



GREENOUGH RIVER FORESHORE ASSESSMENT



WATER AND RIVERS
COMMISSION

GREENOUGH RIVER FORESHORE ASSESSMENT

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Contents

Acknowledgments	ii
Summary	v
1. Introduction	1
1.1 Need for the study	6
1.2 Community involvement process	7
1.3 This report	7
2. The study area	8
2.1 The physical environment	8
2.1.1 Geology, geomorphology and soils	8
2.1.2 Climate	8
2.1.3 Hydrology	8
2.1.4 Bathymetry	8
3. Methodology	9
3.1 Implementing the survey	9
3.1.1 Undertaking foreshore surveys	9
3.1.2 Environmental parameters of foreshore condition	9
3.1.3 Collating the results	11
4. Summary results	13
5. Site reports	19
5.1 Specific site reports	19
6. Common issues	212
6.1 Rights and responsibilities of owning land adjoining the river and foreshores	212
6.2 Foreshore reserves	212
6.3 Bank stability	213
6.4 Salt	213
6.5 Vegetation	214
6.5.1 Tax incentives for protecting vegetation	214
6.6 Weeds	216
6.7 Pest fauna	218



6.8	Farm plans	218
6.9	Fire	219
6.10	Cropping	219
6.11	Fence alignment	220
6.12	Stock access	220
6.13	Grazing	221
7.	General recommendations	223
7.1	Planning	223
7.2	Site preparation	223
7.2.1	Weed control	223
7.2.2	General site preparation	223
7.3	Planting out	224
7.4	Maintenance	224
7.5	Monitoring	224
7.6	General management suggestions for each foreshore rating	225
8.	Working with government	226
8.1	Liaison with government agencies	226
8.1.1	Water and Rivers Commission	226
8.1.2	Local government authorities	226
8.1.3	Department of Environmental Protection	227
8.1.4	Ministry for Planning	227
8.1.5	Main Roads WA	227
8.1.6	Department of Conservation and Land Management	227
8.1.7	Agriculture WA	227
8.1.8	Fire and Emergency Services	227
8.2	Further information	228
9.	References and recommended reading	229

Tables

1.	Greenough River catchment selected sites	7
2.	Stream Condition Index	11
3.	The summary conditions of the environmental parameters assessed to determine foreshore health	12



Summary

The Greenough River is a regionally significant waterway in terms of biodiversity, habitat provision, aesthetic values, cultural values and recreation in the Mid West region. The Greenough River commences in the Yalgoo district approximately 240 kilometers north east of Geraldton, Western Australia, and meanders through a diverse landscape to the river mouth located at Cape Burney 10 kilometres south of Geraldton. To protect and enhance the ecological integrity and social values of the Greenough River a foreshore assessment survey was conducted to identify foreshore condition and present management recommendations for the surveyed sections of the waterway.

This document provides the results of a foreshore assessment survey of the Chapman River in accordance with the Pen and Scott (1999) foreshore condition assessment proforma. Testing and refining the assessment protocol in this work was required to overcome any shortcomings or limitations of the proforma related to this survey occurring in a different environment to that in which the standard was developed.

The foreshore assessment process has been developed to aid interested community groups, officers of State and local government authorities and private landholders in rural, semi-rural and urban areas to gain an understanding of the condition of foreshore areas within their own community. By using a standard methodology to gather information it is possible to compare and contrast the foreshore condition of the same area over time, or of different sites in the same survey season, to prioritise works.

The key findings of the study showed that the health of Chapman River and its tributaries, rated in accordance with the Stream Condition Index, ranged from Very Poor to Very Good. Four areas rated Very Good. Of interest is that the Very Poor ratings occurred throughout the catchment. The key issues requiring action in the sections surveyed are:

- Poor bank stability – because of increased water volumes and loss of vegetation and rising groundwater levels;
- Loss of native vegetation and high levels of weed invasion, particularly in the verge vegetation;

- Lack of stream cover – due to loss of fringing vegetation;
- Reduced habitat diversity;
- Relatively low increases to land values and reduced ability to utilise the land to earn a living; and
- Difficulties associated with managing access.

The priority weeds for control include the grasses (Couch, Red Natal, African lovegrass and Fountain grass), Castor oil, Arum lily, Blackberry and pasture weeds including Doublegee, Lupins, Paterson's curse and Saffron thistle. There are considerable opportunities to protect remnant native vegetation through fencing, weed control and managing access for fire management and recreation.

There are also sections of the brook that have been re-contoured by private landholders and a considerable number of dams blocking the flow. The landholders need to be approached to determine the feasibility of restoring the function of the brook.

Many of the issues require all landholders to work collectively in order to make a difference. The importance of catchment groups in raising awareness, providing technical and on-ground support and encouraging all landholders to become involved, cannot be stressed enough.

This report of foreshore condition is one of many being undertaken. There is a push to assess the health of rivers in rural, semi-rural and urban areas Statewide.





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1. Introduction

The Greenough River is a regionally significant waterway in terms of ecological integrity and social value in the Mid West Region. The Greenough River commences approximately 240 kilometres north east of Geraldton within the Yilgarn Block in the Wandina/Tallering area of the Yalgoo district and continues through the South West terranes and northern undulating sandplains of the Perth Basin. Undulating systems on granitic rock deposited in the Walkaway area form a boundary between the Perth Basin and the Tamala coastal sandplain, the Sugarloaf system on granitic rock supporting numerous permanent pools in this section of the Greenough River channel. The river continues through the Tamala coastal sandplain to the river mouth located at Cape Burney 10 kilometres south of Geraldton, Western Australia, on the Quindalup Dune System. The Greenough River has a large catchment area that has historically been utilised for broad acre agriculture. Significant clearing of remnant vegetation in the catchment area of the river and degradation of the riparian zone of the Greenough River from past and present land uses has resulted in declining water quality, loss of biodiversity and habitat provision, poor bank stability, rising groundwater tables and sedimentation.

The riparian zone next to natural watercourses acts as a buffer to the surrounds. Healthy foreshore vegetation stabilises the foreshore banks and slows and filters water thus reducing erosion of the banks and sedimentation of major channels. Foreshore vegetation also provides stream cover and suitable habitats for aquatic and terrestrial animals. Often these areas are a haven for native fauna, particularly during the dry summer months.

Riparian areas have always been a focus for development and as a consequence are often highly degraded. The major threats to foreshore health are the loss of native vegetation or a decline in health due to weed invasion. The loss of deep-rooted native plants often causes the destabilisation of foreshore banks, leaving these areas prone to erosion, particularly during peak flow events.

Gaining an understanding of the health of river foreshores is the first step towards developing appropriate management strategies to protect and enhance these areas.

Reminding ourselves of the value of rivers

Before European settlement, native vegetation covered both the catchments and foreshores of the rivers and other waterways. The vegetation used most of the rainfall and surface runoff moved very slowly across the ground, which was well covered so there was little erosion. Similarly within the river systems the dense root systems of the native plants helped to hold the banks together. These plants provided habitat and the foundation of the food chain. Aquatic invertebrates such as snails, beetle larvae and insect larvae were fed on by native fish, which in turn were preyed on by waterbirds and other animals. Once the insects hatched, they provided a food source for shrubland and woodland birds, reptiles and other fauna. The deep pools provided drought refuge for these creatures during the dry summer months.

Since European settlement, clearing for mining, agriculture, townships and other developments has occurred and native vegetation has gradually been lost from both the catchments and river systems. As a general rule, there has been an increase in the amount of water running off the land into the waterways following clearing. Rising groundwater and more recent issues with salinity are other widely publicised results of clearing. With the surface water come sand, silt, loam and all types of sediment particles. The faster the water movement, the larger the sediment particle that can be moved. Sediment loaded water acts like liquid sandpaper, scratching the surfaces of plant leaves and trunks, increasing their vulnerability to insect attack and disease, filling up deep pools and being deposited as the flow slows on the floodway. Nutrients, heavy metals and other contaminants are also carried in the water.

The clearing of native vegetation has fundamentally altered the rate of sediment movement within the landscape. Wind and water erosion of topsoil is another outcome of native vegetation loss, which contributes to reduced productivity of the land. While crop plants and weeds that have replaced native vegetation restore some cover, they have a reduced ability to trap sediment or hold the soil during peak rainfall or river flow events, and have minimal habitat value for native fauna.

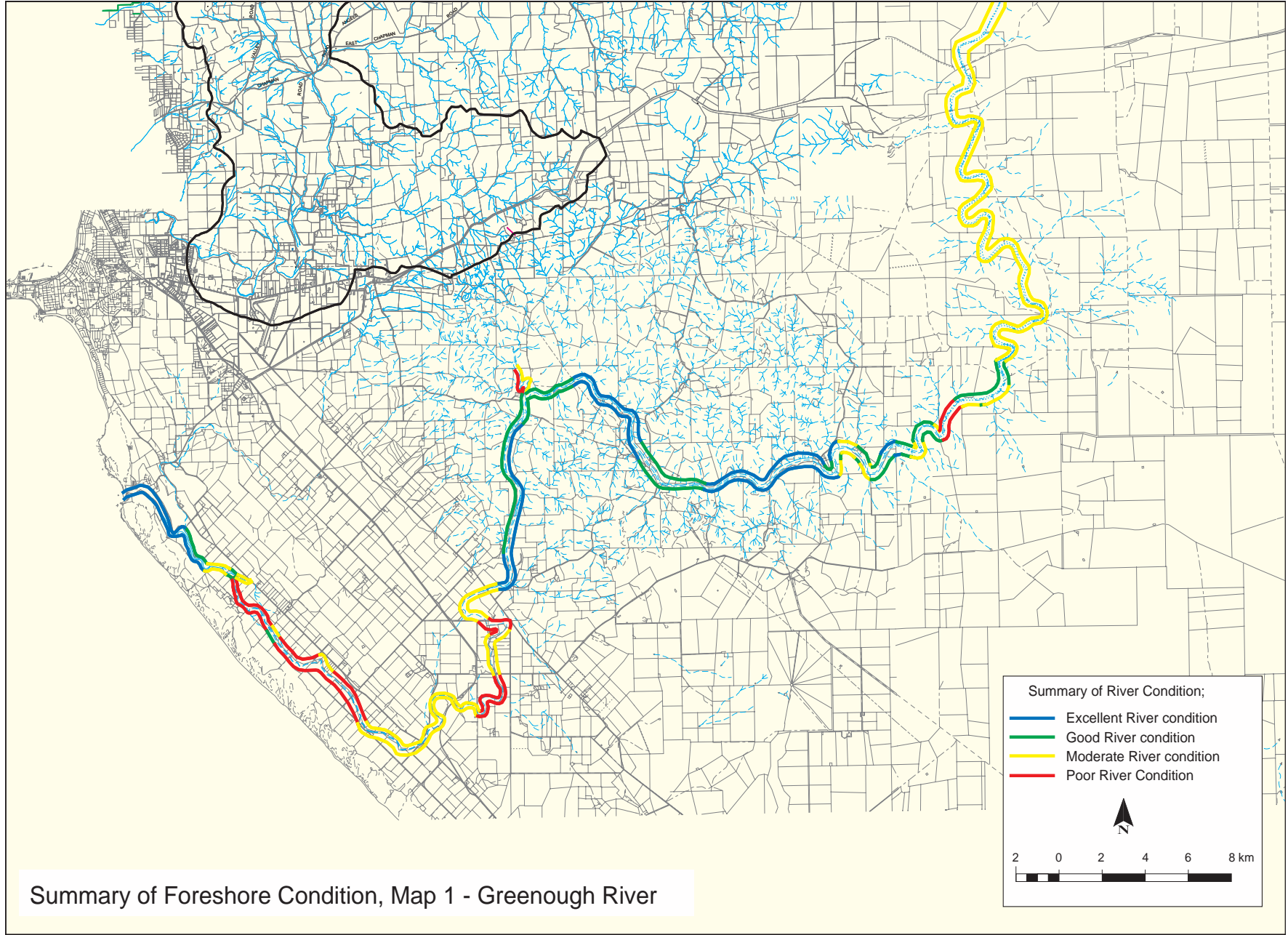


Weed symbol	Common name	Scientific name
	African boxthorn	Lycium ferocissimum
	African lovegrass	Eragrostis curvula
	Annual ryegrass	Lolium spp.
	Arum lily	Zantedeschia aethiopica
	Blackberry	Rubus sp.
	Black berry nightshade	Solanum nigrum
	Blue lupin	Lupinus cosentinii
	Buffalo grass	Stenotaphrum secundatum
	Bulrush	Typha orientalis
	Cape weed	Arctotheca calendula
	Castor oil plant	Ricinus communis
	Chinese pepper	Schinus molle
	Couch	Cynodon dactylon
	Dock	Rumex spp.
	Double gee	Emex australis
	Fleabane	Conyza spp.
	Fountain grass	Pennisetum setaceum
	Giant reed	Arundo donax
	Introduced annual grasses	
	Japanese pepper	Schinus terebinthifolia
	Kikuyu	Pennisetum clandestinum
	Lupins	Lupinus spp.
	Nasturtium	Tropeolum sp.
	Paterson's curse	Echium plantagineum
	Perennial grasses	
	Pie melon	Citrullus lanatus
	Red Natal grass	Melinis repens
	Roly poly	Salsola kali
	Saffron thistle	Carthamus lanatus
	Tamarisk	Tamarix aphylla
	Tree tobacco	Nicotiana glauca
	Vetch	Vicia sativa
	Watsonia	Watsonia sp.
	Weed wattles	Acacia spp.
	Wild radish	Raphanus raphanistrum
	Wild turnip	Brassica tournefortii
	Willow	Salix babylonica

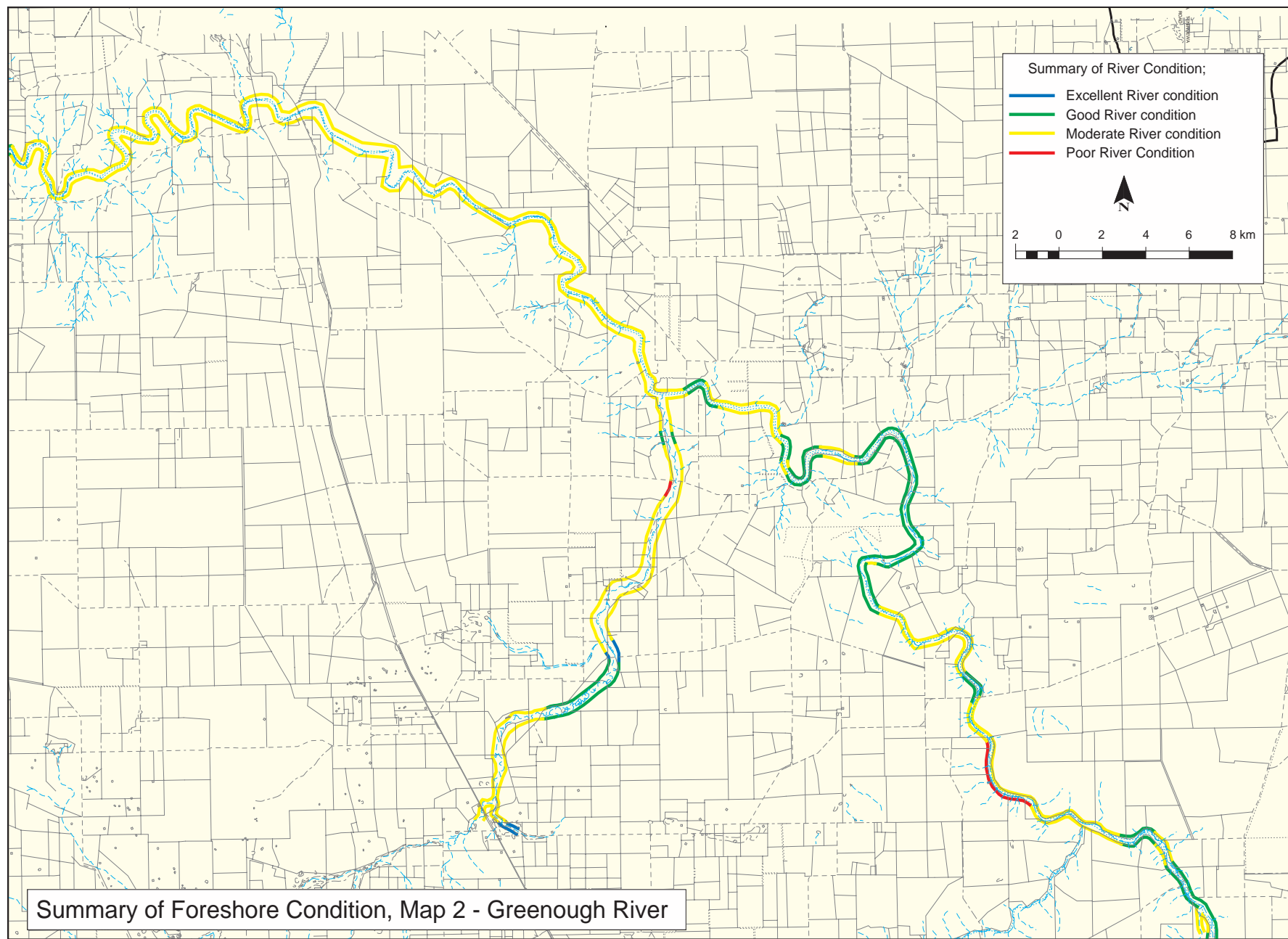
Infrastructure and other symbols	
	Blowouts
	Boulders
	Crossing
	Culvert
	Dam
	Discarded farm material
	Erosion
	Excavation
	Fence line
	Ford (Historic crossing)
	Former river channel
	Gate
	Granite outcrops
	Levee bank
	LWD Lots of woody debris
	Plumes
	Pools
	Power lines
	Power poles
	Quarry
	Railway bridge
	Revegetation lines
	Riparian Vegetation
	Rubbish tip
	Ruins
	Rural buildings
	Single row of trees
	Slumping
	Step in river channel
	Stock crossing
	Tanks
	Tracks
	Trough
	Verge vegetation
	Windmill

Map Legend





Summary of Foreshore Condition, Map 1 - Greenough River


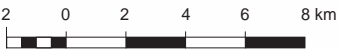
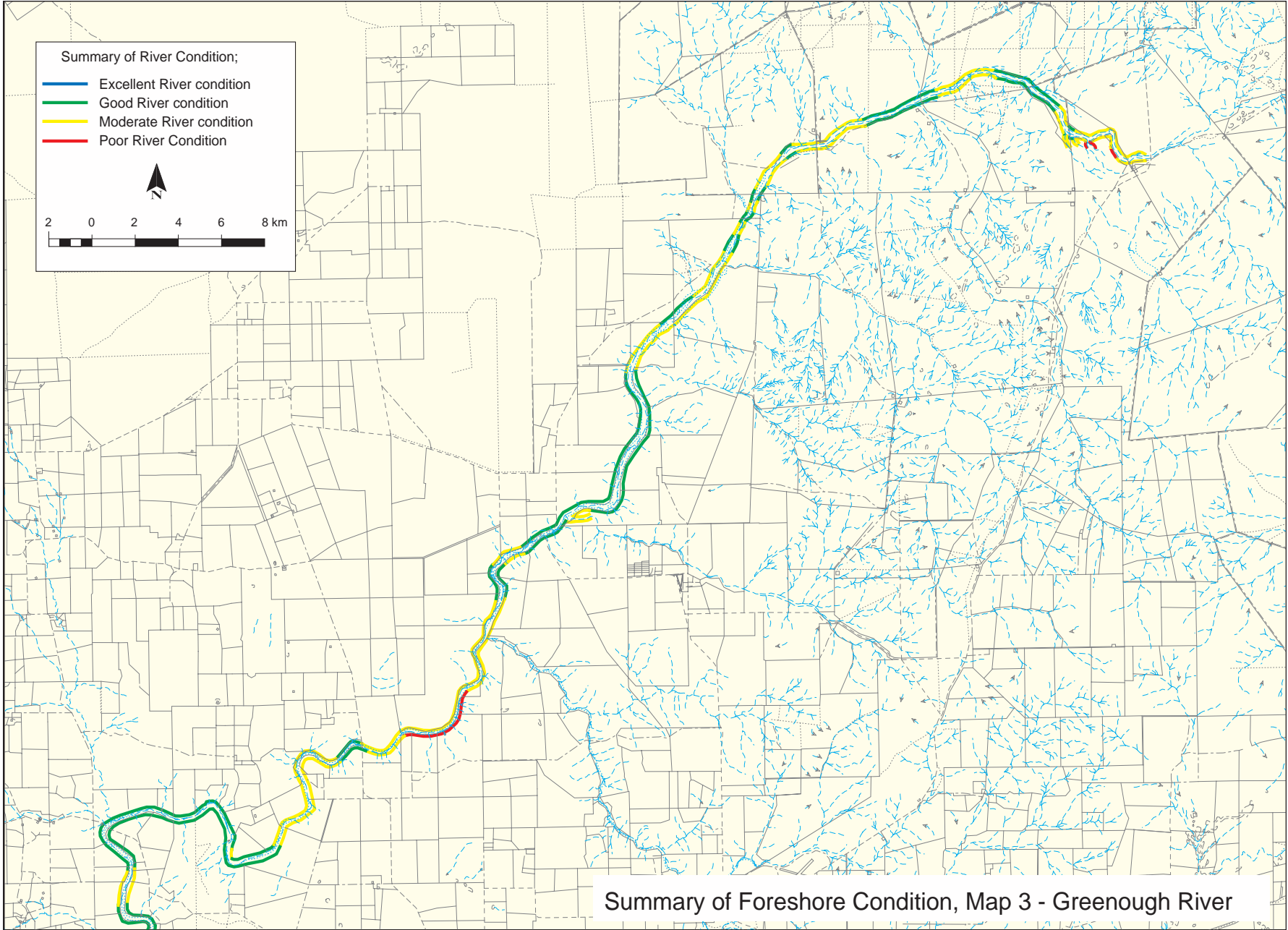


Summary of Foreshore Condition, Map 2 - Greenough River



Summary of River Condition;

- Excellent River condition
- Good River condition
- Moderate River condition
- Poor River Condition

Summary of Foreshore Condition, Map 3 - Greenough River

Rivers and the pools also provide important summer refuges for larger mobile animals, e.g. birds, kangaroos, echidnas and other fauna.

It is therefore possible to assess river health by looking at the plants, animals and physical features present. By assessing entire lengths of rivers, it is also possible to make predictions about likely changes to the river system in the longer term.

Points to remember

Some significant erosion events occurred in the past to form the landscape that is seen today, and some of these events would have been relatively catastrophic floods and peak flows. Comments are often made that because erosion is a natural process and has been ongoing since time began, the land shaping processes of erosion and sedimentation should be left to do what waterways have always done. Some landholders therefore consider river management activities to minimise the rate of changes to the course of river flow to be irrelevant and a waste of money.

While it is true that erosion is a natural process the rate of degradation of the river systems is increasing and becoming more widespread, with dramatic changes being seen in decades rather than over hundreds or thousands of years. For example, as mentioned above, many older members of communities throughout Western Australia recall swimming in river pools that were considered to be bottomless but are now full of sediment. The anecdotal evidence from different families who have owned and farmed properties along the Chapman and Greenough Rivers for generations, indicates that many of these changes have occurred since 1950.

Further, some properties are losing hectares of arable land (up to 10% of the property) following flood events as a result of erosion events. The financial and social implications of unstable river systems are substantial, irrespective of the environmental impacts. Reviewing community opinion following the 1999 flood events reinforces the hardship experienced and the need to actively support the natural physical and biological processes that keep rivers healthy.

Because many of the river management issues arise in the catchments, there is a need to include catchment processes in any designs for works in the river system. The widespread loss of habitat for native animals can make revegetation works more difficult as the native animals that would benefit from the plantings destroy the plants while they are young. This is particularly conspicuous with damage wrought on River Gum and other eucalypts by cockatoos, corellas and other parrots. Windbreaks can act as corridors for animals to move between bushland remnants, but all of the animals are focussed into one thin strip of vegetation. Small ground-dwelling animals are easy pickings for predators such as foxes, cats and others.

In summary, the environment in which we live continually evolves but the rate of change achieved in almost 180 years of settlement within WA has resulted in significant modifications to the landscape and plants and animals within it. This report aims to describe the physical and biological features of the river system and provide suggestions for management by landholders, land conservation district committees, local and State government agencies and community members. Practical achievable suggestions are the key to continue to help maintain and improve the features that are loved and respected along the Chapman and Greenough rivers.

1.1 The need for this study

To date there have been few studies of the Chapman River and this lack of information about the health of the river has provided the impetus for this study. Further, many landholders and landcare groups are becoming increasingly interested in active foreshore management and are seeking more help from agencies such as the Water and Rivers Commission and Agriculture WA to deal with issues affecting the river. The development of a standard methodology to assess foreshore condition in both rural and urban environments is helping to ensure consistency of information gathering. There are two standards for foreshore assessment – for rural areas Pen and Scott (1999), and in urban and semi-rural zones Shepherd and Siemon (1999).

This report presents the findings of work undertaken for the Water and Rivers Commission.



1.2 Community involvement process

The intended audience for the Foreshore Assessment is farmers, landcare district committees, State and local government officers and the community. A considerable amount of work went in to determining farmer interest in the river systems, identifying priority areas for survey and determining the level of support for this project. This was a critical component in gaining the funding from the Natural Heritage Trust.

Discussions were held with LCDC groups and individual landholders to determine specific areas of interest for each group. Each group identified priority river sections to undergo foreshore assessment. The locations selected included areas that were already a focus or are potential sites for future rehabilitation works.

The sites to be surveyed, as nominated by the people of the Greenough River region for these surveys, were as follows:

Table 1. Chapman River catchment selected sites

Site	Location	Situated
•	Greenough River main channel	Upstream to Mullewa–Murchison Crossing
•	Greenough River Tributary–Kockatea Gully	Upstream to Geraldton – Mt Magnet Rd crossing

As a result of time constraints and access difficulties only a small section of the Chapman River east branch nominated was surveyed.

The community living along both the Chapman and Greenough rivers were encouraged to participate in the foreshore assessment survey of these rivers.

Landholders owning properties adjoining the rivers were contacted by mail to advise them of the intention to undertake the assessment. This letter also extended an invitation to attend one of three workshops at which the foreshore assessment survey process was described.

Articles were published in local papers and radio interviews held to encourage community involvement and to inform the wider community of the survey process and early findings.

Further letters were sent to keep landholders informed of the progress of the works. Finally, in September a letter was sent inviting landholders to a series of workshops at which the results of the survey were presented.

A total of 65 people attended the meetings collectively.

The community response was generally very supportive with many landholders providing valuable information on the history of the property and river, landuse, fires, fencing and erosion. Landholders also provided advice about the best way to access difficult parts of the river within their properties.

1.3 This report

This report summarises the results of the Foreshore Assessment Surveys using the foreshore condition assessment proforma (Pen and Scott 1999). It provides a description of the current status of the foreshore environment, and identifies major threats to the health of the area. Recommended strategies for appropriate management of future works on the focus foreshore areas are also detailed in the document. Information is provided on weed control techniques, recommended native species for foreshore rehabilitation and how to undertake soft engineering works.



2. The study area

The foreshore assessment was conducted on the main channel of the Greenough River from the mouth extending upstream to the Mullewa-Murchison crossing. The study included foreshore assessment of a major tributary of the Greenough River, Kockatea Gully, from the Greenough River upstream to the Geraldton-Mt Magnet Road crossing. Approximately 535 kilometres of river channel was surveyed.

2.1 The Physical Environment

The physical environment plays a major role in determining the vegetation complexes associated with the riparian zone of a waterway and susceptibility of the riverbanks and foreshores to erosion processes.

2.1.1 Geology, geomorphology and soils

The Greenough River commences approximately 240 kilometres north east of Geraldton within the Yilgarn Block in the Wandina/Tallering area of the Yalgoo district. The transition from the Yilgarn Block to the undulating sandplains of the Perth Basin is dominated by the Dartmoor system which is level to gently inclined alluvial and colluvial surfaces and shallow to deep sandy to loamy red gradational soils typically well drained of the South West terraces. The river continues south west through the deep pale yellow and white sand, gravelly sands and sandy duplex soils of the undulating northern sandplains of the Perth Basin characterised by Eradu, Binu and Mount Horner soils. Adjacent to the Perth Basin is the Sugarloaf system on granitic rock characterised by reddish brown gritty sandy loam over clay on granite in the Walkaway area. The Greenough River continues through the Tamala coastal sandplain to the river mouth located at Cape Burney 10 kilometres south of Geraldton, Western Australia on the Quindalup Dune System.

The sediments of the riverbed consists of well drained gradational red sands and loams that consist of minor areas of clay deposits which is characteristic of the alluvial valley system. Degredation of the riverbank, the riparian zone and the catchment area of the Greenough River has resulted in the mobilisation of sediment from erosion processes.

2.1.2 Climate

The Geraldton area of the Midwest region has a Mediterranean climate with distinctly dry hot summers. Maximum temperatures range from 19.0°C in winter (May to August) to 32°C in summer (November to March). The average rainfall for the Geraldton area is 464.9mm. Rainfall is receivable on an average of 85 days in the year, falling mainly during the winter season (May to August).

2.1.3 Hydrology

Annual rainfall and groundwater dynamics influence the hydrology of the Greenough River. The estuarine reach of the Greenough River is also subject to the hydrodynamics of tidal exchange.

Flow of the Greenough River is mainly dependent on rainfall events, the middle and upper reaches of the river are ephemeral. A series of permanent pools are associated with the Sugarloaf system on granitic rock in the Walkaway area, these permanent pools are maintained by groundwater influence.

2.1.4 Bathymetry

The Greenough River is an intermittently closed estuarine system by the formation of a sand bar at the mouth of the river. Winter flows breach the sand bar separating the Greenough River from the ocean allowing tidal exchange of water. The estuarine reach of the Greenough River extends approximately 7 kilometres upstream from the mouth of the river.



3. Methodology

3.1 Implementing the survey

The foreshore assessment survey proforma has been developed to enable community groups to assess the condition of foreshores in rural areas. For detailed information on the methodology used to assess foreshore condition refer to Pen and Scott (1999). This methodology was developed for the southwest land division. There are some features of the proforma that reduce its effectiveness in the mid-west region, principally, downgrading of rivers due to a lack of permanent water and presence of salinity. For example, healthy saltmarshes are a natural part of these river systems and are not necessarily the result of degradation.

Further, the use of the summary forms for long river sections was inadequate due to the scale of properties. Providing yes or no answers is not particularly useful over tens of kilometres. These summary forms were modified to include proportional information. Documentation would otherwise have been minimal.

Geographic Positioning Systems (GPS) were also tested to assess the effectiveness of GPS in river mapping. This involved obtaining point data for the upstream and downstream end of key features in the riparian environment, i.e. significant sediment plumes or pools, large weed infestations or equivalent. Dimensions such as depth and width were also recorded.

As outlined above, the idea of the foreshore assessment survey process is to ensure consistency of information gathered over time, allowing the information collected from multiple surveys by various people to be collated. The accumulated information can then be used to prepare management plans and identify priority areas for rehabilitation. The results can also be used to monitor changes over time and to compare different foreshore areas; and be shared amongst State and local government authorities and the community.

3.1.1 Undertaking foreshore surveys

The foreshore areas were traversed and divided into relatively homogeneous sections of similar vegetation structure and landuse. A survey was conducted for each of these sections, and the condition of the foreshore parameters determined. Finally, the overall Stream Condition Index was determined.

In areas where foreshore vegetation was very dense on both banks, both sides were surveyed separately and a form was completed for each side. On highly degraded rivers where the foreshore along both banks was easily observed from one side, and the vegetation and disturbance factors were similar, a single survey form was completed for both sides.

Scaled baseline maps were prepared by WRC showing cadastral boundaries and the waterway. The cadastral information assists in identifying location out in the field. As each homogeneous section was identified, information was sketched onto baseline maps. Other information such as the composition and location of native vegetation along the foreshore, the location and extent of predominant weeds and the presence of disturbance factors such as discharge pipes and other infrastructure were detailed on each map. Fences and remedial works were also noted.

Note that the left and right sides of the main channel are defined by looking upstream.

3.1.2 Environmental parameters of foreshore condition

Principal environmental parameters are used as indicators of foreshore condition and are assessed during the foreshore survey to determine the overall Stream Condition Index.

These parameters are:

- bank stability;
- foreshore vegetation;
- stream cover;
- habitat diversity; and
- verge vegetation.



River zone assessment

The survey used a rating system to assess the health of the foreshore based on a method developed by Pen and Scott (1999). This system was developed for rivers in the southwest land division, and therefore required some amendments to improve the descriptions for rivers in the semi-arid zone.

The variations to the Pen and Scott (1999) methodology relate principally to the breakdown between erosion prone and unstable (C grade). In these systems, perennial grasses such as Couch contribute better support to the soil than annual grasses and herbs. This is because generally the likelihood of cyclone generated rains is greater than in the southwest, which is a winter rainfall dominated system. The frequency of summer rains in the mid-west regions increases the importance of having understorey cover all year round. The annual grasses have died back at this time of year, leaving the soil exposed and more prone to erosion during any flow event. Sections dominated by annual plants are rated lower than those retaining perennial vegetation cover.

Further, the Pen and Scott (1999) system rates rivers with permanent water more highly. While there are permanent pools in some sections of the Chapman River, this criterion has limited usefulness in rivers that are overall considered to be seasonal. The time taken for pools to dry out is more important in this environment. Permanent water may become a feature of these environments if there continue to be changes to groundwater levels in the mid-west region.

Verge vegetation is also included in the summary table for each river section to highlight this issue, however the overall ratings do not include this rating. The decision to exclude the presence of verge vegetation was made because the overall lack of vegetation would downgrade almost all ratings.

A brief overview of the key features and the grading system follows. This document provides ratings only to the four key levels (A, B, C and D). Landholders may wish to try to determine which sub-category is most appropriate for their land.

A grade foreshore

This overall rating is used for river embankments and floodways that are entirely vegetated by native plants. Occasional weeds may be present in small numbers, but if removed the native plants would retain their dominance. There is little evidence of erosion or slumping of the channel banks and across the floodway, limited sedimentation, seasonal river pools and little evidence of human interference. Limited evidence of livestock or feral animal damage also characterises this section.

This general category is divided further to reflect principally the level of weed invasion and evidence of disturbance into three sub-categories.

Rating	Key features
A1 Pristine	Entirely vegetated with native plant species and there is no evidence of human presence, livestock or feral animal damage.
A2 Near pristine	Native vegetation is dominant but with some introduced weeds in the understorey. The weeds are not displacing native species.
A3 Slightly disturbed	Native plants dominate but there are localised infestations of weeds and some exposed soil. This area would regenerate rapidly if there was reduced disturbance

B grade foreshore

This category covers foreshore areas where weeds have become a significant component of the understorey vegetation. The regeneration of all components of the native plant community is threatened and not all species are persisting within the community. There are some localised areas of erosion associated with weed dominated zones.

This general category is divided further to reflect principally the level of weed invasion and evidence of disturbance into three sub-categories.



Rating	Key features
B1 Weed infested	Weeds have become a significant component of the understorey vegetation and are starting to replace the native plants.
B2 Heavily weed infested	Introduced weeds are represented equally with native plants, particularly in the understorey. The weeds are limiting natural regeneration of native species.
B3 Weed dominated	Weeds dominate the understorey and the extent, diversity and abundance of native plants has been reduced significantly.

C grade foreshore

Trees and occasional large shrubs persist along the river lengths but the understorey consists entirely of weeds, particularly annual grasses. The trees are generally long-lived species but there is little or no evidence of young trees or tree seedlings. Physical disturbances to the soil tend to expose the soil, making it vulnerable to erosion.

The sub-categories now focus on the level of vegetation cover and the susceptibility of the substrate to wind and water erosion. Undercutting of mature trees, blowouts and other significant erosion features are common.

Rating	Key features
C1 Erosion prone	The understorey vegetation comprises exclusively or almost exclusively weeds. Typically there are mostly perennial weeds, some annual weeds and a single row or occasional stand of mature trees. Regeneration of native trees and shrubs is minimal. Most of the channel banks and floodway are vulnerable to erosion.
C2 Soil exposed	Older trees remain but there is minimal groundcover provided by annual weeds or any other plant. There is extensive physical disturbance to the soil and there is some evidence of erosion.
C3 Eroded	Weeds dominate the understorey and the extent, diversity and abundance of native plants has been reduced significantly. The soil is being washed away, particularly from around and beneath trees. There is considerable bank collapse, mobile sediment and washouts across the floodway.

D grade foreshore

There is not enough fringing vegetation to control erosion. While some trees and shrubs remain and slow the rate of erosion in localised areas, they are likely to be undermined. Large sediment plumes are visible along the river channel and it is likely that the course of river flow will increasingly fluctuate in the future.

Rating	Key features
D1 Eroding ditch	Weeds have become a significant component of the understorey vegetation and are starting to replace the native plants.
D2 Freely eroding ditch	Introduced weeds are represented equally with native plants, particularly in the understorey. The weeds are limiting natural regeneration of native species.
D3 Simple drain	

Greater detail about the system is provided in Table 3.

The Stream Condition Index is a summary of the foreshore environmental parameters and is an indication of the overall stream condition (Table 2).

Table 2: Stream Condition Index

Colour Code	Parameter Rating	Description
Blue A	Very Good	All parameters rated Blue.
Green B	Moderate	Three to four parameters rated Green or better with only one parameter rated Yellow and no Red ratings.
Yellow C	Poor	Three parameters rated Yellow or better with no more than one Red.
Red D	Very Poor	Three to all parameters rated Red.

3.1.3 Collating the results

The results compiled from the foreshore surveys of the selected sites were collated and a series of maps produced. These maps were digitised to enable presentation of the foreshore information in a visual format with corresponding text.



Table 3: The summary conditions of the environmental parameters assessed to determine foreshore health

	Bank stability	Foreshore vegetation	Stream cover	Habitat diversity	Verge vegetation
Blue (A) Very good	No significant erosion, slumping or sediment deposits in floodway or on lower banks; good native vegetation cover; only isolated areas of exposed soil or thinning vegetation.	Vegetation structure dominated by native plants that comprise 80-100% of the total number of species; weeds only scattered or rarely evident in small clusters; nil or minor signs of disturbance (i.e. tracks, rubbish dumping).	Abundant shade from overhanging vegetation; occasional instream cover from patches of aquatic vegetation and isolated heaps of leaf litter or rocks and logs.	Good water quality and some permanent water; at least three aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for each terrestrial vertebrate category (frogs, reptiles and birds).	Relatively intact shrubland and woodlands adjoining the riparian zone. Structure dominated by native plants with minimal weed invasion and few signs of disturbance.
Green (B) Moderate	Some localised erosion, slumping and sediment deposits; native vegetation cover on verges may be patchy and interspersed with patches of exposed soil.	Some changes in vegetation structure, native plants comprising 50-80% of the total species composition; little revegetation of trees and shrubs; weeds occurring occasionally; moderate levels of disturbance.	Scattered fringing vegetation with occasional patches of shade; infrequent in-stream cover with little aquatic vegetation, very infrequent rocks and logs.	No apparent problems with water quality (i.e. muddy or cloudy in winter); at least two aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for any two of the terrestrial vertebrate categories.	Vegetation patchy but comprises mostly native species. Native vegetation covers more than 50% of the section. Moderate levels of disturbance.
Yellow (C) Poor	Extensive active erosion, slumping and sediment deposition particularly during peak flows; bare banks and verges common.	Modified vegetation structure with native plants comprising only 20-50% of the total species composition. Tress remain with only scattered shrubs and an understorey dominated by weeds; high prevalence of disturbance.	Stream channel mainly clear; fringing vegetation almost absent providing very little permanent shade; instream cover almost absent with generally no instream vegetation and very infrequent rocks and logs.	Possible seasonal problems with water quality and no permanent water; at least one aquatic habitat type; at least one habitat type for terrestrial invertebrates; at least one habitat type for one of the terrestrial vertebrates.	Verge vegetation minimal with occasional individual plants or small groups of plants. Usually shrubs and occasional trees with a dense understorey of weeds. Numerous signs of disturbance and minimal regeneration of native seedlings.
Red (D) Very Poor	Almost continuous erosion; over 50% of banks slumping; sediment heaps line or fill much of the floodway; little or no vegetation cover.	Insufficient vegetation to control erosion; natural vegetation structure absent with occasional native trees and shrubs comprising less than 20% of the total species composition; weeds abundant; very high prevalence of disturbance and extensive areas of exposed soil.	Zero or minimal stream cover with no permanently shaded areas and no instream cover.	Poor water quality; almost no healthy habitats available for aquatic and terrestrial organisms.	Vegetation adjoining the riparian zone is minimal or absent. Disturbance is conspicuous.

