Luke Pen

SURVEY OF FORESHORES OF THE FRANKLAND AND GORDON RIVERS

A REPORT BY APACE GREEN SKILLS AND DR LUKE PEN
FOR THE FRANKLAND GORDON CATCHMENT MANAGEMENT GROUP
JANUARY 1998

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A Report Prepared For The
Frankland Gordon Catchment Management Group

by
APACE Green Skills and Dr Luke Pen (Water and Rivers Commission)

funded through
the Water and Rivers Commission

January 1998

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Cover Photo: Local farmer, Colin Arnold, with Anthony Sutton, Water and Rivers Commission, inspecting a section of the Gordon River foreshore.

Acknowledgments

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Three studies provided the foundation on which the current report was based. The first by Dr Luke Pen, surveyed the condition of the Kalgan River foreshore (Pen, 1994), the second, surveyed the condition of the Hay and Denmark River foreshores (APACE Green Skills and Dr Luke Pen, 1995). The third surveyed the condition of foreshores in the Oyster Harbour catchment (APACE Green Skills, 1997). These surveys were undertaken on behalf of the Albany Waterways and Wilson Inlet Management Authorities, which are supported by the Water and Rivers Commission.

The on-ground survey work for the project was carried out by local landholders and completed by Kevin Hopkinson. Mr Hopkinson prepared the maps for digitising and tables for the report as well as taking the photographs. Basil Schur supervised the overall project for APACE Green Skills, and edited prepared the final report. Other APACE Green Skills staff who assisted in the project included Gerda Vogt, Biddy Myers, Chris Baillie, Louise Duxbury and Sally Haigh.. Craig Chappelle prepared the photographs for publication

John Beaton and Phil Tasker (Geo Task) produced the maps for the project, and entered the survey data onto Geographic Information System (GIS).

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The Frankland-Gordon Catchment stretches from Broomehill to Nornalup. It covers an area of 467,000 hectares and forms part of the Kent Frankland Sub-region (see Map 1.1). The population of the catchment is about 1587. The towns of Broomehill, Tambellup, Cranbrook, Frankland, Rocky Gully and Nornalup occur within or on the boundaries of this catchment. The upper and middle catchment is broadacre agricultural areas, while the lower catchment is mainly publicly owned State Forests or conservation estate. (Frankland Below Gordon Land Conservation District Committee, 1994:4)

The catchment extends over part of 8 shires, and is serviced by eight land conservation district committees. These include Frankland below Gordon and Tunney which are wholly situated within the catchment.

In March 1994, the Frankland Below Gordon Land Conservation District Committee organised a landcare seminar at Frankland called "Reversing The Trends", which highlighted the social and environmental issues facing the catchment (Frankland Below Gordon Land Conservation District Committee, 1994). This seminar emphasised the problems facing the river and the need for riparian zone protection and management.

There is a growing awareness within the rural community of the need for the rivers and other watercourses of the region to be fenced and their riparian zones repaired. This would protect these large natural bio-filters and reduce erosion of the riverbanks, which occurs when the protective fringing vegetation is lost through livestock grazing and trampling.

To assist with the process of riparian repair, the Frankland Gordon Catchment Group undertook a 1995 landholder based survey of foreshores along part of the Frankland and Gordon rivers (see Map 7.1). The group commissioned APACE Green Skills in 1997 to complete this survey work. The survey was largely carried out in 1995 and concluded in August 1997.

This work graded the condition of sections of foreshore of each river bank into three categories: (A) pristine to slightly disturbed, (B) degraded, (C) erosion prone to eroded, and (D) eroding ditch or weed infested drain; on the basis of weed infestation, soil exposure and erosion. The extent of riverbank fencing and revegetation, and the general quality of the fringing vegetation were also assessed.

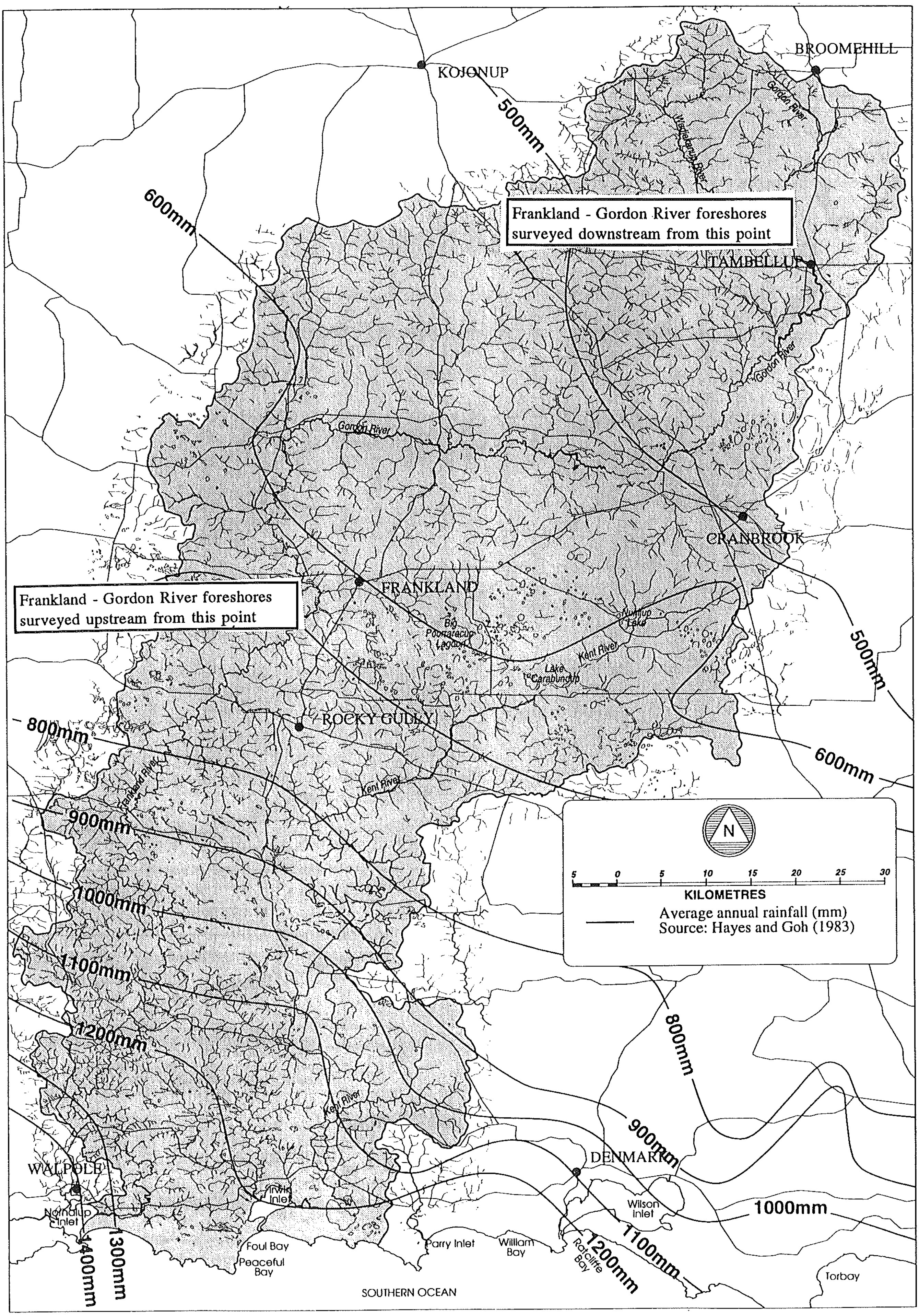
Foreshore condition and fencing status were assessed in detail along with fencing and rehabilitation needs and other information and the results were then collated.

Surveys were conducted on both banks of 128. 5 km section of the Frankland-Gordon River foreshores from near Frankland to Tambellup. Thus, in total 257 km of river foreshores were surveyed and graded. Of the combined foreshore lengths, about 105 km (or 41%) of the riparian zone was A grade, 96 km (or 37%) was B-grade, 56 km (or 22%) was C-grade and 0km was D-grade. Of the 257 km of river foreshores surveyed, about 143 km (or 56 %) was fenced at the time of the survey. Overall, about 112km (or 44%) of river valley embankments and foreshores requires revegetation to stabilise the banks, and maintain both aquatic and terrestrial corridors.

The river foreshores have many points of salinisation, erosion and subsidence with significant sections of degradation. Deposits of course sediments were observed frequently in the river bed. Fencing has been placed along some of these foreshores, but has not always been placed with sufficient distance from the waterway to provide an effective buffer. To protect riverine fringing vegetation and thereby maintain its bio-filtering and erosion control functions, fencelines need to be located above the river valley and, in the case of steep valley embankments, well above it. Not withstanding the above, significant sections of the river were found to be scenic and contained foreshores of a reasonable quality, although the effects of increasing salinisation were observed throughout.

The findings and recommendations of the survey are designed to promote measures which protect and restore river and stream foreshore condition. Farmers who wish to fence rivers, streams or drains on their properties may be eligible for assistance from State and Federal Governments.

This report is part of an approach whereby Government agencies and community landcare groups co-operate with all laundress to assist in protecting the health of a much valued south coast estuary and its associated waterways.



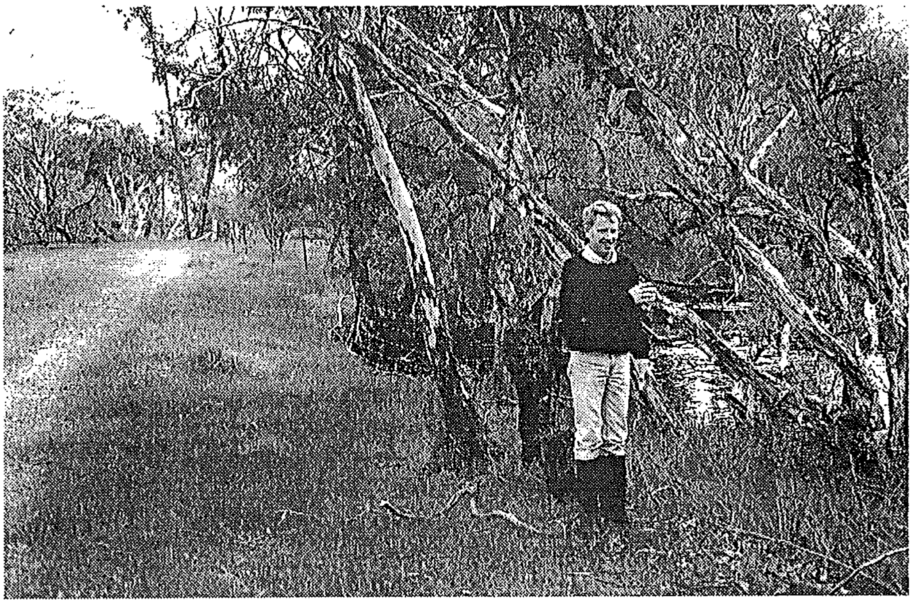
Map 1.1 Location Map for the Kent Frankland Sub-region, showing the section of the Frankland and Gordon River Foreshore surveyed (map taken from South Coast Regional Assessment Panel, 1996). See Map 7.1 for detailed map sections surveyed and index.

Extensive areas of foreshore show riparian vegetation affected by salinisation.

Erosion occurring on an access point to the Gordon River.

Samphire flats on fenced foreshore of Gordon River.

View of Gordon River foreshores:
B3 Grade on opposite bank.
C2 Grade on near foreshore.



Anthony Sutton, Water & Rivers Commission, beside a section of the Gordon River foreshore.

Golden wattle, Acacia saligna, *regenerating along the Gordon River foreshore.*

1. Introduction

1.1 Aims of the study

The aims of the survey were as follows:

1. Survey the condition of selected sections of the Frankland and Gordon Rivers and its fringing vegetation using the system outlined in Section 3.2;
2. Map the extent of fencing and revegetation requirements along the rivers;
3. Provide a general description of the fringing vegetation and landscape;
4. Assess the health of vegetation along the rivers; and
5. To provide a 'snap-shot' of river foreshore conditions, so that resources for waterway management can be appropriately allocated.

1.2 Study area

The study area consists of the land along a section of the Frankland and Gordon Rivers between the Frankland and Tambellup townsites (see Map 1.1-Sub-Region map). The area includes the channel embankments, the floodways and floodplains of the rivers and their tributaries, the valley embankments of the rivers and their tributaries which rise immediately above them and the land use adjacent to the rivers and their tributaries (see Fig. 2.1 for an explanation of the terms used to describe river valley form).

1.3 Study background

The Frankland-Gordon Catchment stretches from Broomehill to Nornalup. The population of the catchment is about 1587. The towns of Broomehill, Tambellup, Cranbrook, Frankland, Rocky Gully and Nornalup occur within on the boundaries of this catchment. The upper and middle catchment is broadacre agricultural areas, while the lower catchment is mainly publicly owned State Forests or conservation estate (Frankland Below Gordon Land Conservation District Committee, 1994:4).

The catchment extends over part of eight shires, and is serviced by eight land conservation district committees. These include Frankland below Gordon and Tunney which are wholly situated within the catchment.

In March 1994, the Frankland Below Gordon Land Conservation District Committee organised a landcare seminar at Frankland called "Reversing The Trends", which highlighted the social and environmental issues facing the catchment (Frankland Below Gordon Land Conservation District Committee, 1994). This seminar emphasised the problems facing the river and the need for riparian zone protection and management.

There is a growing awareness within the rural community of the need for the rivers and other watercourses of the region to be fenced and their riparian zones repaired. This would protect these large natural bio-filters and reduce erosion of the riverbanks, which occurs when the protective fringing vegetation is lost through livestock grazing and trampling.

To assist with the process of riparian repair, the Frankland Gordon Catchment Group undertook a 1995 landholder based survey of foreshores along part of the Frankland and Gordon rivers. The group commissioned APACE Green Skills in 1997 to complete this survey work. The survey was largely carried out in 1995 and concluded in August 1997.

Agriculture Western Australia has emphasised the need for placement and maintenance of vegetative strips along streams and rivers. Such fringing vegetation acts to prevent erosion, filter out suspended solids during flood events and assimilate nutrients carried in runoff (Weaver *et al.*, 1994; SCEP, 1991; Weaver and Prot, 1993).

Thus among many actions to minimise nutrient loss to waterways, Agriculture Western Australia has emphasised the placement and maintenance of vegetative strips along streams. Such fringing vegetation acts to prevent erosion, filter out suspended solids during flood events and assimilate nutrients carried in runoff (SCEP, 1991; Weaver and Prout, 1993).

