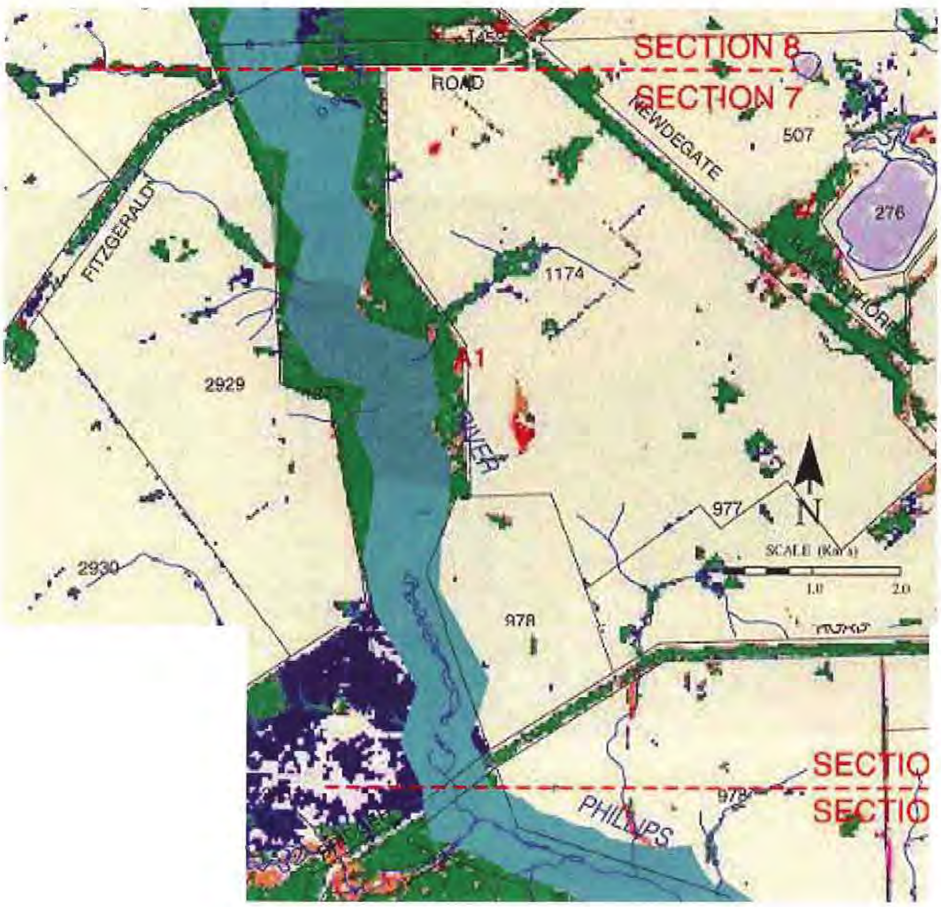


Figure 13. Foreshore survey results - Bridger Road to Fitzgerald Road

5.7 Section 8 (part section 27) Fitzgerald Road to Lake King-Ravensthorpe Road

Vegetation condition

A3

In this section the River forms an intermittently braided-non braided channel through melaleuca shrubland with extensive deaths of young shrubs. There is no evidence of high flow rates; numerous clay pan-like depressions hold water after heavy rains.

Weeds

None noted

Erosion/sedimentation

None noted

Other

A management issue is to monitor the extent of salinisation and/or waterlogging present.