Modified from Shepherd and Siemon (1999).

The summary codes of the condition of environmental parameters and the Stream Condition Index are included on the summary map for each site.

This report also contains a detailed description of the key findings for the five environmental parameters assessed for each survey section within the nominated survey sites. Strategies for appropriate remedial works are recommended for each section.



4. Summary results

The Greenough River ratings are summarised below. The river was divided into 33 overall sections, which have been averaged. Within this average, there is a range of ratings.

The average ratings for each river section are listed below.

Rating	Length
A – Very Good	7,370 m
B – Good	31,795 m
C – Moderate	67,910 m
D – Poor to Very Poor	47,970 m

SECTION 1: GREENOUGH RIVER MOUTH TO DEVLIN POOL MAPS 1 – 7

Length of section (m): 4310m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 30 March and 11 April 2000

Nearest road access: Rudds Gully Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Very Good A	Moderate B	Very Good A	Very Good A	Very Good A

SECTION 2: GREENOUGH RIVER MAPS 1 – 6

Length of section (m): 6690m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 11 April 2000

Nearest road access: Devlin Pool Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Moderate B	Poor C	Moderate B	Moderate B

SECTION 3: GREENOUGH RIVER MAPS 1 – 11

Length of section (m): 11,670m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 11 April 2000

Nearest road access: Devlin Pool Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Poor C	Poor C	Very Poor D	Poor C

SECTION 4: GREENOUGH RIVER MAPS 1 – 3

Length of section (m): 3,760m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 12 April 2000

Nearest road access: Hamersley Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Poor C	Moderate B	Moderate B	Poor C



SECTION 5: GREENOUGH RIVER MAPS 1 – 4**Length of section (m):** 4,710m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 12 April 2000**Nearest road access:** Evans Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Very Poor D	Poor C	Very Poor D	Very Poor D

SECTION 6: GREENOUGH RIVER MAPS 1 – 6**Length of section (m):** 7500 m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 12-13 April & 2 May 2000**Nearest road access:** Evans Road to near Nabeja Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Poor C	Poor C	Very Poor D	Poor C

SECTION 7: GREENOUGH RIVER MAPS 1 – 10**Length of section (m):** 9,700m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 May 2000**Nearest road access:** Nabeja Road and MacCartney Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Very Good A	Very Good A	Very Good A	Poor C	Very good A

SECTION 8: COLILURA BROOK MAP 1**Length of section (m):** 2560m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 May 2000**Nearest road access:** Glengarry Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Poor C	Poor C	Poor C	Poor C

SECTION 9: GREENOUGH RIVER MAPS 1 – 10**Length of section (m):** 9820m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 – 3 May 2000**Nearest road access:** Minnenooka Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Moderate B	Very Good A	Very Good A	Very Good A	Very Good A

SECTION 10: POOL NEAR GLENGARRY MAP 1**Length of section (m):** 270 m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 May 2000**Nearest road access:** Glengarry Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Very Good A	Very Good A	Very Good A	Moderate B	Very Good A



SECTION 11: GREENOUGH RIVER MAPS 1 – 3**Length of section (m):** 2700m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 May 2000**Nearest road access:** Minnenooka Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Very Good A	Moderate B	Moderate B	Moderate B

SECTION 12: GREENOUGH RIVER UNNAMED POOL MAP 1**Length of section (m):** 250m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 May 2000**Nearest road access:** Minnenooka Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Moderate B	Very Good A	Moderate B	Very Good A	Very Good A

SECTION 13: ELLENDALE POOL REGION MAPS 1 – 12**Length of section (m):** 14,490m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 23-24 May, 5 October 2000**Nearest road access:** Ellendale Pool Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Very Good A	Moderate B	Very Good A	Very Good A	Very Good A

SECTION 14: BLUE POOL AND BEETALYINNA POOLS UPSTREAM MAPS 1 – 6**Length of section (m):** 5,920m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 5 & 12 October 2000**Nearest road access:** Eradu South Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Moderate B	Very Good A	Very Good A	Moderate B

SECTION 15: ERADU REGION MAPS 1 – 25**Length of section (m):** 29,370m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 8 & 12 June & 12 October 2000**Nearest road access:** Eradu North Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Very Poor D	Poor C	Poor C	Poor C

SECTION 16: GREENOUGH RIVER MAPS 1 – 11**Length of section (m):** 12,410m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 12 June & 14 October 2000**Nearest road access:** Burton – Williamson Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Poor C	Very Poor D	Poor C	Moderate B	Poor C



SECTION 17: GREENOUGH RIVER CONFLUENCE WITH KOCKATEA GULLY MAPS 1 – 11

Length of section (m): 10,510m

Recorders' names: N Siemon and T Rebola Date surveyed: 8 April 2000

Nearest road access: Burton Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Moderate B	Poor C	Poor C

SECTION 18: KOCKATEA GULLY MAPS 1 – 6

Length of section (m): 8,030m

Recorders' names: N Siemon and T Rebola Date surveyed: 4 April 2000

Nearest road access: Peter Road and Brenkley Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Poor D	Poor C	Very Poor D	Poor C	Moderate B	Poor C

SECTION 19: KOCKATEA GULLY MAPS 1 – 5

Length of section (m): 6,100m

Recorders' names: N Siemon and T Rebola Date surveyed: 4 April 2000

Nearest road access: Brenkley Road and Tenindewa Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Poor C	Very Poor D	Poor C	Poor C	Poor C

SECTION 20: KOCKATEA GULLY MAPS 1 – 2

Length of section (m): 800 m

Recorders' names: N Siemon and T Rebola Date surveyed: 4 April 2000

Nearest road access: Byron Road crossing and Tenindewa Road crossing

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Good A	Very Good A	Very Good A	Very Good A	Moderate B	Very Good A

SECTION 21: KOCKATEA GULLY MAPS 1 – 4

Length of section (m): 5,800m

Recorders' names: N Siemon and T Rebola Date surveyed: 4 April 2000

Nearest road access: Yuna-Tenindewa Road and Byron North crossing

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Moderate B	Moderate B	Moderate B	Moderate B	Moderate B

SECTION 22: KOCKATEA GULLY MAPS 1 – 7

Length of section (m): 8670m

Recorders' names: N Siemon and T Rebola Date surveyed: 4 April 2000

Nearest road access: Yuna-Tenindewa Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Very Poor D	Poor C	Very Poor D	Poor C



SECTION 23: KOCKATEA GULLY MAP 1**Length of section (m):** 910 m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 April 2000**Nearest road access:** Yuna-Tenindewa Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
A Very Good	A Very Good	B Moderate	B Moderate	A Very Good	A Very Good

SECTION 24: GREENOUGH RIVER MAPS 1 – 10**Length of section (m):** 12,520m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 17 October 2000**Nearest road access:** Noondamurra Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Moderate B	Poor C	Poor C

SECTION 25: NOONDAMURRA CROSSING UPSTREAM MAPS 1 – 10**Length of section (m):** 10,300m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 17 October 2000**Nearest road access:** Noondamurra crossing**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B

SECTION 26: ENANGALNOOGOO TO POOTEN MAPS 1 – 4**Length of section (m):** 3,000m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 June 2000**Nearest road access:** Tenindewa North Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Moderate B	Moderate B	Poor C

SECTION 27: ERARANYU TO POOTEN MAPS 1 – 6**Length of section (m):** 8,070m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 17 October 2000**Nearest road access:** Pooten Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Poor C	Very Poor D	Poor C

SECTION 28: POOTEN MAPS 1 – 2**Length of section (m):** 1,440m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 16 – 17 October 2000**Nearest road access:** Pooten Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Moderate B	Very Good A	Moderate B	Moderate B



SECTION 29: POOTEN TO COONAWA MAPS 1 – 16**Length of section (m):** 15,580m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 16 October 2000**Nearest road access:** Coonawa Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Poor D	Poor C	Very Poor D	Poor C	Moderate B	Poor C

SECTION 30: COONAWA AND BARRAWHEELBARRA HILL REGION MAPS 1 – 13**Length of section (m):** 13,830m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 13 and 16 October 2000**Nearest road access:** Coonawa Road and Nubberoo Roads**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Moderate B	Moderate B	Very Good A	Moderate B	Moderate B

SECTION 31: OLD KOLANADGY WELL TO CONFLUENCE OF URAWA RIVER MAPS 1 - 7**Length of section (m):** 6,170m**Recorders' names:** Mullewa CLC, N Siemon and T Rebola **Date surveyed:** 4 October 2000**Nearest road access:** Mullewa – Carnarvon Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Poor D	Poor C	Poor C	Poor C	Poor C	Poor C

SECTION 32: MURGUNDIE, NUNIERRA CREEK TO CADJACOOTERRA MAPS 1 – 14**Length of section (m):** 14,310m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 October 2000**Nearest road access:** Mullewa – Carnarvon Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B

SECTION 33: GREENOUGH RIVER MAPS 1 – 12**Length of section (m):** 13,440m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 7 – 8 June & 9 October 2000**Nearest road access:** Mullewa – Carnarvon Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B



5. Site reports

This section of the report provides a series of descriptions of river sections with characteristics in common. The length of the river sections covered by the descriptions ranges from less than 200 m to several kilometres.

The report follows the standards set for naming flora in a recent publication by Paczkowska and Chapman (2000). All common names for plants observed have been taken from this document.

The maps provide indicative information about the vegetation characteristics at the time of survey. The river sections surveyed prior to the onset of winter rains

have fewer weed species listed, however this does not necessarily mean that they are not there as many annual weeds had not yet germinated. The maps are a tool for each landholder to use to continue documenting changes to their river section, and to monitor the health of their river section. Each landholder should feel free to add information to the map for their section to monitor weed control success for example.

The suggestions in the report are intended to help landholders meet their land management objectives while protecting and potentially improving the natural values of the waterways.

5.1 Specific site reports

SECTION 1: GREENOUGH RIVER MOUTH TO DEVLIN POOL MAPS 1 – 7

Length of section (m): 4310m

Recorders' names: N Siemon and T Rebola

Date surveyed: 30 March and 11 April 2000

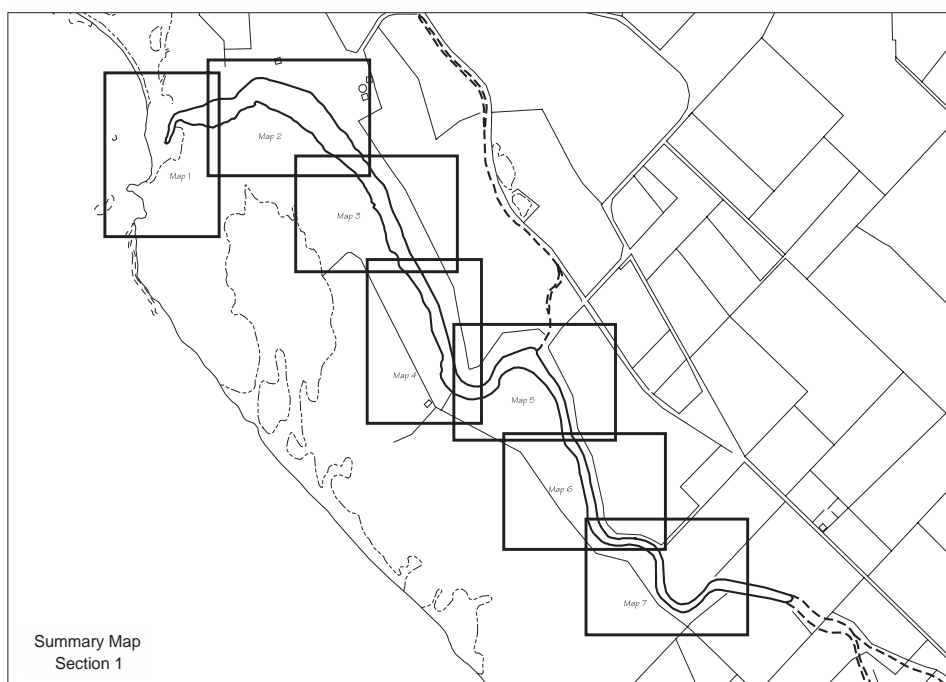
Nearest road access: Rudds Gully Road

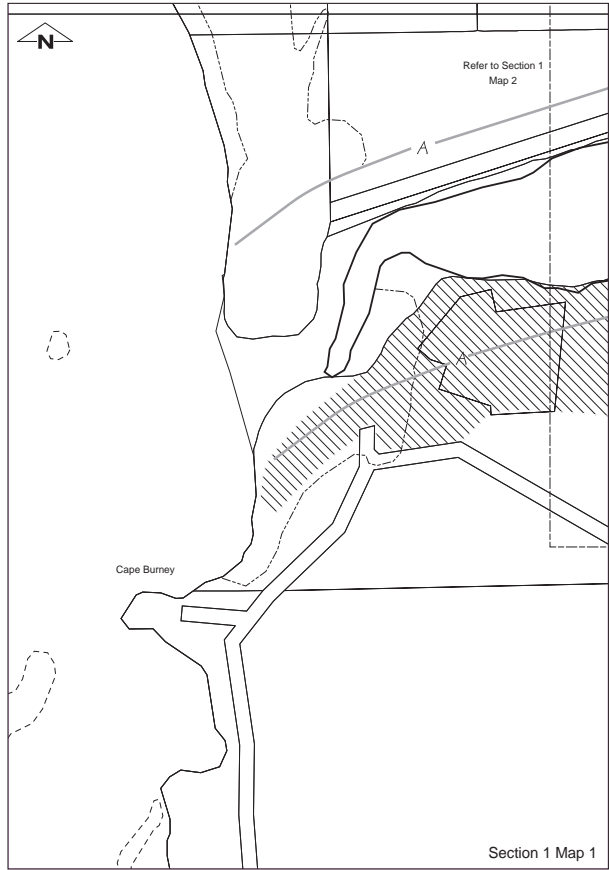
Summary of river health:

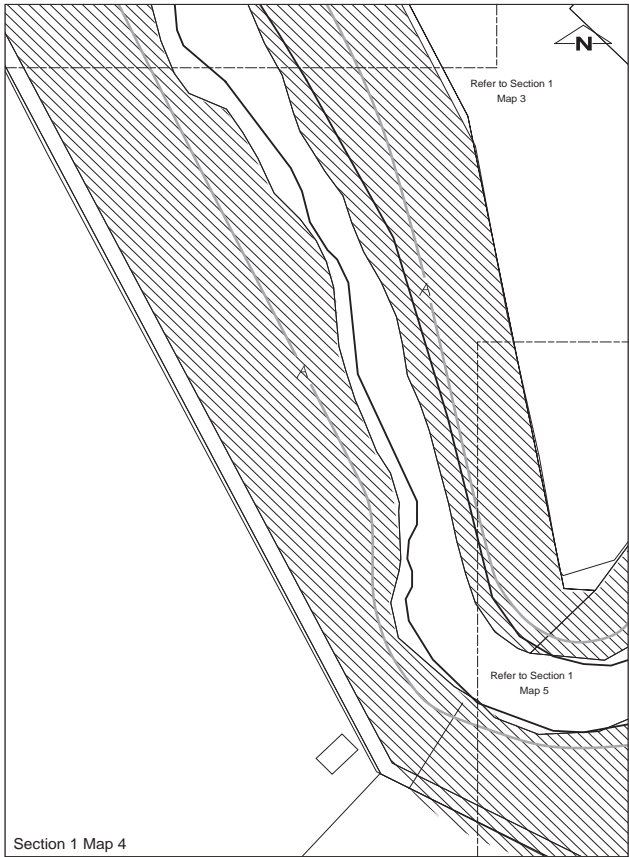
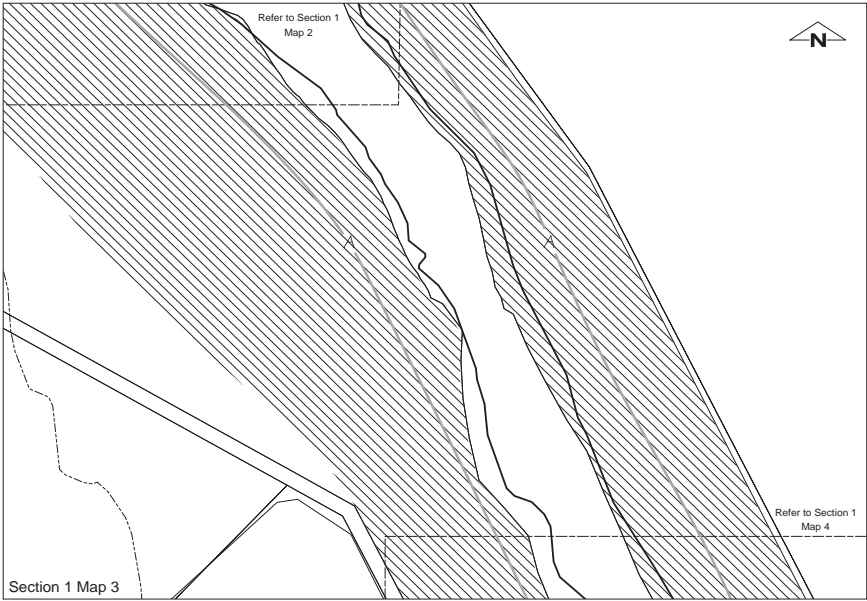
Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Very Good A	Moderate B	Very Good A	Very Good A	Very Good A

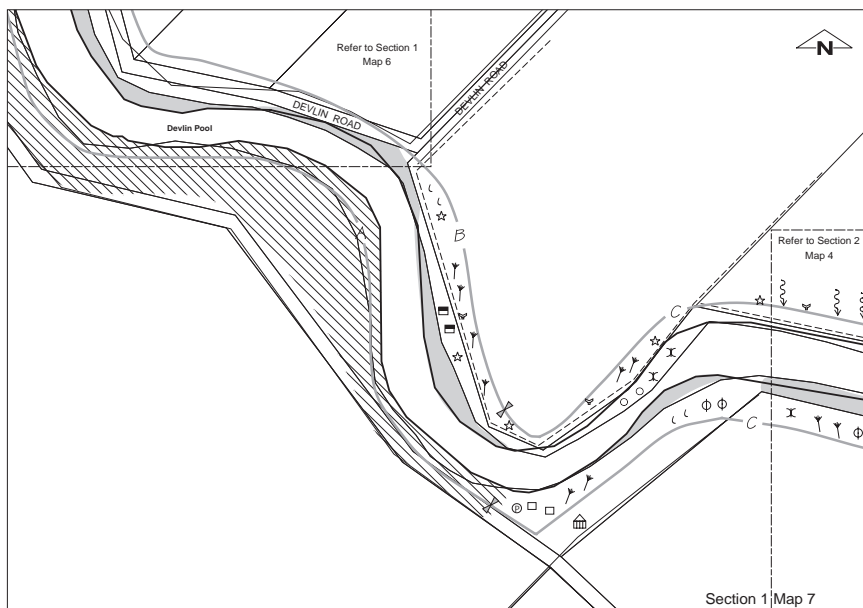
This river section was beyond the scope of the study area, therefore only a visual assessment has been undertaken. No description is provided.

The management plan for this area guides works in the region.









SECTION 2: GREENOUGH RIVER MAPS 1 – 6**Length of section (m):** 6690m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 11 April 2000**Nearest road access:** Devlin Pool Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Moderate B	Poor C	Moderate B	Moderate B

Bank stability

The low flow river channel ranges from < 3 m wide upstream of Bootenal Springs to > 25 m wide near Devlin Pool. Both braided and single channels are present. The banks are characterised by slight to moderate slopes along 60% of the length. The slight river bank gradients are generally well vegetated and stable. The remaining 40% of the section was characterised by very steep bank slopes. In these areas, erosion and slumping are severe and there are significant localised erosion rills forming as a result of sheet runoff and receding floodwaters. In many sections the riverbed has eroded back to a stable base of limestone and clay, with some coarse river sand deposited along less than 5% of the length. There are two river crossings within this section. While these are relatively stable they become impassable during peak flow events. This area is influenced by high tides and groundwater springs.

Comments

The lack of perennial or annual vegetation cover and high levels of stock access have resulted in this section becoming highly unstable and erosion prone. The very steep banks defining the river valley will continue to erode unless there is considerable effort to control water movement down these slopes. The considerable sedimentation observed can be linked to the water slowing as the two rivers meet. Because the instream vegetation is minimal to this point the river tends to carry large amounts of soil during large peak flow events. The sediment that has accumulated in these sections is well-sorted mobile white sand.

Vegetation

The vegetation communities in this section can be described in three zones: dense shrubland on the verges, Swamp sheoak (*Casuarina obesa*) closed woodlands and samphire/rush communities. The extent and density of vegetation is variable but generally poor to moderate, with extensive areas lacking vegetation cover. The

Bootenal Springs area corresponds with an improvement in foreshore health. The extent of riparian vegetation is up to 10 m wide on the left bank, and up to 20 m wide on the right bank. The dominant species on the verge includes One-sided bottlebrush (*Calothamnus quadrifidus*), Summer-scented wattle (*Acacia rostellifera*), Coastal wattle (*Acacia cyclops*) and Coojong (*Acacia saligna*). This is limited to less than 10% of the section. In the remainder, native verge vegetation is patchy or absent. The overstorey is lacking along much of the length.

The most common species are Swamp sheoak (*Casuarina obesa*), River gum (*Eucalyptus camaldulensis*), Swamp paperbark (*Melaleuca raphiophylla*) and Moonah (*Melaleuca preissiana*). African boxthorn (*Lycium ferocissimum*) is starting to invade this region with increasingly dense populations upstream. Some Tuart (*Eucalyptus gomphocephala*) have been planted along Devlin Pool Road. The understorey retains Shore rush (*Juncus kraussii*), Samphire species including *Sarcocornia blackiana*, Shrubby samphire (*Halosarcia halocnemoides*) and patchy Spiny flatsedge (*Cyperus gymnocaulos*). Dodder laurel (*Cassytha flava*) is common. Dominant weeds are Century plant (*Agave americana*), Castor oil plant (*Ricinus communis*), Fleabane (*Conyza bonariensis*) and Saffron thistle (*Carthamus lanatus*). Wild turnip (*Brassica barrelieri*), Couch (*Cynodon dactylon*), annual grasses including Annual Wimmera ryegrass and Drake (*Lolium rigidum* and *L. temulentum*), Lupins (*Lupinus cosentinii* and *L. angustifolius*), Walkaway Burr (*Cenchrus* sp.), Roly-poly (*Salsola kali*) and Nightshade (*Solanum nigrum*) are also present.

Comments

The remnant vegetation is insufficient to exclude weeds that are beginning to dominate in areas that have been disturbed. The disturbance is mostly associated with stock movement across the foreshore area. Controlling weeds on the margins will ultimately benefit the river environment. This is important to help protect the



integrity of vegetation in Bootenal Springs that is relatively intact. The density and extent of Pie melon on the floodway margins in this area was significant, while other weed species are present in moderately low numbers. Selective management of weeds is currently achievable.

The extent and diversity of verge vegetation is limited, although there are some remnants on the hill slopes. Increasing the native vegetation on the floodway margins will help to direct any peak flows, as well as providing habitat for native fauna. Dense native vegetation between paddocks and the riparian zone also helps to reduce weed invasion by trapping seeds and plant segments and out-competing the introduced plants.

Stream cover

The stream cover is minimal along much of the length of the lower Greenough River. There are occasional trees providing some shade, areas of instream debris and occasional rocky zones that provide cover. There are some filamentous and other forms of submerged algae present. The best stream cover occurs in the Bootenal Springs region. Debris is trapped in the floodway vegetation, up to 1.5 m above the low water level.

Comments

The low nature of the fringing vegetation and limited extent of trees, minimises shading. There is excellent stream cover in the woodlands at Bootenal Springs, and where there are instream rocks and branches. Stock camps are present close to the water. This supports the growth of filamentous algae in small pools where faecal material is trapped.

Habitat diversity

The diversity of habitat is limited, particularly in the verge vegetation. There is a considerable amount of instream vegetation close to Bootenal Springs and some saltmarsh sections. These sections provide good habitat for invertebrates, waterbirds and frog species. It is likely that the permanent pool within Bootenal Springs is another important area for fauna. There is a pool that appears to be groundwater fed, probably making it permanent, which has a poorly maintained fence. The

water quality is brackish but had some suspended fine clays in some parts. The water colour was slightly brown, indicating low levels of tannin. There was some evidence that the nutrient conditions are elevated due to the presence of a filamentous green algae. Some pools and river sections had considerable quantities of sheep droppings.

Ant colonies on the verges are contributing to the formation of erosion rills. Woodland and shrubland birds are uncommon in this section.

Comments

The habitat is limited to areas of dense vegetation, with many open expanses of foreshore with minimal vegetation cover. This is particularly important for animals which depend on shrubs. Removal of African boxthorn will reduce the availability of this habitat type. The poor quality of vegetation on the verge reduces the stability of the floodplain during high water events, and also makes it difficult for ground-dwelling animals to move around.

Other issues

There is a poorly maintained fence separating the foreshore reserve from freehold land. During recent flood events, the river has reclaimed some of the floodplain. There is evidence of sheep grazing and trampling along much of the length. There are significant local accumulations of faecal material in stock camps within Bootenal Springs. These are resulting in algal growth in small backwaters and pools that are isolated as the river drops.

The use of the riparian zone as a summer paddock for stock is common, as generally this corresponds with the only remaining tree cover.

The downstream limit of the levee bank extending to the Brand Highway Bridge is set 60 m away from the river's edge. The levee bank on the eastern side of the river was constructed in the 1950s to reduce flooding of agricultural land. The downstream end of the levee bank occurs just north of Bootenal Springs and finishes at Brand Highway. This levee bank has considerably affected the natural flow patterns of the floodwaters as it has effectively isolated part of the natural floodplain from the river system.



There is an existing management plan for the river section between this site and the river mouth.

Suggestions

Bank stability

- B Exclude stock from the riparian zone and reduce general stock numbers to allow the land and vegetation to recover.
- B Liaise with landholders to encourage them to install fencing at least 15 m back at the top of the verge where not present.
- B Liaise with Water and Rivers Commission and Agriculture WA to investigate options to stabilise erosion rills.
- B Initiate direct seeding and tree planting projects from top of the verge to the valley floor in manageable nodes.
- B Develop a farm plan that addresses the impact of stock on this unstable environment.

Vegetation

- V Continue revegetation program ensuring adequate site preparation (deep ripping and weed control).
- V Continue control of Saffron thistle and African boxthorn within private property.
- V Undertake local removal of African boxthorn, Fleabane and Century plant to enable planting and ensure this only occurs where there are sufficient resources to maintain follow-up.
- V Restore the overstorey plants in dense thickets to help exclude weeds. Focus plantings in areas where there are existing trees at risk of being undermined.
- V Encourage landholders to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.

Stream cover

- S Protect remnant vegetation in Bootenal Springs area from disturbance by livestock as the current reserve management practices are contributing to the loss of stream cover.
- S Monitor natural regeneration processes in areas subject to stock exclusion and weed control activities and, if regeneration of native species is limited, implement a selective replacement program.
- S Ensure that instream features such as branches are protected where they are not exacerbating erosion.

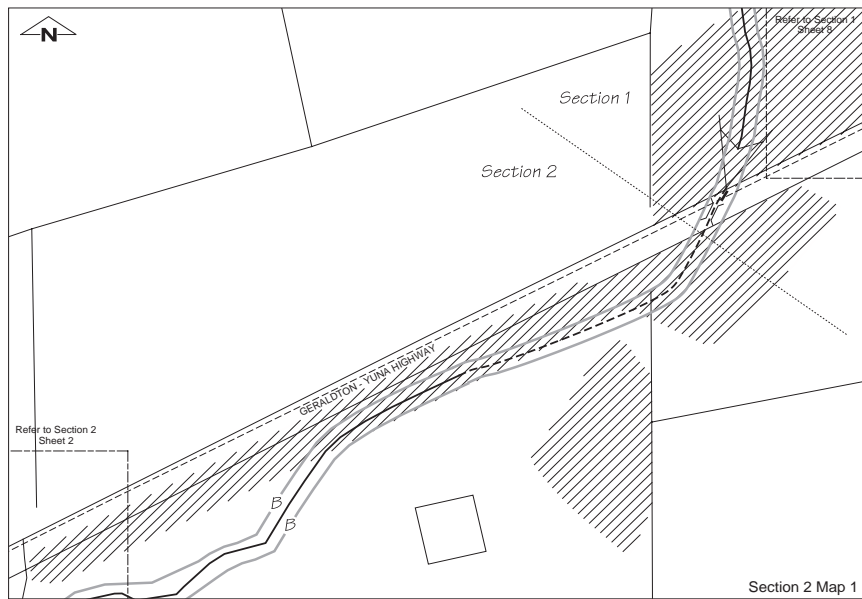
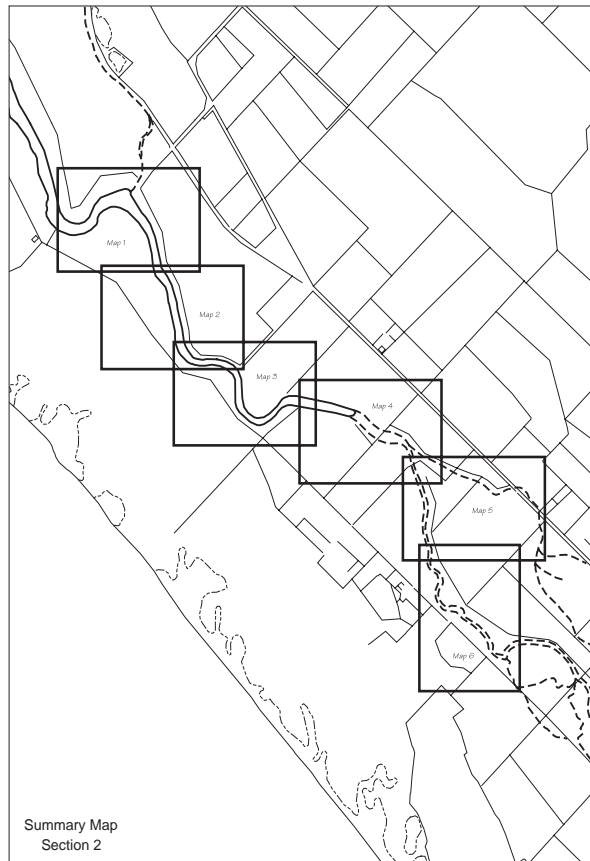
Habitat diversity

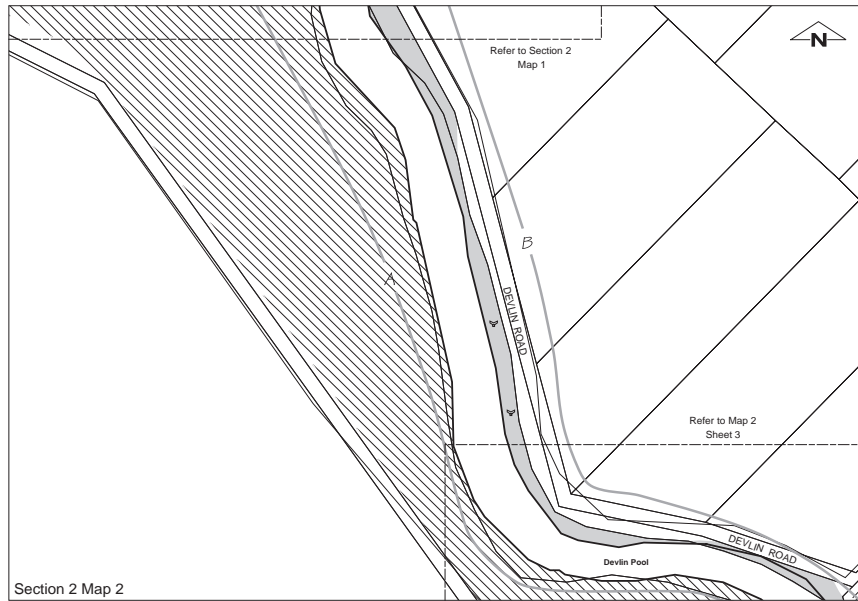
- H Plant tubestock of native plant species adjacent to African boxthorn, and once established remove the boxthorns in nodes. Continue to control the weed and replace them with shrub species such as fast growing wattles.
- H Ensure that weed control occurring on the banks and the floodway takes into consideration the impact of increasing water velocities during peak flows as a result of vegetation removal. Implement control in sections, not including powerbends.
- H Control stock access to the foreshore reserve to reduce trampling and grazing of rushes and sedges.

Other issues

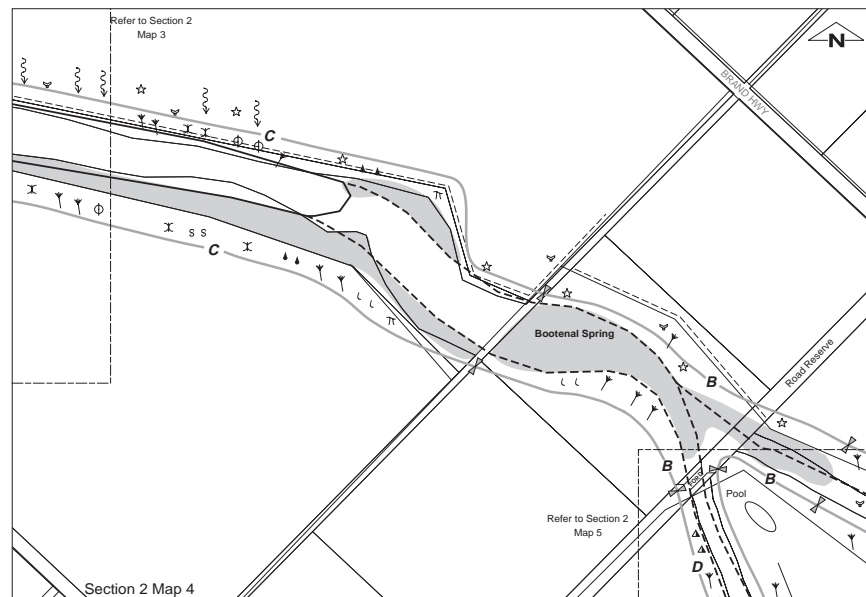
- O Encourage landholders to fence off the foreshore reserve and provide information packs about river management to all landholders.
- O Liaise with Agriculture WA if issues still arise about stock being allowed into neighbouring properties, if no action is taken to control the stock.
- O Ensure fences are maintained adequately to cope with stocking levels.
- O Clarify boundary between reserve and freehold land, and realign/repair fences as required if stocking.
- O Work to revegetate sections of the river floodplain, to help slow water movement.





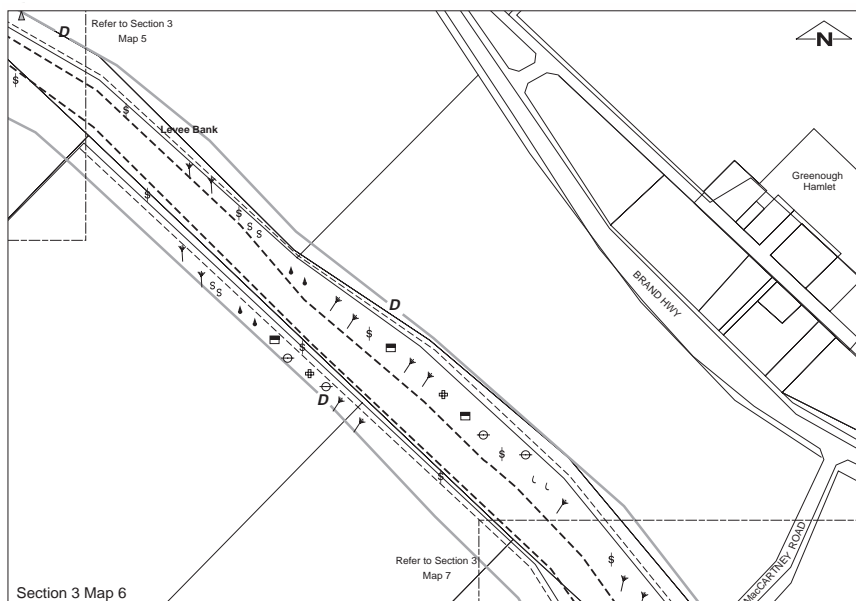
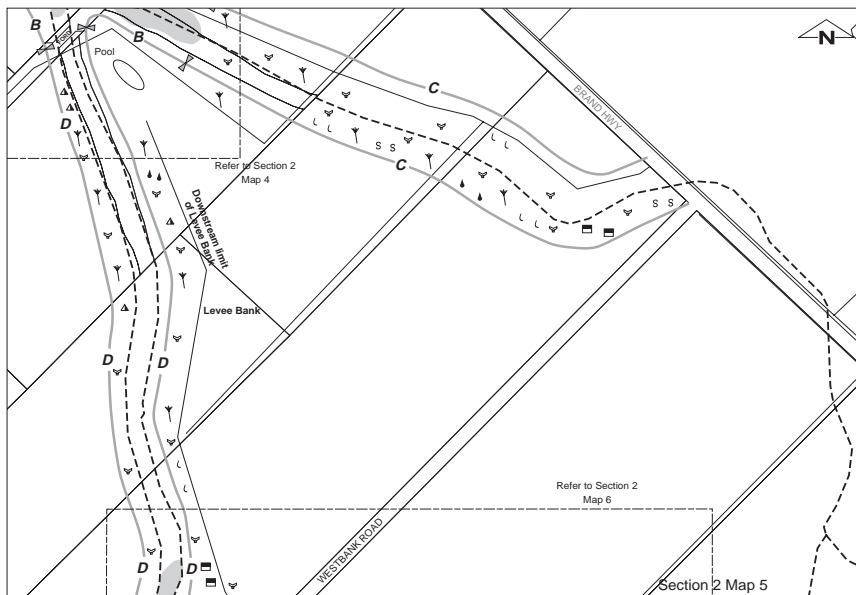


Section 2 Map 2



Section 2 Map 4





SECTION 3: GREENOUGH RIVER MAPS 1 – 11

Length of section (m): 11,670m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 11 April 2000

Nearest road access: Devlin Pool Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Poor C	Poor C	Very Poor D	Poor C

Bank stability

The river channel varies between braided and single channel sections. There are also seasonal creeklines. The bed gradient is generally slight, however there are several significant changes in the height of the riverbed along this section. The water has generally eroded back to the stable clay base on the powerbend side of the

river. The main channel has significant sediment accumulation (along more than 50% of the length). These are mostly coarse river sands with some plumes between 1 and 3 m above the riverbed. Fine compacted clays tend to be the dominant substrate along the tributaries. The banks range between slight to moderate slopes, with small areas of steep slopes. The bank full width ranges between approximately 10 and 120 m, but



averages 80 m.. The constrictions have arisen due to large sediment plumes that have been stabilised by vegetation.

There are numerous severe bank erosion points where creeks meet the main river channel, in areas adjoining and downstream of the sand extraction points and where large sand plumes and woody debris is deflecting the flow. Some of the erosion scours are more than 100 m long with up to 7 m vertical banks. Large sediment plumes occur at the top of the verge approximately 4 – 5 m above the riverbed, along up to 40% in some lots.