This report contains the results of this survey.

1.4 Description of the region

The Frankland- Gordon River catchment covers an area of 467,000 hectares. The area has a pronounced Mediterranean climate, with an average annual rainfall that varies from 454 mm at Broomehill to 1286 mm at Nornalup. The average rainfall of much of the agricultural areas between Frankland and Broomehill is about 500mm per annum.

The upper catchment of the Frankland rivers are largely cleared and nearly all streamflows are brackish to saline. The Frankland River has a mean salinity of 2450 mg/L TDS which is increasing at a rate of 44mg/L TDS per year. (South Coast Regional Assessment Panel, 1996: 29).

The flora of the regional includes areas in both the Avon and Darling Botanical Districts of the South West Botanical Province. In the area north of the public forested areas, the small proportion that is still Crown land is now mainly protected as either conservation or other reserves. All vegetation systems are poorly represented in reserves, and subject to adverse edge effects. Only 18 % of the original native vegetation of the northern parts of the Frankland/Kent catchment remains, with remnant vegetation on farms significantly degraded. (South Coast Regional Assessment Panel, 1996: 31).

A fuller description of the region can be found the reports Frankland Below Gordon Land Conservation District Committee, 1994 and South Coast Regional Assessment Panel, 1996.

1.5. Value of fringing vegetation in catchment management

1.5.1 Stream bank stabilisation and soil conservation

The soils of the natural stream valley support a varied flora of trees, shrubs, sedges and herbs. In turn, the vegetation supports the stream bank and protects it from erosion and subsidence. The vegetation does this in a number of ways. Firstly, fringing vegetation increases stream bank roughness which acts to dissipate the energy of running water, with the effect of reducing the erosive capacity of the stream flow (Troeh *et. al.*, 1980). Secondly, roots and rhizomes bind and reinforce the soil of the embankments. The large roots of trees anchor the embankment in place and the smaller roots and rhizomes of shrubs, sedges and grasses hold the soil firmly in place at the surface of the ground between the large tree roots. In fact, the soil-root matrix can add extra cohesion of the order of ten times that of an unvegetated embankment (Thorne, 1990).

The roots and rhizomes also act to loosen and break up the soil, with the result that a well vegetated bank enables rapid infiltration of rain water (Thorne, 1990; Riding and Carter, 1992). Together with the extraction of the water by the plants themselves, greater hydrological conductivity causes the bank to be drier than a similar unvegetated bank. In wet weather, this means that the vegetated embankment is less likely to become saturated with water, and thus is less prone to mass failure, such as subsidence and toppling caused by the added bulk weight of the water (Thorne, 1990).

Lastly, riparian vegetation is highly resilient, exhibiting quick regeneration and recolonisation following the effects of severe floods. In this way the vegetation helps stabilise the river system against the effects of severe erosion and sedimentation (DeBano and Schmidt, 1990; Wissmar and Swanson, 1990).

1.5.2 Sediment and nutrient retention

Research being carried out in Europe, North America and New Zealand increasingly highlights the important function that riparian zone vegetation has in filtering out sediment and nutrients carried in flowing waters. Work on vegetated buffer strips along waterways or between waterways and agricultural land has shown that vegetation of many forms, including grasslands, sedgelands, woodlands and forests, can filter out and retain substantial amounts of sediment and nutrients (Peterjohn and Correll, 1984; Cooper *et al.*, 1987; Dillaha *et al.*, 1988, 1989; Heede, 1988; Knauer and Mander, 1989; Margette *et al.*, 1989). Dissolved nutrients, especially nitrate, are readily taken up and assimilated by plants (Yates and Sheridan, 1983; Peterjohn and Correll, 1984; Howard-Williams and Downes, 1984; Howard-Williams *et al.*, 1986; Pinay *et al.*, 1990).

By reducing stream flow, riparian vegetation promotes sediment deposition (Thorne, 1990). Sand can be deposited even when water is fast moving and silt will settle out where vegetation causes a marked reduction in flow. However, near-still water, such as that caught in densely vegetated floodplains, is required for the deposition of the very fine clay fractions (Troeh *et al.*, 1980). Over time, substantial stream bank and floodplain accretion can occur in certain areas as a result of sediment deposition, and this can alter hydrological processes (Thorne, 1990). The removal of suspended sediment by vegetation is especially important, as water carrying sediment has a greater momentum and is more abrasive than clean water, and thus has an enhanced capacity to cause erosion (Troeh, 1980).

Much of the nutrients trapped in the vegetation of waterways or in buffer strips is assimilated by the vegetation (Odum, 1990). Generally, the longer the water is held by the vegetation, the greater the uptake of nutrients (Howard-Williams *et al.*, 1986). Of course, the nutrients are eventually released back into the water column when plant material decays, but much of this will once again be assimilated. In this way the riparian system retards the rate of transfer of nutrient particles downstream, in a process known as nutrient spiralling (Pieczynska, 1990; Pinay *et al.*, 1990).

Nitrogen can be removed from riparian systems completely. This occurs via the biochemical process of denitrification, which causes nitrate to be converted to gaseous nitrogen. This process can be the major form of nitrogen removal in certain riparian zones and during particular environmental conditions such as those which occur during and after flooding (Jacobs and Gilliam, 1985; Pinay *et al.*, 1990).

1.5.3 Ecological values

Streamline vegetation not only has natural resource value in its own right, but it also provides a range of habitats for a large variety of plants and animals, particularly species which are restricted to moist or aquatic environments or species which are restricted to particular rivers or streams. For example, the freshwater streams along the south coast provide one of the few breeding environments for the Pouched Lamprey (*Geotria australis*). Furthermore, as stream systems are linear in form and cover large distances, their vegetation helps to create ecological corridors. These natural corridors, along with unnatural ones such as the vegetated strips along road and rail reserves, enable plant and animal species to move between larger patches of remnant habitat (Hussey *et al.*, 1989).

1.5.4 Recreational and landscape values

Foreshore areas alongside rivers and creeks in the Frankland and Gordon Catchment have important landscape protection values. This is especially the case where such waterways are close to population centres, such as Tambellup.

1.6 Use of this Report

This report provides a survey the condition of selected sections of the Frankland and Gordon Rivers. This survey is intended to provide encouragement and advice to landholders and agency managers for future riparian repair work.

The report also aims to provide a 'snap-shot' of river foreshore conditions for these rivers, so that overall resources for waterway management can be appropriately allocated. The survey aims to provide suitable documentation to support applications for regional resources, as well as providing a means for prioritising fencing and other rehabilitation allocations.

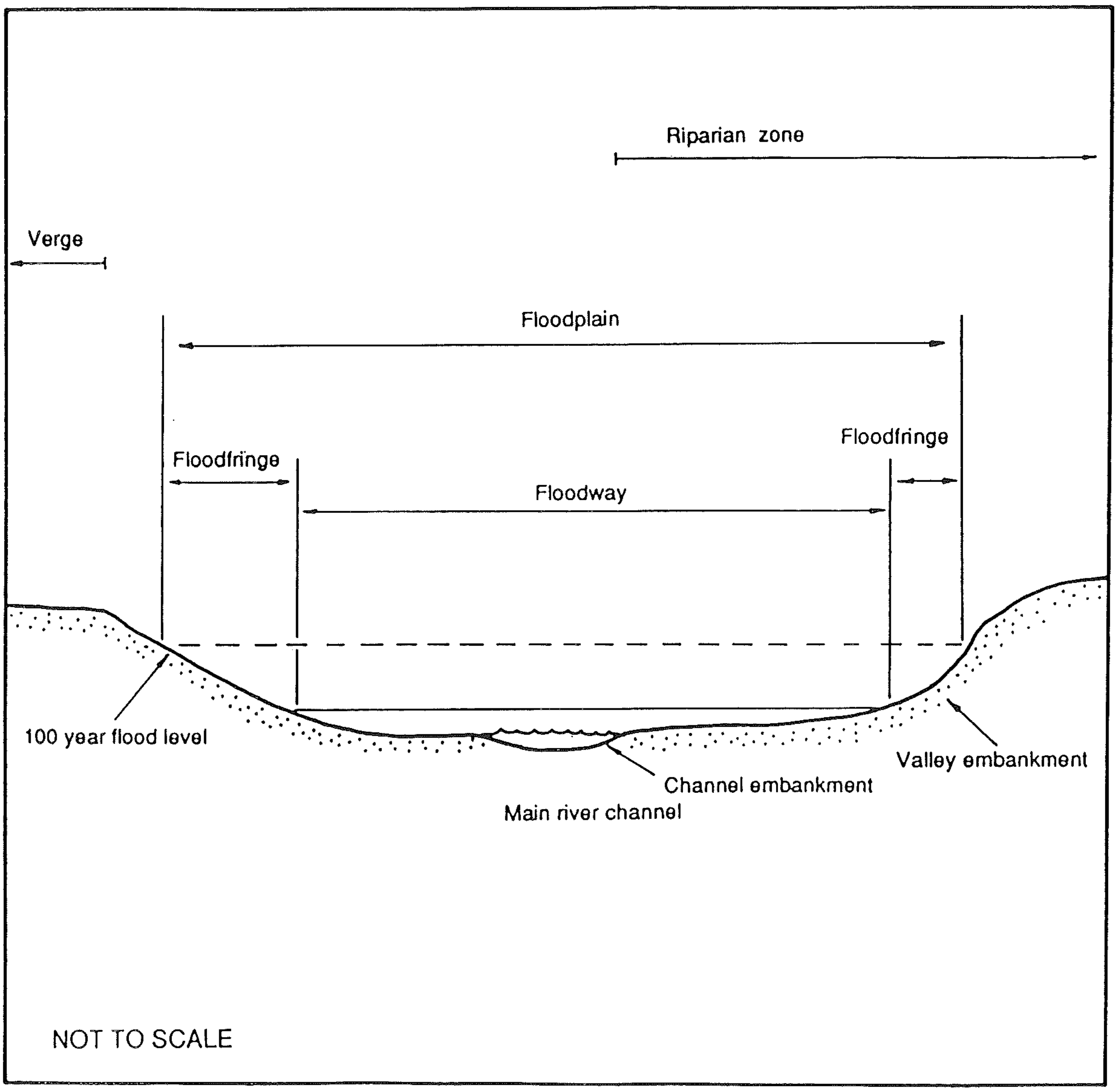


Figure 2.1 - Terms used to describe river valley form.

2. River Valley Form and the Process of River Degradation

2.1 River form

2.1.1 Cross sectional form

Figure 2.1 illustrates typical river valley form in south-west Western Australia and the nomenclature used to describe it.

A typical south-west river consists of a floodway which resides in a valley. Within the floodway, water generally flows along a central channel, which will wander from one side of the floodway to the other as water moves downstream. Sometimes there are two channels: a primary one, which always carries water, and a higher secondary one, which will carry water in times of flood. It is during these large floods, when the broad channel or floodway of the river is full of water, that the river establishes and maintains its form, including the pools and riffles (see below).

When the floodway is contained within a shallow or steep valley, the embankments on each side will contain the water from even the most severe flooding and, therefore, the extent of the extra flood fringe is minor. Conversely, when there is no obvious valley form, the floodplain (ie. floodway plus flood fringe) may extend over a very wide area.

Fringing vegetation seldom occupies the main channel but where water movement is very slow, due to the frictional effects of floodplain vegetation or stream debris, some aquatic species are able to take root. On the other hand, the channel embankment and the floodway support dense vegetation, which may extend over a broad floodplain or up the river valley embankments. Floodplain and river valley embankments can support their own distinctive plant communities, which are often more open than those of the floodway.

2.1.2 Channels, riffles and deep pools

Length-wise, the typical south-west river can be divided into three distinct zones. These are the long narrow channels which meander along the floodplain, broad shallow riffle zones and deep broad pools. A typical central channel is often no more than a few metres across, while the floodway can be 5 to 20 metres broad. Sometimes the riffle zones consist of open areas where shallow water passes over stones, while in other areas it can be densely vegetated, with shallow water passing between clumps of sedges and tree stems. For example, it is not uncommon for the river floodway to support a completely closed canopy of paperbark trees, where, in the absence of an understorey, the water passes freely between the tree stems.

Deep pools are dotted along the length of rivers and are formed as a result of the movement of water (Marsh and Dozier, 1981). In south-western Australia these pools are as long as 50 to 500 metres or more and are typically 20 to 50 metres across and from 3 to 9 metres deep. Ecologically they are integral to the south-western Australian river ecosystem, nearly always retaining water over the hot dry summer/autumn months when the channel and riffle zones dry up, thus providing refuge habitat in times of drought for many aquatic animals, including birds, turtles, water rats, fish, crayfish, shrimp and mussels.

2.2 River valley degradation: from river to drain

Previous work by Pen (1994) indicates that there is a pattern of degradation which can be used to describe the state of rivers in south-western Western Australia (see Fig. 3.1).

2.2.1 The healthy river valley

In a healthy river valley, native vegetation is dominant. Not only does it provide habitat for a huge range of animals, but it also supports the substratum that sustains it (Thorne, 1990). The large root systems of trees, which may extend as far as 50 metres, become interlaced and tangled to form a mesh or matrix of roots to a depth of two to three metres or more. This matrix of roots and soil, where trees become tied to each other and support each other, is found right along each side of the river and holds the river valley embankments securely in place. The smaller root systems of shrubs and rhizomes of sedges and the tiny root and rhizome systems of herbs, grasses and small sedges hold the soil firmly in place between the large tree roots and, most importantly, form dense masses of roots and rhizomes along the actual river channel.

In this way, the most powerful floods and heaviest rainfall cannot dislodge the soil of the river valley for virtually the entire length of the river. Only rarely does the action of water gain the upper hand and erosion occur. This usually happens at power bends along the river and would appear, in most cases, to be quickly arrested by the growth of abundant vegetation.

Dense vegetation also serves to retard the rate of flow of floodwaters and to filter out or cause the settling of suspended particles (Thorne, 1990). This action is enhanced by fallen branches which trap leaf litter and cause the formation of obstructions which dam the floodwaters, further reducing their velocity and capacity to erode and carry sediment. In a totally vegetated catchment, floodwaters are held back by the frictional and damming effects of fringing vegetation along hundreds if not thousands of kilometres of streamline and much of the energy required to erode and to carry sediment has been dissipated by the time the waters have reached the estuary.