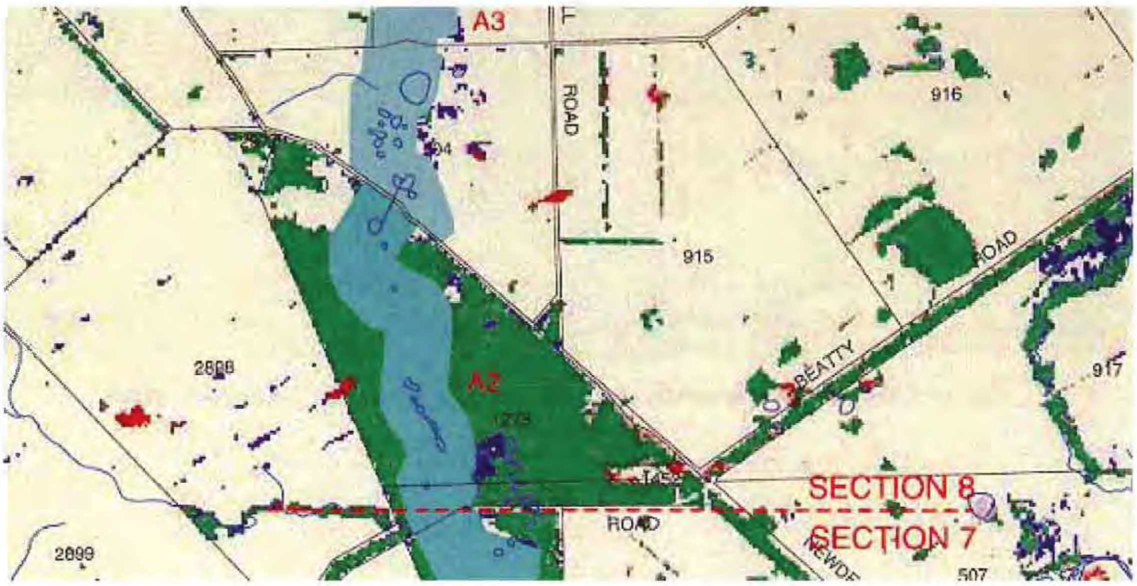


Figure 14. Foreshore survey results - Fitzgerald Road to Lake King-Ravensthorpe oad

5.8 Section 9 & 10 (part sections 28, 29-30) Lake King - Ravensthorpe Road to Muncaster Road

Vegetation condition

Not assessed.

Section 29 (to Hatters Hill Road) is freehold farm land. It was formerly grazed but has been fenced out since 1995. The vegetation is very open melaleuca shrubland with numerous small lakes and claypans. Upstream of Hatters Hill Road (section 30) is also freehold farmland owned by Owen Brownley. It was formerly grazed but is now commited to revegetation with saltbush (*Atriplex spp.*) and wheatgrass in the channel and eucalypts on the outer riparian zone. Some of the eucalypts are showing signs of salinisation stress.

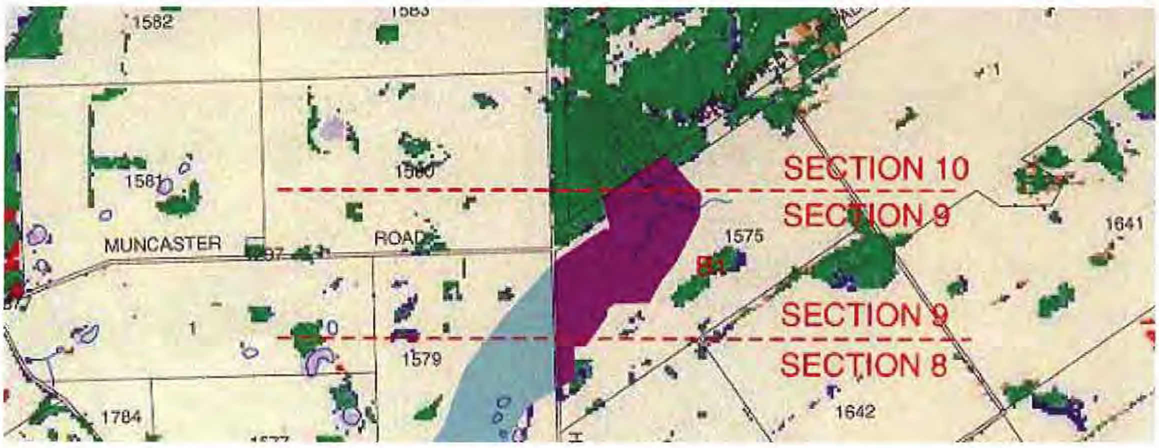


Figure 15. Foreshore survey results - Lake King Ravensthorpe Road to Muncaster Road