The levee bank ranges from 80 m from the river channel to less than 10 m. This continues to impact on the flow characteristics during flood events.

Comments

The Greenough River downstream of the Brand Highway Bridge is quite unstable as the result of significant sediment loads, lack of vegetation, changes to the riverbed characteristics as a result of harvesting of river sand and the recent floods. The considerable undercutting of trees on the river's edge will ultimately result in the persisting trees falling across the main channel. The fallen trees in most cases are not a major obstruction; however, there are some locations where considerable damage is being caused as a result of the loss of trees.

Vegetation

The right bank is almost devoid of vegetation along a significant proportion of the length, and is patchy along the left bank. For the most part there is only a single row of trees and occasional shrubs remaining. These are River gum (*Eucalyptus camaldulensis*) and sparse Coojong (*Acacia saligna*) and Summer-scented wattle (*Acacia rostellifera*). There are some limited patches of Shore rush (*Juncus kraussii*), Pale rush (*Juncus pallidus*), infrequent Swamp sheoak (*Casuarina obesa*) and Saltbush (*Atriplex* spp.). The most common shrubs/small trees are significant populations of African boxthorn (*Lycium ferocissimum*), Castor oil plant (*Ricinus communis*) and Pepper tree (*Schinus molle*). By far the most common and extensive weed population is African boxthorn (*Lycium ferocissimum*). The understorey is annual grasses, pasture plants like Lupins (*Lupinus cosentinii* and *L. angustifolius*) and pasture weeds including Saffron thistle (*Carthamus lanatus*),

Doublegee (*Emex australis*), Wild turnip (*Brassica barrelieri*), Pie melon (*Citrullus lanatus*), Wild radish (*Raphanus raphinistrum*), Clover (*Trifolium* spp.), Walkaway burr (*Cenchrus* sp.) and occasional Curled dock (*Rumex crispus*). The distribution and density of these weeds varies across each property. In some sections, Couch (*Cynodon dactylon*) has colonised instream sand drifts, which has modified the way the river flows. Other weeds within the floodplain are Roly-poly (*Salsola kali*), Black berry nightshade (*Solanum nigrum*) and Fleabane (*Conyza bonariensis*).

Comments

Some landholders are actively controlling weeds in the floodplain and commencing revegetation works. There is a focus on restoring trees and managing African boxthorn. There is a need to start putting shrubs back into the river system, as the habitat for many scrub birds, five types of butterfly and other invertebrates is absent apart from the African boxthorn.

As mentioned in the text, for the most part there is only a single row of mature trees. In a healthy and stable system, the roots of the trees and shrubs across the riverbank and the verge would interlock and provide increased weight in the soil to prevent the trees along the river edge from being undercut. Single rows of trees are highly unstable, as there are no interlocking roots up the bank to help to carry each plant's weight. Further, where there are no groundcovers or rushes/sedges the topsoil has little protection from erosion. Couch performs an important function in stabilising the banks in the absence of native vegetation.

There is also almost no natural regeneration, with seedlings of the River gums and wattles extremely uncommon.

Stream cover

The extent of stream cover is very poor along most of this section. As the vegetation is limited along most of the section to a single row of trees, there is little shade in the river. There is some large woody debris instream.

Comments

The lack of stream cover increases the importance of working to increase the extent and density of native vegetation within the river channel, on the banks and within the floodplain. Where there is instream debris



within the low flow channels it is important for fish and animals without backbones (invertebrates). Although the water may not be permanent, this shelter is still important for the period the river runs. Therefore, retaining stream cover needs to be a priority.

Habitat diversity

There is little diversity in habitat due to the lack of intact vegetation, absence of extensive areas of permanent water and limited groundcovers providing little shelter and protection from foxes and other feral animals.

There is one permanent pool in this reach of the river that is likely to be the result of dredging in the past. While the seasonal nature of the river restricts permanent habitat, many species are adapted to such conditions and are prolific while water is available. Deep pools were present in small sections at the time of survey but are unlikely to persist all year round. Five species of butterflies were noted during the survey. Anecdotal evidence indicates that frogs are relatively uncommon.

The water quality at the time of survey appeared to be moderate, brackish with considerable mobile sediment. The water was slightly stained with tannin.

The introduced White snail (*Theba pisana*) is prevalent along this section of the Greenough River. The presence of large numbers of this animal has implications for revegetation works.

Comments

As mentioned above, the lack of sufficient shrubs close to the river and in the floodplain adjoining the river will impact on broadscale control of African boxthorn. Removal of African boxthorn may result in the loss of the only dense habitat for many bird species including finches, Willy wagtails, fantails and other species. It is important that dense clumps of native plants be established amongst existing African boxthorn prior to broadscale removal so there is no loss of habitat.

Other issues

Sand is being mined from the riverbed and stored on the river margins. Stock troughs and windmills are present close to some tributaries. The location of

troughs close to the river encourages stock to congregate in the area. This tends to result in local concentrations of faecal material, poor bank stability and loss of vegetation cover resulting in unstable, denuded ground.

Stock access has implications for any proposed revegetation works. The lack of fences and some fences requiring maintenance in many properties will limit the ability of the landholder to plant additional trees and shrubs. Excluding stock in some places for a couple of years would allow plants that have germinated naturally to grow to a sufficient size to cope with some grazing. Light stocking can be used to continue to manage weeds and fire risk.

There are several crossings, both historical rock based crossings and current causeways. Many of the old crossings are impassable in their current form, however they continue to affect the way the river flows, causing a deep pool to form upstream and increasing the spilling height. This drop increases the power of the water as it drops.

Some stock crossings have not been aligned with the river flow, which is resulting in localised erosion and blowouts at these points.

Comments

The current sand mining activities contribute to management of the sediment load moving down the river. There are possibilities in using the extraction process to remove plumes that are exacerbating erosion and the subsequent loss of vegetation. Selective removal may be better for the river environment. It may be useful for officers of the Shire of Greenough and the Water and Rivers Commission, and the proponents to discuss the locations and methodology of extraction.

Suggestions

Bank stability

- B Undertake local large woody debris manipulation where fallen trees are directing the river flow into the banks, e.g. Lots 81 and 82.
- B Encourage landholders to establish verge and riparian vegetation and minimise stock access to the foreshore reserve.



- B Determine opportunities to utilise instream woody debris to direct the flow into instream sediment plumes to facilitate the continual movement of sediment downstream. This may reduce the pressure on the riverbanks.

Vegetation

- V Focus control of African boxthorn where interspersed with native trees and shrubs, and work to exclude from these sections initially.
- V Encourage landholders to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Plant fast growing shrubs like Coojong in dense stands (1.5 m apart) within the banks during early winter, ensuring that there is some protection for seedlings upstream (i.e. dense weed stands or fallen logs for example).
- V Deep ripping parallel with riverbank may improve tree and shrub survival.
- V Continue weed control efforts for pasture weeds within the river zone, ensuring thought is given to not causing a new erosion problem.
- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Liaise with TAFE, Water and Rivers Commission and other agencies and request support to undertake weed control, vegetation studies and other activities that will contribute to maintaining the health of this section. This section helps to demonstrate relatively healthy, stable foreshore environments, and the impact of significant contributions of water and sand from tributaries.

Stream cover

- S Retain instream debris where it is not causing a significant erosion problem.
- S Implement revegetation where vegetation is currently absent.

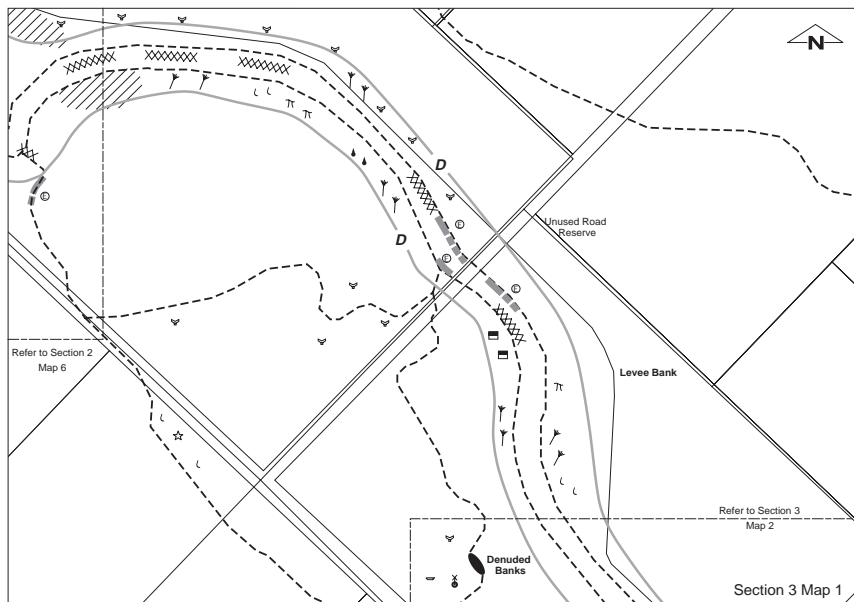
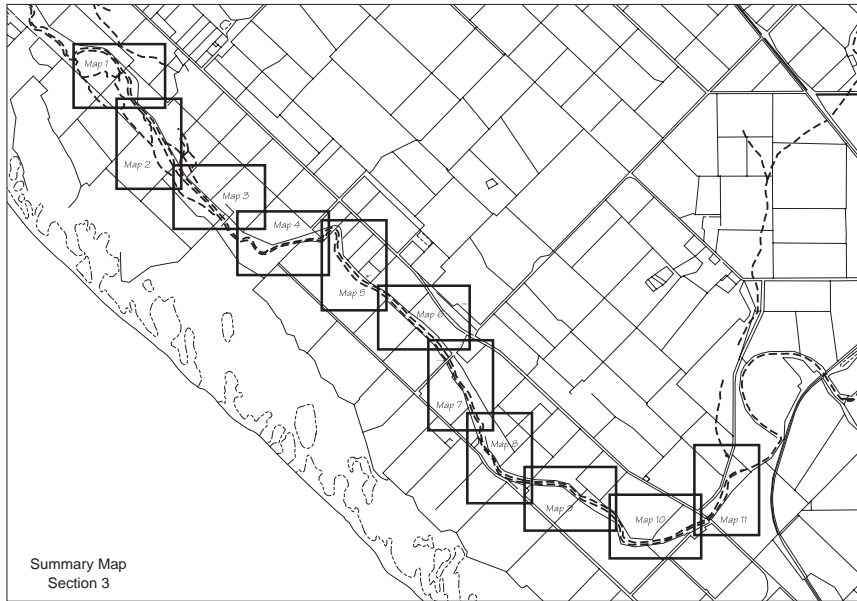
Habitat diversity

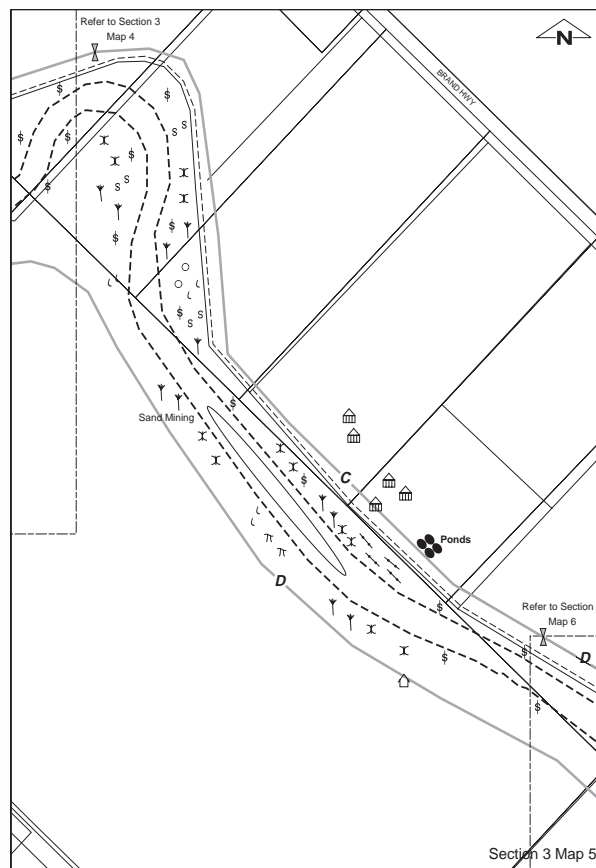
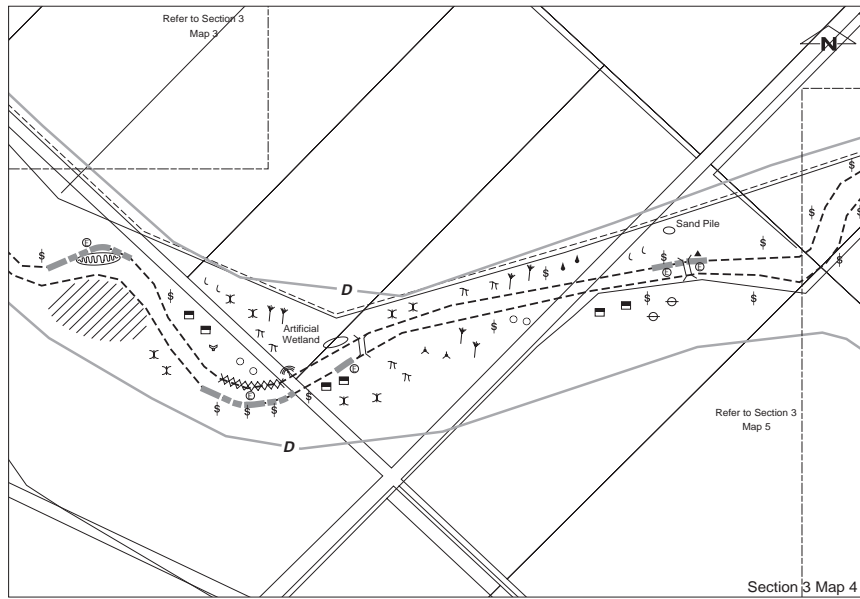
- H Ensure plants, tree guards and stakes are coated with a non-toxic snail repellent called Socusil to minimise snail damage to any plantings.
- H Establish dense stands (nodes) of fast growing trees and shrubs that enable access to the river, but provide habitat and improve bank stability.
- H Encourage landholders to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.

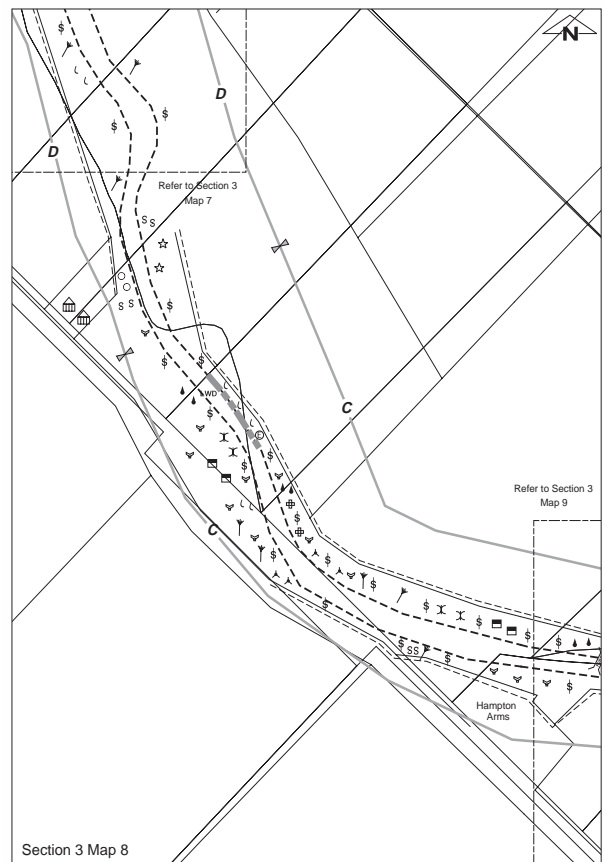
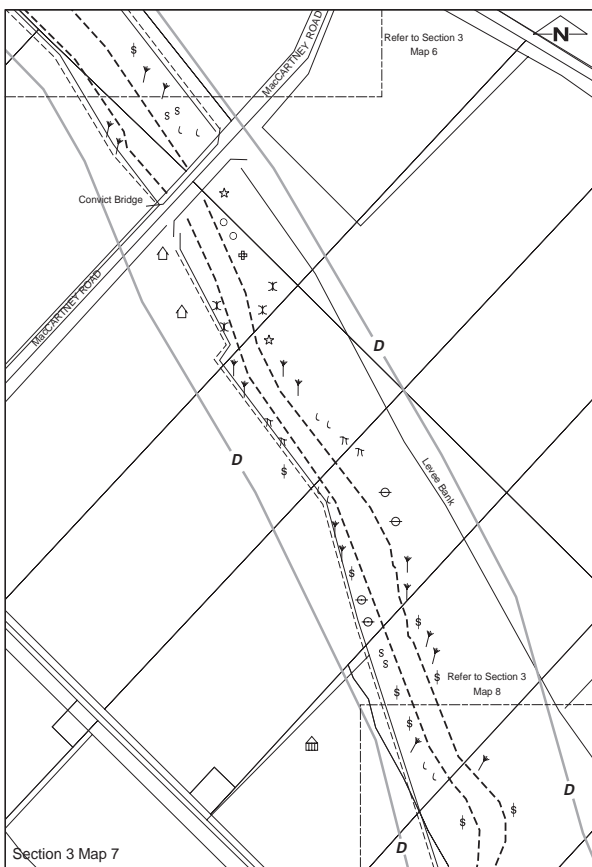
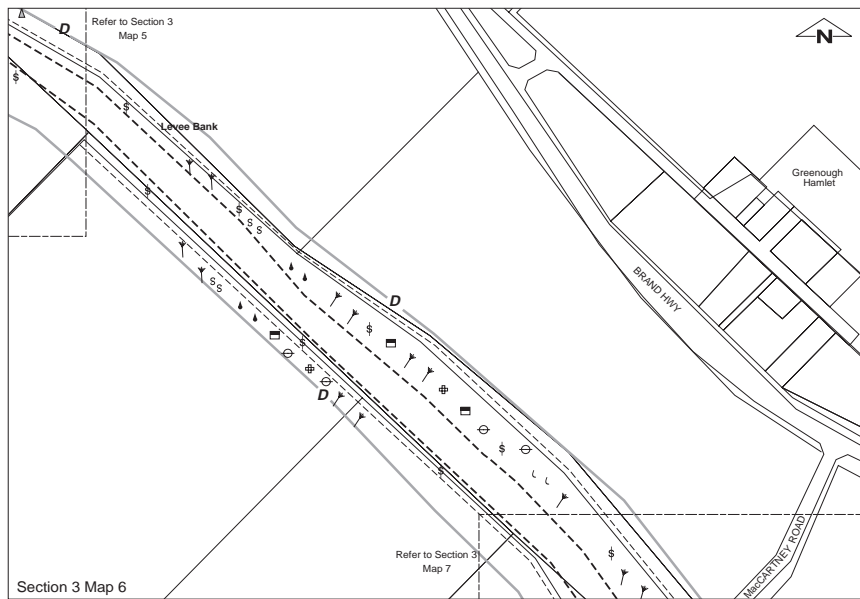
Other issues

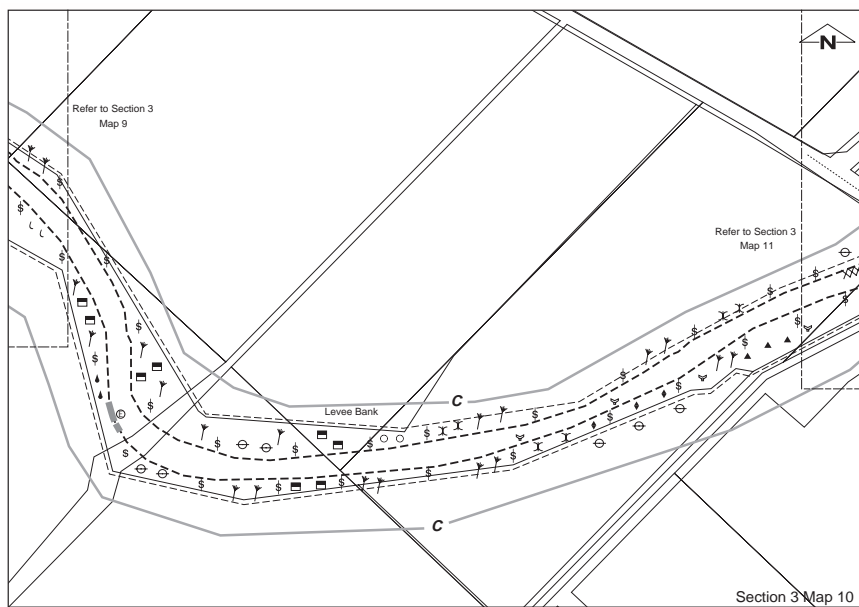
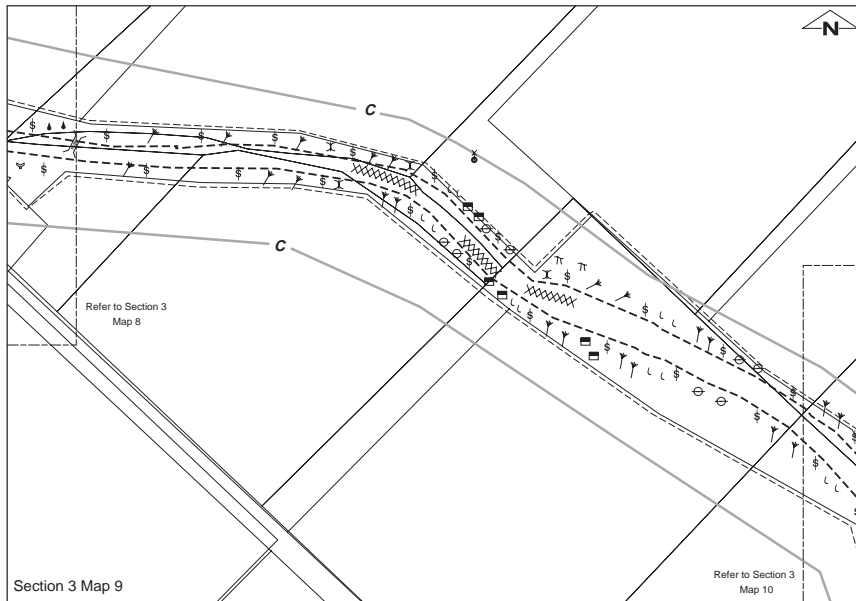
- O Where crossings are not used, consider realigning the instream debris to enable the riverbed to stabilise and encourage the movement of coarse river sand.
- O Encourage training for officers of local and State government in designing river crossings. This might include assessing the feasibility and possible benefits associated with maximising culvert widths to meet river flow characteristics, designing the causeway for peak flow events while maintaining a low flow channel, and ensuring the crossing is set at a level that minimises the length of inundation of a crossing.
- O Encourage WRC officers to liaise with the Shire of Greenough regarding sand extraction, and the licence holders to investigate changes to the extraction process.
- O Clarify the location of foreshore reserve boundaries where present, and establish some means of delineating its locations.

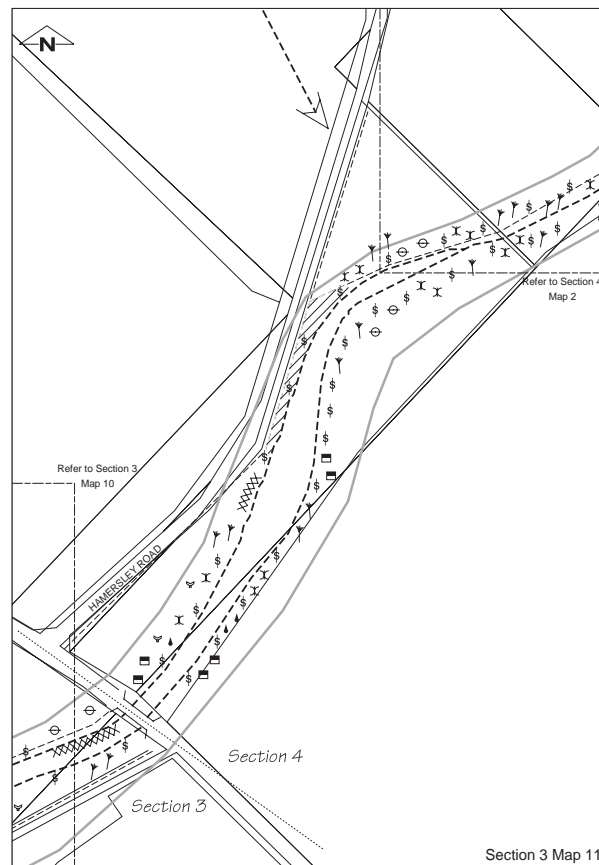












SECTION 4: GREENOUGH RIVER MAPS 1 – 3

Length of section (m): 3,760m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 12 April 2000

Nearest road access: Hamersley Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Poor C	Moderate B	Moderate B	Poor C

Bank stability

The main river channel averages about 20 m wide, with the floodway up to 80 m wide. The low flow water depth during the time of the survey ranged between 0.2 m and 0.4 m deep with occasional sections up to 0.6 m deep. The left channel bank is steep while the right bank is characterised by a slight to moderate slope, until about Lot 726 where it becomes steep. There is a significant sediment plume off the main channel on the left floodplain that is building up the riverbank height. There are few significant erosion problems currently; however, the lack of vegetation and continuing stock pressure is likely to destabilise the banks sufficiently to cause erosion of the valley embankment. There is a

localised erosion problem occurring near a former bitumen crossing. There is a significant volume of large and fine woody debris impacting on the flow dynamics. The Brand Highway Bridge is sufficient to cope with most large flows (excluding flood events) and does not cause a bottleneck in the flow.

Comments

The sediments in the riverbed are very mobile and will continue to be flushed downstream following significant rainfall events in the catchment. The accumulation of woody debris will continue to catch more debris during peak flows. It may be useful to realign some of the large woody debris in this section to encourage the flows to keep within the main channel.



Vegetation

This section is characterised by a single row of River gum (*Eucalyptus camaldulensis*) with an occasional Pepper tree (*Schinus molle*) over an understorey of annual grasses, Lupins (*Lupinus cosentinii* and *L. angustifolius*), Fountain grass (*Pennisetum setaceum*), Clover (*Trifolium* spp.) and Walkaway burr (*Cenchrus* sp.). In other sections, African boxthorn (*Lycium ferocissimum*) is present in small numbers. The native wattle Coojong (*Acacia saligna*) occurs intermittently. There is little evidence of natural regeneration. There is no vegetation in the main channel.

Comments

Single rows of trees are inherently unstable as, once localised erosion exposes the roots, the trees become increasingly likely to fall into the river. The lack of shrubs on the margins of the river reduces the habitat potential of the river. The lack of cover is a significant deterrent to native animals. African boxthorn and the occasional Coojong are insufficient to support diverse birdlife, and currently only occasional woodland birds are heard. There is a need to control the African boxthorn, Fountain grass, Lupins and Walkaway burr while the populations are still manageable. Lupins and particularly the Fountain grass are a significant threat as they increase the fire risk greatly.

Stream cover

There is some stream cover provided by the single row of mature River gums and the large woody debris within the main channel would also provide cover for aquatic animals while the river is running. The extent and quality of stream cover is limited.

Comments

Stream cover is minimal and therefore where debris is present in the stream and not causing an erosion problem, it should be left where it is.

Habitat diversity

The instream habitat is limited due to an absence of permanent water, lack of stream cover and significant levels of mobile sand. The vegetation fringing the river is restricted to a single row of trees for most of the section, with some patches of shrubs and few groundcovers. The leaf litter, however, is very deep

on some properties and provides excellent cover for a range of spiders, insects and related animals (invertebrates).

The water was very clear but deeply stained with tannin.

Comments

Addressing the lack of dense native vegetation is the main priority for this river section. Many landholders are uncomfortable with having dense native vegetation due to a perceived increased fire threat. It is important to balance these concerns, with trying to restore habitat to encourage birds such as Firetail finches to move closer to development. Increased vegetation densities would encourage more native animals.

Other issues

The fences are in variable condition along this section, however the fences requiring maintenance usually correspond with properties where there are no stock. Where stock is present, the fences are generally in good condition and aligned parallel with the river. The fences are set back between 10 m and 25 m from the river channel. This is generally beyond the extent of the floodway. There are some discarded farm materials close to the river.

Fence maintenance needs to be linked with stock management practices of the landholder. Where revegetation is proposed, it would be most successful if the stock can be excluded for at least one year. Small temporary fences around small sections of the river embankments to establish nodes of vegetation may be effective.

Suggestions

Bank stability

- B Undertake local large woody debris manipulation where fallen trees are directing the river flow into the banks.
- B Encourage landholders to establish verge and riparian vegetation and minimise stock access to the foreshore reserve.
- B Determine opportunities to utilise instream woody debris to direct the flow into instream sediment plumes to facilitate the continual movement of



sediment downstream. This may reduce the pressure on the riverbanks.

Vegetation

- V Focus weed control on Fountain grass, Walkaway burr and Lupins in the foreshore.
- V Plant dense clumps of shrubs such as wattles and *Hakeas* 1.5 m away from fencelines, in areas where there is no African boxthorn.
- V Remove African boxthorn once shrubs have grown sufficiently to provide habitat for native birds.
- V Support natural regeneration of the River gum by excluding stock from foreshore areas between May and March the following year – and controlling weeds for a 1 m diameter circle around any seedlings of native plants that appear.

Stream cover

- S Implement weed control, replanting and stock exclusion to assess the rate of native plant establishment on the riverbank.

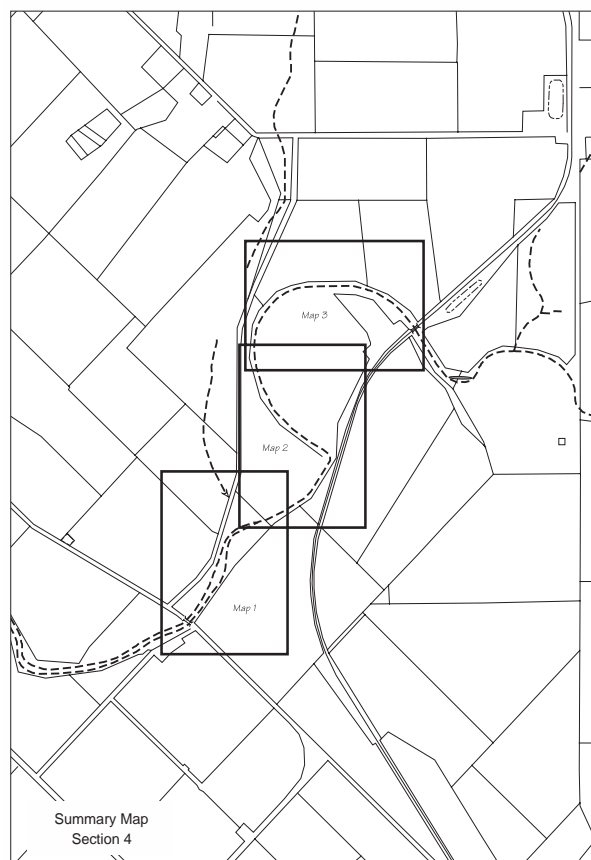
- S Monitor woody debris present following each flow event to determine whether or not it is causing an erosion problem and leave in place or realign as required. If unsure, contact the Water and Rivers Commission for advice.

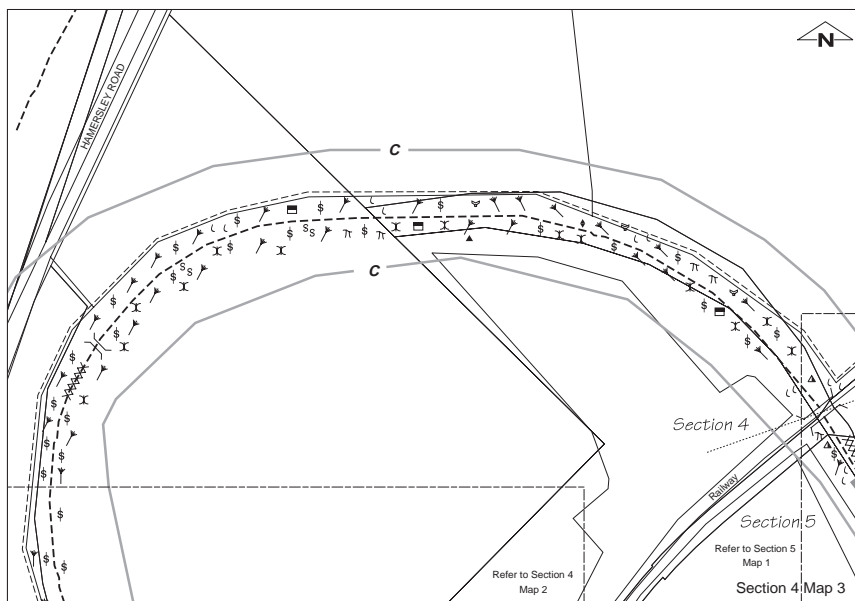
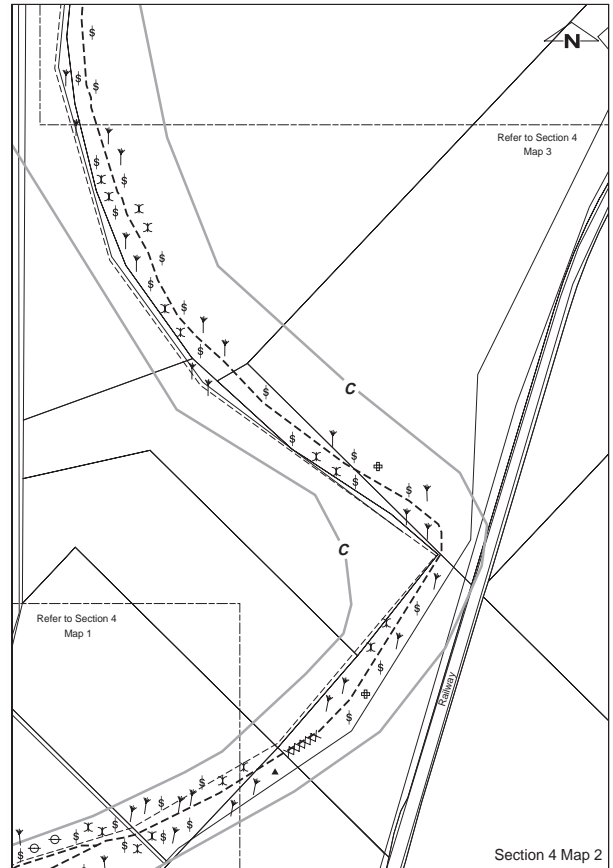
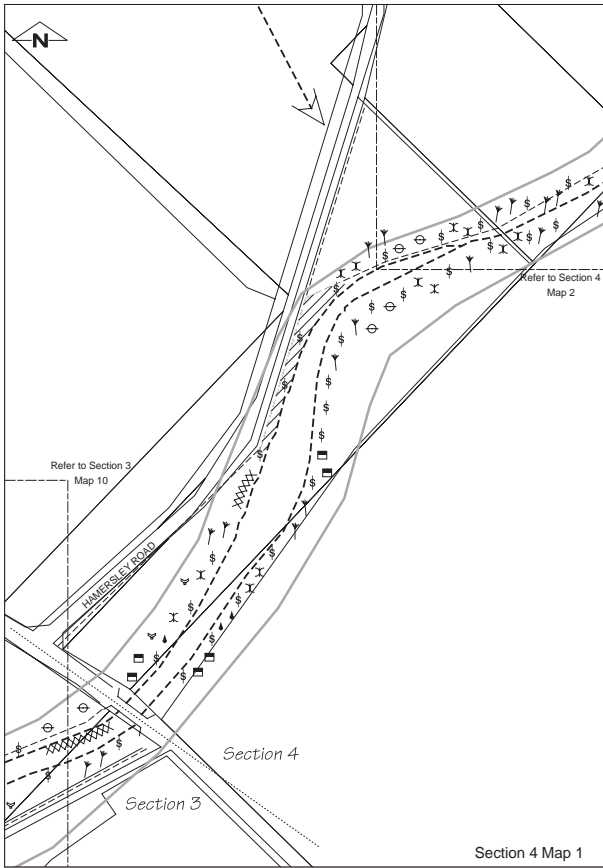
Habitat diversity

- H Implement recommendations relating to weed control, replanting and supporting natural plant colonisation processes.
- H Liaise with landholders to discuss the impact of fire on bank stability, increased debris loads, plant stress, loss of groundcovers and often an increase in the level of weed invasion.

Other issues

- O Liaise with the landholder to determine whether or not there is an opportunity for a CleanUp Australia Day working bee to remove the discarded farm materials.
- O Fence off sections of the foreshore that can be used to re-establish native vegetation.





SECTION 5: GREENOUGH RIVER MAPS 1 – 4**Length of section (m):** 4,710m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 12 April 2000**Nearest road access:** Evans Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Very Poor D	Poor C	Very Poor D	Very Poor D

Bank stability

The river channel is relatively stable with a steep left bank about 6 m high, and slight to moderate slope on the right bank to 2 m above the riverbed. The low flow channel width ranges from 8 to 10 m in the lower sections to only 5 m upstream. There are pools within the main channel up to 1.5 m deep. There are some minor and six significant sediment plumes in the river. There are four significant blowouts in the floodplain that occurred in the 1999 floods – one 40 m wide and 200 m long and another across a 400 m long section and up to 30 m wide. The blowouts are occurring where the riparian vegetation is minimal, and cropping occurs within the floodplain. The bulk of the sediment has been washed back into the river and can be linked with the sediment plumes downstream. There are still significant mounds of coarse river sand on the floodplain. These are still mobile and have not yet been colonised by vegetation.

There are also four severe erosion points with associated slumping that are likely to eventually become secondary channels and cause major loss of remaining mature trees. Most trees on the left bank have their roots undermined. The right bank is being cropped to within 3 m of the main channel, and has only a patchy single row of trees. There are four river crossing points. There are also localised erosion rills adjacent to the Railway Bridge.

There is a fallen tree across the river downstream of the Evans Road Bridge that will disrupt future flows.

Comments

The erosion zones are causing significant disruption to the landholders' ability to farm the land. As outlined in the description, insufficient vegetation cover assisted the river to extend beyond its banks during the 1999 flood events. By increasing the density of vegetation on the banks, the peak flows would be directed to the main channel that is devoid of vegetation. This would

enable the river to continue to scour its bed and move the coarse river sand downstream. This river function is currently limited, as there is insufficient vegetation to direct the flow.

For the two major blowouts, revegetation may not be sufficient to encourage the river flows back into the main channel. It may be beneficial to use large woody debris or localised rock baffles within the floodway to direct the flow. This would need to occur in conjunction with replanting and vegetation protection through fencing.

Some landholders are also cropping within 3 m of the low flow channel, which is a risky strategy. Cropping within the dominant channel places the crop at risk of being washed away prior to harvest. It may also result in considerable loss of fertile soil. These areas tend to suffer from severe erosion and often eventually become alternative river channels. This results in a greater loss of arable land than would otherwise have been experienced.

Vegetation

There is no vegetation in the river. The banks generally support only a single row of River gum (*Eucalyptus camaldulensis*) on the left bank with fewer trees on the right bank. There are occasional Coojong (*Acacia saligna*), Jam wattle (*Acacia acuminata*), Spoon-leaved wattle (*Acacia spathulifolia*) and *Acacia blakelyi*.