2.2.2 The degrading river valley

The earliest stage of degradation is the occasional presence of weeds. In near pristine vegetation, weeds are probably brought in by the wind or animals. This type of degradation is merely floristic and poses no threat to the integrity of the river valley, as the native vegetation remains dominant. However, where there are points of physical disturbance, such as along walking and vehicular tracks or where feral pigs or rabbits have turned over the soil, localised exposures of soil and infestations of weeds may occur. In this situation there is a small risk of severe water erosion.

Typically, severe degradation does not begin until livestock regularly enter the river valley to graze. Here they trample the native vegetation, eat out the more palatable species, trample the soil and bring in weed seed. This serves to encourage the establishment of weeds and to discourage the regeneration of native species. The longer the river valley is subject to livestock and the heavier the stocking levels, the quicker the native vegetation is replaced by weeds. The rate of weed invasion is accelerated by an increase in the frequency of fires, which favours species with short life cycles, which are mostly introduced grasses, over species with long life cycles, which are mostly native (Hussey and Wallace, 1993).

Eventually, the native understorey species are replaced entirely by weeds and the native trees begin to die out as the level of regeneration can no longer keep pace with mortality.

2.2.3 The eroding river valley

With continued livestock grazing and trampling and frequent fires, the deep root systems of native shrubs, sedges, grasses and herbs, which once had a firm hold on the soil between the large tree roots, are largely replaced by the shallow root systems of introduced annual grasses and other weeds. These new species do not bind the surface soil as well as the former native species, especially over the late summer/autumn period when most have senesced, and are quite easily dislodged by livestock trampling and surface water flow. Under these conditions, the river valley is prone to severe erosion.

If the thin protection afforded by annual weeds is lost the soil between the large roots of trees and tall shrubs is easily washed away. Up on the valley embankment surface flow from adjacent pastured areas or high flood waters can dig long furrows, exposing tree roots and undermining trees and tall shrubs. Lower down, huge bites can be taken out of the river channel embankment and the valley embankment can be undermined, causing further sections to be undercut beneath the root zone and to collapse into the river. Where this occurs, the remaining part of the embankment can be held in place by tree roots until further undercut, but if trees are not present to support the embankment, parts of the embankment can subside into the river. This would appear to occur in very wet weather where unsupported valley embankments become sodden (Thorne, 1990).

At first, only the most prone areas will exhibit severe erosion, but gradually more and more areas will become eroded, until the river resembles a ditch. Not only will the river valley become increasingly prone to erosion as a result of loss of supporting native fringing vegetation, but as it does so the river can become smoother in parts, and the energy which was once dissipated by the vegetation will become available to erode and to carry sediment. There is also less vegetation to intercept the sediment, and thus prevent it from being washed downstream and ultimately into the estuary.

Ironically, coarse sediment lost from the stream banks can build up in places in the stream bed, which becomes wider and shallower as the material of the eroded embankments fills the floodway. In this situation, high bed sediment loads can have two effects: increased bed roughness can retard stream flow and cause upstream flooding; or conversely, large sediment accumulations can deflect flow into the adjacent stream bank or even onto adjacent land, causing further erosion (Schmidt and DeBano, 1990; Thorne, 1990).

The progressive degradation of riparian vegetation has a compounding effect on the waterway, as the reservoir of sediment and nutrients filtered out and assimilated by downstream vegetation over many years begins to be released. This factor could be responsible for the sudden discharge of large quantities of sediment and nutrients into estuaries when parts of this reservoir of material are dislodged by severe floods.

3. Materials and Methods

3.1 Vegetation description

River foreshore survey forms devised by Dr Luke Pen were then taken into the field by landholders and annotated with relevant information on landscape, plant communities, foreshore condition, points of severe erosion and fencing status. Remnant vegetation occurrence along the river foreshores was not mapped.

The surveys of the selected tributaries in the Frankland and Gordon Rivers took place mainly in 1995 by local landholders but with followup survey work in August 1997 conducted by APACE Green Skills.

3.2 River foreshore condition assessment

3.2.1 System of assessment

The condition of a section of river foreshore or riparian zone was assessed using a simple system developed by Pen (1994) from observations of river system degradation throughout the south-west of Western Australia . The methods, grades and system of assessment have been summarised in Pen and Scott (1995). The system consists of a number of stages or grades - A, B, C and D - beginning at pristine and running through to completely degraded, following the general process of degradation outlined in Section 2.2. Each grade has three sub-levels which are easy to recognise.

This system is described below.

A-Grade foreshore

A1. Pristine

The river embankments and/or channel are entirely vegetated with native species and there is no evidence of human presence, including livestock damage (Fig 3.1A). This category, if it exists at all, would be found only in the middle of large conservation reserves where the impact of human activities has been negligible.

A2. Near pristine

Native vegetation dominates but introduced weeds are occasionally present in the understorey, though not to the extent that they displace native species. Otherwise there is no human impact. A river valley in this condition is about as good as can be found today (Fig. 3.1A).

A3. Slightly disturbed

Here there are areas of localised human disturbance where the soil may be exposed and weed density is relatively heavy, such as along walking or vehicle tracks (Fig. 3.1A). Otherwise, native plants dominate and would quickly recolonise disturbed areas should human activity decline.

B-Grade foreshore

B1. Degraded - weed infested

In this stage, weeds have become a significant component of the understorey vegetation (Fig. 3.1B). Although native species remain dominant, a few have probably been replaced or are being replaced by weeds.

B2. Degraded - heavily weed infested

In the understorey, weeds are about as abundant as native species (Fig. 3.1B). The regeneration of some tree and large shrub species may have declined.

B3. Degraded - weed dominated

Weeds dominate the understorey, but many native species remain. Some tree and large shrub species may have declined or have disappeared (Fig. 3.1B).

C-Grade foreshore

C1. Erosion prone

While trees remain, possibly with some large shrubs or grass trees, the understorey consists entirely of weeds, mainly annual grasses (Fig. 3.1C). Most of the trees will be of only a few resilient or long-lived species and their regeneration will be mostly negligible. In this state, where the soil is supported by short-lived weeds, a small increase in physical disturbance will expose the soil and render the river valley vulnerable to serious erosion.

C2. Soil exposed

Here, the annual grasses and weeds have been removed through heavy livestock damage and grazing, or as a result of recreational activities. Low level soil erosion has begun, by the action of either wind or water.

C3. Eroded

Soil is being washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D-Grade foreshore

D1. Ditch - eroding

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

D2. Ditch - freely eroding

No significant fringing vegetation remains and erosion is completely out of control (Fig. 3.1D). Undermined and subsided embankments are common, as are large sediment plumes along the river channel.

D3. Drain - weed dominated

The highly eroded river valley has been fenced off, enabling the colonisation of perennial weeds (Fig. 3.1D). The river has become a simple drain, similar, if not identical, to the typical major urban drain.

3.2.2 Application in the field

A section of foreshore would be recognised for assessment on the basis of general homogeneity. For example, a section of foreshore which was fenced off was assessed separately from an adjacent section that was not fenced off and subject to grazing. The floodway and a section of the valley embankment were assessed together. The opposite banks of the river were assessed separately and the maps show class boundaries for the right and left banks of the river. The right and left banks are the right and left when facing upstream.

The condition of each bank was recorded, along with other relevant foreshore management information, such as access for stock, sections of erosion, fencing in place, sites of severe erosion, and areas requiring revegetation.

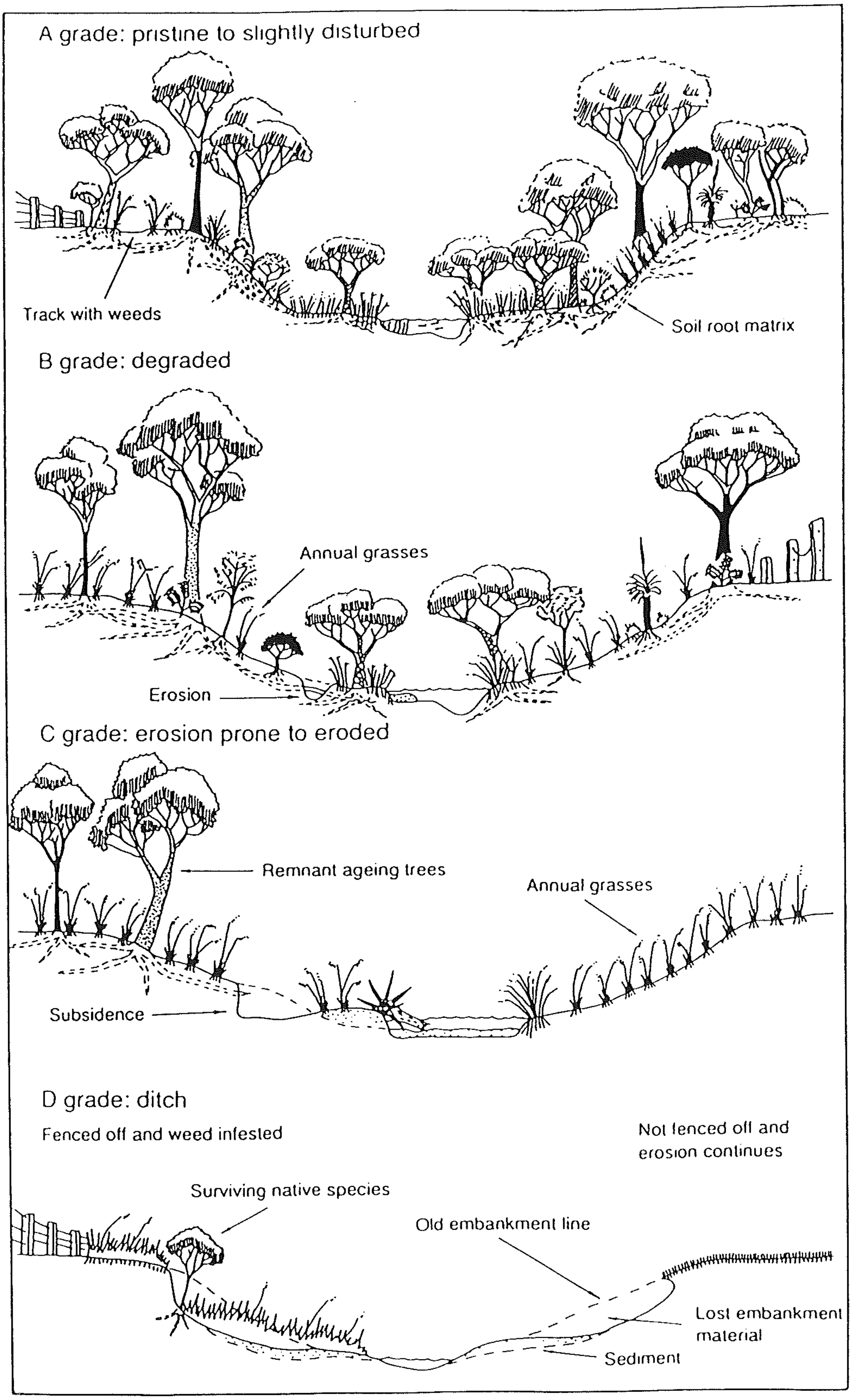


Figure 3.1 - River foreshore condition divided into four stages or grades following the general process of river valley degradation, from pristine river (A) to ditch (D).

4. General Condition of the Foreshores of Selected Tributaries in the Catchment

Table 4.1.1 provides details of the Condition of the rivers surveyed in this project, the length of surveyed rives and tributaries adjoined to farmland, riparian condition, current fencing on farms, recommended fencing and recommended revegetation on farms in the study area.

Surveys were conducted on both banks of 128. 5 km section of the Frankland-Gordon River foreshores from near Frankland to Tambellup. Thus, in total 257 km of river foreshores were surveyed and graded. Of the combined foreshore lengths, about 105 km (or 41%) of the riparian zone was A grade, 96 km (or 37%) was B-grade, 56 km (or 22%) was C-grade and 0km was D-grade. Of the 257 km of river foreshores surveyed, about 143 km (or 56 %) was fenced at the time of the survey. Overall, about 112km (or 44%) of river valley embankments and foreshores requires revegetation to stabilise the banks, and maintain both aquatic and terrestrial corridors.

More detailed descriptions of required fencing, vegetation rehabilitation and foreshore condition are provided with maps in Chapter 7.

Table 4.2.1 Condition of Foreshores of Selected Sections of the Frankland and Gordon Rivers (See Map 7.1 page 23 for Base Map Location and Index)

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring revegetat.
	m	A	B	C	D	m	m
Map 3 Left	8950	8400		550		8400	550
Map 3 Right	8950	5850		3100		3050	5900
Combined	17900	14250		3650		11450	6450

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	m	m
Map 4 Left	11400	10300	1100			10300	1100
Map 4 Right	11400	8800	2600			9000	2400
Combined	22800	19100	3700			19300	3500

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring revegetat.
	m	A	B	C	D	m	m
Map 5 Left	12400	8550	1950	1900		8550	3850
Map 5 Right	12400	8900	1600	1900		8900	3500
Combined	24800	17450	3550	3800		17450	7350

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	m	m
Map 6 Left	8800	7100		1700		8800	nil
Map 6 Right	8800	6900	950	950		6900	1900
Combined	17600	14000	950	2650		15700	1900

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	m	m
Map 7 Left	10200	800	4700	4700		800	9400
Map 7 Right	10200	800	4700	4700		800	9400
Combined	20400	1600	9400	9400		1600	18800

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	m	m
Map 8 Left	12550	7050	3500	2000		10150	3150
Map 8 Right	12550	4300	3700	4550		5100	8250
Combined	25100	11350	7200	6550		15150	11400

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	m	m
Map 9 Left	12700	6350	6350			12700	n/a
Map 9 Right	12700	6350	6350			12700	nil
Combined	25400	12700	12700			25400	nil

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveg.
	m	A	B	C	D	m	m
Map 10 Left	12100	5200	6900			8900	3200
Map 10 Right	12100	5200	5300	1600		10150	3200
Combined	24200	10400	12200	1600		19050	6400

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveget.
	m	A	B	C	D	km(%)	km (%)
Map 11 Left	10150	3000	2900	4250		3000	7150
Map 11 Right	10150	900	1300	7950		2400	6900
Combined	20300	3900	4200	12200		5400	14050

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveg.
	m	A	B	C	D	m(%)	m
Map 12 Left	11500		7300	4200		4200	8100
Map 12 Right	11500		7400	4100		nil	7750
Combined	23000		14700	8300		4200	15850

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveg.
	m	A	B	C	D	m	m
Map 13 Left	10050		7950	2100		550	9500
Map 13 Right	10050		6700	3350		550	9500
Combined	20100		14650	5450		1100	19000