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Appendix 1
Water quality samples recorded on the Phillips River 1971– 997

SITE	SAMPLE	CHLORIDE (F) MG/L	COND UNCOMP LAB U.SIE/M	COND UNCOMP	NITROGEN TOTAL TOTAL (UF) MG/L	TOTAL PHOSPHOROUS
601007	15/10/1997			2 480 000		
601007	15/10/1997	9336	2 440 000		1.41	0.03
601007	29/10/1998			2 450 000		
601007	29/10/1998	9436	2 280 000		1.37	0.02
6011006	08/06/1971	12072				
6011006	15/11/1971	3700				
6011006	02/12/1971	1638				
6011006	22/10/1973	3670				
6011006	15/12/1973	9645				
6011006	20/05/1974	14 740				
6011006	05/07/1974	16 500				
6011006	03/12/1974	10 252				
6011006	18/04/1975	910				
6011006	23/05/1975	4270				
6011006	02/09/1976	6612	1 435 000			
6011006	22/06/1977	6855	3 300 000			
6011006	09/09/1977	7960	2 330 000			
6011006	18/10/1977	9453	2 580 000			
6011006	12/01/1978	2350	810 000			
6011006	21/08/1975	10070	188 000			
6011006	27/11/1975	8128	200 000			
6011006	19/07/1971	25 113				
6011006	11/09/1997				1.63	0.09
6011006	14/07/1997			5 320 000		
6011006	11/09/1997			2 770 000		
6011006	15/10/1997			3 570 000		
6011006	15/10/1997				0.32	0.06
6011006	24/07/1998			2 190 000		
6011066	19/06/1997			7 940 000		

*Site 6011006 – is the South Coast Hwy

*Site 601007 – is Pitchie Ritchie

Appendix 2
Phillips River water quality monitoring results – sampled by Andy Chapman

DATE	LOCATION	EC (mS/cm	DO_2 (mg/l)	pH	TEMP (0^c)	FLOW (l/sec)
17.08.01	Lake King Road	17.36	NA	NA	NA	600
08.09.01		51.7	NA	NA	NA	100
10.10.01		74.2	NA	NA	16.8	25
04.08.01	Moir Road	29.3	6.42	7.56	12.7	1680
19.08.01		7.71	6.49	7.67	14.5	1650
17.01.00	Fitzgerald Road	13.34	7.93	7.22	21.8	Undet.
03.11.01		128.90	10.48	8.00	32.6	NIL
17.01.00	Bridger Road	18.18	7.07	7.07	22.5	Undet.
03.11.01		54.50	6.43	8.20	22.3	NIL
16.12.01		38.80	NA	7.65	21.0	NIL
16.01.02		55.9	NA	7.61	20.6	NIL
13.02.02		64.2	NA	8.10	19.8	NIL
13.03.02		70.7	18.92	8.23	19.5	NIL
17.04.02		69.4	7.08	7.94	18.6	NIL
31.05.02		71.4	9.94	7.96	17.6	NIL
17.01.00	Aerodrome Road	21.00	8.07	7.36	23.6	Undet.
03.11.01		58.40	6.94	8.20	25.0	7.5
16.12.01		58.8	NA	8.40	23.7	15
16.01.02		102.90	NA	8.13	21.8	NIL
13.02.02		202.00	6.28	7.65	22.8	NIL
31.05.02		178.8	3.89	7.40	18.9	NIL
17.04.02		195.20	2.46	7.42	20.6	NIL
17.01.00	Highway One	19.04	7.25	7.14	23.8	Undet.
24.01.00		1.30	8.97	7.29	18.6	Undet.
17.01.00	Cocanarup Road	18.03	7.04	7.20	23.9	Undet.
03.11.01		42.10	9.57	8.20	24.0	21
16.12.01		42.5	NA	8.16	20.4	80
13.01.02		23.7	NA	8.62	20.8	Trickle
5.02.02		17.51	NA	8.19	20.1	Trickle
13.03.02		16.28	10.72	8.07	20.5	NIL
17.04.02		15.09	6.36	8.15	18.3	Trickle
31.05.02		23.8	7.78	8.64	13.8	Trickle
08.08.01	Pitchie Ritchie	31.5	8.80	NA	NA	445
22.08.01		10.6	6.80	NA	16.6	Undet.
24.01.00	Culham Inlet	4.92	7.28	7.28	20.2	NA
22.08.01	Culham Inlet	37.5	7.69	8.41	16.8	NA
22.08.01	'Lagoon'	53.5	7.30	8.38	15.6	NA