Most of these occur within one property. The understorey is composed entirely of weeds. The dominant weeds are annual grasses, Pie melon (*Citrullus lanatus*), Black berry nightshade (*Solanum nigrum*), Wild radish (*Raphanus raphanistrum*), Wild turnip (*Brassica barrelieri*), Walkaway burr (*Cenchrus*), Clovers (*Trifolium* spp.), Lupins (*Lupinus cosentinii* and *L. angustifolius*) and other pasture species. There are frequent African boxthorn (*Lycium ferocissimum*) and Pepper tree (*Schinus molle*) on the left bank, in the



steep sections. Castor oil plants (*Ricinus communis*) are also present.

There is one significant area of remnant vegetation up the verge. Wattles, *Hakeas*, *Melaleucas* and related plants dominate this remnant.

Burning the foreshore is many landholders' preferred management technique to reduce woody debris and leaf litter. Fire can cause mature trees to drop branches, impact on plant health, remove leaf litter and any groundcovers and increase the susceptibility of the riverbank to erosion. Further, fire tends to encourage weed regeneration in preference to the regeneration of native species. Short-lived wattles such as Coojong may respond to fire, however frequent fires encourage this type of plant to grow. This can also increase fire risk.

Comments

Protecting the remaining River gums, and encouraging natural regeneration by excluding stock are two priorities for this river section. There are only mature trees along this river reach and no regeneration. The current level of vegetation present is not sustainable. The long-term stability of the riverbanks is under threat as a result of vegetation loss.

The lack of native shrubs and vegetation on the banks reduces habitat value for a number of birds, butterflies and other native animals. By increasing the extent of shrubs landholders are likely to attract shrubland birds that eat insects. This may benefit the landholder by having natural predators of locusts, grasshoppers, moths and other insects that can impact on crops and the success of herbicide use.

Stream cover

There is minimal stream cover along this stretch of river. The overhanging branches shade the water, keeping the water temperature down and slowing the rate of evaporation. There is one area of large woody debris that provides some instream cover.

Comments

Stream cover is important for a number of reasons (refer Chapter 2 of this document). Without stream cover, the pools dry out more quickly, water temperatures rise and available nutrients either support algal growth or

support bacterial action in the pools. Often the algae and bacteria are toxic to native insects and other animals.

Habitat diversity

The water was clear and stained brown by tannin. The left bank provides a more diverse habitat than the right bank due to greater patchy shrub cover, beneath the single row of River gum. The extent of vegetation is not sufficient to encourage significant use of the river environment, due to a lack of shelter, cover and food sources. Woodland birds like Willy wagtails, fantails and Silvereyes are present in limited numbers. Invertebrates like dragonflies and damselflies are uncommon in this section of river.

Comments

Increasing the extent of trees and shrubs and encouraging groundcovers is an important part of helping to restore the river's balance. Currently disturbance factors are more active than river processes to restore stability such as natural regeneration of the existing trees and shrubs. The balance needs to be returned to allow the vegetation to grow and stabilise the banks.

Other issues

There is a decommissioned rubbish tip site containing various townsite and farm waste. The fences are in variable condition and some river sections remain unfenced. Some fences are in need of repairs to enable effective stock control. Some of the fences crossing the floodplain have considerable amounts of suspended fine leaf, woody debris and stubble trapped in them following the last peak flow and flood event. Some fence alignments are set very close to the river, while others are set at least 3 m back from the top of the river valley which ensures minimal maintenance requirements, as it is well above peak flow or flood levels.

The river height during peak flows indicates that the water was travelling up to 5 m above the riverbed, with debris suspended in trees at this height. The floodway is much narrower in this section.

There is considerable cropping very close to the remnant trees and the river channel through this section.



Preparation for cropping and installing crops in these sections is risky. In the event of unseasonal rains, or high winter flows, there is a considerable risk of significant erosion problems. The importance of minimising cropping within the floodway on both banks cannot be overstressed due to the potential threat of erosion and further blowouts occurring.

Comments

The proximity of the tip to the river may eventually result in discarded materials being washed into the river during flood events. Fence maintenance is an ongoing job for landholders. Ensuring removal of woody and leafy material that is suspended in fences between river runs will reduce damage to fences in future events.

Suggestions

Bank stability

- B Invite Water and Rivers Commission officers to assess the blowouts and undermining of the trees and develop strategies to prevent further erosion in the event of future flood events.
- B Install fencing above the floodway and commence revegetation works in sections that have suffered severe blowouts.
- B Upgrade river crossings with the advice of officers of the Water and Rivers Commission to minimise erosion and disruption to flow.
- B Undertake selective manual removal of woody debris suspended parallel with the ground where it is causing scouring at the base of trees.
- B Realign the large tree that has fallen across the river immediately downstream of Evans Road Bridge.
- B Provide landholders with information about river and river processes from the Water Notes and Water Facts series from the Water and Rivers Commission.

Vegetation

- V Consider cropping to the outside boundary of the floodway to enable natural regeneration of River gums, wattles and other shrubs and rushes and sedges on the riverbanks.

- V If stocking the paddocks, upgrade or install fencing to exclude stock until the plants are at least 2 m tall.
- V Actively plant River gums and the fast growing Coojong to provide some immediate cover in sections where stock can be excluded.
- V Provide an information brochure on the impact of fire on foreshore environments and offering alternative management practices such as selective removal of debris and realignment of instream debris.

Stream cover

- S Retain large woody debris instream where it is not impacting on the flow dynamics of the river, i.e. deflecting the flow into the riverbanks.

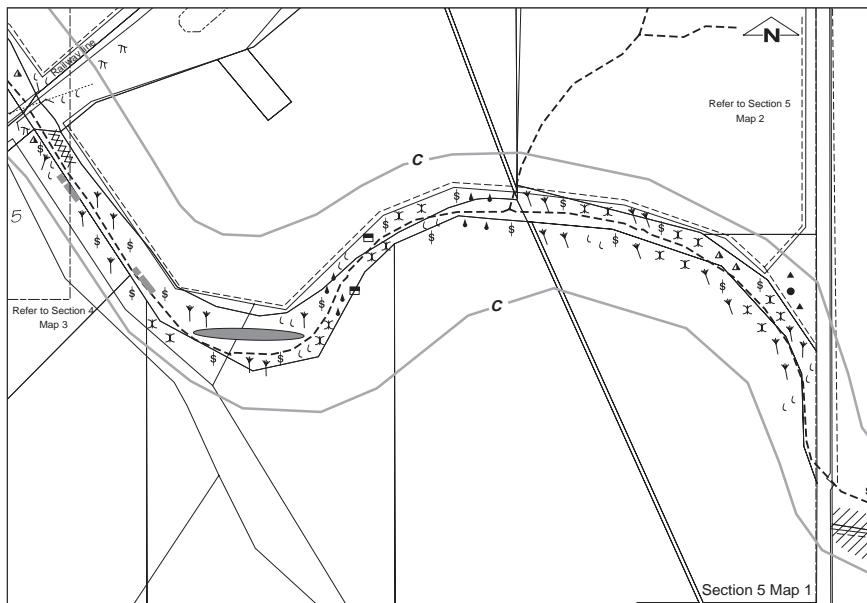
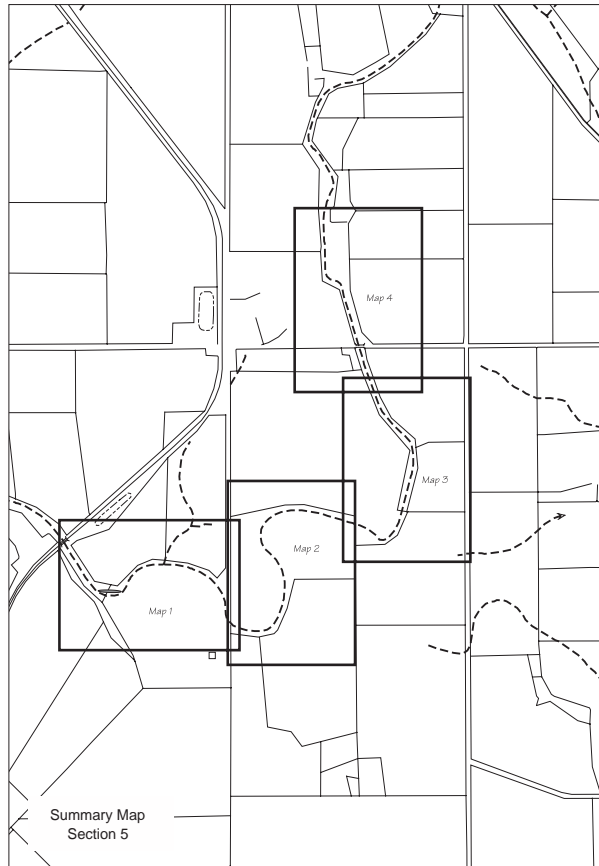
Habitat diversity

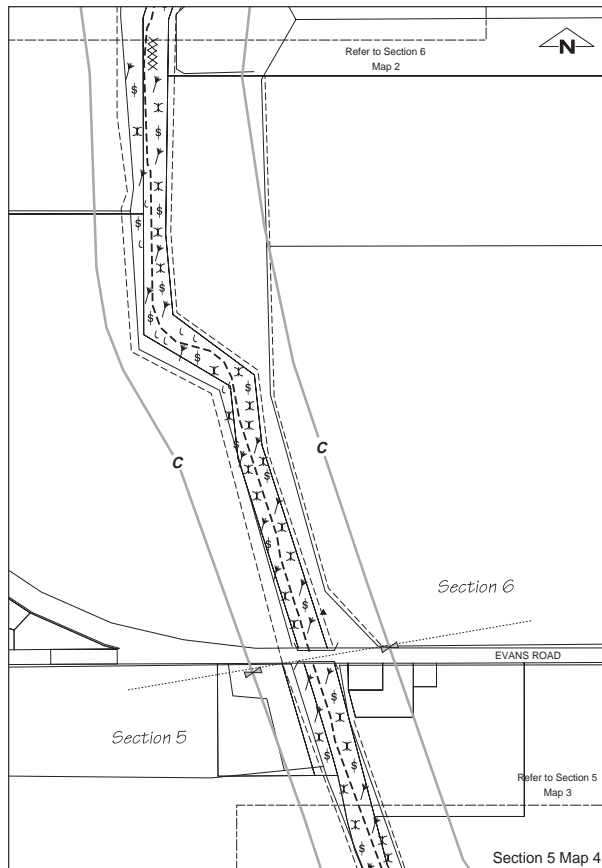
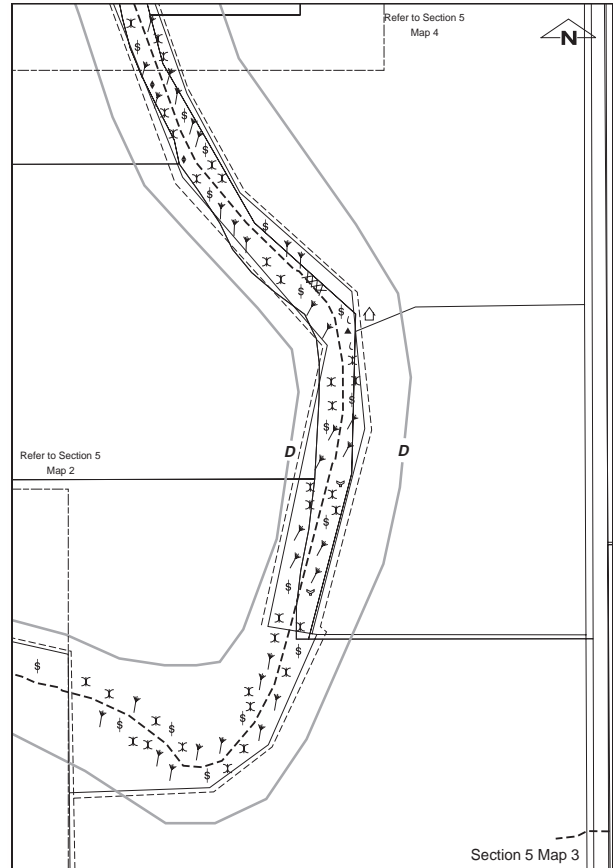
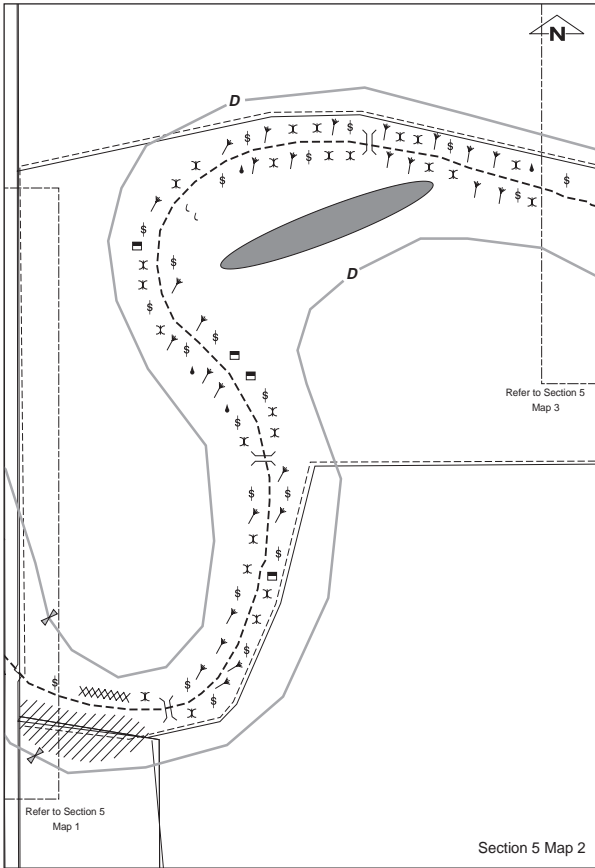
- H Modify current management to increase the distance between cropping sections and the river channel.
- H Install fences beyond the floodway and/or repair existing fences.

Other issues

- O Continue fence maintenance programs, focussing on sections where increasing the extent of vegetation will help to reduce future erosion.
- O Ensure debris trapped in fences is removed between river flow events to reduce the frequency of fences being washed out.
- O Consider realigning fences above the river valley in sections where fences within the floodplain are washed away regularly.
- O Determine the feasibility of holding a CleanUp Australia Day working bee in the former tip site, or encourage collectors to visit this site. Prior to such an activity the Shire of Greenough would need to erect signage stating that people are entering this site at their own risk, and the Council will accept no responsibility for any injury.
- O Identify and mark the foreshore reserve, and discourage landholders from continuing to crop within the reserve.







SECTION 6: GREENOUGH RIVER MAPS 1 – 6**Length of section (m):** 7500 m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 12-13 April & 2 May 2000**Nearest road access:** Evans Road to near Nabeja Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Poor C	Poor C	Very Poor D	Poor C

Bank stability

The river channel ranges between 12 m to 20 m wide within a floodplain that ranges from 100 m through a constricted section at Short Road where the floodplain is about 50 m wide. This constriction resulted in water banking back a considerable distance in 1999 and water flowing across small depressions in paddocks in three properties. This caused localised blowouts and erosion in three properties.

The average low flow depth at the time of the survey ranged between 0.15 m and 0.6 m, before drying out in late May. Tree roots are exposed along a significant proportion of this section. There is considerable debris instream, which is deflecting water into the riverbanks and creating new localised erosion problems. Stock movement and camps are contributing to erosion of the banks by creating weakness in the soil structure. There are some significant sediment plumes, generally trapped behind instream woody debris or in straight river sections.

Comments

There are several sections where woody debris instream requires realignment or removal completely. The sections where river flow would benefit from removal of woody debris need to be identified. Many other sections are causing significant erosion.

The flow is restricted at the Short Road crossing during flood events, causing water to bank up. This impact would be reduced if the vegetation upstream was denser and restricted the flow evenly across the river section.

Vegetation

The vegetation is still absent within the stream channel. The vegetation on the channel banks is characterised by either single or double rows of River gum (*Eucalyptus camaldulensis*) with occasional Swamp

sheoak (*Casuarina obesa*) and Tuart (*Eucalyptus gomphocephala*) occurring near old settlements. Tamarisk, Castor oil plant (*Ricinus communis*), Pepper tree (*Schinus molle*) and Moreton Bay fig (*Ficus macrophylla*) occur within the foreshore reserve or near the homestead. There is minimal verge vegetation in this river section.

There are no native groundcovers, rushes, sedges or native grasses. The dominant flowering weeds are Pie melon (*Citrullus lanatus*), Walkaway burr (*Cenchrus ciliaris*), Wild radish (*Raphanus raphanistrum*), Petty spurge (*Euphorbia peplus*), Fleabane (*Conyza bonariensis*), Caltrop (*Tribulus terrestris*), Nightshade (*Solanum nigrum*) and Clover (*Trifolium* spp.). Other weed species present are Doublegee (*Emex australis*), Paterson's curse (*Echium plantagineum*). Grasses including Annual Wimmera ryegrass and Drake (*Lolium rigidum* and *L. temulentum*) and Red Natal grass (*Melinis repens*) and Couch (*Cynodon dactylon*) occur periodically.

Some landholders prune the foreshore vegetation to enable cropping closer to the river's edge. While this gains extra land area for cropping, it increases the risk of erosion in the event of peak flows or future flood events. Further, it impacts on the habitat values of the river, is an unauthorised activity within the foreshore reserve area and changes the way in which the river flows.

Some landholders are working to restore the foreshore area within their properties. Some individuals have made a considerable effort to increase the extent of native plants within the riparian zone.

Comments

The existing vegetation is not sufficiently wide to be sustainable in the long term. Many trees have their roots exposed by erosion of the riverbanks, and do not have support usually provided in undisturbed river environments by plants upslope. These are likely to



be undermined by natural river flows due to the level of disturbance along the river zone. This disturbance can for the most part be attributed to grazing and trampling by livestock. The minimal number of seedlings of native plants, and the prevalence of weed species and areas supporting only annual plants are all indicators of prolonged disturbance to the river environment. The current fence arrangement is further evidence of uncontrolled stock access.

There are very few native shrubs on the river verge along the entire length. This minimises the habitat value provided within the river foreshore environment. Very few birdcalls were heard during the survey.

Stream cover

There are several forms of stream cover present within this river section. Instream woody debris, overhanging branches and rocky sections all provide some cover. As mentioned, there are considerable volumes of mobile sediment in the river.

Comments

The lack of vegetation within the waterway and limited cover along the channel bank is resulting in low levels of use by native animals. The lack of cover along the riverbanks tends to exclude native animals from moving along the river. The instream woody debris is currently providing the only cover for aquatic animals.

Habitat diversity

The diversity of habitat is limited due to the lack of vegetation structure in the river, on the banks and extending up the verge. There is little leaf litter and vegetation. Woodland birds are present in low numbers in the River gums. Western minnows and the introduced Mosquito fish were seen instream.

Comments

An increase in habitat diversity for native plants and animals is unlikely to occur naturally. The river system has limited resilience within this river section due to stock access along most of the river length. The absence of native shrubs and understorey plants in this section will not be easily rectified. It will take a concerted effort to restore these components of the river ecosystem. The large plumes of mobile sediment also limit the river's ability to maintain permanent pools.

Other issues

There are fenced and unfenced sections within this river reach. The fences are in variable condition and in many cases do not provide the landholder with the option of excluding stock from the river and its foreshore. Fire appears to be used as a management tool. There is little recognition of the presence of foreshore reserves. Some landholders would appreciate support for their revegetation work.

The absence of fencing reduces landholder options for controlling stock access to the river and its foreshore. Further, with the presence of toxic plants such as Castor oil plants, there are benefits in being able to exclude stock until the plants are removed and controlled over time. The river environment can be described as parkland cleared with trees over annual plants, all of which are introduced. This is not a stable system, and does not represent the way the river would have been in the past.

Suggestions

Bank stability

- B Remove the local areas of large woody debris that are causing an erosion problem.
- B Work with landholders to develop stock management systems that allow natural regeneration of the trees.
- B Liaise with landholders to increase the density of vegetation between the river and the blowouts, to help deflect peak flows into the main river channel.
- B Realign debris behind which sediment is accumulating to encourage sand movement along the riverbed.

Vegetation

- V Continue revegetation works in sections where stock can be excluded from the foreshore.
- V Support natural regeneration by implementing localised weed control around any seedlings that appear.
- V Investigate opportunities for support and resources (tubestock or seed) that may become available through the Water and Rivers Commission and the Natural Heritage Trust.



- V Extend weed control activities within paddocks to the foreshore reserve, focussing around any native tree or shrub seedlings that have germinated or strips within the verge.
- V Focus weed control on plants that are toxic and present in low numbers such as Castor oil plants, particularly where stock accesses the foreshore.

Stream cover

- S Assess whether or not instream woody debris is disrupting water movement, realign if necessary and remove only where critical.
- S Consider excluding stock from sections lacking native vegetation and regeneration for about two years. Because the weed control aspect of grazing will be lost, the landholder needs to commit to weed control within the foreshore reserve for the duration.

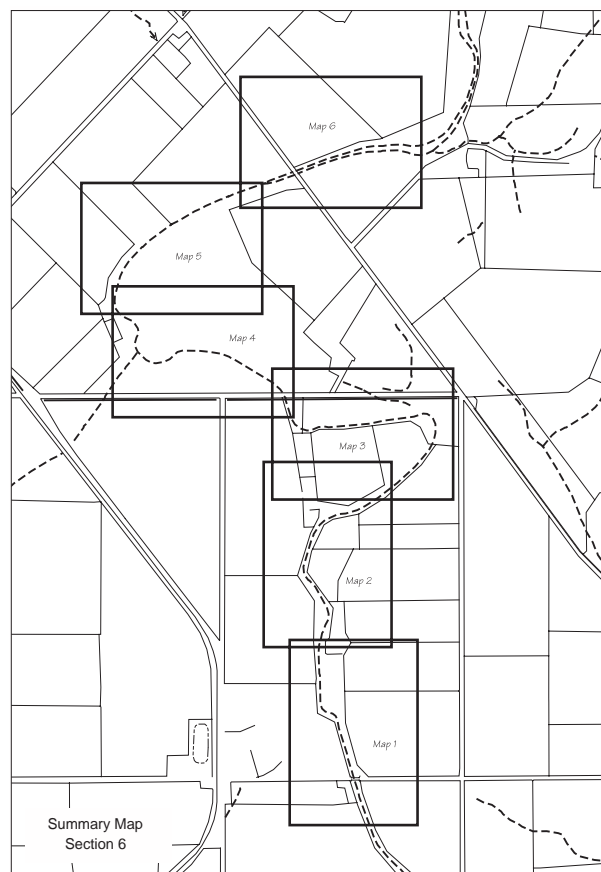
Habitat diversity

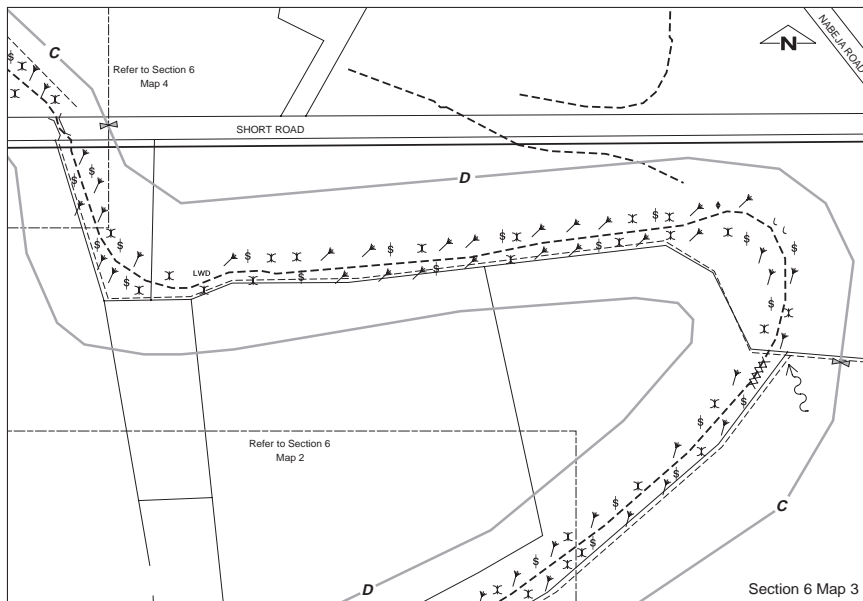
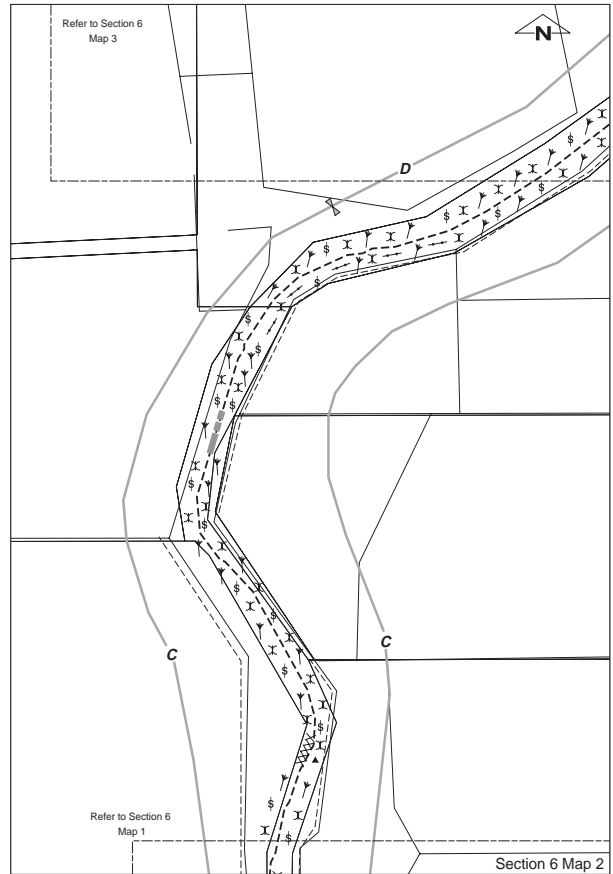
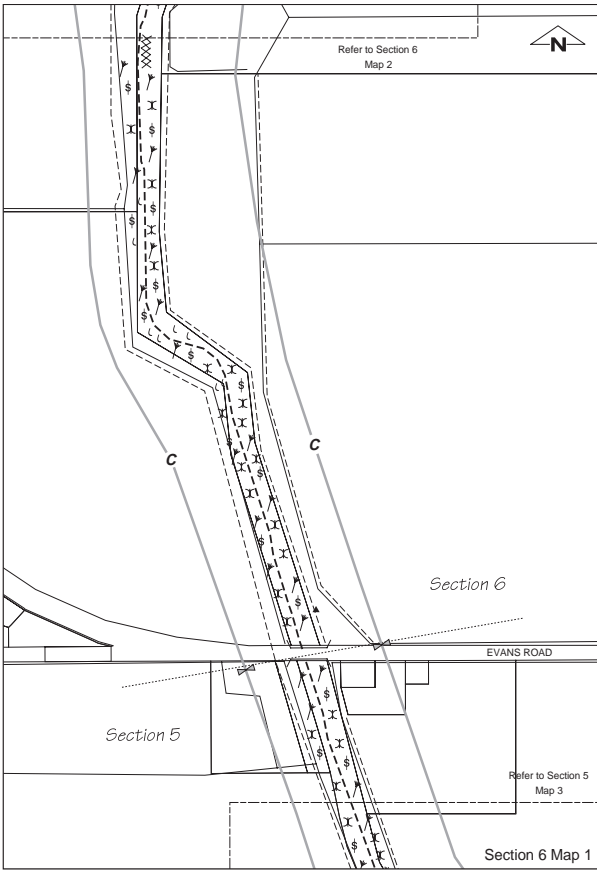
- H Determine the priorities for the river environment and encourage landholders to support the natural values of the river.

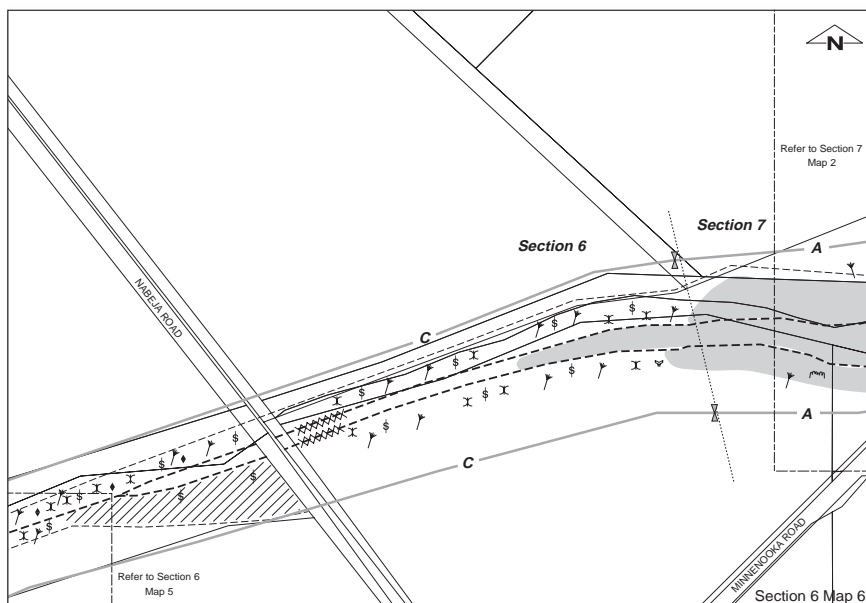
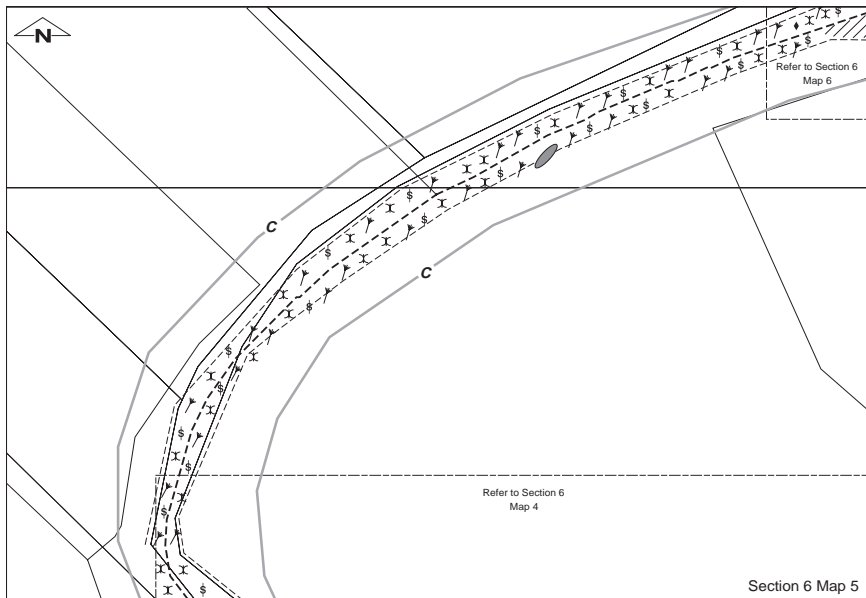
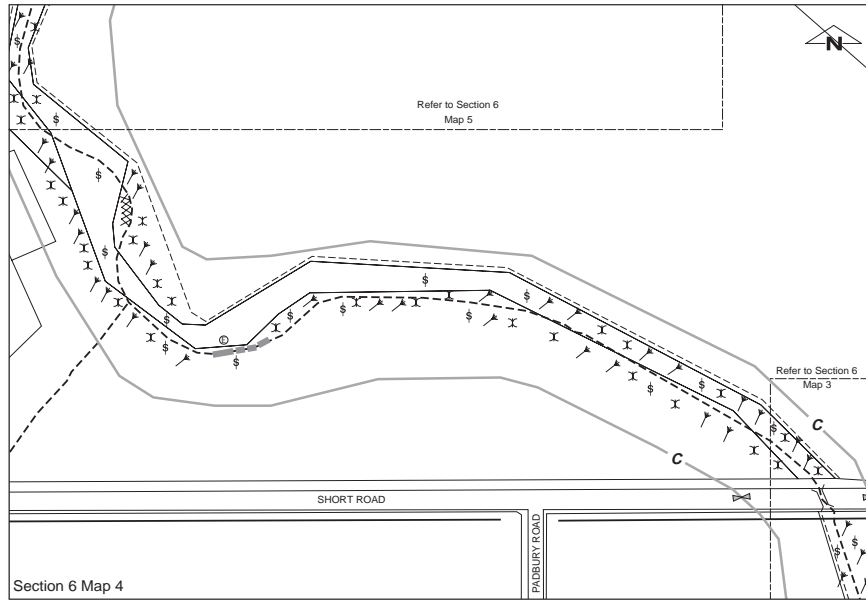
- H Encourage landholders to plant verge vegetation where it is feasible, to protect plants from grazing animals.
- H Provide information brochures to landholders about the benefit of maintaining vegetation along the rivers.

Other issues

- O Install fencing along river sections that are currently not fenced to protect stock from toxic plant species and provide for greater stock management options.
- O Determine the location of the foreshore reserve boundary and show its location in some manner (e.g. fencing, star pickets or other forms of markers).
- O Implement weed control of toxic species, as discussed above.
- O Provide information packs to landholders about river systems, the role of vegetation and the importance of careful stock management, and advising them of statutory requirements associated with the river systems.







SECTION 7: GREENOUGH RIVER MAPS 1 – 10**Length of section (m):** 9,700m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 May 2000**Nearest road access:** Nabeja Road and MacCartney Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Very Good A	Very Good A	Very Good A	Poor C	Very good A

Bank stability

This section of the Greenough River shows the first significant improvement in vegetation health and bank stability compared to the Greenough flats. There are significant groundwater contributions that provide all year round water to a pool near the junction of McKay's Brook and periodically along the section length. The pool at the upstream end of this section marks a transition from the upland to the foothills part of the river system. The pool (known locally as the Duck Pond) is a permanent feature. There is some evidence of sedimentation on margins of the upstream pool (Duck Pond) only. The low flow river channel ranges from 3 m to 15 m wide at the downstream end of this section, with some secondary channels present on the margins of the floodplain. There were some localised areas of severe erosion on the flood fringe in areas that had little vegetation cover prior to the 1999 floods and high flow conditions in March 2000. The low flow channels are generally very stable. The permanent waterlogging is indicated by the presence of Lake club rush (*Schoenoplectus validus*). The river has changed its course following accretion of the main channel on the eastern side of the floodplain. This has resulted in the flow being deflected to the western side of the watercourse. One access track and some fences have required realigning due to washouts.

Comments

The minimal grazing management patterns that occur in this section are excellent in protecting river function. There are some localised areas of soil disturbance where stock access the foreshore for water and feed, however overall there is sufficient vegetation cover to maintain bank stability.

The blowouts occur on the western bank of the river, and coincide with areas that lack good vegetation cover on the flood fringe, and within the floodway. Vegetating these areas and possibly undertaking minor re-contouring may reduce any future erosion of these

areas.

There is some interest in restoring the original river course by digging out the original river channel. Such an action requires the approval of the Water and Rivers Commission, and would be best achieved with their technical input to develop a strategy to protect the floodplain and its banks.

Vegetation

The native vegetation cover ranges from moderate to excellent for this part of the survey. The dominant vegetation community is patchy (20 – 80% cover) and comprises a mosaic of River gums (*Eucalyptus camaldulensis*), Swamp sheoaks (*Casuarina obesa*) and very occasional Swamp paperbark (*Melaleuca raphiophylla*). These provide a continuous canopy for all but approximately 400 m of this section. Anecdotal evidence suggests that spray drift was responsible for killing the trees in the section lacking mature trees. The understorey within the floodway is continuous (> 80% cover) and consists of dense Spiny flatsedge (*Cyperus gymnocaulos*) with some Shore rush (*Juncus kraussii*) and occasional stands of Lake club rush (*Schoenoplectus validus*). The margins of the floodplain have variable levels of weed invasion. The introduced perennial Couch (*Cynodon dactylon*) has invaded some sections, while Castor oil plants (*Ricinus communis*), Thornapple (*Datura stramonium*), Black berry nightshade (*Solanum nigrum*), Pie melon (*Citrullus australis*) and Curly dock (*Rumex crispus*) occur periodically. Control of these is required immediately. Immediately beyond the floodway is a significant infestation of Fountain grass (*Pennisetum setaceum*).

Comments

Selective weed control is feasible and currently requires minimal resourcing. This indicates that the landholders in this river section actively control weeds on a regular basis. Immediate control of toxic plants such as



Thornapple, Black berry nightshade and Castor oil is recommended to reduce their spread and to protect livestock. The focus should be on encouraging regeneration or planting of the verge, as it is limited along most of the river length.

Controlling the Fountain grass should also be a priority as this species poses a significant fire risk.

Stream cover

There is excellent stream cover along this section. The dense Spiny flatsedge and Shore rush overhang the low flow channel providing shelter for aquatic animals. The overstorey of River gum and Swamp paperbark provides cover for most of the length. There is a 300 m long band where the overstorey has died, and the bank vegetation provides the only cover. In these sections there is a proliferation of the filamentous green algae *Spirogyra*. Instream debris and rocks also provide excellent instream cover.

Comments

The extent of shading in this river section is sufficient to protect the contributions of springs from evaporating immediately. Protecting the health of the riparian vegetation is a key to ensuring adequate stream cover into the future. The fallen trees and occasional branches are generally not exacerbating erosion, and should be retained for habitat and stream cover.

Habitat diversity

There is considerable habitat diversity within the floodplain; however, there is an acute lack of shrubs, native groundcovers and other vegetation on the verge. The absence of this vegetation reduces the habitat available for birds such as finches, fantails and other shrubland birds. Within the floodway and the river itself, however, there is considerable habitat diversity. A range of aquatic invertebrates were seen during the survey including nine types of beetle, three types of aquatic snails, three species of fish and different larval stages of animals such as dragonflies and caddisflies. There was considerable diversity in the dragonflies and damselflies, frogs such as *Litoria* and *Heleioporus* were seen and heard, and tadpoles of three species were observed in off-line river pools.

The rich animal life occurred in pools fed by groundwater springs and in the main river channel.

There were also some pools that persisted following the last peak flow event. The pools provide easy pickings for foxes and other predatory animals. Foxes were seen during the survey.

The diversity of instream fauna indicates that the water quality is pretty good. The lower reaches are tannin stained. In the upstream sections, there is insufficient tannin to influence water colour.

Comments

The current stock management practices are protecting the riverbed and banks for most of this river section. There are localised areas where stock cross and graze periodically that would benefit from some adjustments to the grazing schedules. Generally the floodway vegetation is sufficient to protect bank stability and provide habitat.

The most pressing need for these areas is the re-establishment of the bank vegetation, beyond the floodway. By improving this vegetation it will be possible to encourage finches and other insectivorous birds to the areas adjoining crops. This helps to support native animals to move between areas of native vegetation in search of mates, food and other needs.

Other issues

As mentioned in the section on bank stability, one landholder is having considerable difficulty maintaining an access track into the property following a change in the course of river flow. This needs to be addressed with the assistance of officers of the Water and Rivers Commission. Fencing is generally in very good condition and most fences are aligned well above the top of the floodway. Where the locations are less appropriate, it may be worthwhile to realign the fence once its usefulness has come to an end. There is some evidence of stock access, which may eventually result in the loss of vegetation and bank stability in the long term. Careful grazing should minimise this risk, however it is important that stock management in the reserve follows the principles of grazing a sensitive paddock.

One landholder has considerable trouble crossing the river during flow events, and appears to need to replace the informal ford annually. It may be useful to assess this site with officers from the Water and Rivers



Commission to determine whether or not an alternative design would minimise management effort.

Some landholders have focussed considerable attention on active weed control. There is an old quarry site.

Suggestions

Bank stability

- B Liaise with landholders to determine the most appropriate flood management technique for this river section.
- B Send an information pack containing Water Notes and information about the legal implications of disturbing the bed and banks of waterways.
- B Undertake a direct seeding program in the blowouts, to encourage regeneration of native plants. This may reduce damage during future flood events, contribute habitat and reduce available bare ground for weed invasion.
- B Control stock access to allow understorey rushes and sedges to grow beneath the sheoak woodland, to reduce the threat of erosion to this area.
- B Invite Water and Rivers Commission officers to meet with the landholders to assess the feasibility of undertaking minor re-contouring of the valley slopes where erosion is severe.