River Map	Length of section	Foreshore Condition By Distance (m)				Section Fenced	Section requiring reveg.
	m	A	B	C	D	m	m
Map 14 Left	7700		7700			3400	4300
Map 14 Right	7700		4950	2750		4050	3650
Combined	15400		12650	2750		7450	7950

Table 4.1.2 - **General Condition of the foreshores of selected sections of the Frankland and Gordon Rivers (Combined Banks)**

River Maps Combined Banks	Water-course length surveyed - Combined banks.	Foreshore Condition By Distance (m) and Percentage (%)				Section Fenced and Percentage	Section requiring revegetation
	km	A	B	C	D	m(%)	m (%)
Map 3	17900	14250 (80)	nil (0)	3650 (20)		11450 (64)	6450 (36)
Map 4	22800	19100 (84)	3700 (16)	nil (0)		19300 (85)	3500 (15)
Map 5	24800	17450 (70)	3550 (14)	3800 (16)		17450 (70)	7350 (30)
Map 6	17600	14000 (80)	950 (5)	2650 (15)		15700 (89)	1900 (11)
Map 7	20400	1600 (8)	9400 (46)	9400 (46)		1600 (8)	18800 (92)
Map 8	25100	11350 (45)	7200 (29)	6550 (26)		15150 (60)	11400 (45)
Map 9	25400	12700 (50)	12700 (50)	nil		25400 (100)	nil
Map 10	24200	10400 (43)	12200 (50)	1600 (7)		19050 (79)	6400 (26)
Map 11	20300	3900 (19)	4200 (21)	12200 (60)		5400 (27)	14050 (69)
Map 12	23000	nil (0)	14700 (64)	8300 (36)		4200 (18)	15850 (69)
Map 13	20100	nil (0)	14650 (73)	5450 (27)		1100 (5)	19000 (95)
Map 14	15400	nil (0)	12650 (82)	2750 (18)		7450 (48)	7950 (52)
Total and averages	257000	104750 (41)	95900 (37)	56350 (22)		143250 (56)	112650 (44)

5. Major Threats to the Foreshores of Selected Tributaries in the Catchment

Access of livestock into the river valley is a significant cause of soil loss along tributaries in the Frankland and Gordon Catchment study area. In some areas, erosion was extensive but moderate, but at watering and crossing points where stock trampling is extreme, erosion is quite severe. This was particularly the case where water draining from adjacent pastures flowed down to the crossing or watering point, causing further erosion. Crossing points which were made at fast flowing sections of the river, where embankments were of the non-cohesive type, also suffered heavy erosion.

5.1 Loss of native riparian vegetation

Along much of the rivers, the fringing vegetation is in transition from forest, woodland or heath, to grassland. Only in areas where the fringing vegetation is backed by substantial remnant bush, or where it has been fenced off for a long period of time, is the integrity of the riparian vegetation secure. Otherwise the native herbs, sedges, shrubs and trees of the rivers are slowly being replaced by introduced annual and perennial grasses and other weeds.

These introduced grasses and other weeds do not create the deep soil-root matrix required to support the river embankment. In the drier regions, the annual grasses or sparsely distributed tussock grasses, such as veldt grass do not even afford adequate superficial protection against water erosion. This means that many kilometres of the river valleys are becoming increasingly prone to erosion.

Furthermore, introduced species do not provide the full range of habitat requirements for native fauna, while still supporting vermin such as rabbits. Riverine aquatic ecosystems depend on native fringing vegetation to provide shade, shelter, leaf litter and debris, and to stabilise pool embankments and riffle zones.

5.2 Breaks in the ecological corridor

The replacement of native plant communities with grasslands represents breaks in the ecological corridor. Some areas of embankment and floodway are devoid of native vegetation. These breaks not only retard the movements of mammals and birds, but fish are reluctant to move into open sunlit areas of water where they are prone to predation and heat stress (Olsen and Skitmore, 1991).

5.3 Erosion and siltation

From fence to fence, the land given over to the river is often only a few metres wide, which means that undercutting and subsidence can eventually bring the river back to the fenceline and eventually beyond it.

5.4 Salinisation

Major and shrub die-off due to salinisation is evident along many sections of the Franklanda and Gordon Rivers. Dead and moribund trees were noted only around pools and along stretches of the tributaries of flowing into the two rivers. In a few of these areas, floodplain forest had been replaced by salt-pan. In less salt-affected areas, many of the less salt tolerant tree species remain healthy but are not regenerating and, therefore, their populations are threatened by death from old age. This loss of trees destabilises the lower valley embankments and the central channel embankments, and increases the risk of major erosion during flood events.

In some sections of both rivers, salt-tolerant tree species are replacing less salt-tolerant species, the increasing level of salinity may be bringing about a successional shift rather than a simple die-off. There is potential downstream to augment this process by direct seeding or hand planting with an appropriate suite of upstream plant species.

5.5 Major weed invasion

With respect to river management, major weed species are those which cannot be controlled by simply eliminating the disturbance regimes which facilitate the establishment and regeneration of common weeds. Major weeds can become established in relatively undisturbed vegetation and soon proliferate to become dominant species, even replacing the tall native trees in time. Examples of weeds include the giant grasses, pampas grass (*Cortaderia selloana*) and giant reed (*Arundo donax*), the vines and creepers morning glory (*Ipomoea indica*) and dolichos pea (*Dipogon lignosus*), and the climbing shrub blackberry brambles (*Rubus spp.*). These species, and many more, infest large sections of the moist humid river valleys near Perth, Mandurah and Bunbury (Pen, 1992, 1993; Siemon *et al.*, 1993).

Significant sections along the banks of the surveyed tributaries are generally free from major weed invasions. However, some outbreaks of serious weed species occur in riparian bushland. If left unchecked, these plants will spread and dominate the indigenous species.

Pasture plants have replaced native vegetation in many areas. These plants may not be weeds in the agricultural sense, but they do not perform the functions that native vegetation does. Being shallow-rooted, they leave the soil prone to erosion. their low height provides no shade or shelter for native birds, animals or fish.

No systematic weed survey has yet been conducted for Frankland and Rivers

6. Rehabilitation

6.1 Rivers and Creeks

The foreshores of the two rivers which have existing stock grazing as an adjacent land use, should be fenced off to protect the fringing vegetation of the river valleys from the effects of livestock grazing and trampling, and to prevent the slow degradation of riparian vegetation. Further, all foreshores already degraded need vegetation rehabilitation. Protecting and reinstating the vegetation will maximise the natural bio-filtering and energy dissipation function of riparian vegetation, which is needed to remove nutrients and sediment entering the river via tributary creeks and directly from farmland and to prevent foreshore erosion.

It is worth noting that it will not be sufficient to fence and rehabilitate only the foreshores of the main rivers and creeks of the Catchment. These represent a minor proportion (<15%) of the waterway length. The remaining minor waterways will continue to deliver salt, nutrients and sediment to the main river channels, which will remove some of this material. The main river channel cannot perform all the necessary buffering to reduce nutrient and sediment loss. Nutrient and sediment loss should thus also be tackled on farms, and on the first and second order streams if the values of rivers are to be retained and enhanced (Weaver and Prout, 1993).

6.2 Placement of fences

Ideally, fences should be placed above the river valley (see Fig. 6.1). Depending on the steepness of the embankment, the fence should be placed 5m to 20m back from the edge of the river valley (Fig. 9.1A). Five metres is sufficient for a shallow valley a couple of metres deep but a broader zone, greater than ten metres, is required for valleys deeper than five metres. The purpose of fencing off the shoulders of the river is to enable trees on the upper part of the embankment and those above the river valley to anchor the embankments to the adjacent, land and thereby prevent subsidence. It should be mentioned that while sections of the tributaries are fenced off, a number of fences are inappropriately placed to provide maximum support against subsidence.

In the case of shallow river valleys, there is little chance that embankments will subside. Nevertheless, fencelines should be located above the river valley (Fig. 6.1B). This is because fences and firebreaks located within the river valley will be damaged and eroded by floodwaters. When they occur, firebreak washouts can be severe and contribute large quantities of sediment to the river system.

If the river valley is particularly broad and floodplains have been cleared for grazing, fencing them off may mean sacrificing good farmland. In this case it is necessary that only those areas that are prone to water erosion or stock damage, such as embankments and secondary river channels which only flow strongly at times of flood, need be fenced off (see Fig. 6.1C). Some of these fencelines will be prone to flood damage, but this can be minimised if fences run, as much as possible, parallel to the direction of floodwaters.

6.3 Types of fences

Needless to say, fencing should be appropriate to the livestock being grazed. In some cases this means purchasing expensive materials and much time-consuming effort. But fencing along a river need not be too expensive, especially if electric fences are used. Some farmers have found that, for cattle, a single strand of 'hot' wire nailed from tree to tree is effective in keeping stock out of the river. While this is an excellent idea there are a number difficulties which require attention. Firstly, the nail used to attach the wire will wound the tree and open it to infection and, gradually, the tree will grow around and over the nail. A better idea is to tie the wire to the tree and to loosen the tie as the tree grows.

6.4 Vegetation rehabilitation

The general subject of vegetation rehabilitation on cleared land is beyond the scope of this report and the reader is referred to the excellent publications listed in Appendix 2. Local nuseries and landcare groups can also provide information on this subject.

6.4.1 Weed management

Mechanical control of weeds, either by grubbing out or slashing will be possible for the small areas of weeds. If the area weeded is too large to be re-colonised by native regeneration, direct-seeding and/or planting of local indigenous species will be necessary. Chemical control—using the preparation of carefully formulated herbicides, may be necessary in areas where mechanical control is not possible.

Timing is crucial to the successful eradication of weeds. Control work should generally be carried out before seed set. If mature seeds are present, care must be taken not to disperse them into clean areas. Monitoring to assess the need for follow-up weeding is also of utmost importance. In all weed control work, care should be taken to minimise disturbance. Erosion, and or further weed growth can occur if large areas of weeds are removed without subsequent seeding or planting with suitable species (See local nurseries for advice).

Once waterways are fenced off from stock, weed management problems can arise relatively quickly, particularly if there is insufficient cover of native vegetation on the foreshore. It is vital that landholders who are fencing off waterways from stock, monitor protected areas and plan appropriate means for controlling problem weeds.

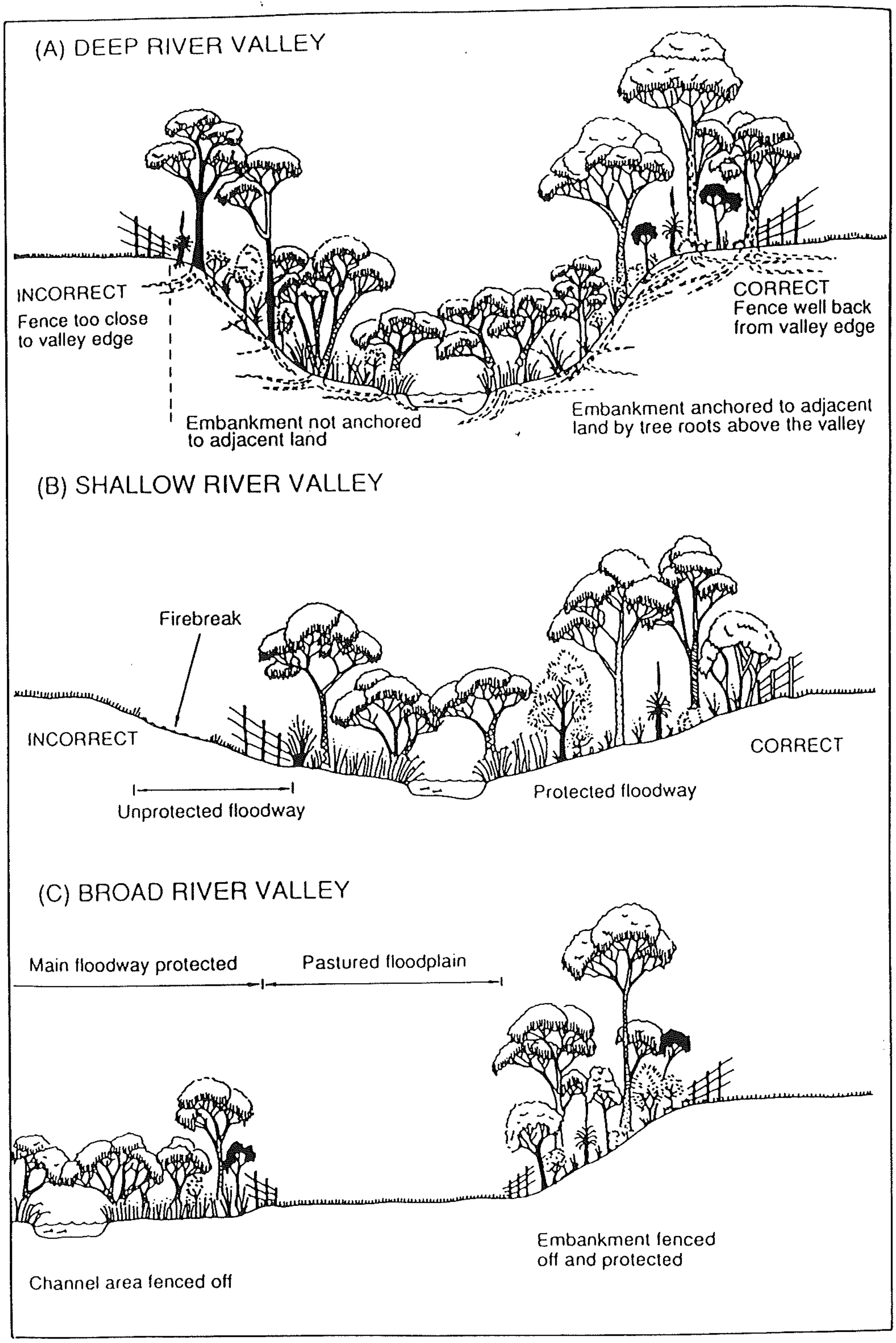


Figure 6.1 - The correct placement of fences in relation to the river valley: (A) the deep river valley, (B) the shallow river valley and (C) the broad river valley with broad floodplain.

6.4.3 Planting along the river valley

Areas of exposed river embankment need to be planted to control erosion. Actual sites of erosion cannot be planted until they are stabilised, as plantings would easily be washed away in the first winter. However, plantings can be carried out just upstream, on cleared non-eroded embankments, to retard flow rates and encourage sedimentation in the former erosion sites, which, in turn, will create sites which can be planted or will be recolonised naturally by plants.