Chronology: 14 and 15 January 2000 – first flood pulse Phillips River.
22 to 26 January 2000 – second flood pulse Phillips River.
23 January 2000 – Culham Inlet flooded causeway and broke bar to sea.

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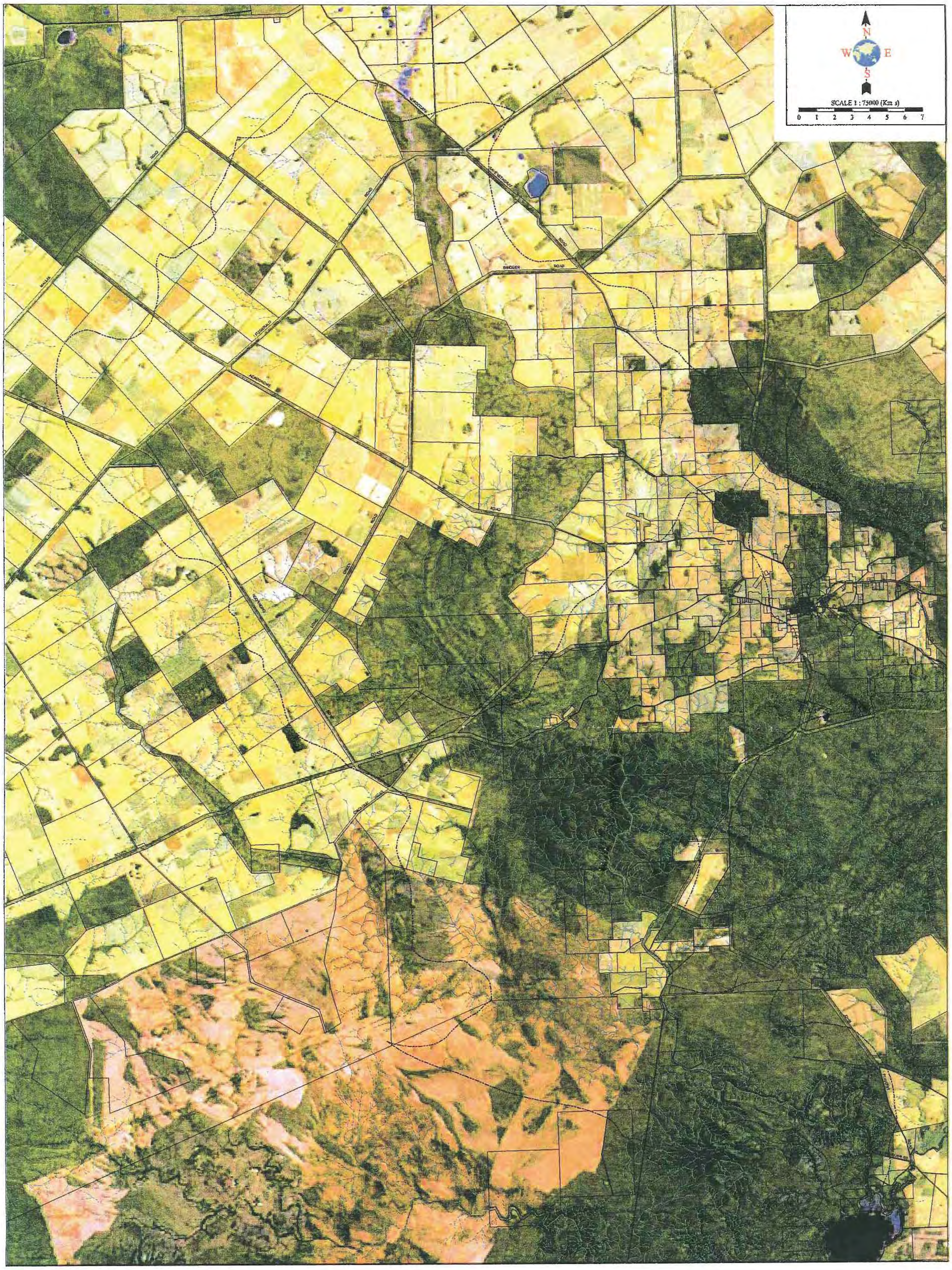