Vegetation

- V Continue revegetation works in sections where stock can be excluded from the foreshore.
- V Support natural regeneration by implementing localised weed control around any seedlings that appear.
- V Investigate opportunities for support and resources (tubestock or seed) that may become available through the Water and Rivers Commission and the Natural Heritage Trust.
- V Extend weed control activities within paddocks to the foreshore reserve, focussing around any native tree or shrub seedlings that have germinated or strips within the verge.

- V Focus weed control on plants that are toxic and present in low numbers such as Castor oil plants, Thornapple and Black berry nightshade, particularly where stock accesses the foreshore.

Stream cover

- S Protect stream cover by ensuring the long-term survival of remnant vegetation and encouraging natural regeneration processes to replace the dead and sick trees.
- S Protect instream features from removal by land managers (where there is no threat to bank stability) by providing information on the importance of such features.

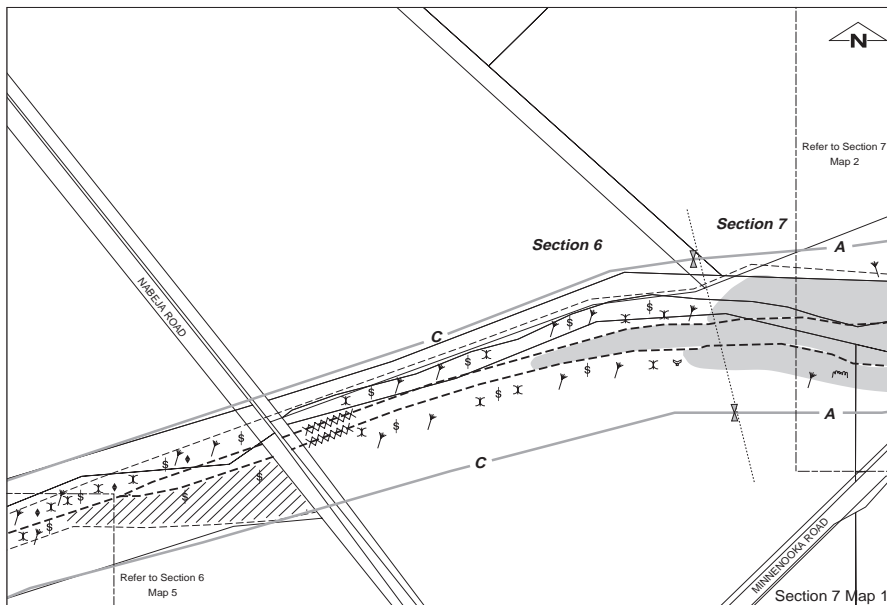
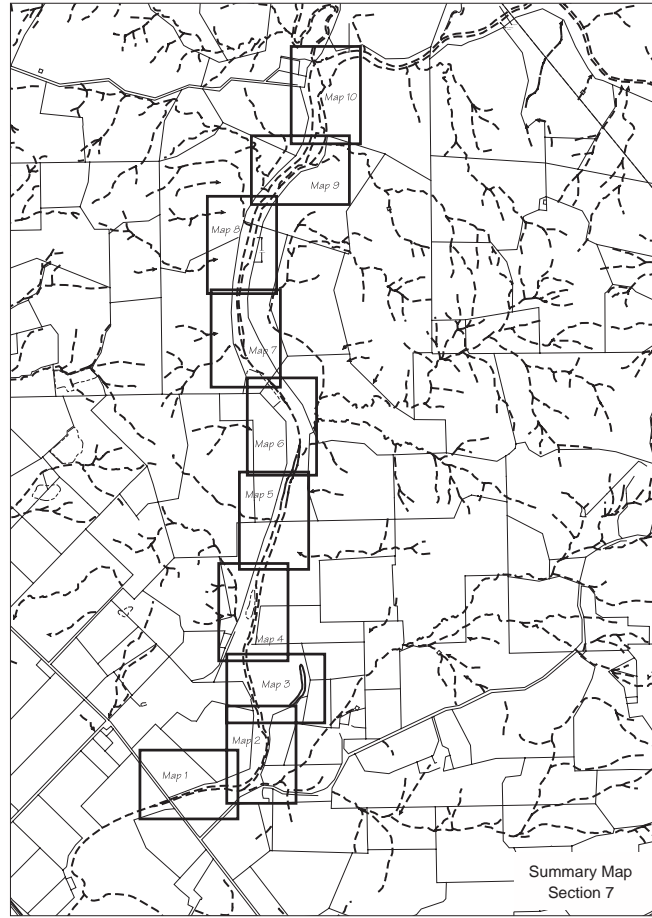
Habitat diversity

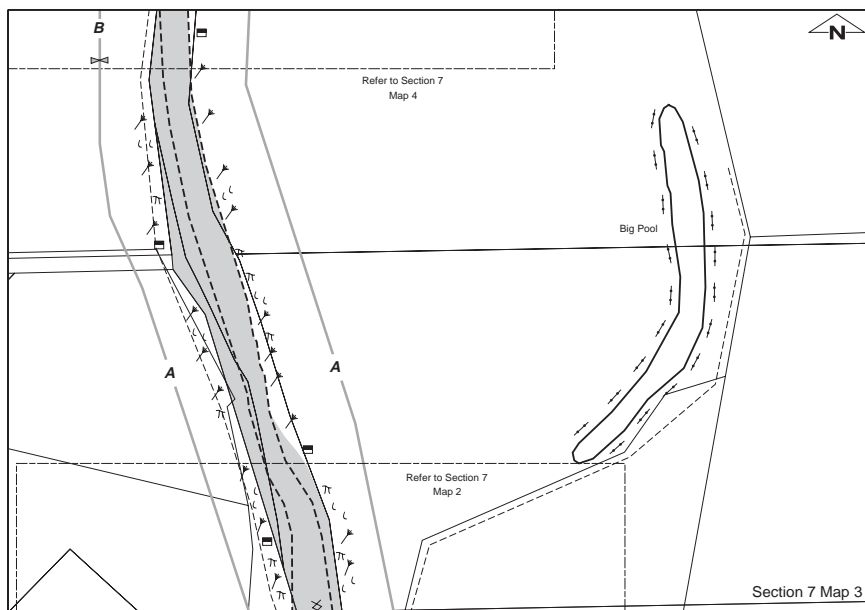
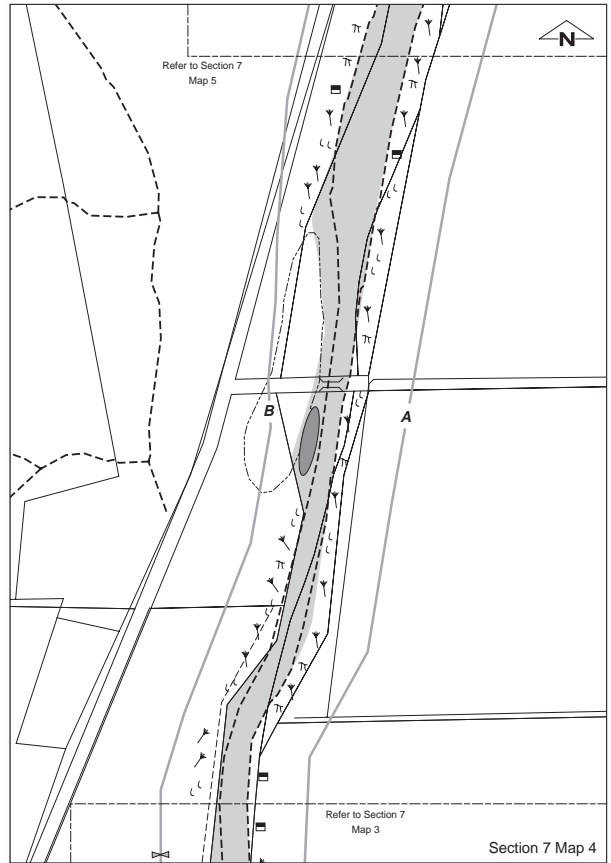
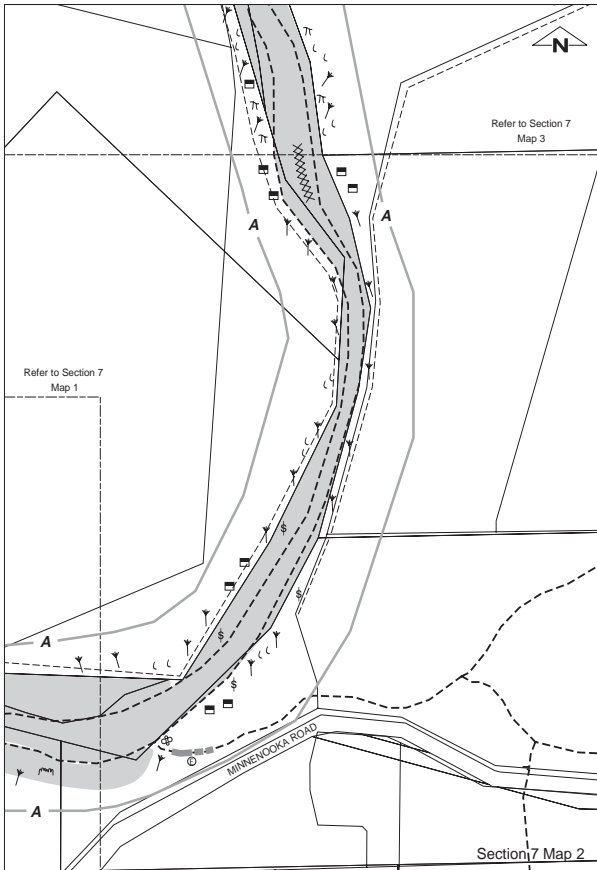
- H Protect the instream remnant vegetation from clearing and/or other activities that will increase degradation.
- H Encourage landholders to plant shrubs and trees on the verges to provide a buffer between paddocks and the riparian zone.
- H Implement selective weed control as listed above.
- H Undertake a fauna survey to assess the diversity of aquatic and terrestrial fauna, focussing on invertebrates.

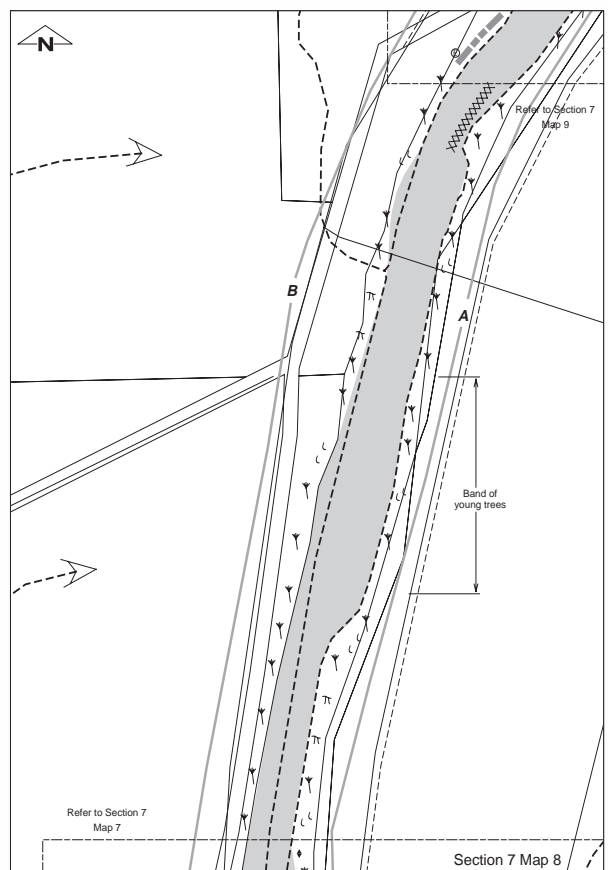
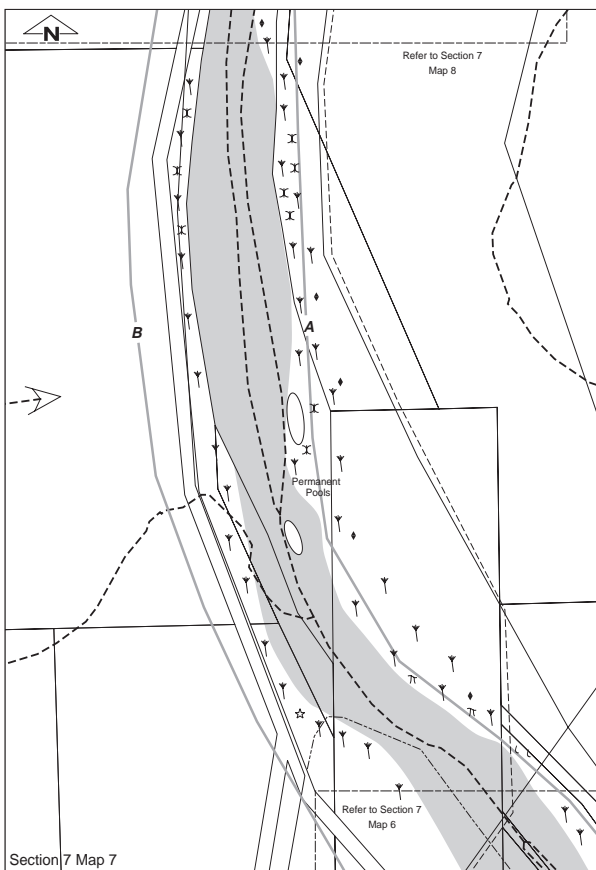
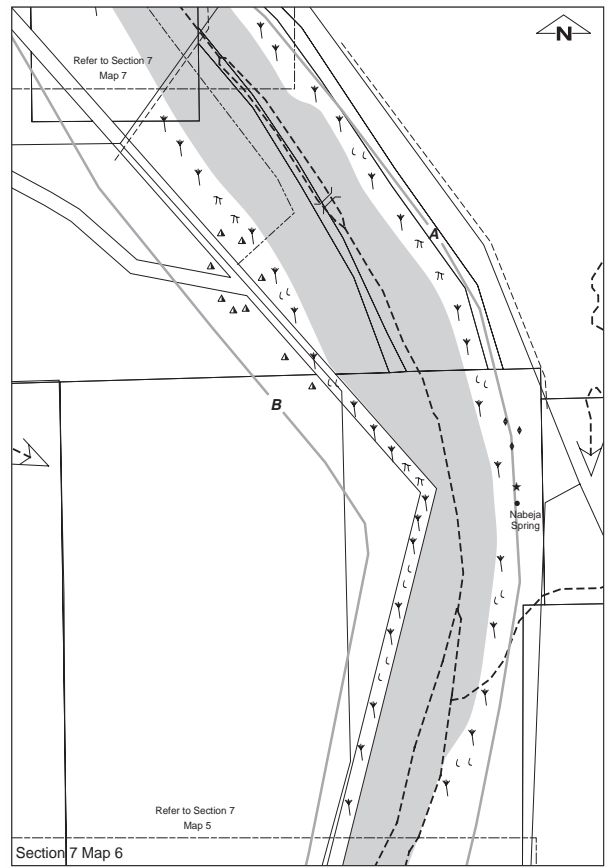
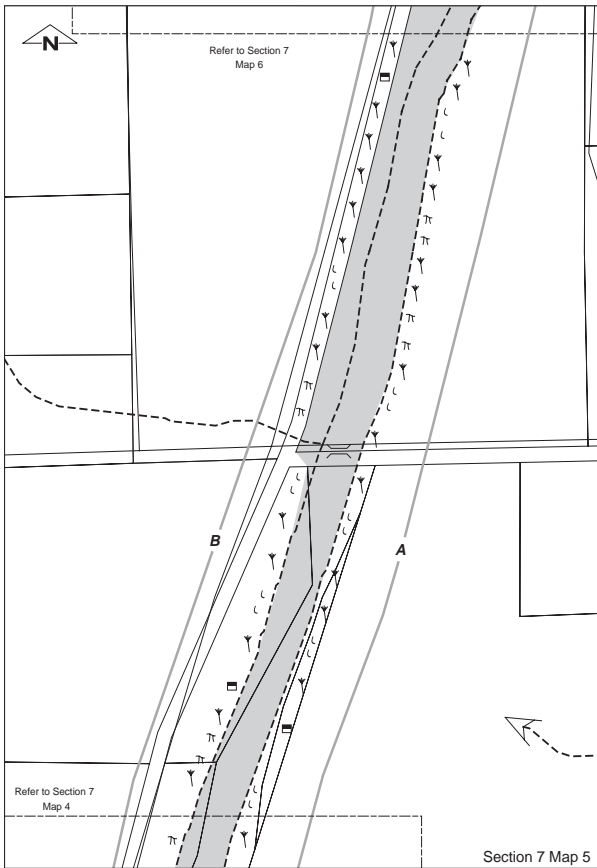
Other issues

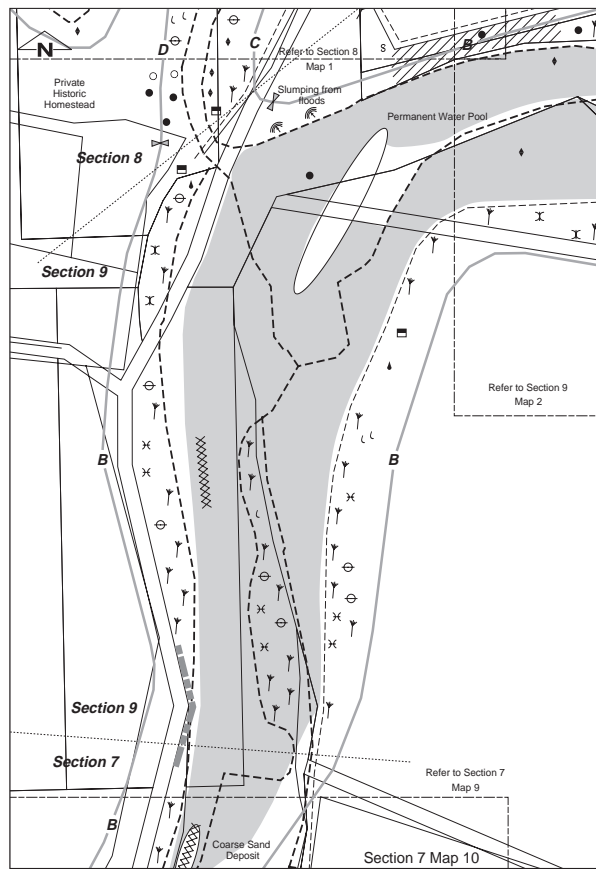
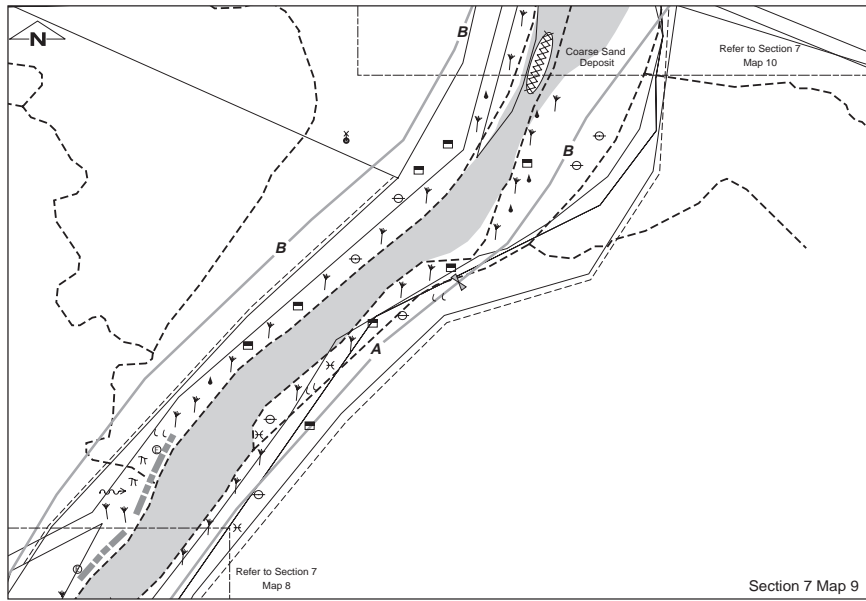
- O Invite Water and Rivers Commission officers to review the crossing and track, and course of river flow to determine if there are any other possible solutions for river management.
- O Provide all landholders with a Water Notes information pack to improve access to river management information.
- O Realign fences washed out during major flow events, and reinstall above the floodway to minimise the risk of losing them in the future.
- O Ensure stock management practices minimise damage to the foreshore reserve, its vegetation and bank stability.











SECTION 8: COLILURA BROOK MAP 1**Length of section (m):** 2560m**Recorders' names:** N Siemon and T Rebola**Date surveyed:** 2 May 2000**Nearest road access:** Glengarry Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Poor C	Poor C	Poor C	Poor C

Bank stability

The low flow channel was approximately 2 m wide at the time of survey. The dominant channel averaged 30 m wide along most of the surveyed length. The bank height ranged from less than 0.5 m to 4 m on the powerbends.

Bank steepness ranged from slight slopes to very steep on the powerbends. There were significant numbers of erosion rills down the banks and considerable mobile sediment plumes. Considerable changes to the brook's bed and bank structure are evident, and likely to be contributing to the poor bank stability. There is a crossing that is maintained to improve access. The channel bed falls quite quickly across the section. The brook contributes significant amounts of water. Anecdotal evidence suggests that this brook is becoming increasingly susceptible to flooding. The catchment is large and contributes significant volumes of flow to the Greenough River.

Comments

The river crossing could be rearranged slightly to improve the ford to reduce disturbance to the course of water flow. The current arrangement blocks the flow and deflects the water into an existing fenceline. There may be an opportunity to use rocks to direct the flow into the main channel. Modifying the bed and banks without approval from the Water and Rivers Commission is not permitted under the *Rights of Water and Irrigation Act 1914*.

It may be worth reviewing the catchment and assessing the entire length of this brook if resources become available.

Vegetation

The vegetation surveyed along the length of Colilura Brook was generally very poor to poor. The overstorey instream is very patchy (<20% cover). The main

species are Swamp paperbark (*Melaleuca raphiophylla*), Saltwater paperbark (*Melaleuca cuticularis*) and Swamp sheoak (*Casuarina obesa*). There are very occasional River gum (*Eucalyptus camaldulensis*), an unidentified eucalypt and Black marlock (*Eucalyptus arachnea*). Mistletoe (*Amyema* spp.) and Dodder (*Cassytha flava*) are both present in the trees and shrubs. There were considerable infestations of Castor oil plants (*Ricinus communis*) present along this river section. Near the confluence there are numerous Pepper trees (*Schinus terebinthifolia*). Dense stands of Cumbungi (*Typha domingensis*) and occasional clumps of Shore rush (*Juncus kraussii*) provide instream and floodplain cover. Fleabane (*Conyza bonariensis*) is prevalent in the main channel. There were some floodplain areas dominated by Couch (*Cynodon dactylon*) and a range of annual grasses. Considerable areas were totally denuded.

There was no canopy present in the verge vegetation. The middlestorey was very sparse, but moderately diverse. The dominant plants in this open community were *Hakea* spp., *Acacia stereophylla*, *Dryandra* and Jam (*Acacia acuminata*). Clover (*Trifolium* spp.) and annual grasses, Lupins (*Lupinus cosentinii* and *L. angustifolius*) and Pie melon (*Citrullus lanatus*) and Black berry nightshade (*Solanum nigrum*) dominated the understorey.

Comments

The extent and diversity of remnant vegetation is minimal for most of this river section and there is insufficient groundcover to minimise erosion processes. The parts lacking vegetation correlate with the sections with the widest main channel. The few remnants of verge vegetation provide limited cover for fauna and would benefit from protection from grazing. Stock exclusion would also encourage natural regeneration. There appears to be minimal shade/shelter in most paddocks, with stock camping beneath trees in the waterways.



Stream cover

There was very little stream cover along the surveyed section (<20% cover). Some persistent stands of Swamp paperbark (*Melaleuca raphiophylla*) and River gum (*Eucalyptus camaldulensis*) provide some shade for the waterway. Overall there is insufficient instream vegetation to provide good cover. There was no woody debris instream at the time of survey.

Comments

The remnant vegetation provides the only stream cover. The stream cover is insufficient to support much aquatic life or enhance the length of time water stays in the shallow pools.

Habitat diversity

The section is characterised by poor habitat diversity for native fauna. Some woodland and shrubland birds persist, particularly in the areas with *Hakea* cover. Willy wagtails, finches, Silvereyes and occasional Port Lincoln parrots were observed. Large flocks of Pink and grey galahs pass through this area regularly. A pair of Wedge-tailed eagles was observed during the survey. Pacific black ducks were using the small pool near the confluence of the brook with the river.

At the time of survey, the water was clear with very slight discolouration by sediment.

Comments

The overall lack of cover limits the number of suitable habitats for terrestrial and aquatic life forms. The lack of native vegetation along the creekline encourages fauna to graze in the paddocks, which is likely to cause localised crop damage. Increasing the extent of native vegetation may encourage the native animals to return to their historical food sources.

Other issues

There is a lot of discarded farm materials adjacent and within the brook and its floodplain. Some of this material may be washed downstream during a peak flow or flood event. Old tyres have been used for some erosion control. Some of these were stabilised with star pickets. The brook floodplain is partially fenced, and there were significant numbers of stock in the paddock at the time of survey. Ground preparation for

cropping extended to within 5 m of the top of the verge in some places.

As mentioned in the section on bank stability, the volume of mobile sediment and corresponding volume of water during peak flow events appears to be significant. Anecdotal evidence indicated that during the last flood event, the water almost reached the historic homestead.

Suggestions

Bank stability

- B Invite officers of the Water and Rivers Commission to review the river crossing as they may be able to offer alternatives.
- B Provide all landholders with a Water and Rivers Commission Water Notes information pack.
- B Undertake a foreshore assessment process of the entire brook and its catchment to develop a better understanding of the flows contributed to the river by this waterway. Strategies for slowing water movement may be appropriate along the brook's entire length.
- B Install fencing away from the top of banks to exclude stock access. This may help reduce loss of vegetation cover and the resulting formation of erosion rills.
- B Seek additional information about controlling erosion rills and encouraging sedimentation from Agriculture WA or the Water and Rivers Commission.

Vegetation

- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Target Castor oil plants immediately as the population is significant and control will become more difficult if work is not initiated now.
- V Encourage the landholders to fence off the persistent native remnant vegetation within their properties and establish shelter belts of deep-rooted trees to provide shade and shelter for stock.



- V Protect the riparian zone from grazing and trampling for some time to enable the vegetation to recover. Periodic crash grazing may be useful to control fire hazard and limit the production of weed seed.

Stream cover

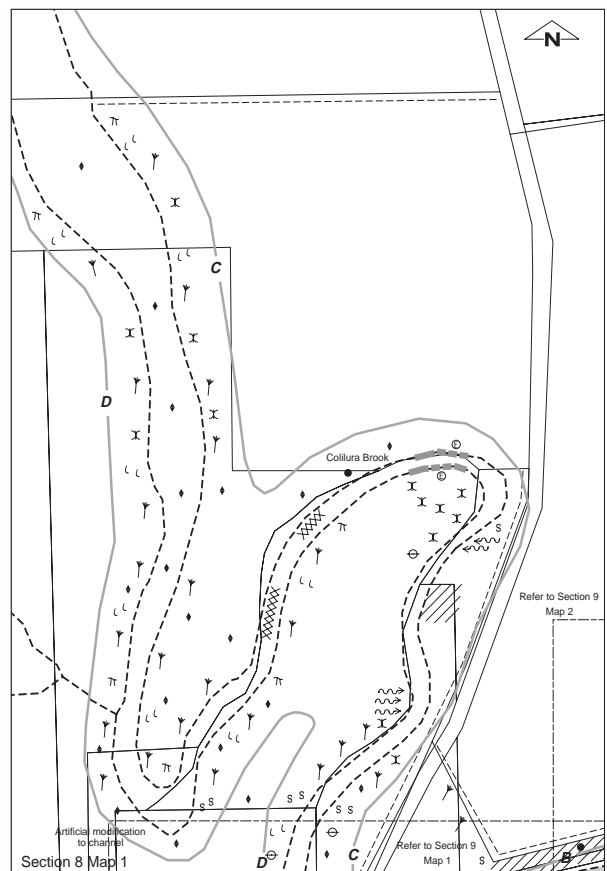
- S Fence off the tributary and protect the remaining vegetation along the length of the waterways. These fences need to be set back to the edge of the floodplain to ultimately encourage the river to reform a single main channel and reduce the fluctuations in river flow characteristics.
- S Minimise stock access until perennial vegetation cover is well established and likely to cope with the pressures of grazing.

Habitat diversity

- H Work to restore vegetation and minimise disturbance to the soil structure for the length of the waterway.
- H Develop strategies to control water flow and sediment movement throughout this section length with the support and advice of relevant government agencies.

Other issues

- O Provide information relating to farm planning, protection of remnant vegetation, opportunities to gain funding and preferred land management techniques to landholders in this sub-catchment.
- O Assess the sub-catchment waterways and develop a water management plan if required.



SECTION 9: GREENOUGH RIVER MAPS 1 – 10**Length of section (m):** 9820m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 2 – 3 May 2000**Nearest road access:** Minnenooka Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Moderate B	Very Good A	Very Good A	Very Good A	Very Good A

Bank stability

This section of the Greenough River marks the transition from lowland, predominantly sandy riverbeds into upland, granite dominated riverbed sections. The downstream end of the survey area was wide and flat, with significant levels of mobile sand. Upstream, the granite riverbed is generally very stable with patchy accumulations of coarse sediment ranging from 1 mm grains to pebbles ~ 10 mm diameter. There are natural granite spillways and small waterfalls in the upper parts of the study area. There is some stock damage to both vegetated and unvegetated sediment plumes. The channel width ranged from 1 m to 12 m. The depth ranges from 0.15 m to < 2 m in two pools. The floodplain width ranged from 60 to 150 m. The bank slopes are generally slight to moderate. The river valley is clearly defined and has moderate to steep slopes.

Comments

The bank stability is generally excellent due to the extent of granite and the dense understorey of rushes and sedges, protecting the foreshore and riverbanks from the erosive forces of water. The localised areas of erosion are linked with stock and vehicle crossings of the floodway. Formalising these crossings may reduce the localised erosion. Further, maintaining current stock access or reducing this access may help to protect the vegetation in the longer term. Careful monitoring will help prevent any additional damage from occurring.

Vegetation

The riparian and verge (buffer) vegetation is generally very good through this river section. Native plants dominate all layers of the verge vegetation, the overstorey, middlestorey and understorey. Instream vegetation is exclusively native species, while the floodway supports native patchy overstorey, generally native middlestorey and a weed dominated understorey. The extent of the vegetation ranges from 30 m to 200

m wide remnants on the left bank and a single row of trees to 100 m on the right bank.

The canopy in the riparian zone is predominantly Swamp sheoak (*Casuarina obesa*), with occasional Lesser bottlebrush (*Callistemon phoeniceus*) and River gum (*Eucalyptus camaldulensis*). The overstorey is patchy due to the rocky substrate limiting tree establishment. The understorey vegetation adjoining the low flow and main river channel varies between a mosaic of Shore rush (*Juncus kraussii*) with Spiny flatsedge (*Cyperus gymnocaulos*) to sections dominated by Bare twig rush (*Baumea juncea*) and Coast saw sedge (*Gahnia trifida*). The instream vegetation is excellent although grazed heavily. The dominant emergent plant is the Lake club rush (*Schoenoplectus validus*) while the submerged plant Triglochin (*Triglochin procera*) is common. Annual grasses dominate the understorey along with pasture plants including Lupins (*Lupinus cosentinii* and *L. angustifolius*) and Clover (*Trifolium* spp.), and other weed species such as Saffron thistle (*Carthamus lanatus*), Paterson's curse (*Echium plantagineum*) and occasional Doublegee (*Emex australis*).

The verge vegetation is generally well represented with a diverse range of species. Four species of *Acacia*, three species of *Hakea*, *Grevillea crithmifolia*, *Scholtzia*, *Baeckea* and six species of native grasses are present. The diversity of middlestorey and understorey is excellent in this region, however the health of the shrubs varies greatly.

There was some significant death of Shore rush (*Juncus kraussii*) stands adjacent to the river pool.

Comments

The in-river grazing has the potential to cause some destabilisation of the river in some years, depending on river flow events. Rushes and sedges tend to stop actively growing (senesce) during the cooler winter months. These plants often provide feed during the



late summer and autumn, when paddock cover is minimal. Some of the grazing is also a function of the animals seeking shade and water during the heat of the day in the river zones. These plants are adapted to cope with periods of seasonal inundation. When stock or other animals graze these plants to less than 100 mm tall immediately prior to the time of hibernation (rest period) of the plants, they often do not re-shoot and grow new leaves. This can result in the plants drowning if the river flows over the two winter months. The smaller the plant, the less the ability to cope with prolonged inundation.

Stream cover

The stream cover in this river section is excellent due to the density of remnant vegetation, large instream pools and riffles and presence of shade trees. The overhanging and instream vegetation provides cover for most of the main river channel. There are occasional off-line pools that were isolated following a drop in the peak flow and lack shade. Instream woody debris was present.

Comments

Maintaining the vegetation health and reducing stock traffic would help to maintain good stream cover in the long term. This vegetation community has sufficient resilience to deal with changing hydrology, however it may be threatened if additional stresses are placed on the vegetation. The spring that feeds into this river section provides an important haven for native animals during the dry summer months.

Habitat diversity

The water at the time of survey was tannin stained, but very clear. The fauna observed indicated brackish conditions. This section has excellent habitat diversity both instream and within the floodplain and verge buffer. The emergent and submerged vegetation provides habitat for numerous invertebrates and vertebrates such as fish and frogs. The granite riverbed also acts to aerate the water, improving conditions for instream fauna. The introduced Mosquito fish (*Gambusia holbrooki*) is present.

Comments

It would be worth assessing the invertebrate communities associated with the springs and comparing

them with the invertebrates in the Chapman River. This could be undertaken at different times of the year to develop a baseline data set from which to make comparisons over time. The Ribbons of Blue program may be willing to provide support.

The presence of a diverse range of predators indicates a relatively high level of foreshore health as the top order consumers are still present. This means that the ecosystem has sufficient resilience to manage crop pest animals such as grasshoppers.

Other issues

Foreshore reserves and another larger reserve are present in this river section. Fences are present for much of the river length and the locations are generally good. Stock access to this section of the river is evident, although the numbers appear to be relatively low. This management style is not causing widespread damage at this point in time, however stock need to be monitored closely to ensure that the banks are not destabilised.

There is a Water and Rivers Commission gauging station situated on a rocky granite outcrop and pool. This station provides information about flood levels, water velocities and related information. One powerline crosses the river in this section.

Suggestions

Bank stability

- B Seek advice from the Water and Rivers Commission on stock crossing designs that have minimal impact on stream dynamics.
- B Monitor stock impact on the river system and remove stock from the foreshore if necessary.
- B Protect the remnant vegetation from disturbance to enable the vegetation to continue to stabilise the riverbed, banks and floodways.

Vegetation

- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.



- V Liaise with landholders, TAFE, Water and Rivers Commission and other agencies and request support to undertake weed control, vegetation studies and other activities that will contribute to maintaining the health of this section. This section helps to demonstrate relatively healthy, stable foreshore environments, and the impact of significant contributions of water and sand from tributaries.
- V Encourage restoration of the verge by increasing the setback and fire access tracks from the riparian zone.
- V Monitor the level of natural regeneration and, if inadequate, source tubestock of middlestorey and overstorey species to plant some zones of verge.

Stream cover

- S Protect the springs, pools, floodplain wetlands and river system from disturbances that will reduce the health and resilience of this plant and animal community, through fencing, good fire protection, stock rotation and weed control.

Habitat diversity

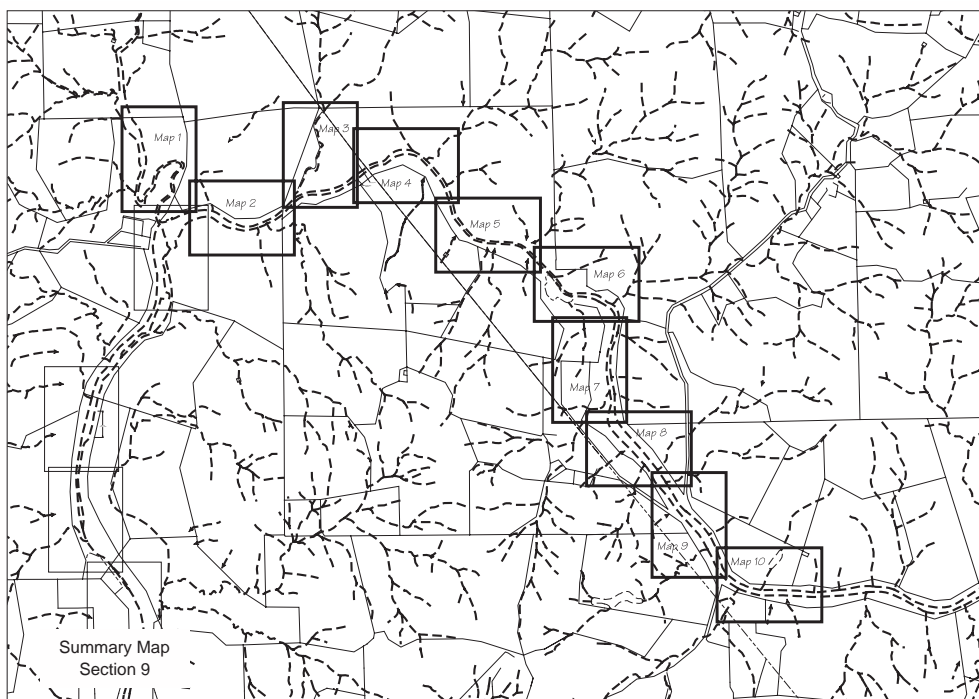
- H Encourage the Ribbons of Blue program to develop and implement an invertebrate survey (snapshots)

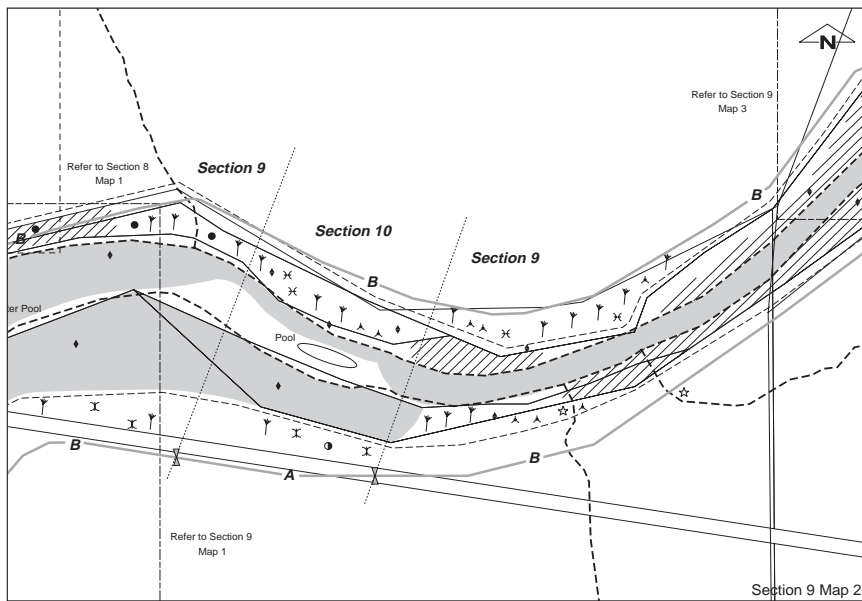
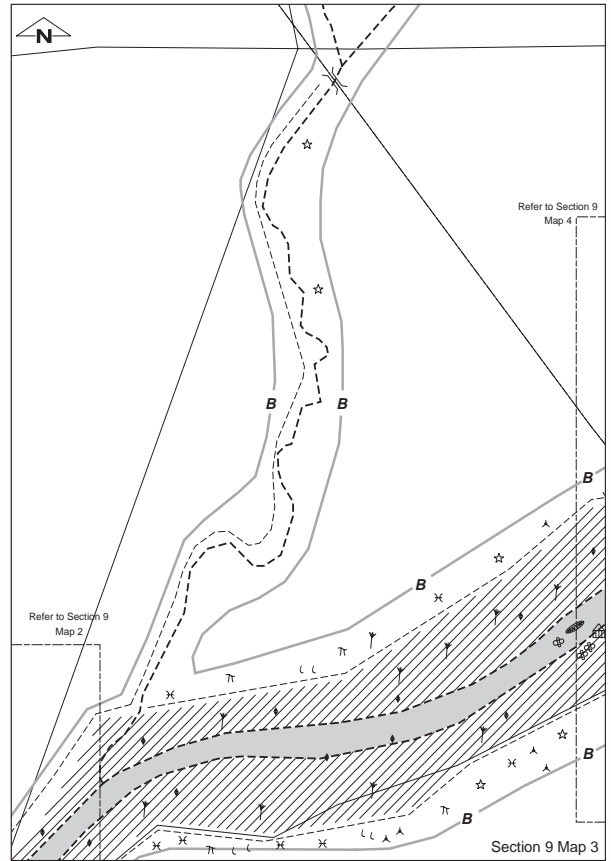
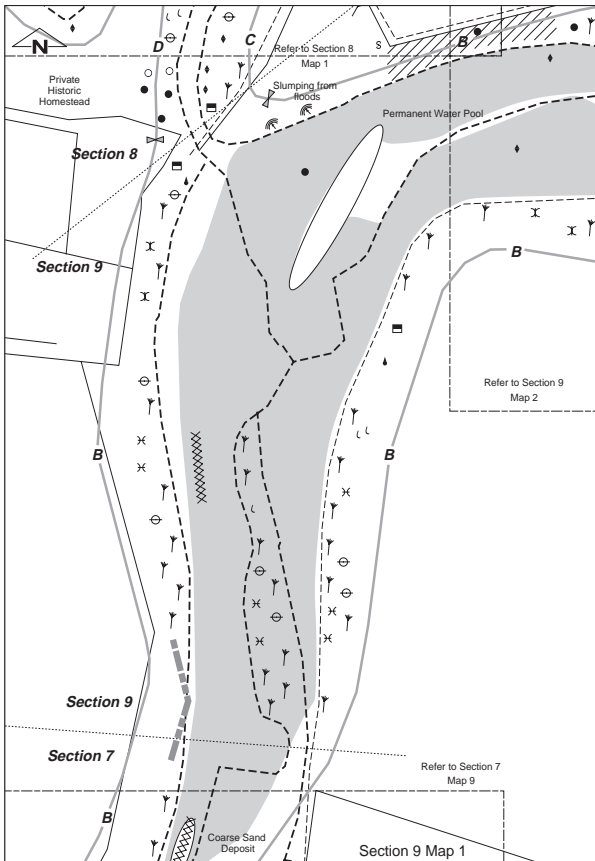
of the two ecosystems present within this section to enable future monitoring of population diversity and numbers.