For areas affected by actual or potential salinisation, it is important to consult expert advise in planning for site preparation, including drainage, for these areas. Landcare technicians are available to provide surveying and site advice.

6.4.4 Minor useful work

There is much useful work that can be done to accelerate regeneration of native riparian vegetation in those B grade areas of the rivers which have recently been fenced off. Tree and shrub seedlings can be protected from rabbit grazing by placing wire cages or old tyres around them, until the plants are large enough to fend for themselves. The cages or tyres can then be moved to other young plants. On a larger scale, small areas can be surrounded by enclosures to reduce grazing by rabbits and small marsupials. This method produces spectacular results on Rottnest Island where Quokka grazing is a major problem. Even clearing or spraying weeds around young plants will encourage growth.

The ground can be prepared below trees and tall shrubs to encourage seed germination and early growth can be encouraged by spraying weeds and by scarifying (shallow ripping) the soil. Deep ripping is not recommended within 20m of trees as it could damage root systems essential for the stability of the embankment and the trees themselves. Scarification has been observed by the authors to produce good results along the Brunswick and Collie rivers. It should not be done in areas subject to swift flood waters, as severe washouts may result.

Even though these suggested activities are on a small scale, taken across the whole river over many years, they will make a very useful contribution to river rehabilitation.

6.5 Stock crossings and watering points

Where properties cross the river, or where farmers own or manage both sides of the river, livestock crossings are required. The heavy livestock trampling associated with crossings often exposes the soil and initiates serious water erosion. However, simple river crossings, if located and managed properly, need not present an erosion hazard to the river banks. For example, a crossing point could be located just downstream of dense riparian vegetation, where flow rates, even during floods, are minimal, or it could be located in a stony area where erosion is not possible.

In areas where the soil is not cohesive and easily washed away, stones can be placed along the track to dissipate energy and buffer the soil against livestock trampling. At the embankments, where the soil is often worn down by livestock, large stones or logs can be placed over small ones to form revetments. Ideally, crossing points should be fenced off when not in use, to prevent livestock access to the river valley.

Because crossings run up and down the river embankments they are prone to erosion by water running off the paddocks and channelling down the tracks. To prevent this, tracks leading down to crossing points should not be aligned with the natural drainage lines of the adjacent paddocks.

6.6 Plant species for rehabilitation

Long term general rehabilitation of parts of the fringing vegetation of the Frankland and Gordon rivers will be necessary to maintain the habitat, bio-filter and ecological corridor functions of the rivers, to combat erosion and preserve the riverine landscape of the region. Lists of native plant species likely to be suitable for the Frankland and Gordon Rivers and its tributaries should be obtained from local landcare officers or local nurseries.

7. Description of the Condition and Rehabilitation Needs of Surveyed Rivers

The selected sections of the Frankland and Gordon rivers have been divided into 12 maps (Maps 3 to 14). Maps 1 and 2 covered areas in State Forest or public land outside of scope of this survey. Figure 1.1 shows the map index for the various sections.

Please note the following:

Financial assistance may be available for landholders (either as part of catchment groups or as individuals) for watercourse fencing and other waterways rehabilitation work. Landholders are encouraged to contact the Water and Rivers Commission, Agriculture Western Australia or the Cranbrook Landcare Centre to check on the availability of such assistance.

Landholders noting any mistake or modification required of any of these maps are encouraged to provide this information in writing to the Frankland Gordon Catchment Management Group.

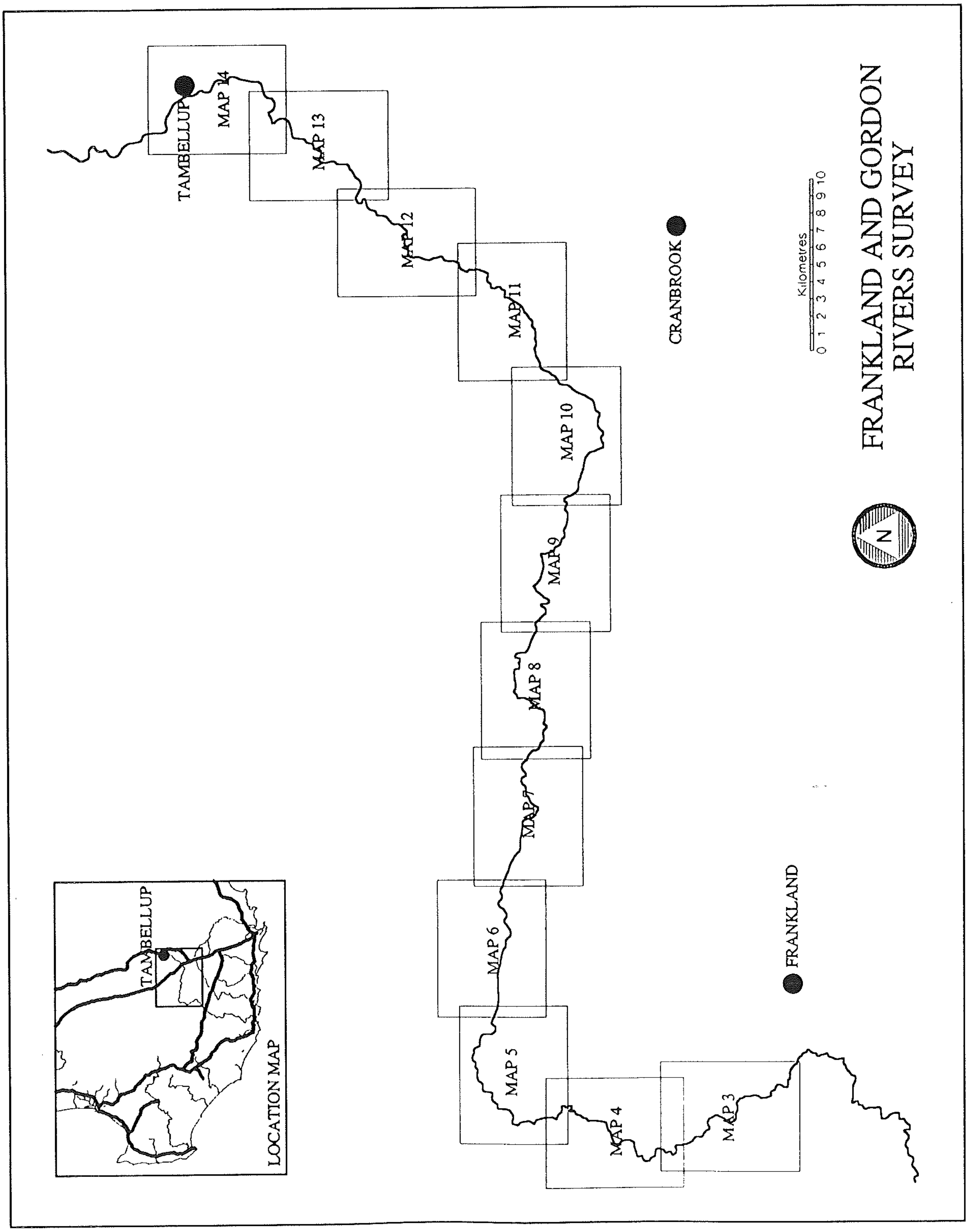
NB Please use the Foreshore Survey Map Legend on the following page of this report when consulting the maps

Figure 7.1 Foreshore Survey Map Legend

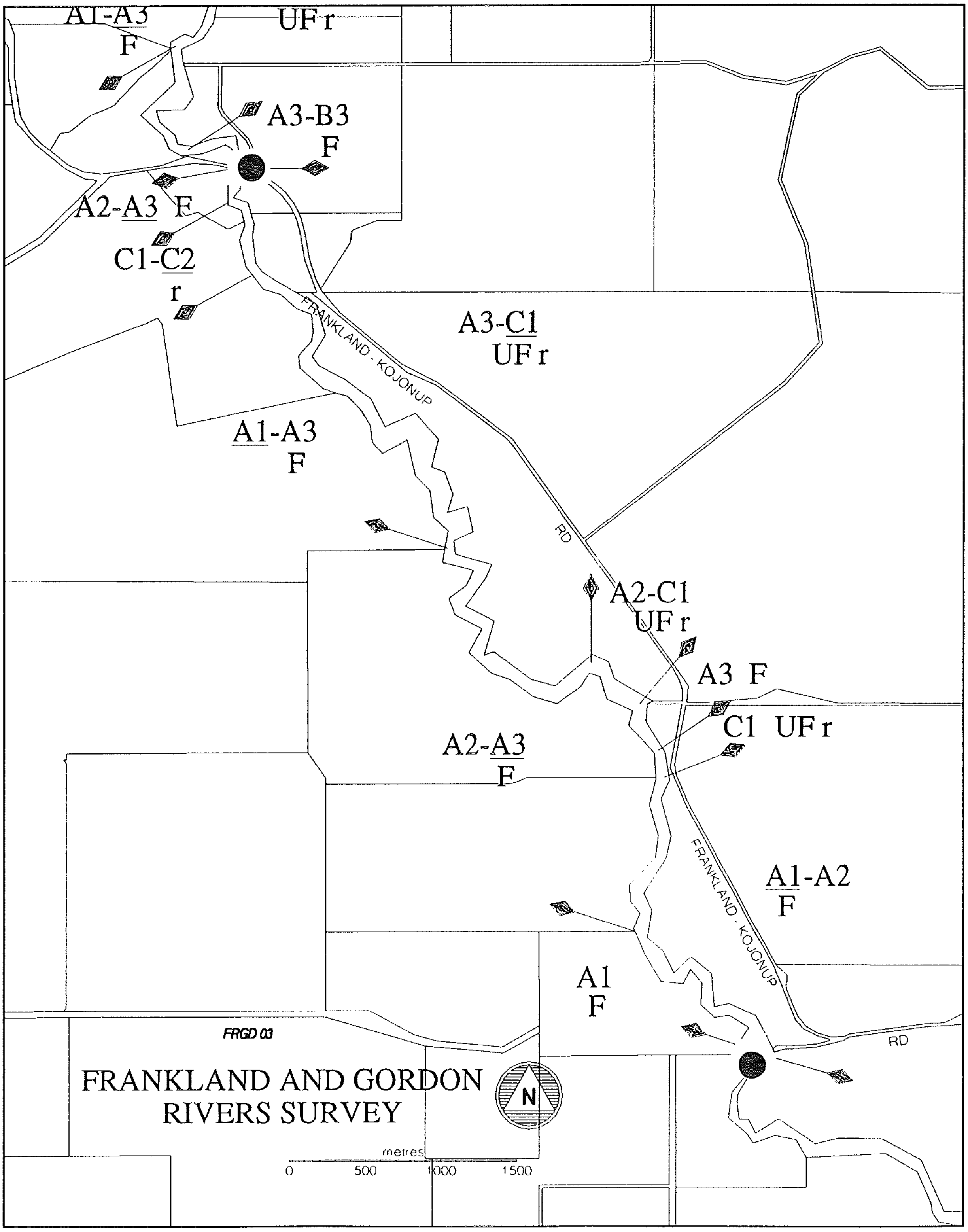
LEGEND - RIVER SURVEY MAPS.

Survey class	Description
A (grade foreshore)	A1. Pristine A2. Near pristine A3. Slightly disturbed
B (grade foreshore)	B1. Degraded - weed infested B2. Degraded - heavily weed infested B3. Degraded - weed dominated
C (grade foreshore)	C1. Erosion prone C2. Soil exposed C3. Eroded
D (grade foreshore)	D1. Ditch - eroding D2. Ditch - freely eroding D3. Drain - weed dominated
Foreshore Condition ie A1-A2-3-B1	(eg mainly A2-3 extending to A1 and B1)
——◆	Class Boundary Symbol

●	**Map Section Boundary**
F	**Section fenced**
UF	**Section unfenced**
r	**Revegetation required along this section of river**



Map 7.1 Location Map, Base Map and Index for the Frankland Gordon Catchment


A1-A3
F
UF r
A3-B3
F
A2-A3 F
C1-C2
r
A3-C1
UF r
FRANKLAND - KOJONUP
A1-A3
F
RD
A2-C1
UF r
A3 F
C1 UF r
A2-A3
F
FRANKLAND - KOJONUP
A1-A2
F
A1
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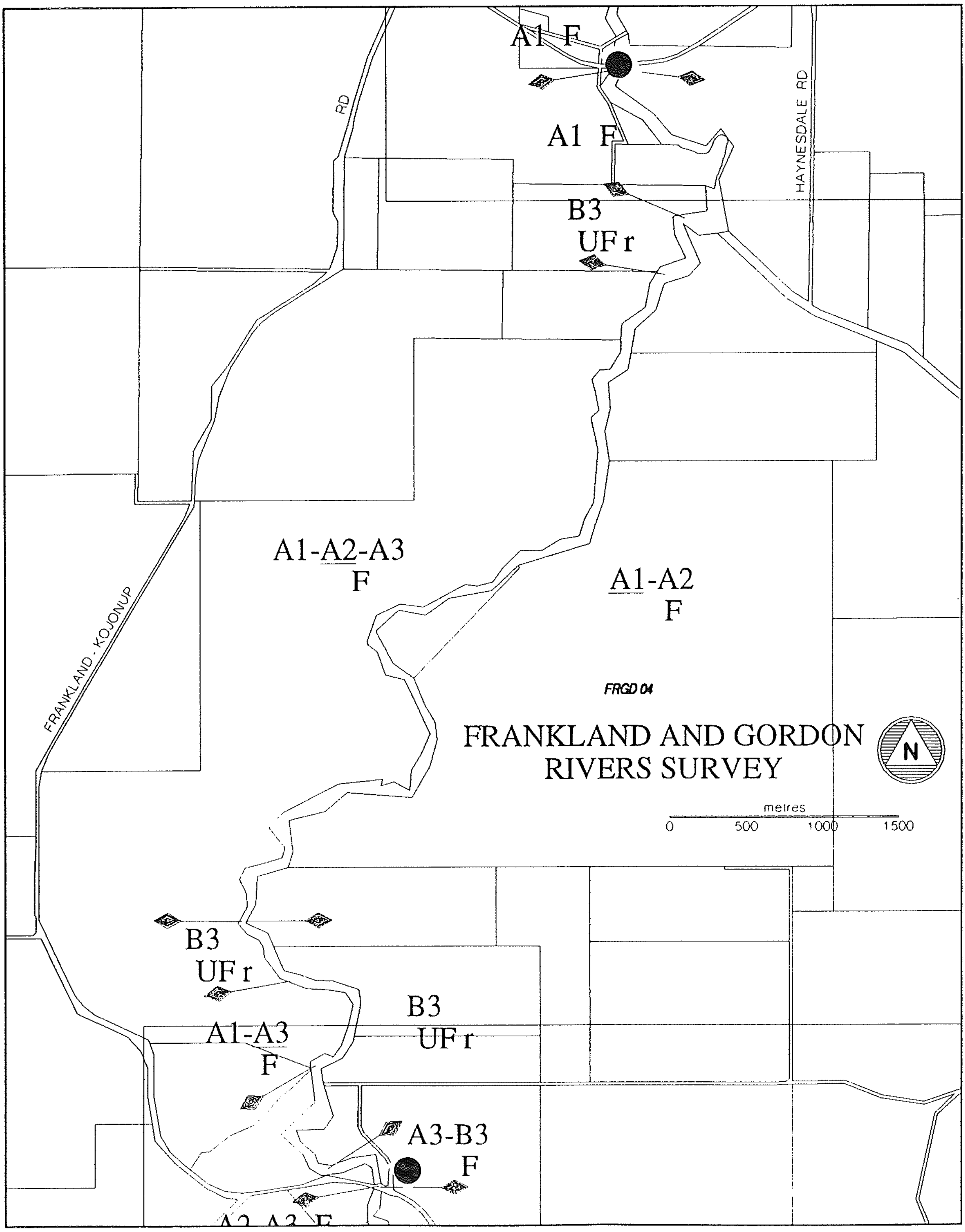
FRANKLAND AND GORDON
RIVERS SURVEY
N
metres
0 500 1000 1500