180000E | 190000E | 200000E | 210000E | 220000E | 230000E

6240000N

LOCATION DETAILS:

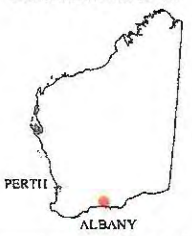
NAME:

PHILLIPS RIVER CATCHMENT AREA

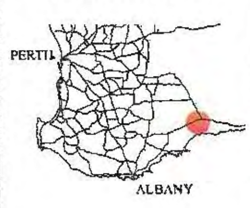
ACKNOWLEDGEMENTS:

TOPOGRAPHIC DATA PROVIDED BY DOLA.
SATELLITE IMAGERY PROVIDED BY SRSS-DOLA
CADASTRAL DATA PROVIDED BY DOLA
ZONE51

LOCATION MAP A:



LOCATION MAP B:



LEGEND:

- - - - Catchment Boundaries
—— Cadastre
—— Watercourse

PRODUCED BY:

Task GEO MAPPING

Suite 6
57 - 59 Lockyer Ave
Albany 6330
Western Australia
Tel: (08) 98423642
Fax: (08) 98423641
enquiry@geotask.com.au
www.geotask.com.au

PRODUCED FOR:

WATER AND RIVERS

PHILLIPS RIVER CATCHMENT

SCALE: 1:75000	DRAWN: DPT
DATE: 16.08.00	REVISED: - Rev. -

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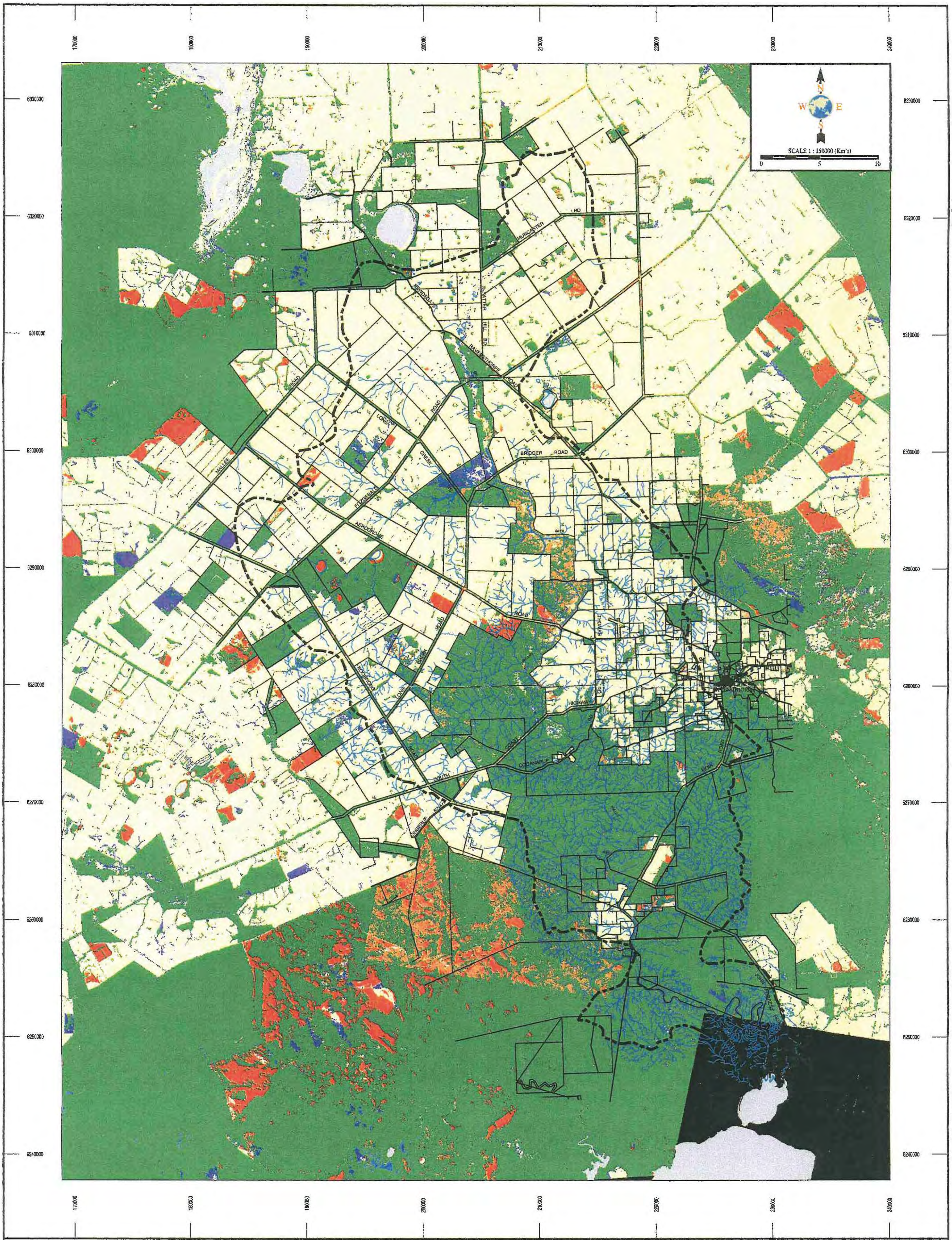
A0



LOCATION DETAILS:

NAME:

PHILLIPS RIVER CATCHMENT AREA

ACKNOWLEDGEMENTS:

TOPOGRAPHIC DATA PROVIDED BY DOLA.
SATELLITE IMAGERY PROVIDED BY SRSS-DOLA
CADASTRAL DATA PROVIDED BY DOLA
VEGETATION CHANGE BASE DATA PROVIDED BY THE LAND MONITOR PROJECT. RAVENSTHORPE 1988-2000 SCENE 109/083, NEWDEGATE 1988-2000 SCENE 110/083, BREMER BAY 1988-2000 SCENE 110/084

LOCATION MAP A:

LOCATION MAP B:

LEGEND:

- Catchment Boundaries
- Cadastre
- Watercourse
- Existing Revegetation

VEGETATION CHANGE LEGEND:

- Water
- Never Bush
- Vegetation Loss 1988-2000
- Vegetation Gain 1988-2000
- Ever Bush

PRODUCED BY:

Task GEO MAPPING

Suite 8, Peterssons Arcade
9 Albany Hwy
Albany 6330
Western Australia

Tel: (08) 98423842
Fax: (08) 98423641
enquiry@geotask.com.au
www.geotask.com.au

PRODUCED FOR:

WATER AND RIVERS COMMISSION
SOUTH COAST REGION

PHILLIPS RIVER CATCHMENT VEGETATION CHANGE 1988-2000

SCALE: N.T.S.	DRAWN: DPT
DATE: 16.08.00	REVISED: - Rev. -

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