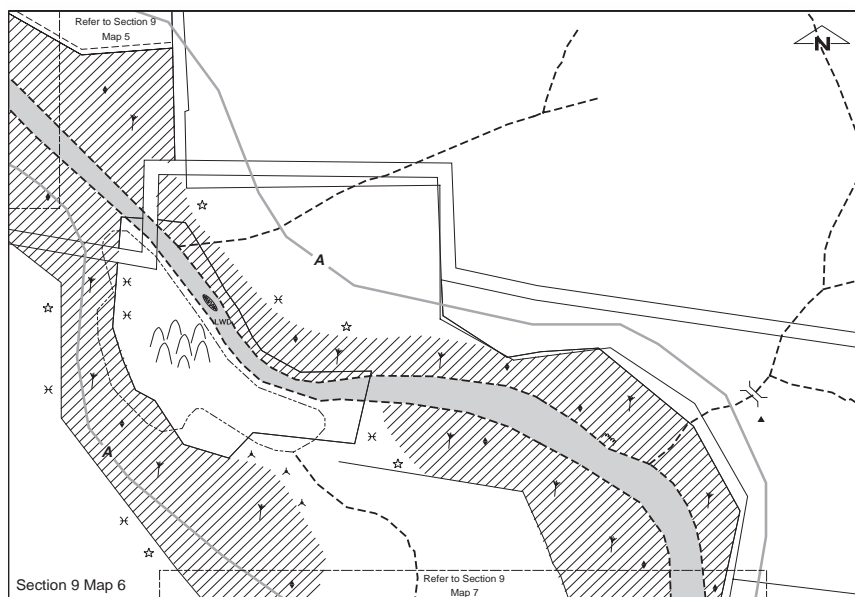
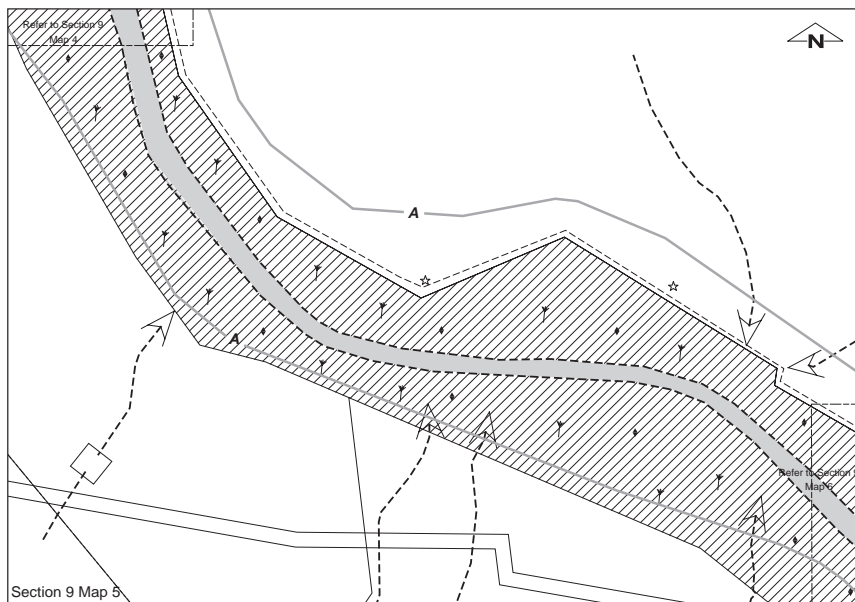
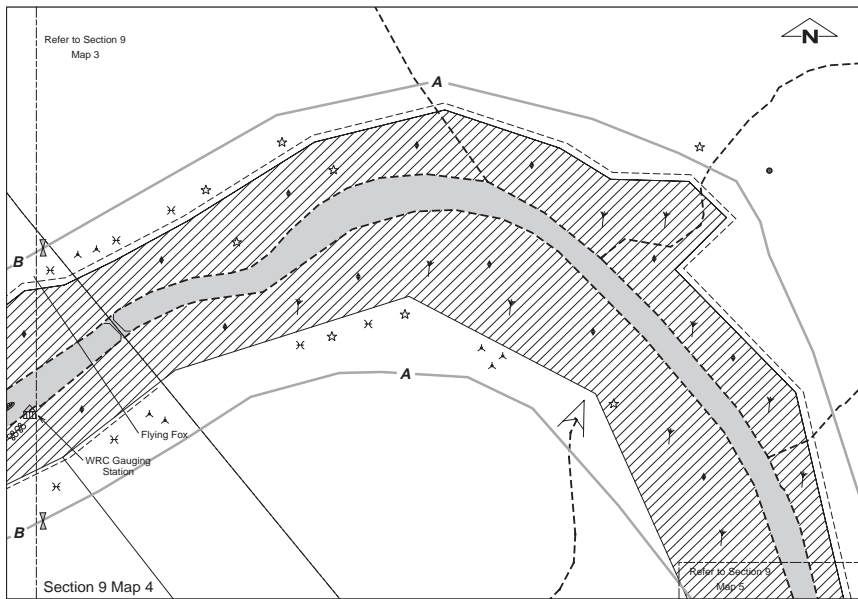
- H Focus on protecting the remaining vegetation and encourage natural regeneration processes through controlling soil disturbance and undertaking localised areas of weed control.
- H Work to maintain the dense nodes of verge vegetation to increase habitat availability for shrubland bird species that feed on insects such as grasshoppers.

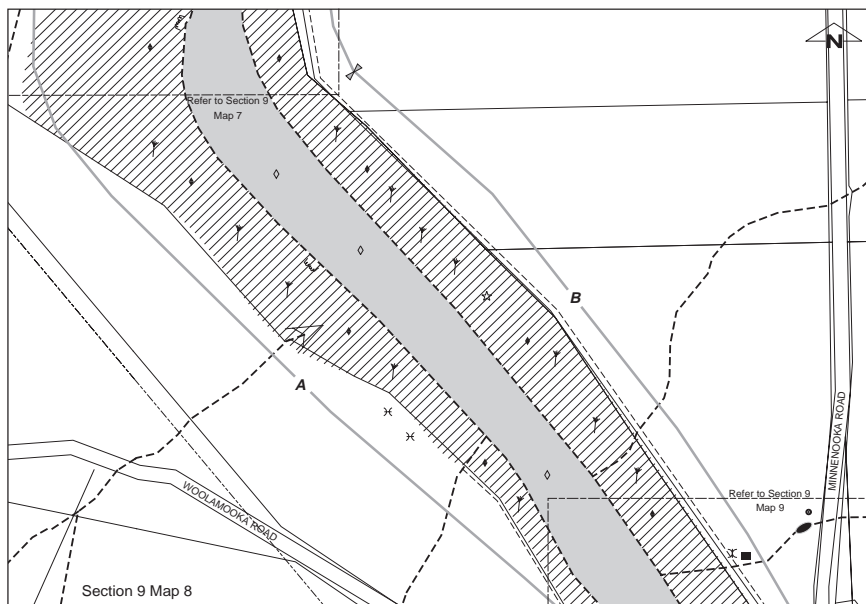
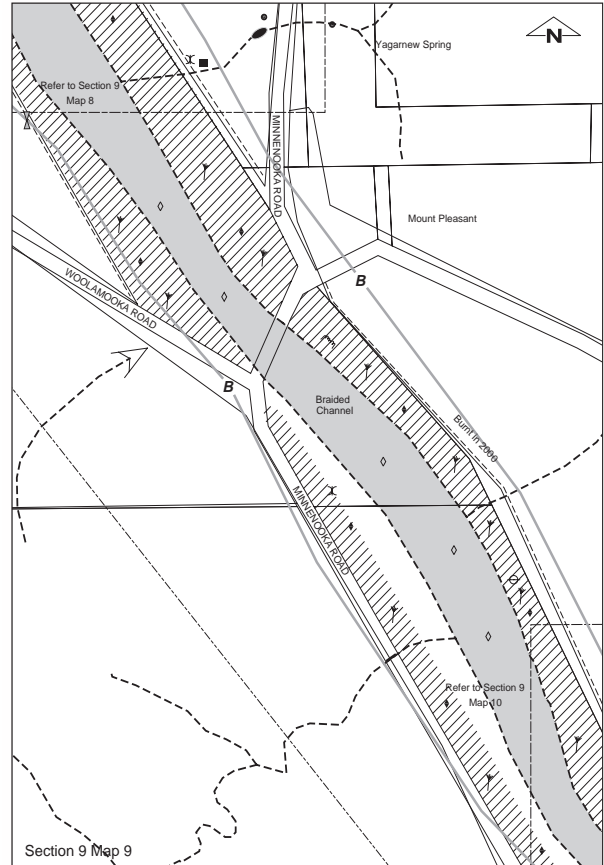
Other issues

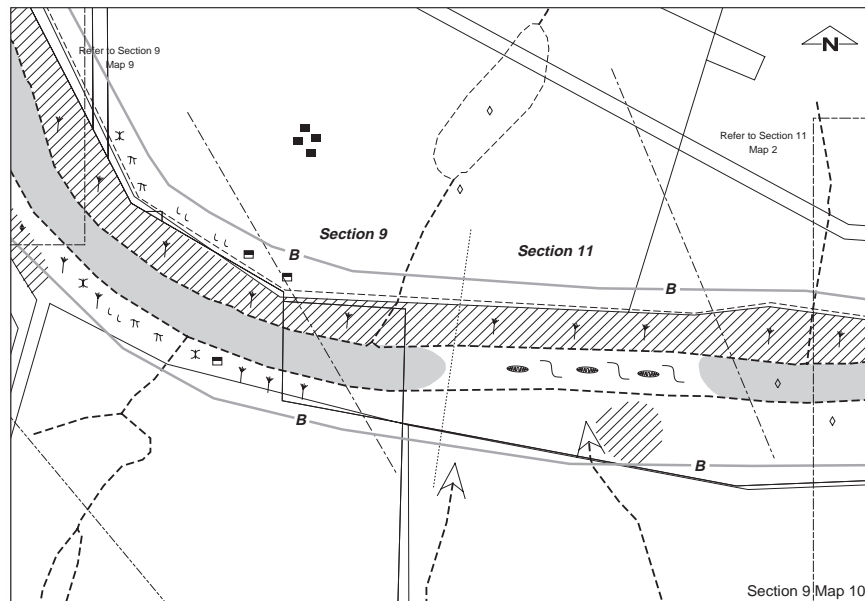
- O Obtain advice on crossing design to reduce the impact on river flow characteristics.
- O Ensure that fences are maintained and improved if larger numbers of stock are to be farmed.
- O Exclude stock from river system between April and the end of the winter flow events, to allow the emergent vegetation to recover prior to the winter flows.
- O Provide Water and Rivers Commission Water Notes information pack to landholders.











SECTION 10: POOL NEAR GLENGARRY MAP 1

Length of section (m): 270 m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 2 May 2000

Nearest road access: Glengarry Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Very Good A	Very Good A	Very Good A	Moderate B	Very Good A

Bank stability

The banks of the pool are very steep on the right bank, and moderately sloping on the left bank. The banks are very stable and well vegetated. The pool is approximately 40 m wide and 120 m long. The depth ranges from 0.5 m to 1.5 m at the margins, and the maximum depth is unknown but likely to be greater than 2.5 m. There is a section of foreshore rushes that were coated with fine clays at the time of survey. This was impacting on plant health and, in the event of the death of these plants, is likely to cause a reduction in floodplain stability. There are large granite boulders present within the pool and on the banks. The river valley is clearly defined and both banks are moderate to steep slopes. There are minor erosion rills and compacted stock tracks impacting on the stability of the valley slopes.

Comments

This pool is in excellent condition and has sufficient vegetation to maintain its form. The granite boulders help to armour the riverbanks, and deflect the flow to the centre of the pool. Stock access to the pool may

ultimately result in destabilising of the right bank due to trampling and vegetation loss.

Vegetation

This pool has considerable numbers of plants that indicate permanent water. Lake club rush (*Schoenoplectus validus*) occurs in dense stands along with Cumbungi (*Typha domingensis*) on the left bank. The verge vegetation provides good cover on the left bank only. Some sections of the bank support Marsh club rush (*Bolboschoenus caldwellii*). The submerged plant Triglochin (*Triglochin procerum*) is abundant.

The riparian vegetation on the left bank is characterised by a mosaic of closed Swamp sheoak (*Casuarina obesa*) stands or River gum (*Eucalyptus camaldulensis*) dominated woodlands. The communities tend to be mono-specific with very little mixing of the two overstorey species. The understorey is generally dense Shore rush (*Juncus kraussii*) or Bare twig rush (*Baumea juncea*). The right bank retains generally only a single row of trees, backed by patchy *Acacia* and *Hakea* groups.



The verge vegetation on the left bank is relatively diverse, but has little evidence of regeneration. The understorey is almost entirely native grasses with some annual grasses and pasture weeds. Localised infestations of Pie melon (*Citrullus lanatus*) are present.

Comments

The paucity of vegetation on the right verge could be addressed to increase the values of the pool.

Stream cover

The stream cover in the pool is excellent due to the density of remnant vegetation, riffles and presence of shade trees. The overhanging and instream vegetation such as Lake club rush (*Schoenoplectus validus*) provides cover for most of the main river channel. The granite boulders on the right bank also provide some shade for aquatic fauna.

Comments

Maintaining the vegetation health and reducing stock traffic would help to maintain good stream cover in the long term. This vegetation community has sufficient resilience to deal with changing hydrology, however it may be threatened if additional stresses are placed on the vegetation. The spring that feeds into this river section provides an important haven for native animals during the dry summer months.

Habitat diversity

The instream water quality at the time of survey was very good. The water contained tannin and was a deep, clear brown. The vegetation present indicates that the water is brackish. This section has excellent habitat diversity both instream and within the floodplain and verge buffer. The emergent and submerged vegetation provides habitat for numerous invertebrates and vertebrates such as fish and frogs. The introduced Mosquito fish (*Gambusia holbrooki*) is present. The tall Swamp sheoak (*Casuarina obesa*) and River gum (*Eucalyptus camaldulensis*) provide roosting and breeding places for waterbirds including Spoonbills, Greater egrets, Little black cormorant, Great cormorant, White-faced heron, Australian darter and Pacific black ducks. Predatory birds such as Wedge-tailed eagle, falcons and kites were relatively common in this stretch of river.

Comments

This section has extremely high conservation values because of the intact nature of the plant and animal communities. The large amount of mobile sediment that is being transported down the river system has the potential to reduce the health of this section. This area is a suitable site for detailed studies of the aquatic life and could be used to monitor changes over time.

Other issues

Both banks of the pool were fenced above the top of the verge. There were some compacted sheep tracks on both banks, exhibiting some early signs of erosion. The pool appears to be contained entirely within a reserve.

This site is a significant wildlife refuge. The reserve needs active management to control weeds and fire risk. The lack of continuous access to this site makes it difficult for the vested agency to manage the reserve. The private landholders are helping to control weeds in this section by grazing stock.

Suggestions

Bank stability

- B Monitor stock access to the pool, and use a periodic short-term crash grazing approach if any to help achieve weed control.
- B Monitor vegetation health and if there is continued decline, investigate with the support of officers of the Water and Rivers Commission.

Vegetation

- V Encourage landholders to continue to meet the statutory requirements to control weeds in the foreshore reserve, if they wish to continue to graze the reserve.
- V Determine feasibility of sourcing funding and labour resources to plant and direct seed verge vegetation in this section, to maximise the habitat values.
- V Monitor vegetation health and, if any decline becomes apparent, investigate.



Stream cover

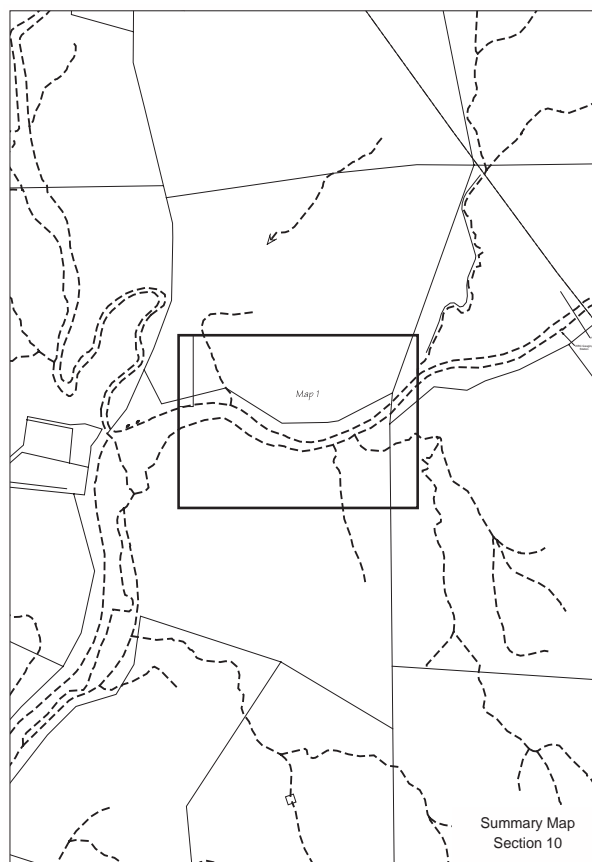
- S Protect this pool from disturbances that are likely to result in a loss of natural values.
- S Ensure that the vegetation health is monitored and stock impacts assessed regularly to minimise the threat to stream cover.

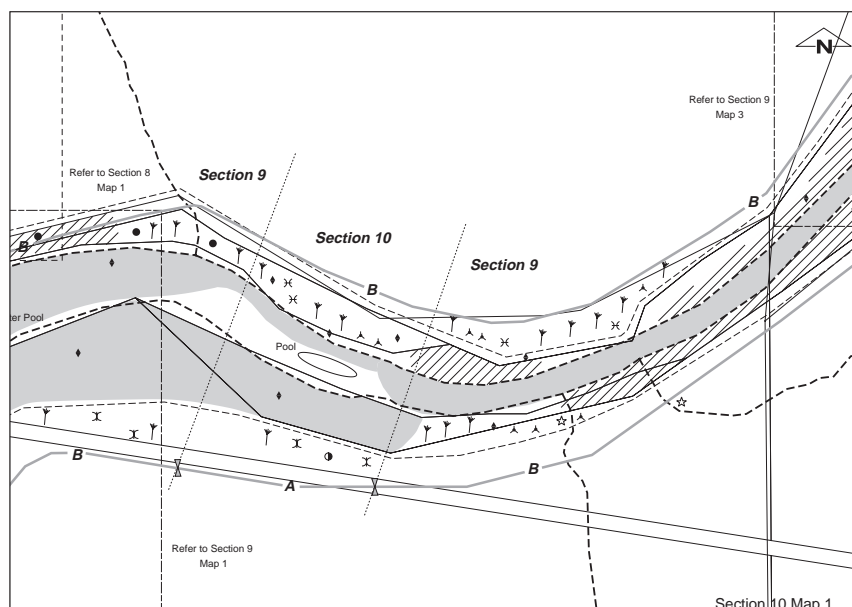
Habitat diversity

- H Undertake a fauna survey of aquatic and terrestrial invertebrates to develop baseline data sets against which comparisons can be drawn in the future.
- H Protect the remnant vegetation in the area from clearing and/or other activities, which will increase degradation.
- H Manage stock access to limit damage to the native vegetation while achieving weed control.

Other issues

- O Consider the feasibility of developing a small foreshore management plan for the pool and determine the feasibility of upgrading the reserve in this section for bird watchers. This would require defining access, undertaking weed control and possibly installing some minor infrastructure. Such a plan would provide a foundation against which funding can be sought. This would require the adjoining landholders' agreement and cannot be pursued without it.
- O Control stock access to minimise the formation of defined tracks that increase the susceptibility of the foreshore to erosion.
- O Recognise the immense value of this pool as a summer refuge for native animals and provide these animals with primary access rights, by controlling stock.





SECTION 11: GREENOUGH RIVER MAPS 1 – 3

Length of section (m): 2700m

Recorders’ names: N Siemon and T Rebola

Date surveyed: 4 May 2000

Nearest road access: Minnenooka Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Very Good A	Moderate B	Moderate B	Moderate B

Bank stability

This section of the river is dominated by a series of braided channels across a floodway that is up to 250 m wide. The riverbed is granite, however over a series of relatively dry years there has been some sediment accumulation on the margins of the floodplain along 40% of the section (left bank). Many sediment plumes are still unstable and mobile, mostly as a result of feral pig and deer activity. There is some evidence of cattle. The main and secondary channels range in width from 2 m to 4 m, while the depth varies from 0.15 m to 0.6 m. The right bank has a moderate slope rising to 1 m above the current water level, while the left bank has a slight slope to 0.6 m. The left bank provides for most flood events, with the right bank only likely to be breached in significant flood events. There are several pools persisting in the floodplain following the March rains. The Minnenooka Road crossing is generally stable, however some re-gravelling is undertaken following peak flows.

Comments

The steepness of the channel bed is sufficient to minimise sedimentation, however, it also ensures that

river flow passes through this section at relatively high velocities. This increases the erosive power of the flow which, when coupled with high sand loads, has high abrasive capacity. The steep river valley limits the extent of cutting away from the banks, however new processes associated with undercutting and slumping are possible in the floodway.

This site demonstrates the relationship between channel width and riparian vegetation. Where dense vegetation exists the main channel is narrow as are the small braids that form during major flow events. The blowouts occur adjacent to sections with minimal vegetation cover and ultimately may result in the formation of braided channels.

Vegetation

The vegetation is relatively consistent with the centre of the floodplain dominated by Swamp sheoak (*Casuarina obesa*) with an understorey of Shore rush (*Juncus kraussii*), Spiny flatsedge (*Cyperus gymnocaulos*) and occasional dense patches of Bare twig rush (*Baumea juncea*). The Lake club sedge (*Schoenoplectus validus*) grows in dense groups in



permanent pools. The exposed granite on the left bank is dominated by open Lesser bottlebrush (*Callistemon phoeniceus*) shrublands with occasional Mohan (*Melaleuca viminea*) and Broom bush (*Melaleuca uncinata*) while the right bank is more open. This bank has Saltbush (*Atriplex* sp.), annual grasses in particular Wild oats (*Avena fatua*), Annual Wimmera ryegrass or Drake (*Lolium rigidum* and *L. temulentum*), and other pasture weeds such Paterson's curse (*Echium plantagineum*), Wild radish (*Raphanus raphanistrum*), Fleabane (*Conyza bonariensis*), Bushy starwort (*Aster subulatus*) and Doublegee (*Emex australis*).

A small patch of Kikuyu (*Pennisetum clandestinum*) is present in two seeps and across the verge. The verge vegetation is patchy with uncommon mature River gum (*Eucalyptus camaldulensis*), alternate patches of two species of *Acacia* and two *Hakea*, and Camphor myrtle (*Baeckea camphorosmae*). There are also dense stands of Spiked scholtzia (*Scholtzia involucreta*), Rock sheoak (*Allocasuarina huegeliana*) and a type of *Melaleuca*. The understorey in the verge is dominated by Lupins (*Lupinus cosentinii* and *L. angustifolius*), Couch (*Cynodon dactylon*) and Wild radish (*Raphanus raphanistrum*), although occasional native *Wahlenbergia* spp., *Desmoclados myriocladus* and *Lyginia imberbis* persist. One species of *Chaemescilla* is also present.

Comments

There is minimal evidence of regeneration in some parts of this section. The relatively low numbers of Paterson's curse limits the resources required to control these weeds in this section. If these populations are left unchecked then the resources required are likely to increase exponentially. Control of the perennial grasses would be beneficial to help the persisting rushes and sedges.

Stream cover

There is considerable stream cover provided by the dense Swamp sheoak (*Casuarina obesa*), instream Lake club sedge (*Schoenoplectus validus*) and Shore rush (*Juncus kraussii*) on the banks. Large woody debris, filamentous and epiphytic algae (which both grow attached to rocks) and instream cobbles (rocks) all provide excellent cover for fauna instream. For example, 40 species of invertebrates were observed, including Caddisfly larvae, three species of aquatic

snails, a bivalve, seven species of dragonflies, four species of fish including Western minnow (Galaxid) and the introduced Mosquito fish (*Gambusia holbrooki*).

Comments

The diversity of instream fauna and invertebrates indicates a healthy system because all levels of the food chain are present. The amount of instream leaf litter and decaying matter provides food for bacteria and microscopic animals living in the soil. These animals release organic nutrients that provide for aquatic plants. These aquatic plants, including alga and emergent plants, feed a diverse range of herbivores, and in turn provide food for predators of all sizes. Many large predators eat smaller predators such as Dragonfly larvae and beetle larvae. These animals are voracious predators, eating anything that is in their way.

As these animals emerge from the water, they are extremely vulnerable. To emerge from the water, they need vegetation or instream woody debris. This allows them to break the surface tension. Without it, the animals cannot leave the water to fulfil their lifecycle. As they emerge, other predators like spiders and frogs eat them. The birds eat the spiders and frogs and so the food web continues.

Healthy systems tend to have very few mosquitoes and their larvae present.

This site can be used to help landholders identify a healthy foreshore environment. This section retains the necessary values to design and implement other revegetation works in the area. This area will also reflect any changes to groundwater conditions including higher water levels and salinity fluxes. The diversity of habitats here also provides a node from which seed and juvenile animals can disperse downstream to recolonise other areas.

Habitat diversity

This section of river provides extremely diverse habitat with permanent water, dense overstorey and some shrubs both instream and on the verge. Tadpoles of three frog species were identified and calls of the Motorbike frog (*Litoria moorei*), Western spotted frog (*Heleioporus albopunctatus*) and the Banjo frog (*Limnodynastes dorsalis*) were heard. Discussions with local residents indicate that spraying for locusts during



the plague of 1990 seriously affected the frog populations. This year (2000) was the first time frogs have been heard since the spraying. A few terrestrial predators, particularly spiders, were present.

Comments

Frogs are one of the more conspicuous elements of wetland systems. These animals are sensitive to chemicals both through direct contact and through consumption of their invertebrate prey. The impact of spraying on these populations is also reflected in the lack of predators present within this section.

Other issues

Large groups of feral pigs and deer frequent the area and are having a detrimental effect on the environment. There are real concerns among the local farming community that the dense vegetation harbours feral animals. The feral pig and deer damage to the foreshore poses a significant threat to bank stability along this river length. Large areas of soil have been disturbed while the pigs feed and camp. These areas will be easily eroded, increasing the sediment load downstream and causing other landholders significant management issues.

There is also concern that the river zone represents a significant fire threat. Some landholders have difficulty maintaining their fences because of fire responsive species such as wattles. Wattles are often found growing along fencelines. An accidental wildfire that escaped from a paddock will result in regeneration of wattles as the seeds of the species respond to fire. This will cause greater fenceline management issues.

The fire escaped as a result of burning off debris within a paddock. The material was stockpiled less than 10 m from the top of the verge. The loss of vegetation in the floodway following the fire also makes this area more susceptible to erosion damage in the next flow event, and also may make it attractive to feral animals seeking young succulent shoots.

There is occasional stock access.

Fence maintenance is an ongoing issue for all landholders. Natural regeneration of shrubs and trees beneath fences often results in these fences becoming ineffectual. One technique to overcome this is to

establish the fence 3 m upslope of the foreshore reserve boundary and to establish chemical fire access tracks on each side of the fence. Over time, the maintenance costs are likely to be lower. Using fire in areas where the dominant species are fire-responsive primary colonisers, i.e. the seeds require fire to germinate, is pointless. It will result in greater difficulties managing plant growth through fencelines. Plants such as wattles are short-lived and highly flammable to encourage the conditions that will help them to dominate. For this reason, fire in the riparian zone and verge is not recommended.

Suggestions

Bank stability

- B Continue program to control feral pigs and deer.
- B Consider increasing the number of culverts in the Minnenooka Road crossing and align these culverts with the existing secondary channels.

Vegetation

- V Remove some of the dead wattles and woody debris from adjacent to the fence to protect fenceline from damage.
- V Construct a firebreak on both sides of fences by realigning fence to the outside of current track. This will provide a wider barrier between paddock and the remnant vegetation.
- V Continue control of feral pigs, deer, cats and foxes and investigate alternative control techniques particularly for the deer and pigs.
- V Continue stock exclusion practice to reduce:
 - stock loss;
 - the need for fencing across the river; and
 - damage to vegetation.

Stream cover

- S Undertake a survey of the aquatic and terrestrial invertebrates to obtain baseline data, against which future studies can be compared.
- S Monitor the health of this remnant annually to determine whether or not there are any significant changes to the foreshore health.



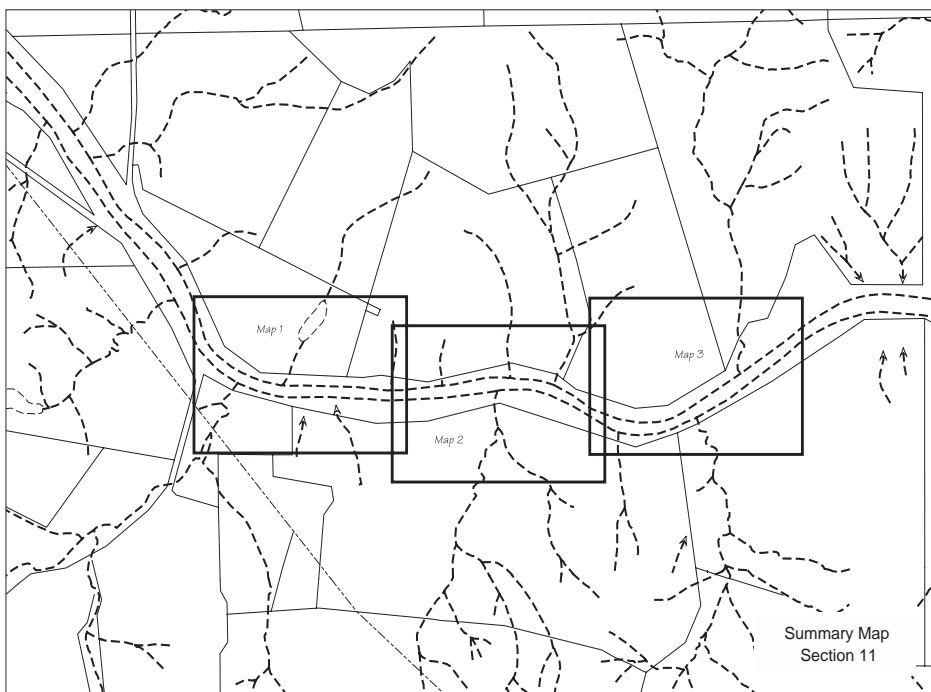
Habitat diversity

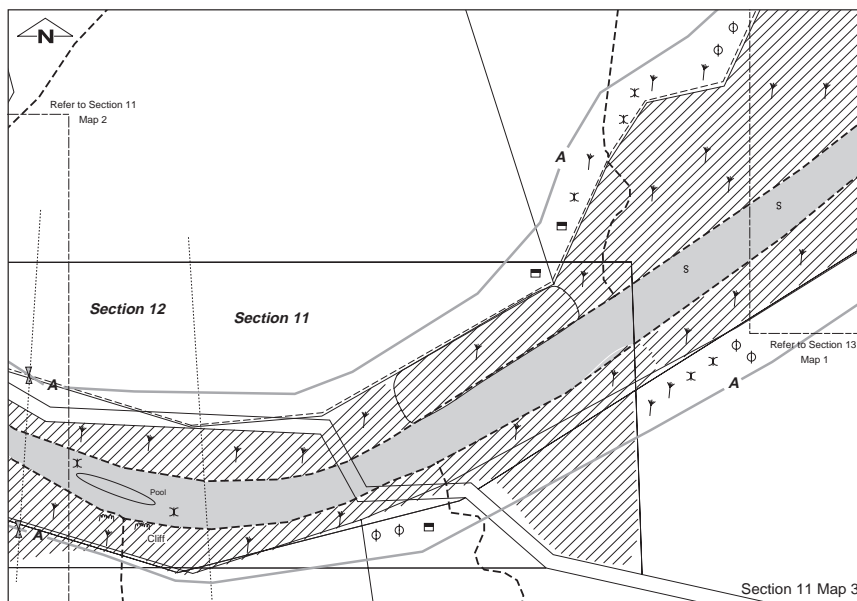
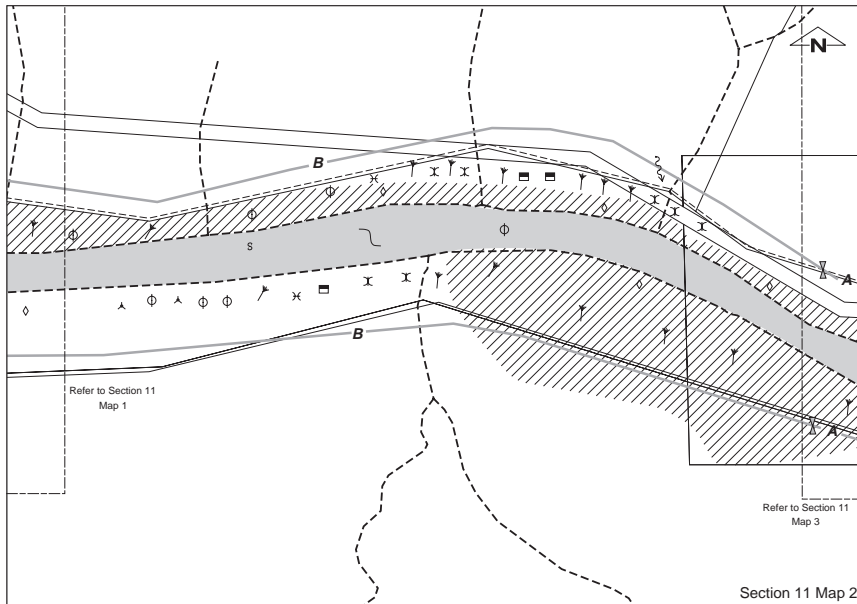
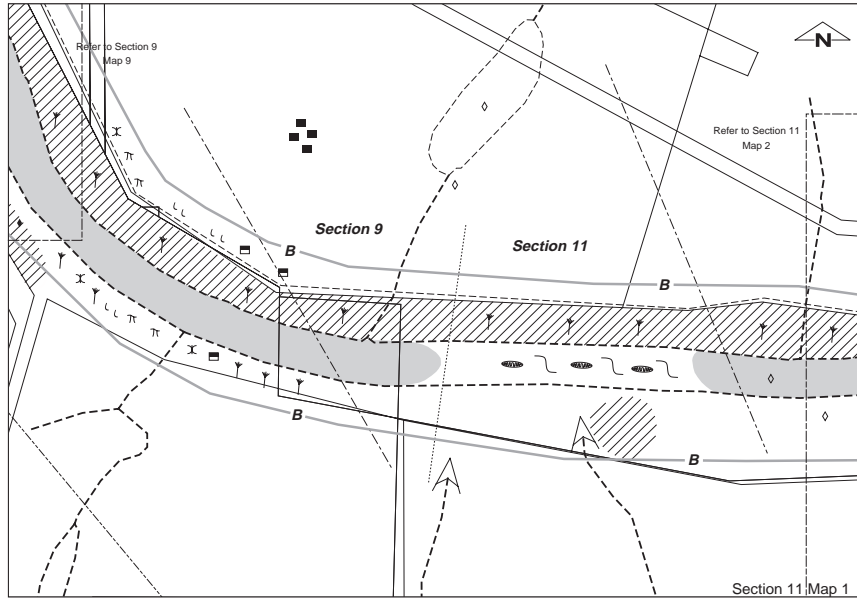
- H Reinforce verge vegetation.
- H Consider realigning the fence to beyond the floodway margin to minimise the risk of it being washed away during flood events.
- H Encourage landholders to become involved in the Ribbons of Blue program, to investigate aquatic fauna diversity and populations. Monitor invertebrates periodically.
- H Join the WA Museum FrogWatch program and start to record frog species heard, frequency and any other related information.

Other issues

- O Stockpile debris for burning in the centre of the paddock and monitor to ensure that the fire does not escape into foreshore reserves or remnant bushland.

- O Develop an information brochure or obtain existing leaflets from the Department of Conservation and Land Management, Water and Rivers Commission and Agriculture WA and provide to all landholders adjoining river reserves or with waterways through their properties.
- O Develop and implement an intensive feral animal control program to try to eradicate feral pigs and deer. It may be worthwhile investigating opportunities to run hunting tours for experienced people. This would need to be investigated thoroughly to ensure that only hunters with appropriate backgrounds and experience are invited. Further, all landholders in the region would have to agree.
- O Minimise use of fire in the foreseeable future to help long-lived plants that do not respond well to fire to regenerate and return to the region.