Map 3



A1 F
A1 F
HAYNESDALE RD
RD
B3
UF r
A1-A2-A3
F
A1-A2
F
FRANKLAND - KOJONUP
FRGD 04
FRANKLAND AND GORDON
RIVERS SURVEY
N
metres
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1500
B3
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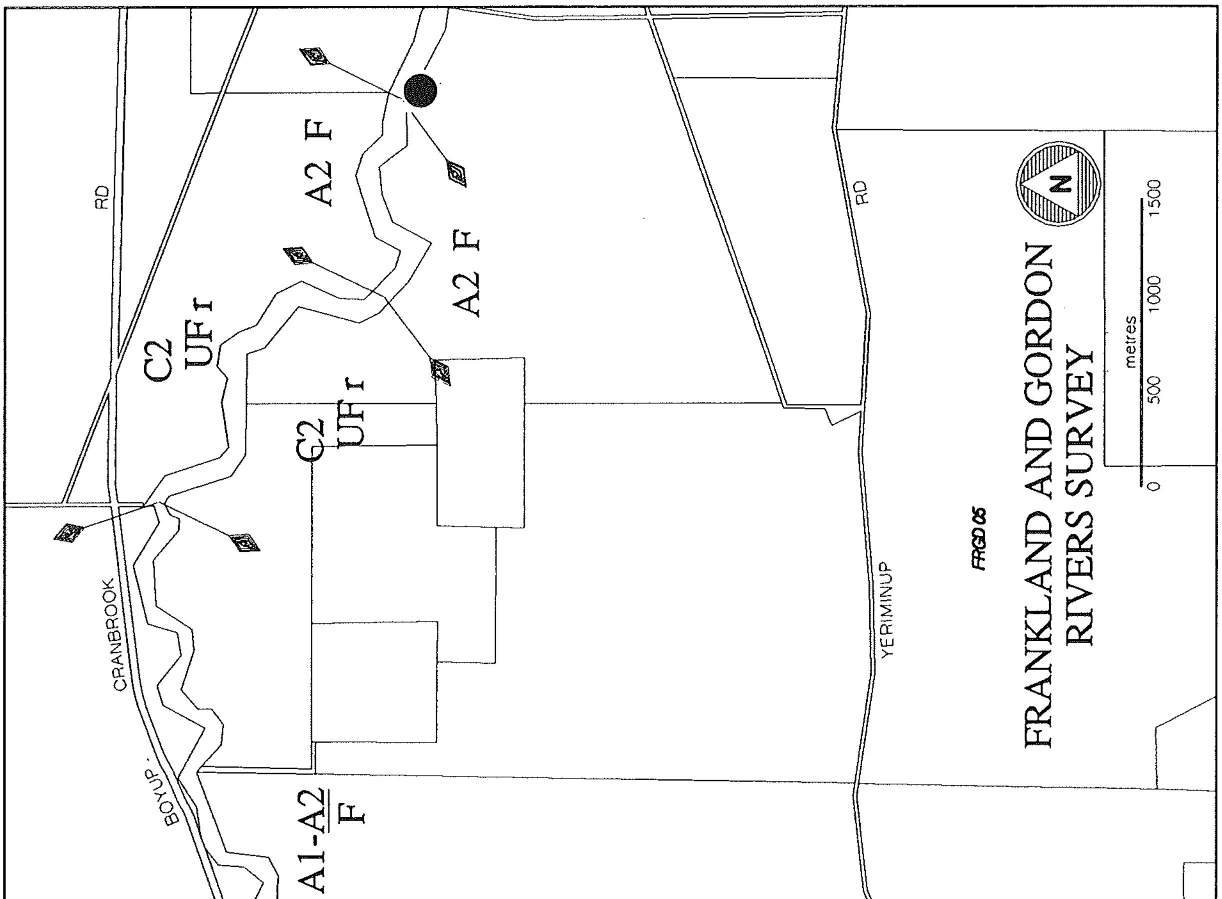
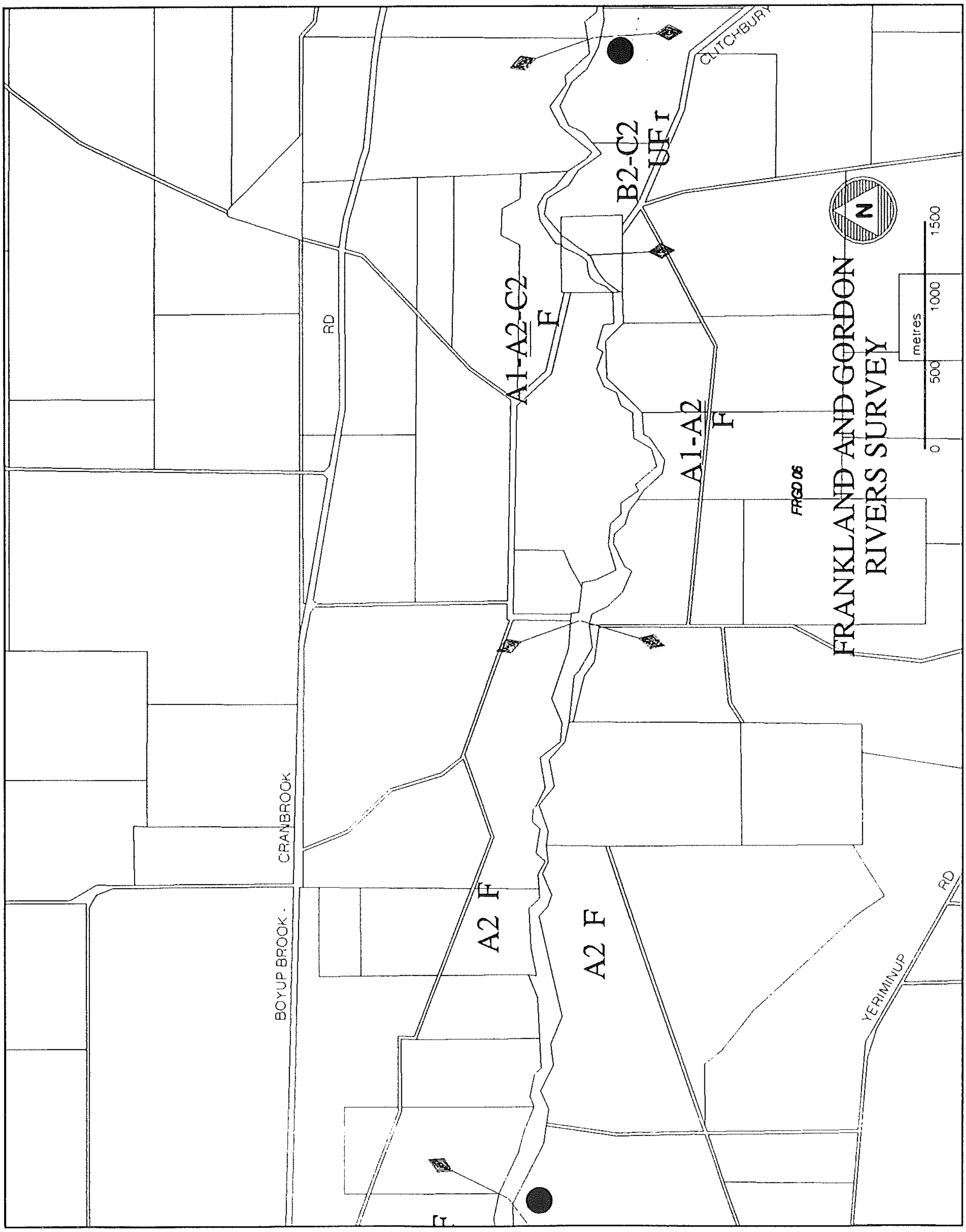
B3
UF r
A1-A3
F
A3-B3
F

Map 4



FRANKLAND AND GORDON
RIVERS SURVEY
FRGD 05
N
0 500 1000 1500
metres
RD
BOYUP - CRANBROOK
YERIMINUP
RD
HAYNESDALE RD
TOWERLUP BROOK
FRANKLAND - KOJONUP
RD
A2 F
A2 F
C2 UF r
C2 UF r
A1-A2 F
A1-A2 F
B2 UF r
B3 UF r
A1-A2 F
A1-A2 F
A1-A2 F
A1 F
A1 F
A1 F

Map 5


FRANKLAND AND GORDON
RIVERS SURVEY
FRGD 06
A1-A2-C2
F
B2-C2
UF r
A1-A2
F
A2 F
A2 F
BOYUP BROOK - CRANBROOK
RD
CLITCHBURY
YERIMINUP
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metres
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500
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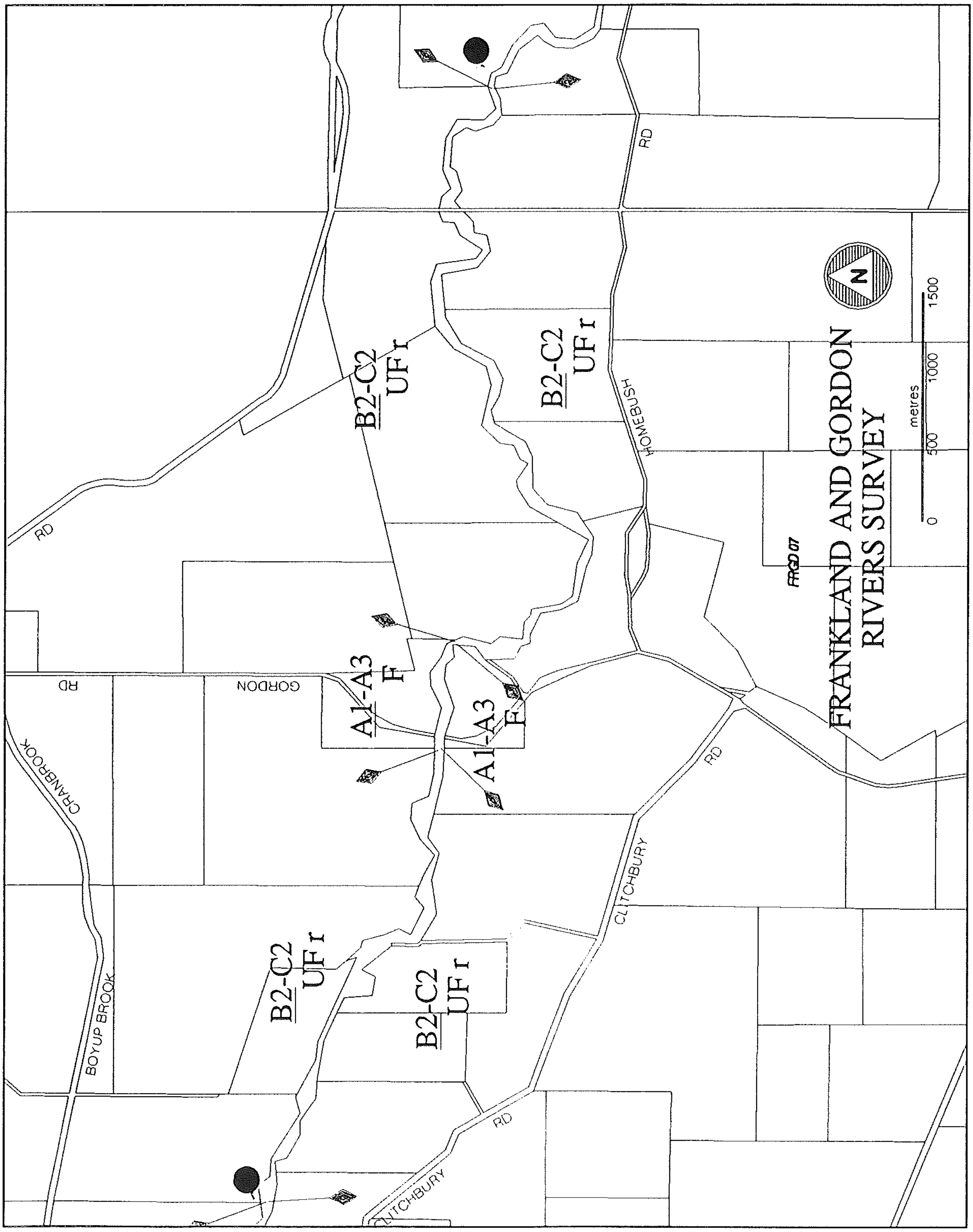
N