SECTION 12: GREENOUGH RIVER UNNAMED POOL MAP 1**Length of section (m):** 250m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 May 2000**Nearest road access:** Minnenooka Road**Summary of river health:**

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Good A	Moderate B	Very Good A	Moderate B	Very Good A	Very Good A

Bank stability

This section of the river contains a significant river pool. The channel bank stability was excellent with the margins dominated by exposed rocks. The river valley has localised soil disturbance caused by feral pigs. There are no significant sediment plumes within the river itself, however there were some coarse white sediment plumes on the margins of the floodplain.

The right bank was steep while the left had a slight slope, grading up to moderate slope up the river valley.

Comments

The nature of the landform protects this area from widespread erosion or damage from flood events. The feral animal activity, and evidence of livestock in the river system, may contribute to localised loss of soil and vegetation cover. This may ultimately cause some of the large trees lining the waterway to fall in, however the pool will not change significantly.

Vegetation

The vegetation is relatively consistent, with the pool fringed by patchy (20 – 80% cover) Swamp sheoak (*Casuarina obesa*) with a continuous (> 80% cover) understorey of Shore rush (*Juncus kraussii*), Spiny flatsedge (*Cyperus gymnocaulos*) and occasional dense patches of Bare twig rush (*Baumea juncea*). The Lake club sedge (*Schoenoplectus validus*) grows in dense groups. The exposed granite on the left bank is dominated by open Lesser bottlebrush (*Callistemon phoeniceus*) shrublands with occasional Mohan (*Melaleuca viminea*) and Broom bush (*M. uncinata*) while the right bank is more open. This bank has Saltbush (*Atriplex* sp.) and considerable cover provided by the introduced Annual Wimmera ryegrass (*Lolium rigidum*).

The verge vegetation is patchy with uncommon mature River gum (*Eucalyptus camaldulensis*), alternate

patches of a diverse range of wattles including Kurara (*Acacia tetragonophylla*), Wait-a-while (*Acacia colletioides*), Wodjil (*Acacia neurophylla*), Mimosa bush (*Acacia farnesiana*) and occasional Jam (*Acacia acuminata*). Hedgehog hakea (*Hakea erinacea*), Stand back (*Hakea preissii*), Honey bush (*Hakea lissocarpa*) and Camphor myrtle (*Baeckea camphorosmae*) occur spasmodically. There are also dense stands of Spiked scholtzia (*Scholtzia involucrata*) and Tamma (*Allocasuarina campestris*). The understorey on the verge is dominated by Lupins (*Lupinus cosentinii* and *L. angustifolius*), Couch (*Cynodon dactylon*) and annual grasses such as Blowfly grass (*Briza maxima*) and Wild oats (*Avena fatua*), although occasional native species including *Wahlenbergia* spp., *Desmoclados myriocladus* and *Lyginia imberbis* persist. One species of *Chaemescilla* is also present.

Comments

Localised weed control would benefit this foreshore area and help to maintain the integrity of this river section. It will be important to establish clearly defined access points to minimise widespread trampling of the understorey. It is possible that greater damage could occur than benefit gained if the weed control is not managed well.

Stream cover

There is considerable stream cover provided by the dense Swamp sheoak (*Casuarina obesa*), instream Lake club sedge (*Schoenoplectus validus*) and Shore rush (*Juncus kraussii*) and Spiny flatsedge (*Cyperus gymnocaulos*) on the banks. Large woody debris, filamentous and epiphytic algae (which both grow attached to rocks) and instream cobbles (rocks) all provide excellent cover for fauna instream.

Comments

Protecting and maintaining the vegetation cover will secure the current status of this area. Any activity that



disturbs the vegetation cover and extent will significantly impact on stream health.

Habitat diversity

The habitat diversity was excellent as well. The water in the waterway was clear and light brown and the channel is > 1.5 m in depth. The leaf litter and material, instream logs and rocks all provide suitable habitat for aquatic invertebrates. Approximately 40 species of invertebrates were observed, including Caddisfly larvae, three species of aquatic snails, a bivalve, seven species of dragonflies, four species of fish including Western minnow (*Galaxid*) and the introduced Mosquito fish (*Gambusia*). Waterbirds observed during the survey included grebes, crakes, Coots, Greater egrets, Little black cormorant, Great cormorant, White-faced heron, Australian darter and Wood and Pacific black Ducks. Many woodland bird species were also identified with Red-winged blue wrens, Port Lincoln parrots, Willy wagtails, Firetail finches, Red-capped and Hooded robins noted.

The terrestrial and aquatic invertebrate life was prolific. Eight types of spider, multiple species of dragonflies and damselflies, three species of aquatic snail and numerous types of fly occurred consistently around the margins of the pool.

Comments

The water is slow moving, however the extent of instream vegetation facilitates aeration of the water. The emergent rushes and sedges also provide for aquatic invertebrates that emerge from the water for a flying phase. Protecting the instream and emergent vegetation will help to support the fauna populations. The extent of verge vegetation, the surrounding shrublands and the diversity of fauna correlates with the riparian fauna.

This site can be used to help landholders identify a healthy foreshore environment. This section retains the necessary values to design and implement other revegetation works in the area. This area will also reflect any changes to groundwater conditions including higher water levels and salinity fluxes. The diversity of habitats here also provides a node from which seed and juvenile animals can disperse downstream to recolonise other areas.

Other issues

The pool occurs within a reserve. The reserve is fenced along its boundaries and was in excellent condition when surveyed. There was no evidence of cattle, however there is some evidence of feral pigs and deer.

Suggestions

Bank stability

- B Continue program to control feral pigs and deer, and stock access to protect the vegetation cover in the riparian zone.

Vegetation

- V Remove some of the dead wattles and woody debris from adjacent to the fence to protect fenceline from damage.
- V Construct a firebreak on both sides of fences by realigning fence to the outside of current track. This will provide a wider barrier between paddock and the remnant vegetation.
- V Continue control of feral pigs, deer, cats and foxes and investigate alternative control techniques particularly for the deer and pigs.
- V Continue stock exclusion practice to reduce:
 - stock loss;
 - the need for fencing across the river; and
 - damage to vegetation.

Stream cover

- S Protect the remnant vegetation in the area from clearing, fire and/or other activities that will increase degradation.

Habitat diversity

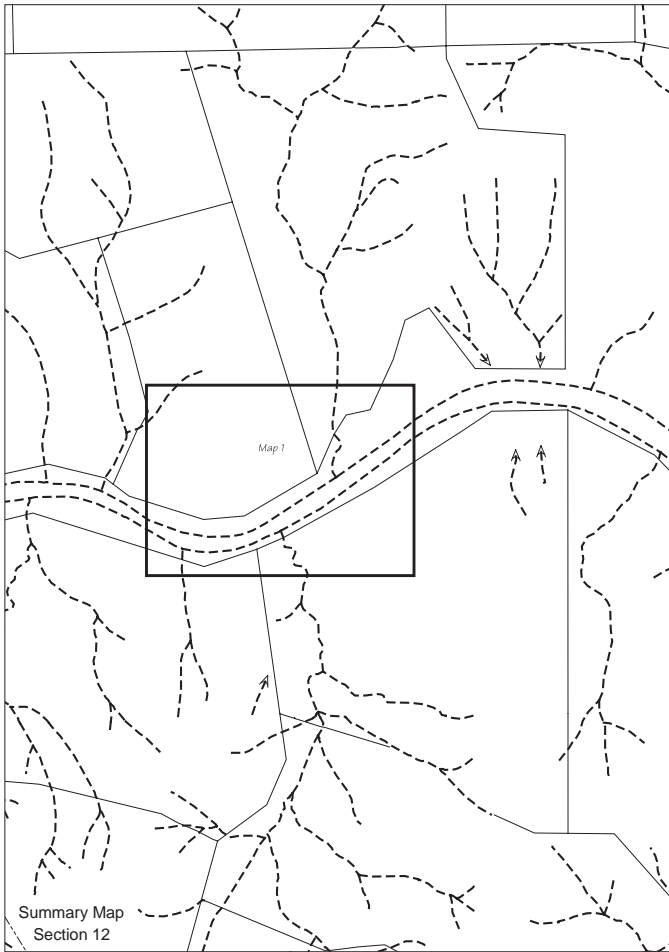
- H Undertake a survey of the aquatic and terrestrial invertebrates to obtain baseline data, against which future studies can be compared.
- H Monitor the health of this remnant annually to determine whether or not there are any significant changes to the foreshore health.



Other issues

- Investigate the feasibility of establishing a minor walk trail along this river section with a picnic spot

provided at this pool. This would enable bird watchers and people interested in local fauna to enjoy this location.



SECTION 13: ELLENDALE POOL REGION MAPS 1 – 12**Length of section (m):** 14,490m**Recorders' names:** N Siemon and T Rebola**Date surveyed:** 23-24 May, 5 October 2000**Nearest road access:** Ellendale Pool Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Very Good A	Moderate B	Very Good A	Very Good A	Very Good A

Bank stability

The main river channel ranges from less than 3 m wide to more than 40 m wide, with some braided sections. The channel bed falls through a series of low steps and rocky spillways. The channel banks rise on slight to moderate slopes for much of the river length, except on the outside curve of the powerbends, where the bank slopes are very steep. There are nine substantial pools in this section, the best known of these being Ellendale Pool. Steep bluffs characterise the outer curves of the powerbends in the river valley and alternate through the landscape. There are no significant sediment plumes within the river itself, however there were some coarse white sediment plumes on the margins of the floodplain. In some locations sediment deposits have been colonised by rushes and sedges. There is a river crossing that impedes flow from the pools at the downstream end of the section. The parking area at Ellendale Pool contributes runoff directly into river, and suffers from some minor erosion.

There are a limited number of erosion rills forming down the steep bluffs, where there are clearly defined stock tracks and in areas lacking vegetation cover. The bluffs are conglomerate, laterite based or with granitic screes.

There is one area of severe erosion in the upstream end of this section. There are numerous dead and living trees that have been undermined. This section lacks vegetation cover and appears to be a preferred stock camping and loafing area.

Comments

The nature of the landform protects this area from widespread erosion or damage from flood events. The feral animal activity, and evidence of livestock in the river system, is exacerbating erosion and contributing to localised loss of soil and vegetation cover. This may ultimately cause some of the large trees lining the waterway to fall in. Where the impact of stock can be

seen for sections greater than 150 m, it is considered to be an issue. The threat to the river pools of being infilled by mobile sediment is significant. Recreational pressure in the Ellendale Pool area is also causing localised erosion.

Vegetation

The overstorey is continuous (> 80% cover) along each bank and is broken by large pools. Dominant species are Swamp sheoak (*Casuarina obesa*) and Mohan and Swamp paperbark (*Melaleuca viminea* and *M. raphiophylla* respectively). River gums (*Eucalyptus camaldulensis*) are present in the upstream parts of this section. Swamp sheoak (*Casuarina obesa*) occurs in dense stands periodically along this section. The extent of overstorey varies from less than two rows of trees to more than 50 m either side of the river. Occasional Swamp banksia (*Banksia littoralis*) are present. There is an area where there are many dead and dying trees.

The middlestorey is patchy (20 – 80% cover) with a mosaic of dense stands of Coojong (*Acacia saligna*) and Broombush (*Melaleuca uncinata*) interspersed amongst the woodland. The emergent rush, Lake club rush (*Schoenoplectus validus*) is present, indicating water permanency.

Native plants dominate the understorey, although the length of time this dominance can be maintained is unknown under the current management systems. Diverse native rushes and sedges including Bare twig rush (*Baumea juncea*), Spiny twig rush (*Cyperus gymnocaulos*), Shore rush (*Juncus kraussii*) and Saw sedge (*Gahnia* sp.) are present. The introduced annual grasses Annual Wimmera rye (*Lolium rigidum*) and Wild oats (*Avena fatua*) are common, while there are patchy occurrences of Wild radish (*Raphanus raphanistrum*) and Flatweed (*Hypochaeris radicata*). There is some African lovegrass (*Ehrharta calycina*) present along the roadways. Doublegee (*Emex australis*), Pimpernel, Dandelions (*Arctotheca*



calendula), Cape weed (*Arctotheca calendula*), Paterson's curse (*Echium plantagineum*) and Lupins (*Lupinus* spp.) are prevalent beyond the riparian zone. Saffron thistle (*Carthamus lanatus*) is present in clusters on the verge, and also infrequently within the riparian zone.

Dodder laurel (*Cassytha* sp.) is present periodically.

There are some significant stands of verge vegetation extending to the top of many of the small rocky hills and bluffs.

Comments

Managing and reducing disturbance factors is important to enable protection of the riparian and verge vegetation in the long term. Processes that encourage degradation of the foreshore need to be minimised through increased monitoring of use of the area. Selective removal of weeds, designating access to reduce indiscriminant trampling and possibly installing signage to encourage visitors to enjoy this region while protecting the area's values would help.

There are some parts of this section where the vegetation has been reduced to a single row of trees over an understorey of annual grasses and pasture weeds. The management practices in these areas need to be modified to ensure the long-term survival of vegetation. The area with many dead and dying trees is also of concern as it correlates with a seep. This indicates that the groundwater levels and water quality are changing, becoming increasingly saline.

Stream cover

The continuous overstorey and dense streamside vegetation provides areas of permanent stream cover and shade along the margins of the waterway. The presence of leaf litter and detritus, logs and branches and occasional rocks provides good instream cover.

Comments

Protecting and maintaining the vegetation cover will secure the current status of this area. Any activity that disturbs the vegetation cover and extent will significantly impact on stream health. The instream woody debris is generally not exacerbating erosion.

Habitat diversity

The water in the waterway was clear and light brown and the pools up to < 1.0 – > 5 m deep. The leaf litter and material, instream logs and rocks all provide suitable habitat for aquatic invertebrates. The water is slow moving, however the extent of instream vegetation facilitates aeration of the water. The emergent rushes and sedges also provide for aquatic invertebrates that emerge from the water for a flying phase. There is sufficient emergent vegetation for insects such as dragonflies, damselflies and other large creatures that need debris or plants sticking out of the water to break the surface tension, to leave the water. These animals develop their wings in the water and then when they crawl out, they need to rest and dry their wings.

There were large numbers of predators such as orb weaver spiders in this section, which is indicative of good waterway health. Healthy ecosystems retain large invertebrate predators such as spiders. Woodland birds and other vertebrate fauna such as frogs then feed on these animals. Some fish were observed during the survey. The dense streamside vegetation is suitable for terrestrial invertebrates as outlined above, and vertebrates such as frogs and lizards. The continuous overstorey and dense cover provides nesting and roosting sites for birds.

Comments

This site can be used to help landholders identify a healthy foreshore environment. Other revegetation works in the area can be designed to attain similar values. This area will also reflect any changes to groundwater conditions including higher water levels and salinity fluxes. The diversity of habitats here also provides a node from which seed and juvenile animals can disperse downstream to recolonise other areas.

There are comparative areas with minimal vegetation cover, lacking the diversity.

Other issues

Ellendale Pool is a popular recreation area. Some facilities are available for recreational users including toilets, barbecues and information signage. The signage relates principally to the risk of amoebic meningitis and cautioning against swimming.



Fencing is discontinuous along the river section, and where it is present is in variable condition. The unfenced sections that correspond with poor vegetation extent and quality need to be fenced on the outside margin of the floodplain to encourage natural regeneration. This is critical in the upper reaches of the section covered by this description.

Foreshore reserves and conservation reserves are present and form a continuous band in this section. Some landholders do not recognise the presence of the reserve boundary and are grazing and cropping close to the riparian zone. It is appropriate to survey the location of the foreshore reserve boundaries, and liaise with the landholders to encourage some modifications to their current management regime.

The landscape values of this section are superb, and the site lends itself to a walk trail from Ellendale Pool. This opportunity could be investigated if a process to develop a small foreshore management plan for the Ellendale Pool section is undertaken. A management plan would help to establish and manage the existing infrastructure.

Suggestions

Bank stability

- B Review the river crossing with a Water and Rivers Rivercare officer who can provide advice on the design to reduce the downstream and upstream impacts of the crossings.
- B Fence off area where loss of vegetation and bank erosion is severe immediately along the reserve boundary or at the floodplain margin, to exclude stock and reduce trampling.
- B Liaise with officers of the Water and Rivers Commission to address river dynamics in this section.
- B Provide landholders with information packs including Water Notes, Water Facts and relevant materials to support their interest in river management.
- B Investigate the groundwater hydrology and water quality in the zone where salt is accumulating on the surface and there are numerous recent tree deaths.

- B Protect the dense remnant vegetation from disturbance to maintain its function in stabilising the foreshore and floodplain.
- B Monitor the flows in this waterway and changes to the groundwater levels in the catchment.

Vegetation

- V Exclude stock for a period of time where the vegetation is minimal and undertake localised areas of weed control to encourage natural regeneration of instream vegetation.
- V Direct seed or plant rushes and sedges including Shore rush (*Juncus kraussii*), Spiny flatsedge (*Cyperus gymnocaulos*) or the native Saltwater couch (*Sporobolus virginicus*) to provide all year groundcover following fence establishment in the badly degraded areas.
- V Monitor natural regeneration following weed control activities and implement intensive planting programs if required.
- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Focus attention on localised weed control.
- V Commence a program to restore verge vegetation, possibly using this site as a demonstration. Consider making part of the area a 'landscaped zone' to enable use of this site for picnics.
- V Monitor the vegetation health in case changes to the length of inundation and salinity levels result from changing groundwater conditions.

Stream cover

- S Reinforce the plant community by planting overstorey trees where no natural regeneration is occurring.
- S Establish fencing in degraded areas, and increase monitoring of stock while grazing in paddocks adjoining this river section.
- S Undertake weed control around existing clumps of rushes/sedges to encourage their spread and promote stream cover.



- S Protect the remnant vegetation in the area from clearing, fire and/or other activities that will increase degradation.
- S Ensure that designated access points are established for visitors if the area is to be used as a demonstration site.

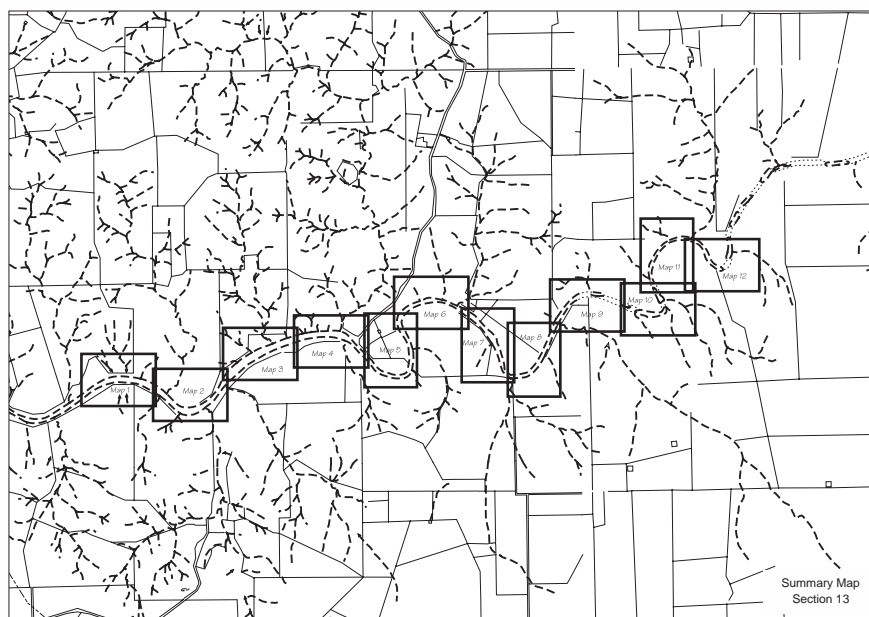
Habitat diversity

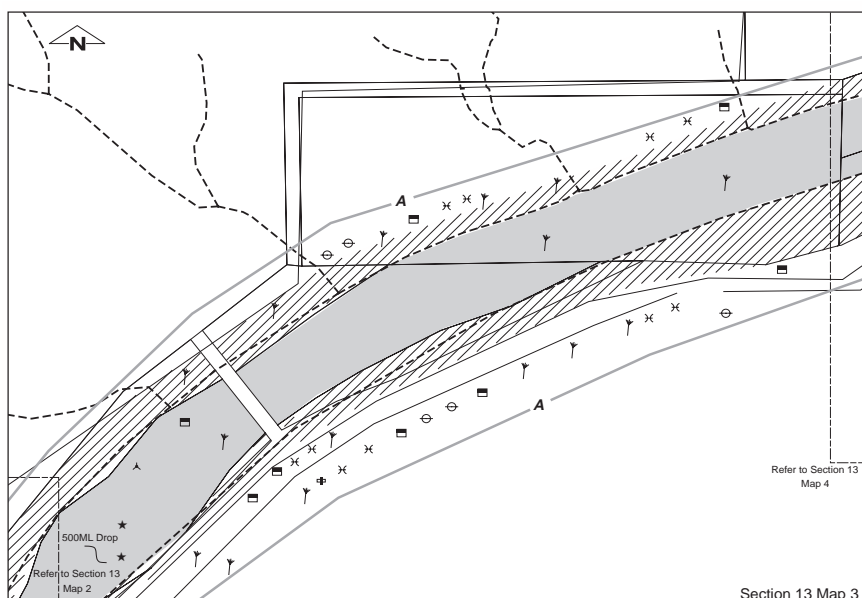
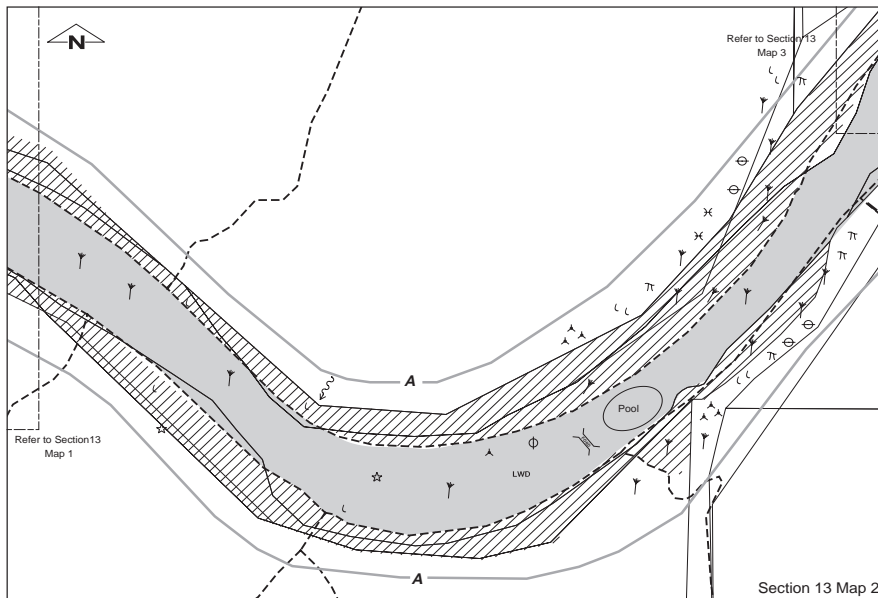
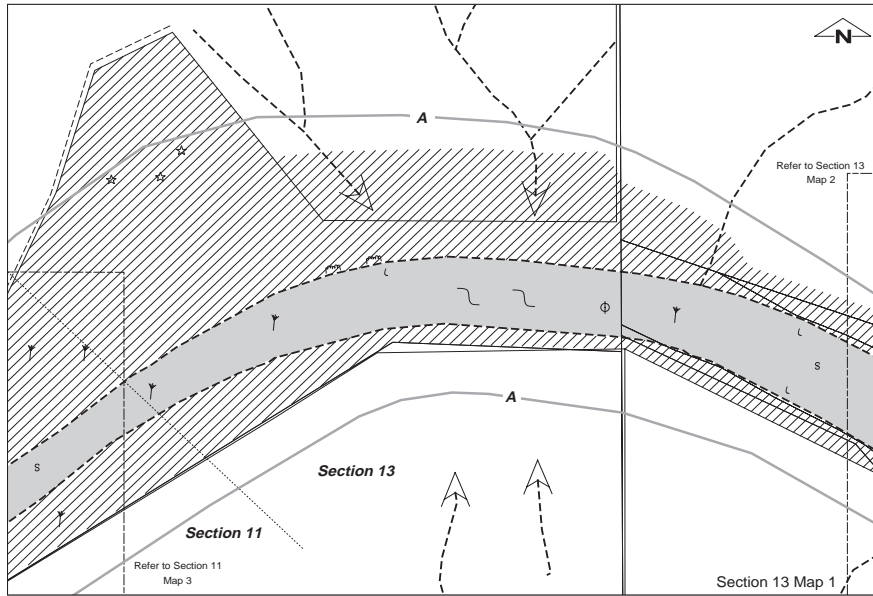
- H Endeavour to restore continuity of vegetation by modifying management practices to encourage natural regeneration processes within the riparian zone and the verge area.
- H Undertake a survey of the aquatic and terrestrial invertebrates to obtain baseline data, against which future studies can be compared.
- H Monitor the health of this remnant annually to determine whether or not there are any significant changes to the foreshore health.
- H Undertake weed control to reduce fire risk and protect habitat diversity.
- H Maintain the fire access track between the crops and the waterway beyond the floodplain of the creek. Use this as a weed control buffer.

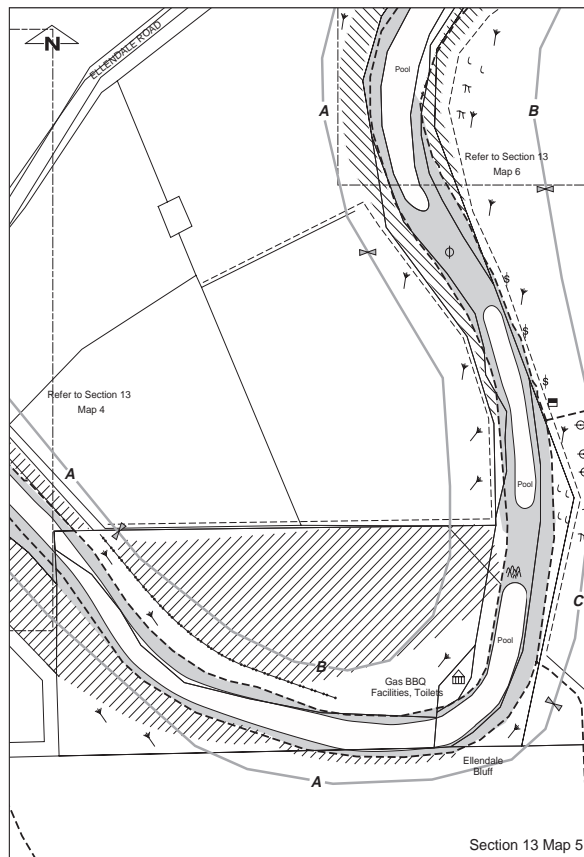
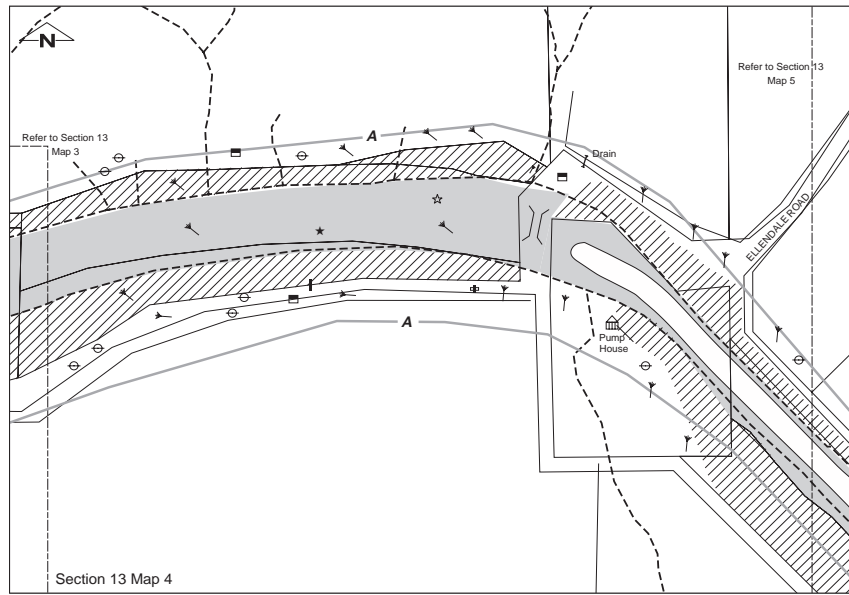
- H Maintain instream features where they do not exacerbate foreshore erosion.

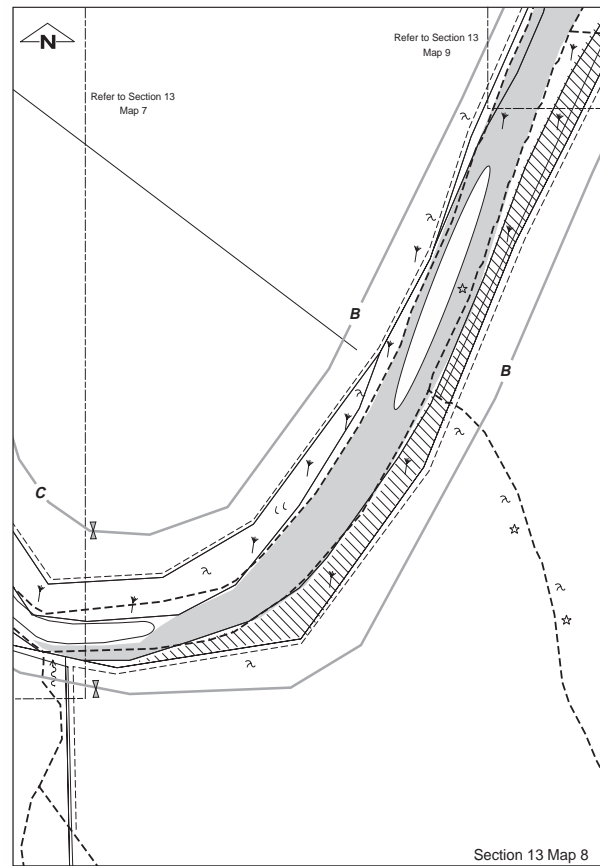
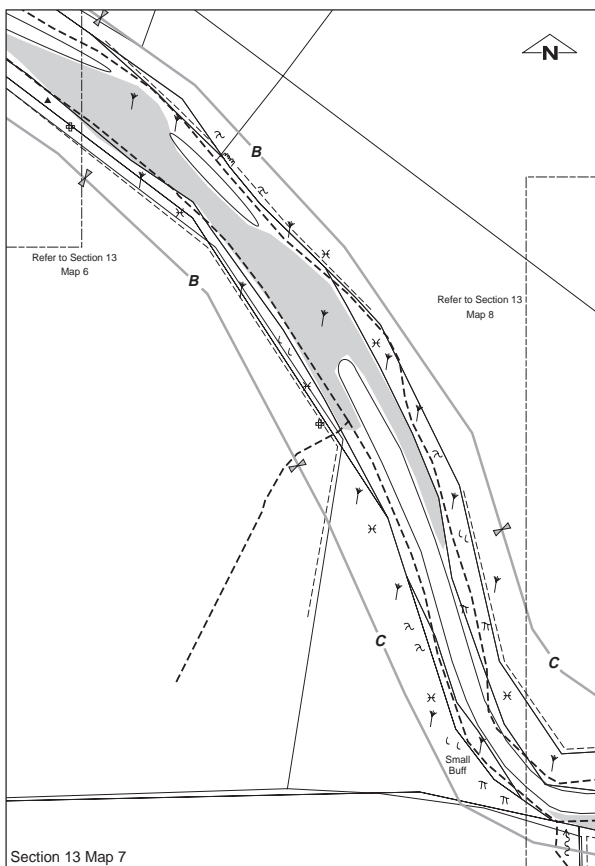
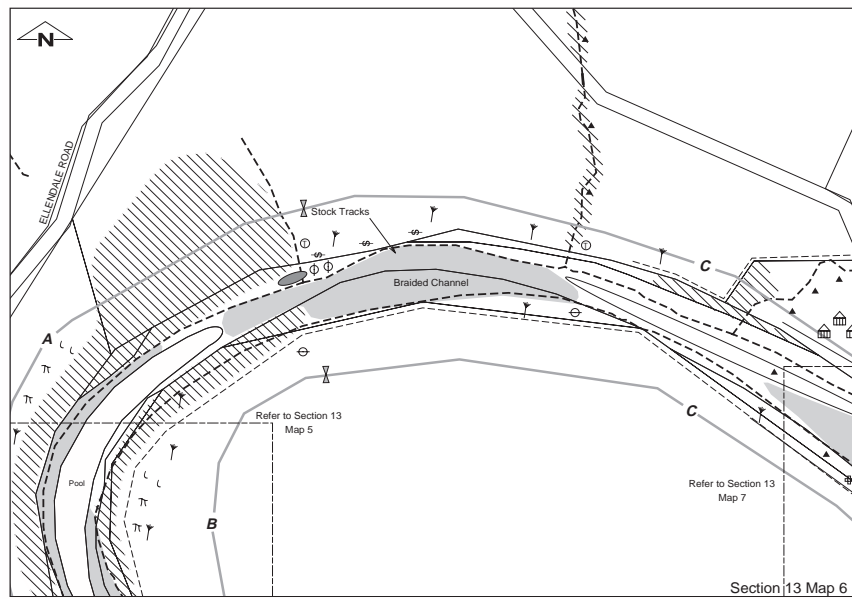
Other issues

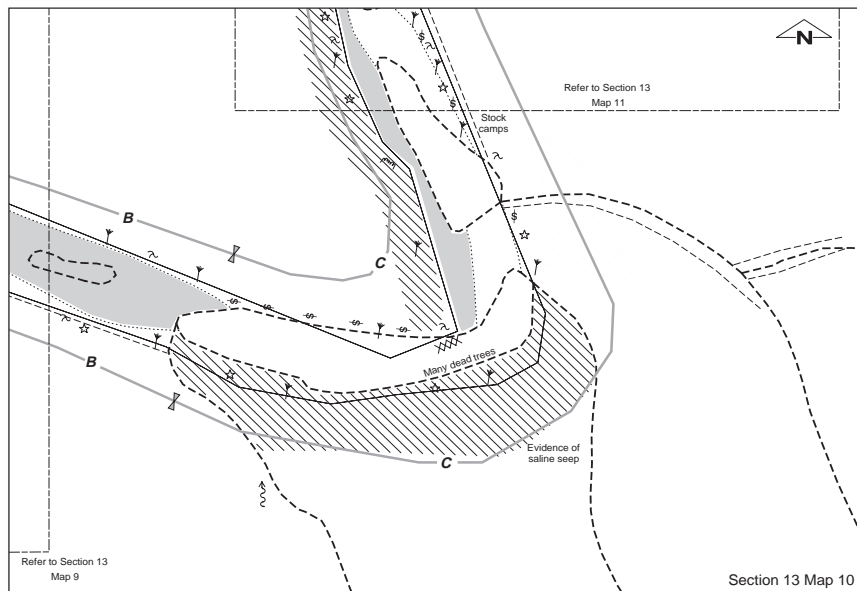
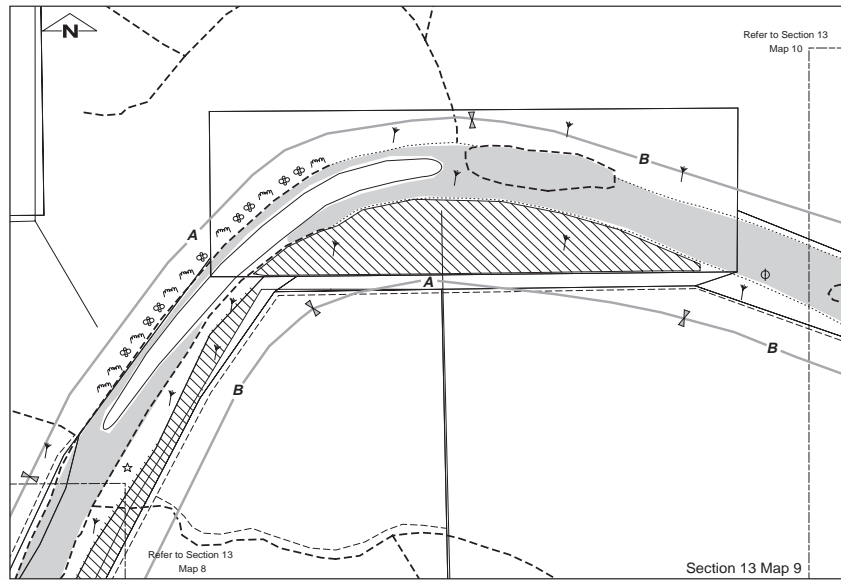
- O Provide non-threatening support and information to landholders about ways in which they can contribute to protecting the river, its banks and the associated vegetation on a one-to-one basis, not a bulk mail out.
- O Seek assistance from Water and Rivers Commission officers and Agriculture WA to develop farm management plans that include the river system.
- O Clarify the reserve boundary location and review the alignment.
- O Consider holding a CleanUp Australia Day working bee to remove as much of the rubbish as possible in a joint project between the landholder, Agriculture WA, Water and Rivers Commission and the Shire of Greenough.
- O Ensure fencing is established prior to stocking again. The preferred alignment is beyond the floodplain of the waterway.
- O Develop a foreshore management plan for the Ellendale Pool region and investigate opportunities to develop a walk trail along part of this river section.

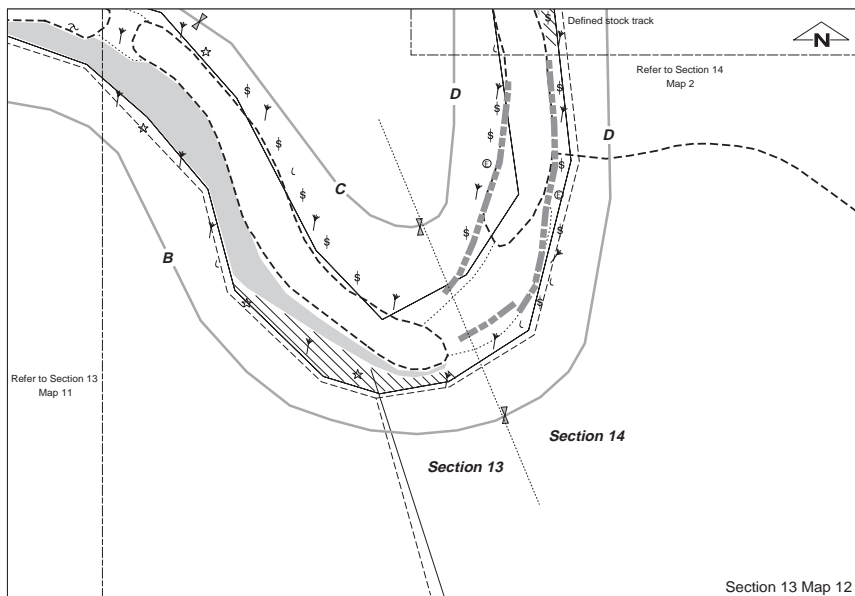
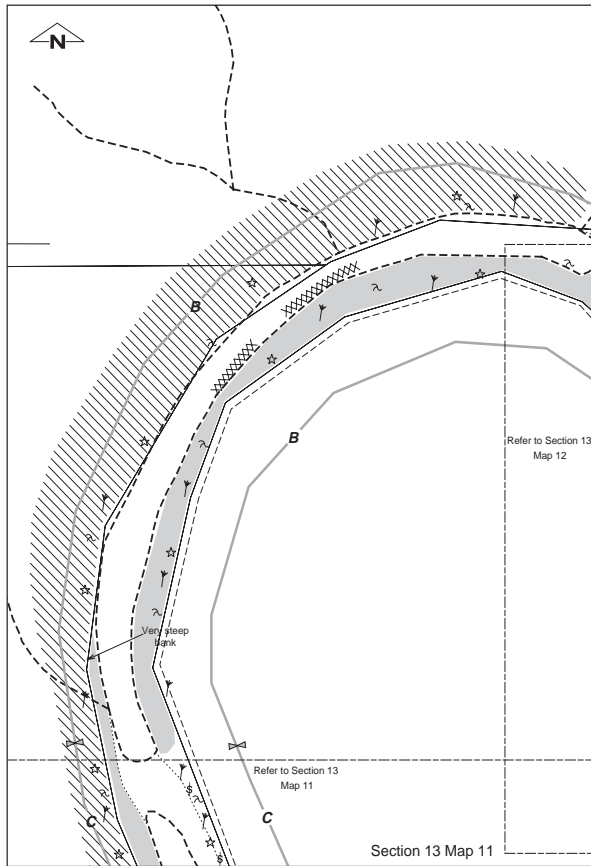












SECTION 14: BLUE POOL AND BEETALYINNA POOLS UPSTREAM MAPS 1 – 6**Length of section (m):** 5,920m**Recorders' names:** N Siemon and T Rebola**Date surveyed:** 5 & 12 October 2000**Nearest road access:** Eradu South Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Moderate B	Very Good A	Very Good A	Moderate B

Bank stability

The Greenough River main channel is 9 - 16 m with steep banks rising to about 1.5 m. The channel is clearly defined in this section although some sections are starting to develop a braided channel form. The floodplain is approximately 80 m wide with the valley slopes rising on a steep gradient. There are rocky slopes with exposed granite or laterite conglomerate. There are ten pools within this section, 50% appear to be spring fed. The extent of these pools varies and ranges from 50 m long by about 15 m wide to 50 m wide and more than 500 m long. Erosion along the foreshore banks is minimal, occurring along less than 5% of the area, and erosion of the floodway is localised (5 – 20%). Focal points of erosion correspond with areas where there is pig damage to the floodplain. Some boulders also occur close to the main river channel. There are four significant mobile sediment plumes adjacent to the main river channel.