Map 6


FRANKLAND AND GORDON
RIVERS SURVEY
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metres
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500
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N
B2-C2
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B2-C2
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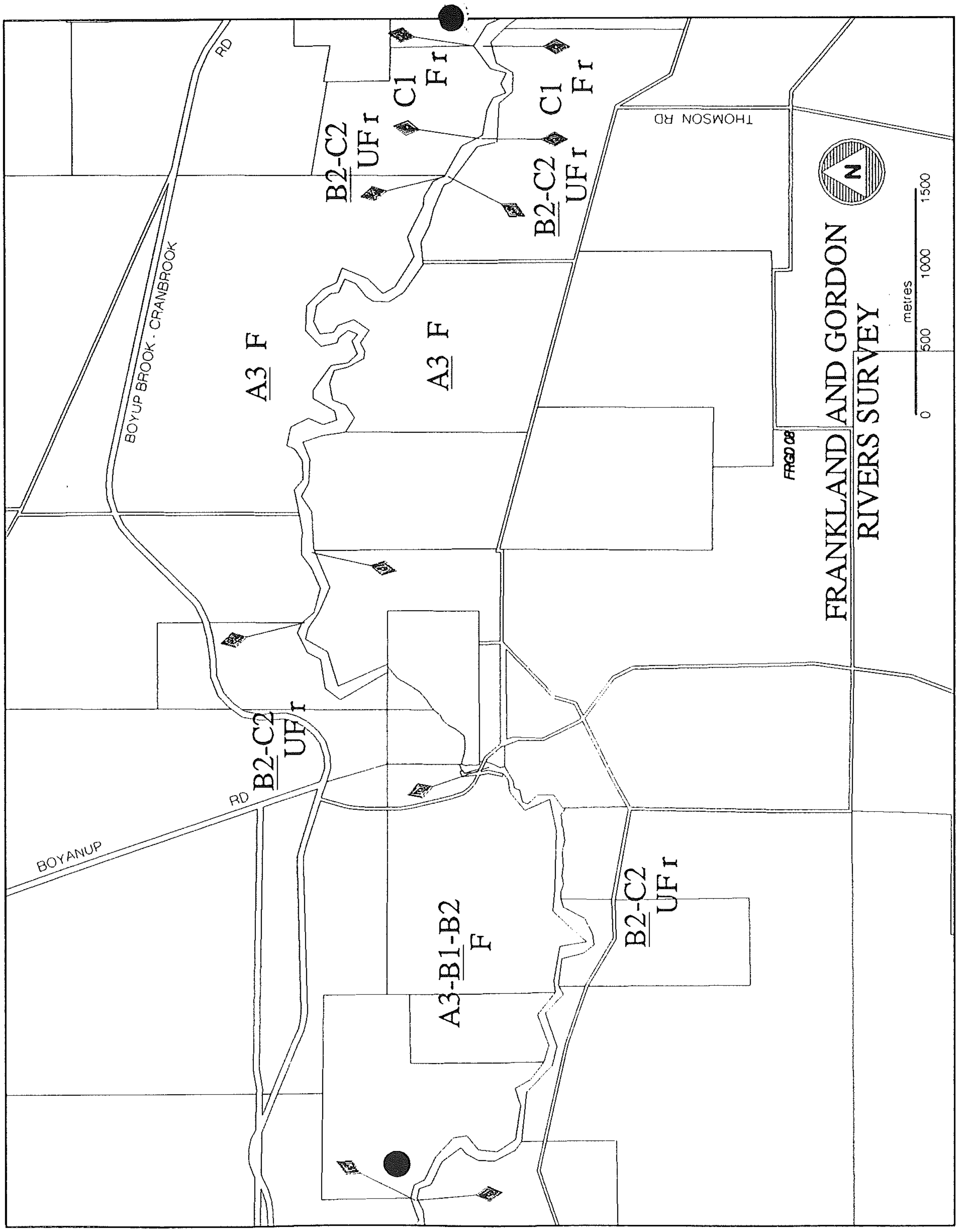
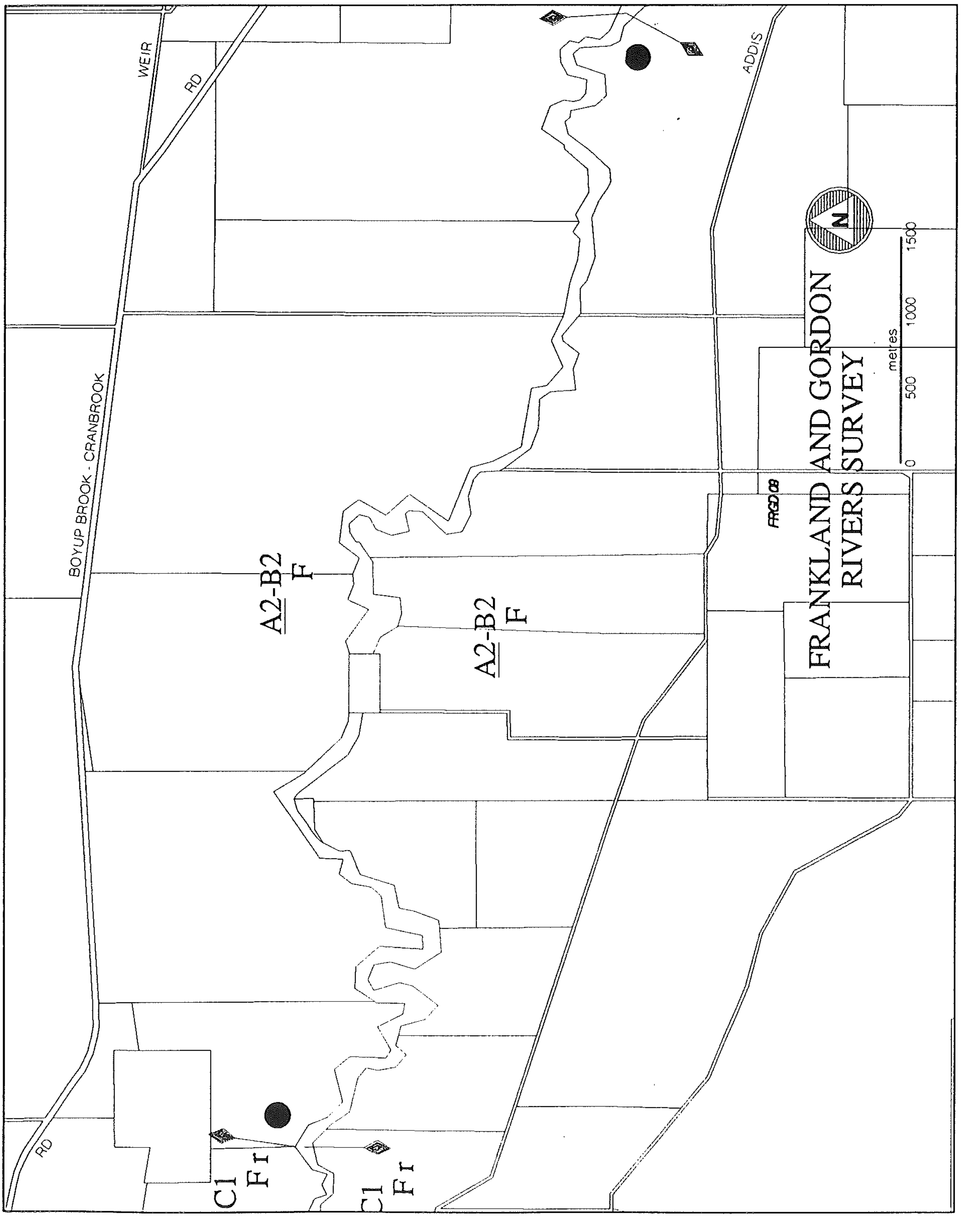
A1-A3
F
A1-A3
F
B2-C2
UF r
B2-C2
UF r
HOMEBUSH
RD
RD
GORDON
RD
CRANBROOK
BOYUP BROOK
CLITCHBURY
RD
RD
CLITCHBURY

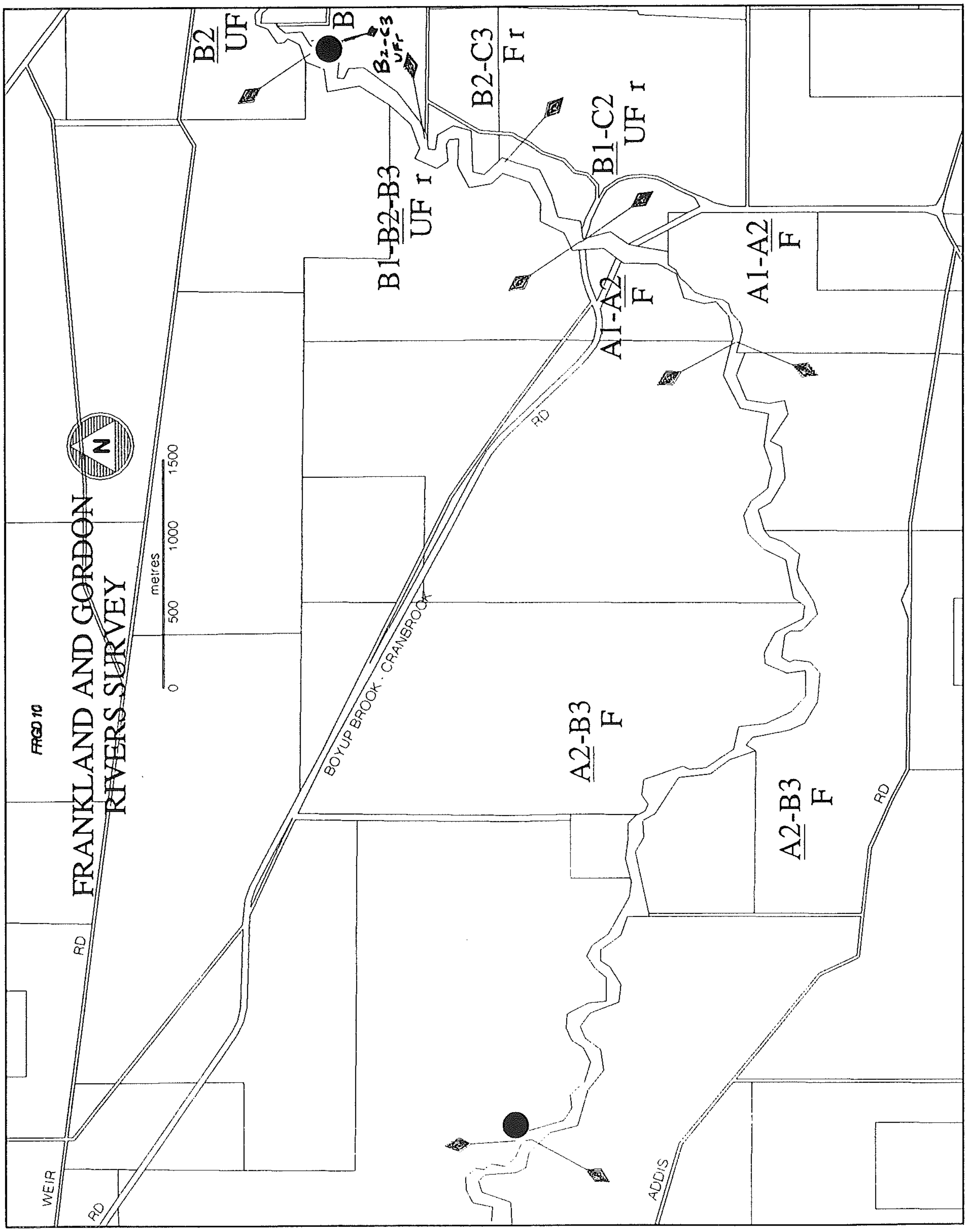
Map 7


FRANKLAND AND GORDON
RIVERS SURVEY
metres
0
500
1000
1500
N
THOMSON RD
BOYUP BROOK - CRANBROOK
RD
BOYANUP
RD
FRGD 08
A3 F
A3 F
B2-C2
UF r
C1
F r
B2-C2
UF r
C1
F r
B2-C2
UF r
A3-B1-B2
F
B2-C2
UF r

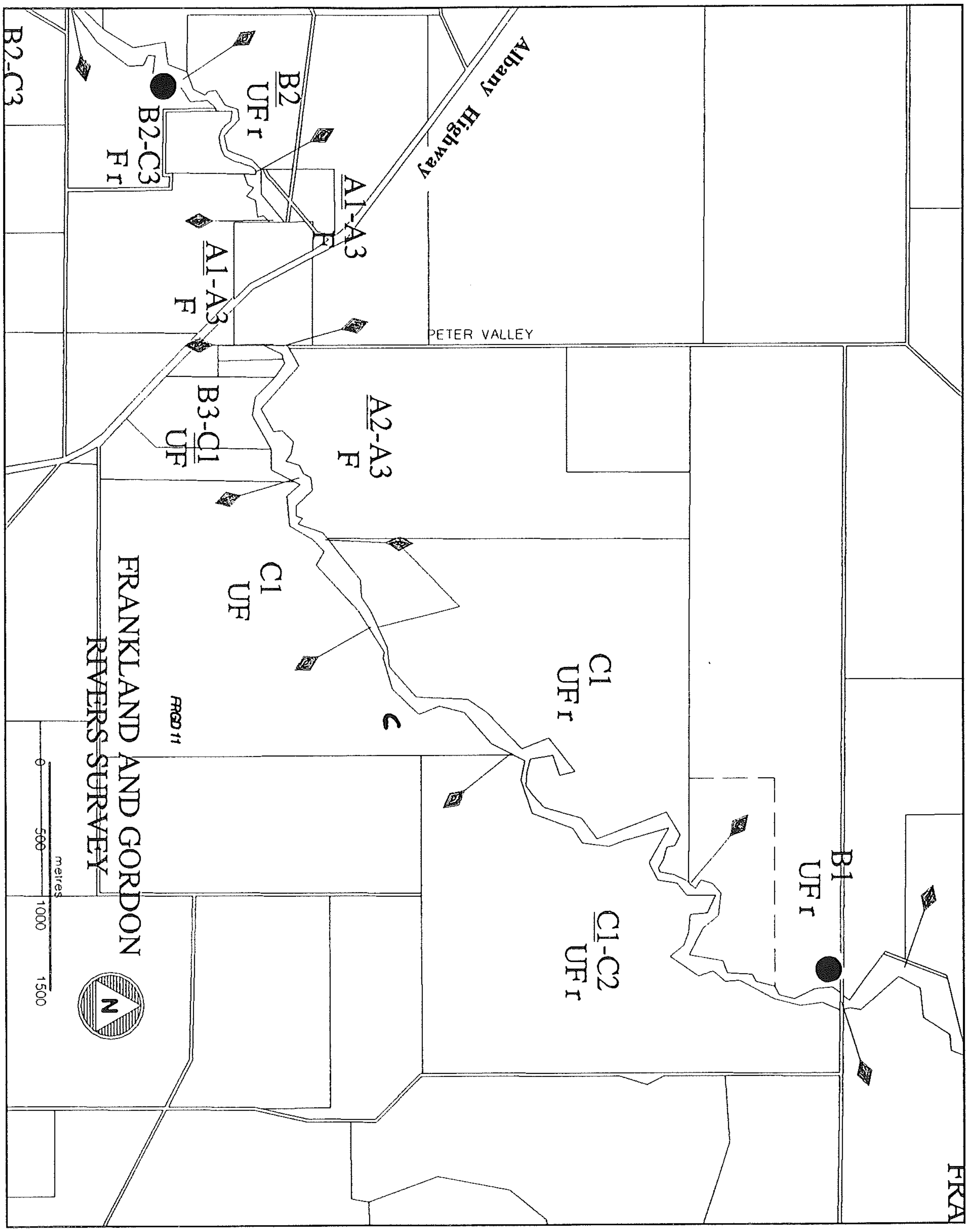
Map 8


BOYUP BROOK - CRANBROOK
RD
WEIR
RD
ADDIS
A2-B2
F
A2-B2
F
C1
Fr
C1
Fr
FRGD09
FRANKLAND AND GORDON
RIVERS SURVEY
metres
0
500
1000
1500
N

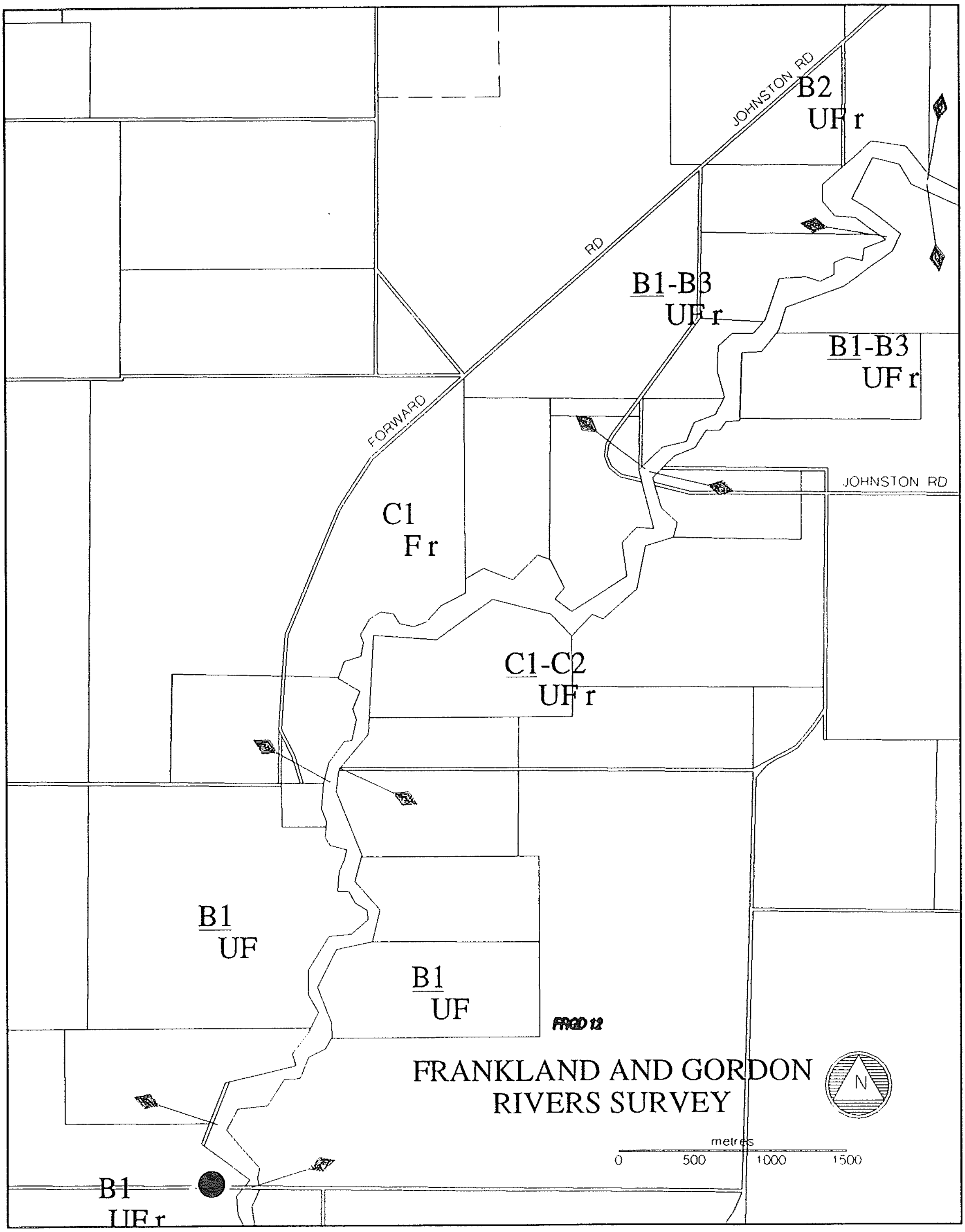
Map 9


FRGD 10
FRANKLAND AND GORDON RIVERS SURVEY
metres
0 500 1000 1500
N
BOYUP BROOK - CRANBROOK
RD
WEIR
RD
ADDIS
RD
B2 UF
B
B2-C3 UF r
B2-C3 F r
B1-C2 UF r
B1-B2-B3 UF r
A1-A2 F
A1-A2 F
A2-B3 F
A2-B3 F

Map 10

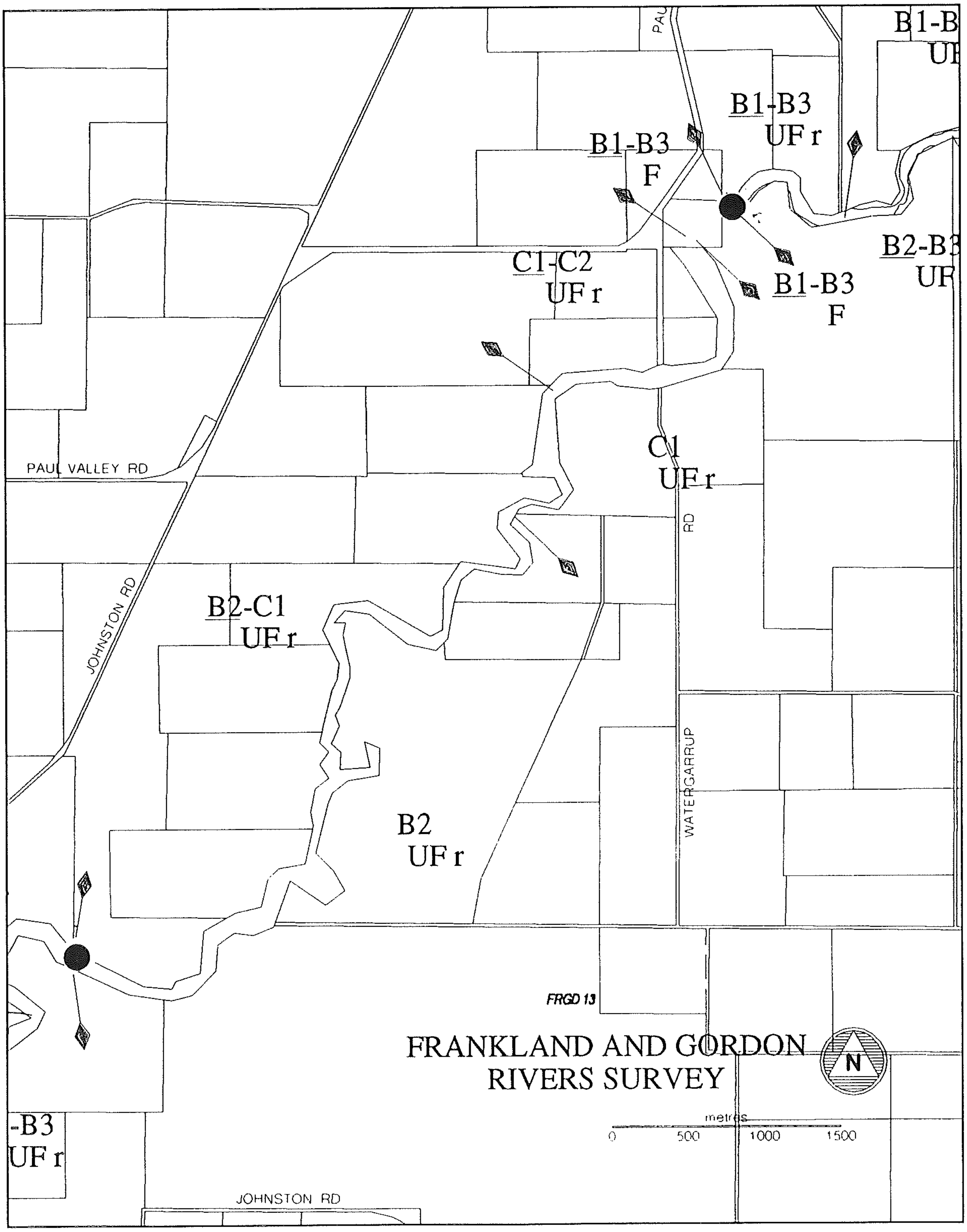

B2-C3
B2
UF r
B2-C3
F r
Albany Highway
A1-A3
F
A1-A3
F
PETER VALLEY
B3-C1
UF
A2-A3
F
C1
UF
C1
UF r
FRGD 11
FRANKLAND AND GORDON
RIVERS SURVEY
0
500
1000
1500
metres
N
B1
UF r
C1-C2
UF r
FRA

Map 11



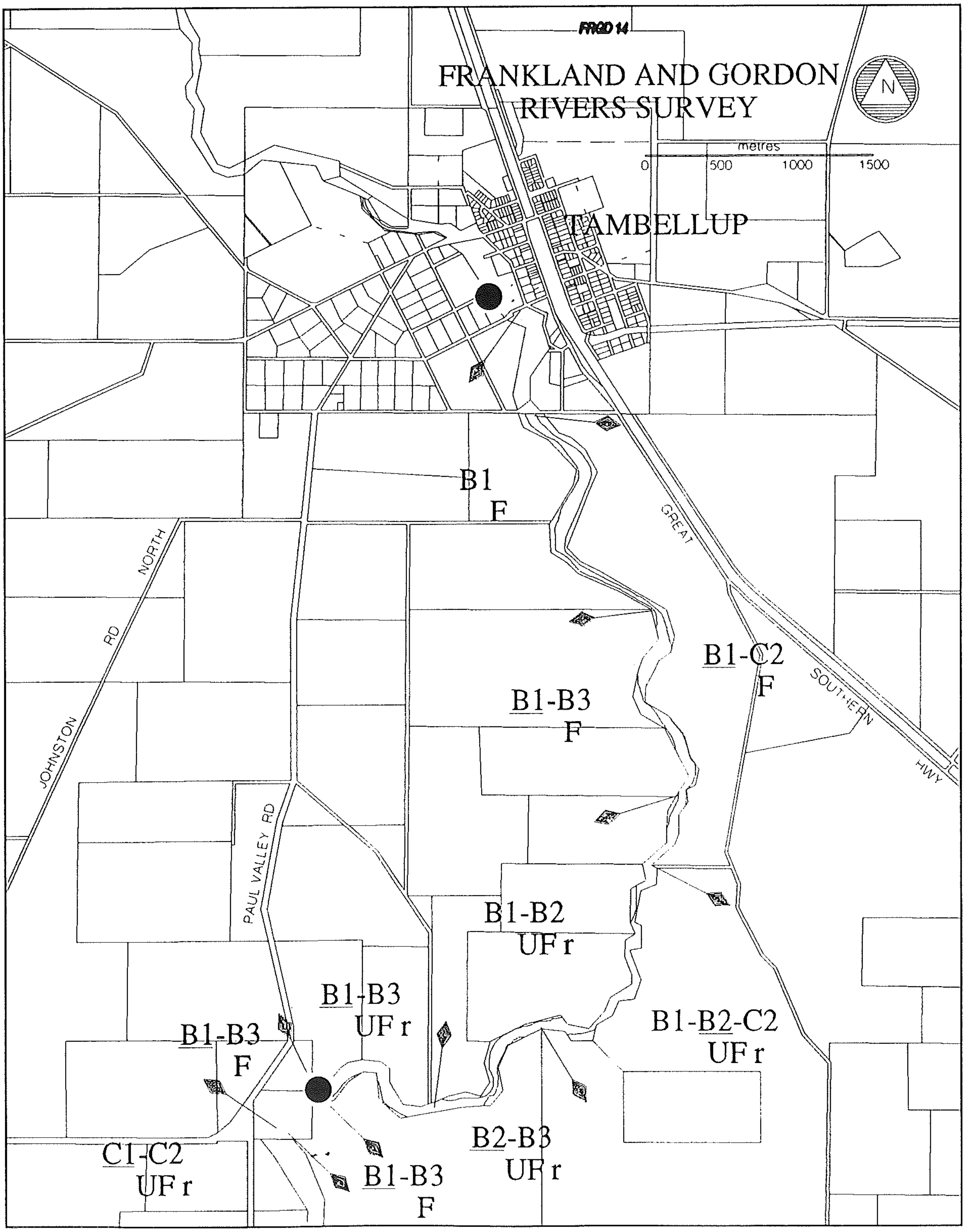
JOHNSTON RD
B2
UF r
RD
B1-B3
UF r
B1-B3
UF r
FORWARD
JOHNSTON RD
C1
F r
C1-C2
UF r
B1
UF
B1
UF
FRGD 12
FRANKLAND AND GORDON
RIVERS SURVEY
N
metres
0 500 1000 1500
B1
UF r

Map 12



B1-B
UF
B1-B3
UF r
B1-B3
F
C1-C2
UF r
B2-B3
UF
B1-B3
F
PAUL VALLEY RD
C1
UF r
RD
JOHNSTON RD
B2-C1
UF r
WATERGARRUP
B2
UF r
FRGD 13
FRANKLAND AND GORDON
RIVERS SURVEY
N
metres
0 500 1000 1500
-B3
UF r
JOHNSTON RD

Map 13



FRGD 14
FRANKLAND AND GORDON RIVERS SURVEY
N
metres
0 500 1000 1500
TAMBELLUP
GREAT SOUTHERN HWY
NORTH RD
JOHNSTON RD
PAUL VALLEY RD
B1
F
B1-C2
F
B1-B3
F
B1-B2
UF r
B1-B3
UF r
B1-B3
F
B1-B2-C2
UF r
C1-C2
UF r
B2-B3
UF r
B1-B3
F

Map 14

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Appendices

Appendix 2: Recommended books and other literature on waterways management and native vegetation rehabilitation

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