Comments

The dense native vegetation across much of the floodplain is successfully protecting the banks from erosion. Because native rushes are cylindrical and long they tend to 'lie down' when peak flows occur. The friction forces associated with the water moving over these plants is sufficient in this case to protect the banks from erosion. This is seen immediately downstream where the instream vegetation has been lost and there are significant areas of erosion.

Vegetation

The overstorey is dominated by River gum (*Eucalyptus camaldulensis*) and occasional dense woodlands dominated by Swamp paperbark (*Melaleuca raphiophylla*). Swamp sheoak (*Casuarina obesa*) occur sporadically. The overstorey is patchy (20-80% cover) due to the presence of shallow soils. The middle storey is also patchy within the floodway (20-80% cover). Tall Labichea (*Labichea lanceolata* subsp. *lanceolata*), Swishbush (*Viminaria juncea*), Mohan

(*Melaleuca viminea*) are also present. One species of *Jacksonia* is present, however many are dead or dying. Other native species occurring occasionally are Coojong (*Acacia saligna*), Winged wattle (*Acacia alata*), Kurara (*Acacia tetragonophylla*) and Grass wattle (*Acacia willendowiana*). The riparian understorey is continuous (>80% cover) and is dominated by Spiny flatsedge (*Cyperus gymnocaulos*), Saltbush (*Atriplex* spp.) and Shore rush (*Juncus kraussii*). Shrubby samphire (*Halosarcia* spp.) is present in low numbers. Introduced couch (*Cynodon dactylon*) occurs periodically in the flood zone. The emergent Lake club sedge (*Schoenoplectus validus*) and Villarsia (*Villarsia capitata*) are present on the margins of two pools, which is indicative of permanent water. Introduced annual grass and pasture species dominate the floodway including Wild oats (*Avena fatua*), Blowfly grass (*Briza maxima*) and occasional clumps of Red Natal grass (*Melinis repens*). Wild radish (*Raphanus raphanistrum*) occurs in dense groups periodically.

Verge vegetation is present for approximately 50% of the section and is very diverse. Assorted *Hakeas* are regenerating in dense stands along this length.

Comments

Localised weed control would benefit this foreshore area and help to maintain the integrity of this river section. It will be important to establish clearly defined access points to minimise widespread trampling of the understorey. It is possible that greater damage could occur than benefit gained if the weed control is not managed well.

Stream cover

The overstorey is relatively narrow, however the continuous understorey overhangs many sections of the river providing some stream cover. In the well-vegetated sections there is considerable leaf material, rocks and branches that provide instream cover.



Comments

Protecting and enhancing the remnant vegetation will contribute to improving stream cover within this section. Monitoring stock access and minimising trampling around persistent pools will also help protect not only stream cover, but the longevity of the pools.

Habitat diversity

Water depth ranged from 0.6 to > 1.5 m in the remaining pools at the time of survey. The water is light brown to dark brown in colour with little suspended material in the water column. The overhanging vegetation, rocks and riffle zones would act to aerate the water while the river flows. The deepest and largest pools at Beatalynna appear to be spring fed and therefore water is likely to be permanent. The springs feeding these pools are fresh, however other pools appear to be saline. Invertebrates with life cycles reliant on water are common in this section, e.g. dragonflies, damselflies, caddisflies and crane flies. The habitat diversity for terrestrial organisms is excellent due to the persisting healthy native understorey and middlestorey. The hollows and branches in the trees provide suitable habitats for cockatoos and woodland birds.

Comments

Anecdotal evidence suggests that poachers often steal eggs and fledglings from this area. All landholders can help to reduce this threat by keeping an eye on the river and its foreshores, and checking access on their properties. The habitat diversity is very good due to the diversity and extent of remnant vegetation, and the permanency of water. It is a good location to monitor changes to groundwater quality and volumes over time, by assessing both the physical characteristics of the major pools and the invertebrate populations within.

Other issues

There is a continuous foreshore reserve and a small conservation reserve managed by CALM. There was considerable evidence of feral cats, pigs and foxes. There was some discarded farm material within the floodway. There is limited access to the river through most of this section with a fire access track on approximately 30% of the length of the foreshore. Fencing is continuous on the left bank but not on the right bank. The fences are generally set back above

the floodway which minimises maintenance requirements. It is unknown, however, whether this alignment reflects the boundary with freehold land. Woody debris and herbicide drums were trapped in the fringing vegetation 2 m above riverbed heights, which provides an indication of flood levels.

Stock was observed in a neighbour's crop due to a lack of fencing on the neighbour's side. The foreshore condition was very poor on the right bank, so fencing would not only help the neighbour protect his crop but also encourage natural regeneration of plants to help stabilise the riverbank and foreshore.

Suggestions

Bank stability

- B Monitor health of the vegetation, and work to increase its extent on the right bank (east side) to reduce the potential for the course of river flow to change in future flow events.
- B Protect the dense remnant vegetation from disturbance to maintain its function in stabilising the foreshore and floodplain.
- B Consider undertaking selective pruning of woody debris where natural dams are forming as a result of widespread deaths of shrubs such as *Jacksonia*.
- B Monitor the flows in this waterway and changes to the groundwater levels in the catchment.

Vegetation

- V Undertake control of the occasional patches of Red Natal grass before this species becomes a significant management issue for the region.
- V Protect the remnant vegetation from excessive stock access and any other disturbances that may reduce the health and extent of this vegetation.
- V Encourage landholders on the right bank to fence off the reserve boundary and encourage natural regeneration through stock exclusion for a period of time.
- V Ensure fire access tracks are installed and maintained on both sides of the river beyond the verge vegetation to reduce the risk of wildfire through this section.



Stream cover

- S Protect the remnant vegetation in the area from clearing, fire and/or other activities that will increase degradation.

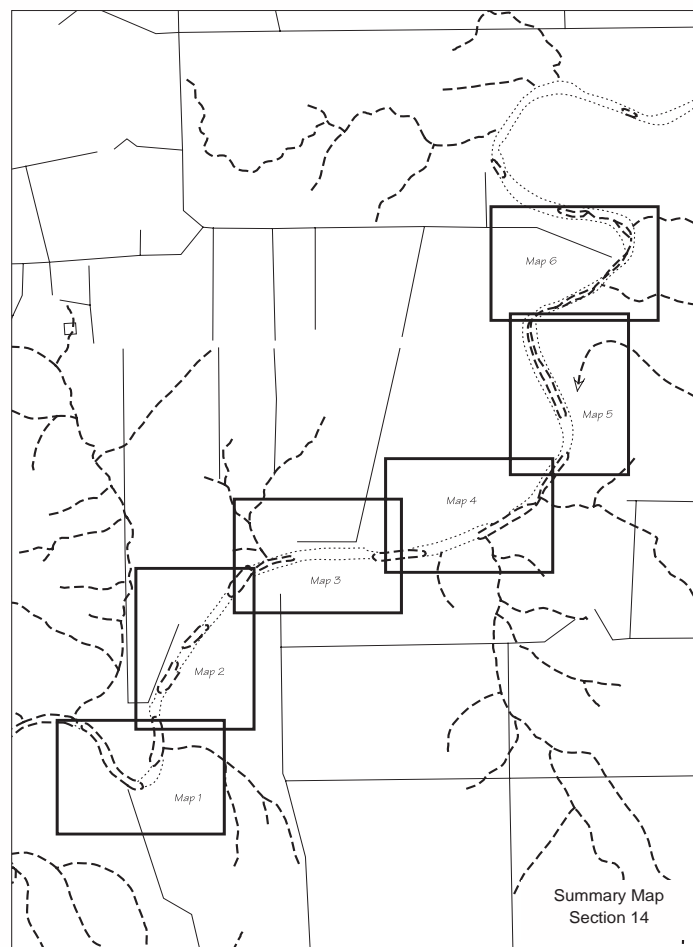
Habitat diversity

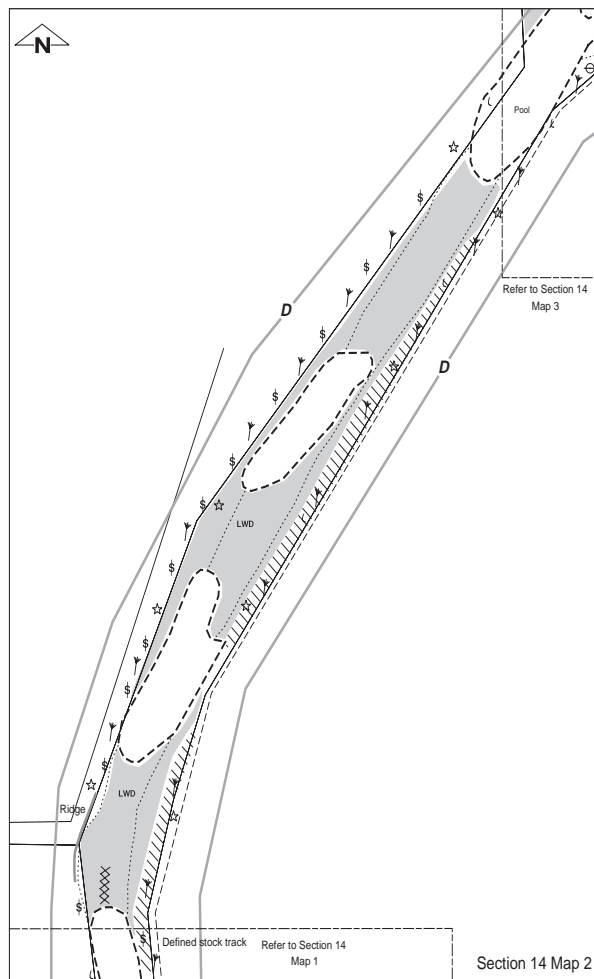
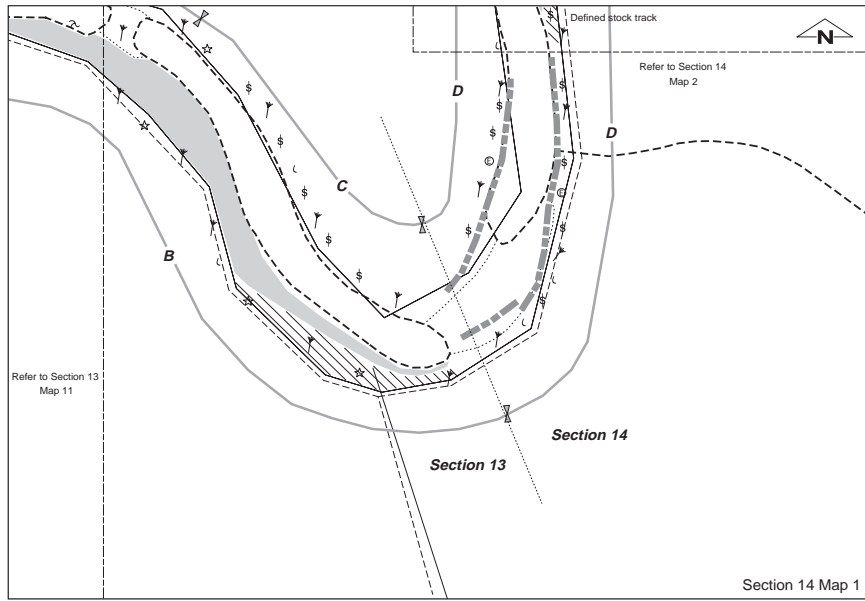
- H Undertake a survey of the aquatic and terrestrial invertebrates to obtain baseline data, against which future studies can be compared.
- H Monitor the health regularly to determine whether or not there are any significant changes to the foreshore health, and modify land management practices as required.

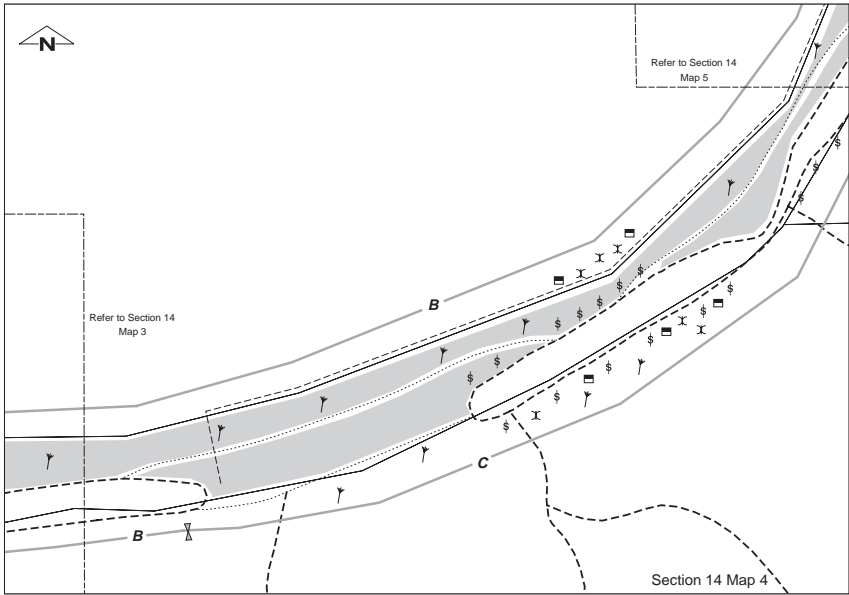
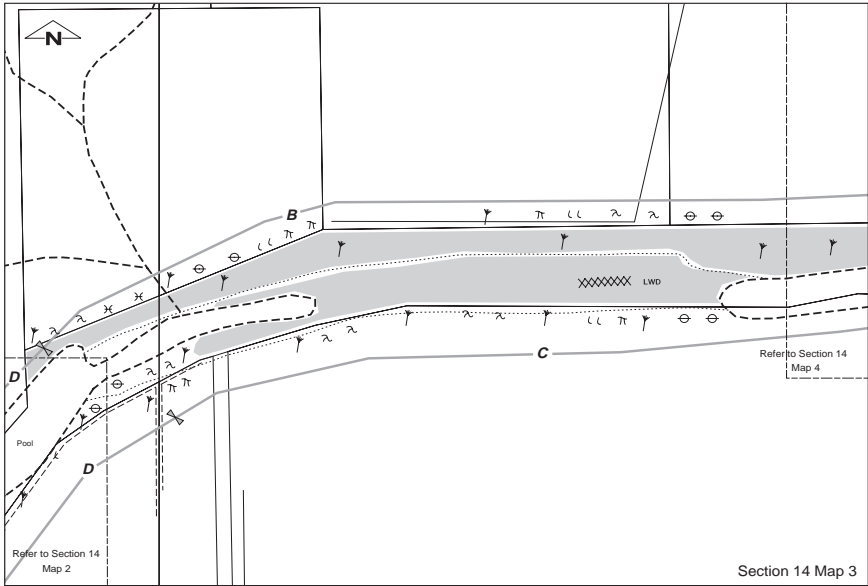
- H Control feral animals on a regular basis.

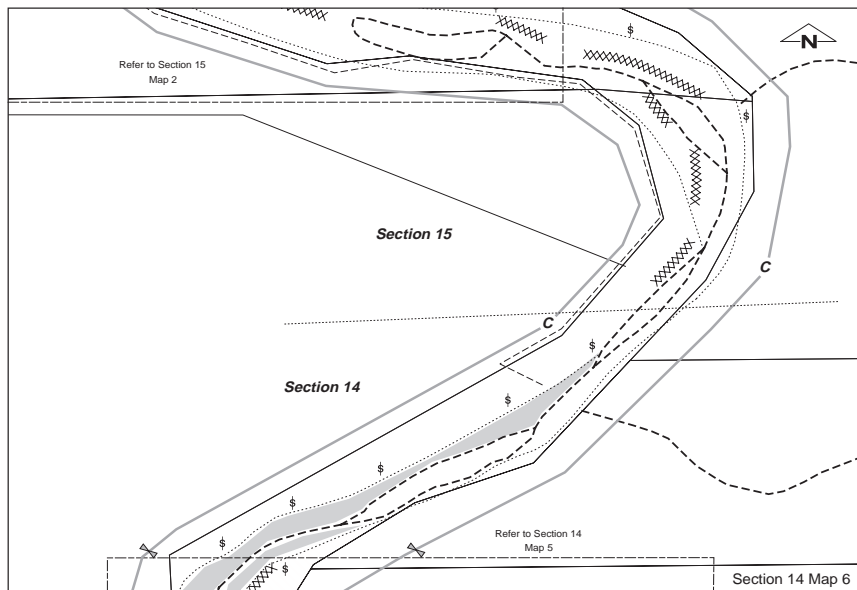
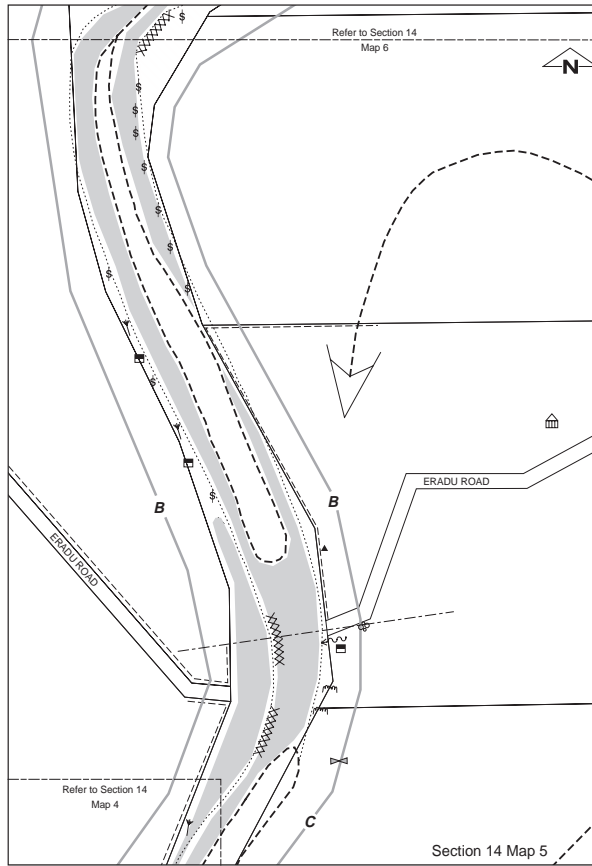
Other issues

- O Encourage landholder to fence off the foreshore reserve, and provide information packs about river management to all landholders.
- O Liaise with Agriculture WA if issues still arise about stock being allowed into neighbouring properties, if no action is taken to control the stock.
- O Ensure fences are maintained adequately to cope with stocking levels.









SECTION 15: ERADU REGION MAPS 1 – 24**Length of section (m):** 29,370m**Recorders' names:** N Siemon and T Rebola**Date surveyed:** 8 & 12 June & 12 October 2000**Nearest road access:** Eradu North Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Very Poor D	Poor C	Poor C	Poor C

Bank stability

The main river channel is very wide (up to 80 m) with sediment plumes spreading the flow into two or more braids in some sections. The channel banks are slight to moderate, having eroded back to a single row of mature River gum (*Eucalyptus camaldulensis*). Erosion is significant occurring along > 50% of the river section. There are occasional strips of persistent understorey that restrict erosion in some sections, however these will inevitably be undermined. Erosion is localised beneath the single row of trees that for the most part defines the width of the river channel. Almost the entire riverbed is composed of mobile, well-sorted white sand, with occasional sections with exposed clay banks. Most of the pools in this section have been filled or are in the process of being in-filled.

The channel banks are mostly sandy in this section, although there are some sections with exposed laterite or calcrete on the powerbends.

There are three gravel ford crossings in this section of the river. The outer bank on the powerbends is characterised by low cliffs. There are numerous substantial blowouts beyond the river channel. There are a considerable number of large trees that have been undermined and have fallen in, and frequent piles of large woody debris are present.

Comments

This river section is highly unstable and the course of river flow is likely to change in the future. The areas prone to flooding are clearly defined and there is some infrastructure at risk. The loss of river pools through sedimentation poses a threat to the survival of many native animals. Many of the piles of large woody debris are exacerbating bank erosion and affecting the way in which sediment is deposited. The considerable undercutting of trees on the river's edge is likely to ultimately result in the persisting trees falling across the main channel. The fallen trees in most cases are

not a major obstruction; however, there are some locations where considerable damage is being caused as a result of the loss of trees.

Vegetation

This section of foreshore has been highly disturbed with a patchy overstorey (20 – 80% cover) and extends only a few metres either side of the Greenough River. Generally the mature River gum (*Eucalyptus camaldulensis*) occur in single rows, or at most four widely spaced rows across the floodway. Occasional Swamp sheoak (*Casuarina obesa*) are present. There are many sick and dying trees throughout this river section and minimal evidence of regeneration. The middlestorey is limited to sporadic occurrences of Lesser bottlebrush (*Callistemon phoeniceus*), Tall labichea (*Labichea lanceolata*) and occasional Coojong (*Acacia saligna*) although there is considerable regeneration of this species. The only middlestorey weed is Black berry nightshade (*Solanum nigrum*).

The understorey is patchy and dominated by annual grasses although occasional dense stands of Spiny flatsedge (*Cyperus gymnocaulos*) occur in small areas. Other relic understorey species identified in the riparian zone are Yellow autumn lily (*Tricoryne elatior*), Native bluebell (*Wahlenbergia communis*) and Mulla mulla (*Ptilotus* spp.). Common flowering weeds are Mint (*Mentha* sp.), Wild radish (*Raphanus raphanistrum*), Lupins (*Lupinus cosentinii* and *L. angustifolius*), Paterson's curse (*Echium plantagineum*), Cape weed (*Arctotheca calendula*), Fleabane (*Conyza bonariensis*), Flat weed (*Hypochaeris radicata*), Saffron thistle (*Carthamus lanatus*) and Pie melon (*Citrullus lanatus*). Many grasses are present including Wild oats (*Avena fatua*), Annual Wimmera ryegrass (*Lolium rigidum*) and infrequent African lovegrass (*Eragrostis curvula*). Verge vegetation is present for < 20% of this river section. The extent was limited and the diversity is moderate.



Comments

The extent and diversity of remnant vegetation is minimal for most of this river section and there is insufficient groundcover to minimise erosion processes. The parts lacking vegetation correlate with the sections with the widest main channel. The few remnants of verge vegetation provide limited cover for fauna and would benefit from protection from grazing. Stock exclusion would also encourage natural regeneration. There appears to be minimal shade/shelter in most paddocks, with stock camping beneath trees in the waterways.

Stream cover

The narrow overstorey provides limited stream cover. The intermittent rocks, logs, branches and some vegetative material in the stream also provide some cover during flow events. There is minimal cover associated with the persisting pools.

Comments

The extent of shading in this river section is insufficient. Protecting the health of the riparian vegetation is a key to ensuring adequate stream cover into the future. The fallen trees and occasional branches are exacerbating erosion, however any that are not exacerbating erosion should be retained for habitat and stream cover.

Habitat diversity

The water within the main channel is not permanent and it is unlikely that the pools exist all year. However it is also likely that there is some sub-surface water movement, as there was considerable evidence of kangaroos digging for water. The water in the pools was generally shallow and clear to light brown in colour. The minimal woody debris within the pool provides some habitats for aquatic invertebrates. The absence of healthy riparian vegetation limits the diversity and extent of suitable habitats for native terrestrial animals. The hollows in the River gum are occupied by Corellas and Pink and grey galahs. One Masked owl was disturbed. The sections retaining healthy vegetation on the verge conversely provided excellent habitat for a high diversity of shrubland birds. The calls of at least twelve species of small shrubland and woodland birds were heard at the time of survey.

Comments

The habitat diversity is minimal in the riparian zone, but the verge vegetation supports a diverse fauna. The lack of vegetation and instream cover minimises the habitat value for fauna. Stabilising the sediment and encouraging natural regeneration will help fauna to utilise the area.

Other issues

Fences were not continuous along each foreshore reserve boundary. In some sections the fences could be realigned to the top of the verge. Generally the fence alignments need to be reviewed where they occur within the floodway. There are irrigation pipes traversing the river.

Suggestions

Bank stability

- B Exclude stock from the riparian zone and reduce general stock numbers to allow the land and vegetation to recover.
- B Liaise with landholders to encourage them to install fencing at least 15 m back at the top of the verge where not present.
- B Liaise with Water and Rivers Commission and Agriculture WA to investigate options to stabilise erosion rills.
- B Initiate direct seeding and tree planting projects using species listed from top of the verge to the valley floor in manageable nodes.
- B Develop a farm plan that addresses the impact of stock on this unstable environment.

Vegetation

- V Focus weed control on Saffron thistle, Paterson's curse, Pie melon and Lupins in the foreshore and in the neighbouring properties.
- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.



- V Plant dense clumps of shrubs such as wattles and *Hakeas* 1.5 m away from fencelines, in areas where stock can be excluded from the foreshore environment.
- V Support natural regeneration of the River gum by excluding stock from foreshore areas between May and March the following year – and controlling weeds for a 1 m diameter circle around any seedlings of native plants that appear.

Stream cover

- S Retain large woody debris instream where it is not impacting on the flow dynamics of the river i.e. deflecting the flow into the riverbanks.

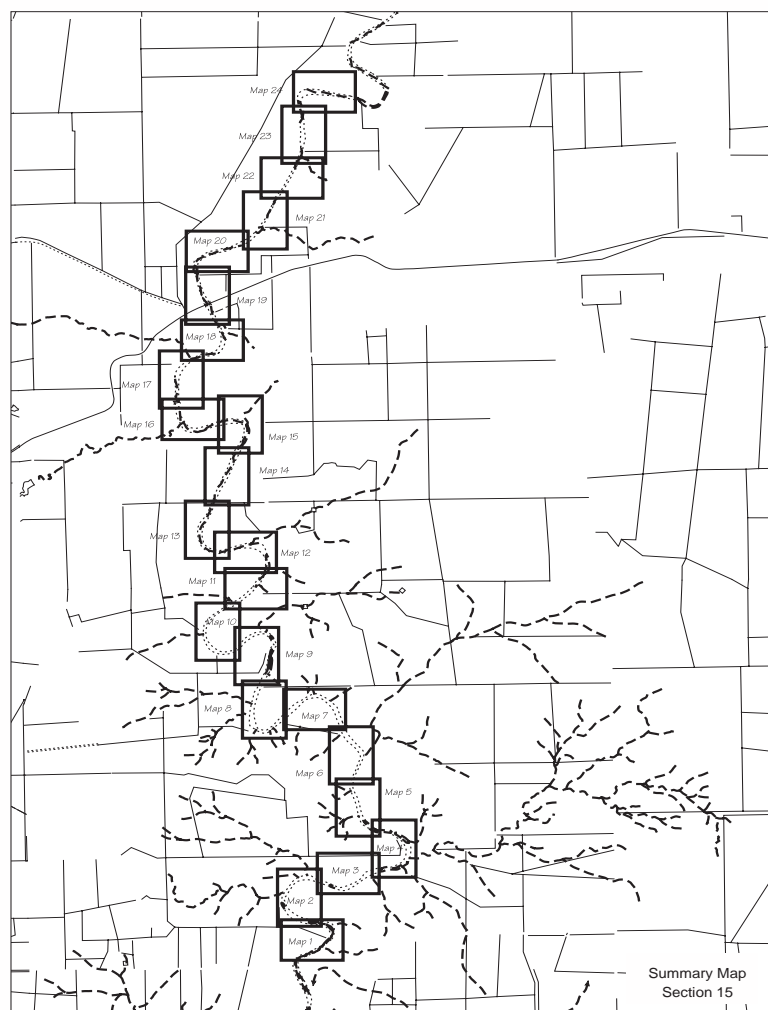
Habitat diversity

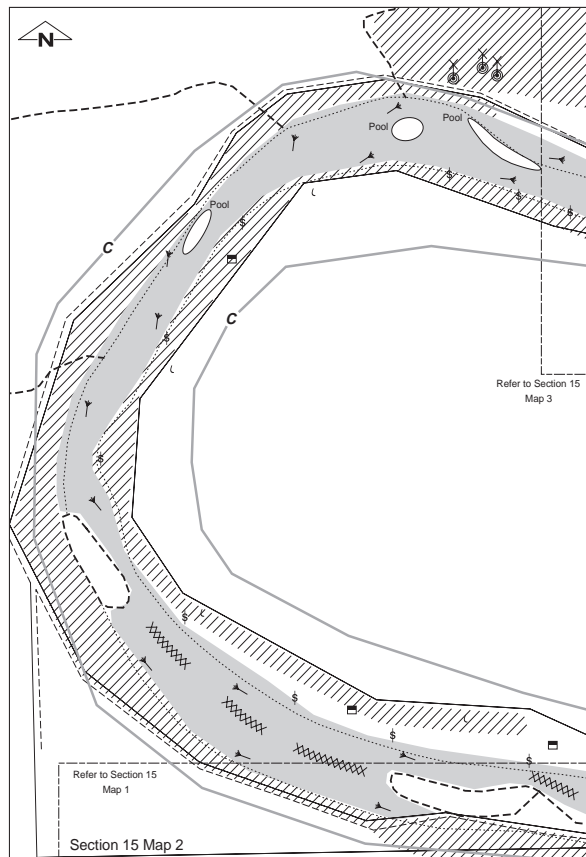
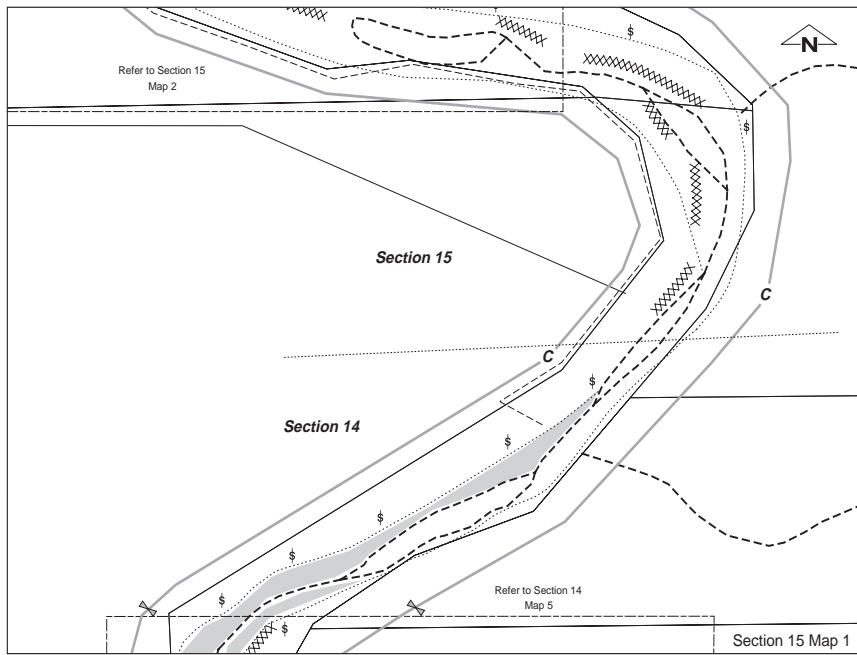
- H Determine the priorities for the river environment and encourage landholders to support the natural values of the river.

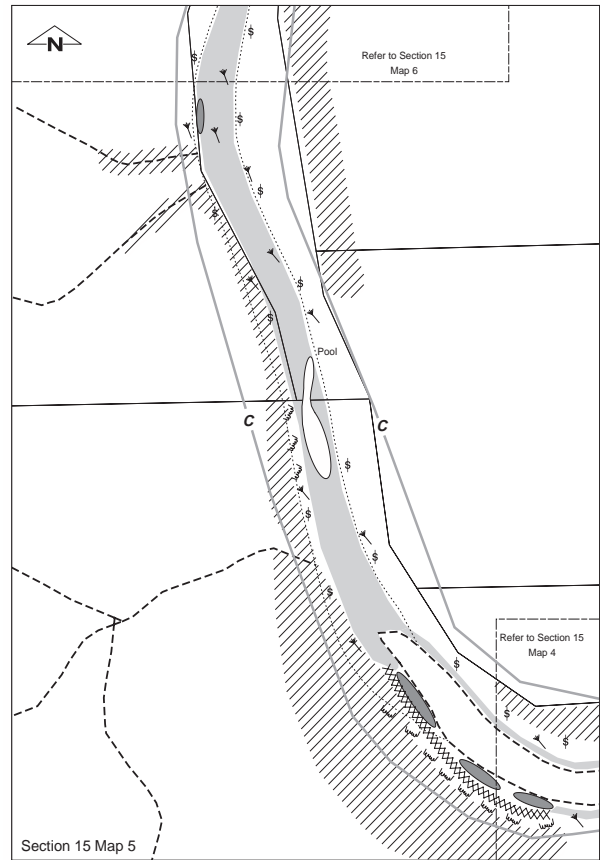
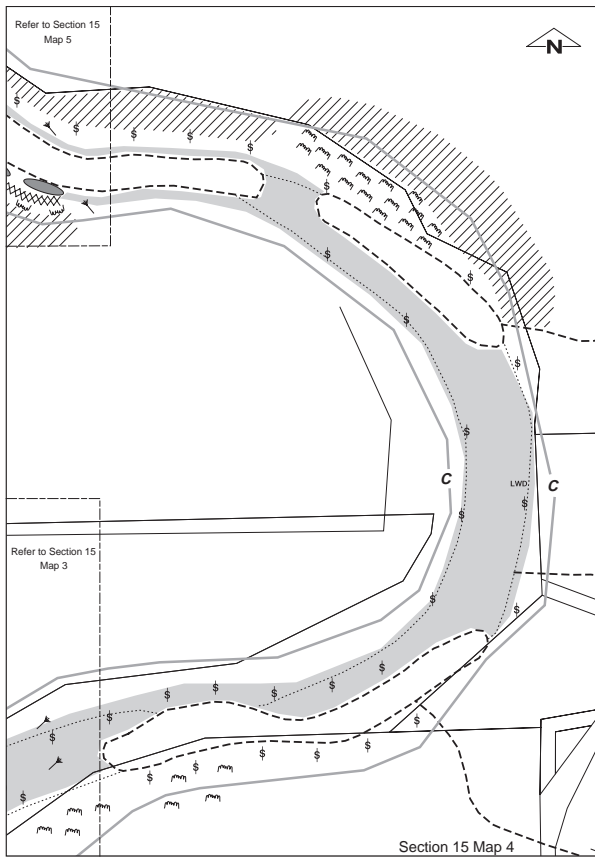
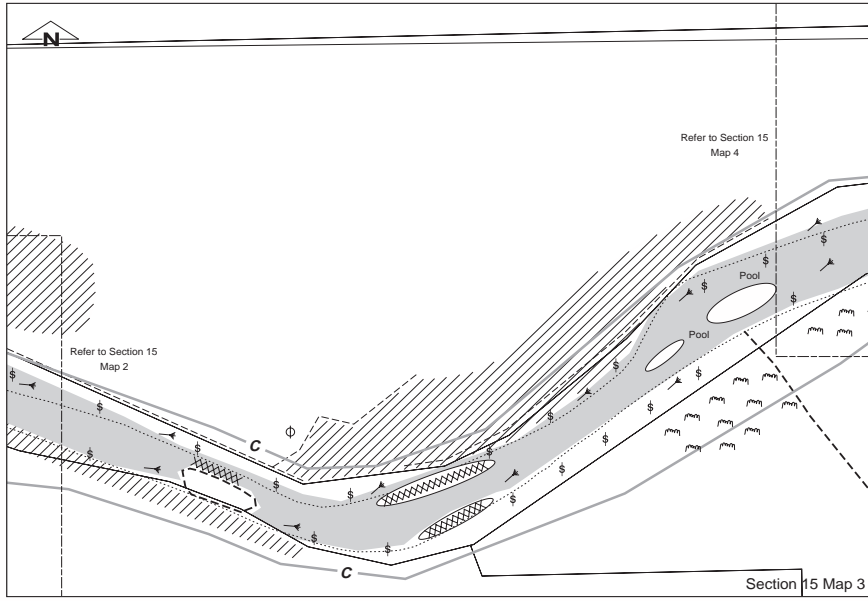
- H Encourage landholders to plant verge vegetation where it is feasible to protect plants from grazing animals.
- H Provide information brochures to landholders about the benefit of maintaining vegetation along the rivers.

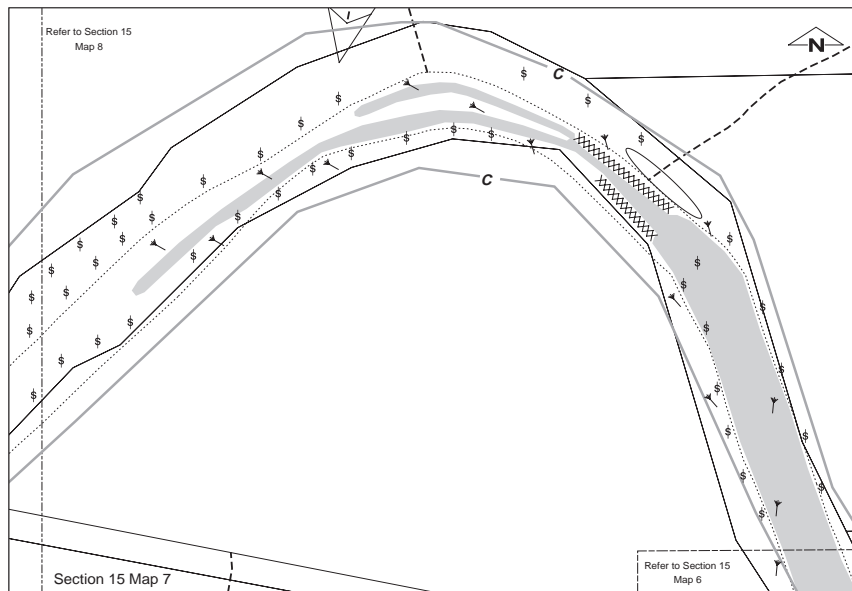
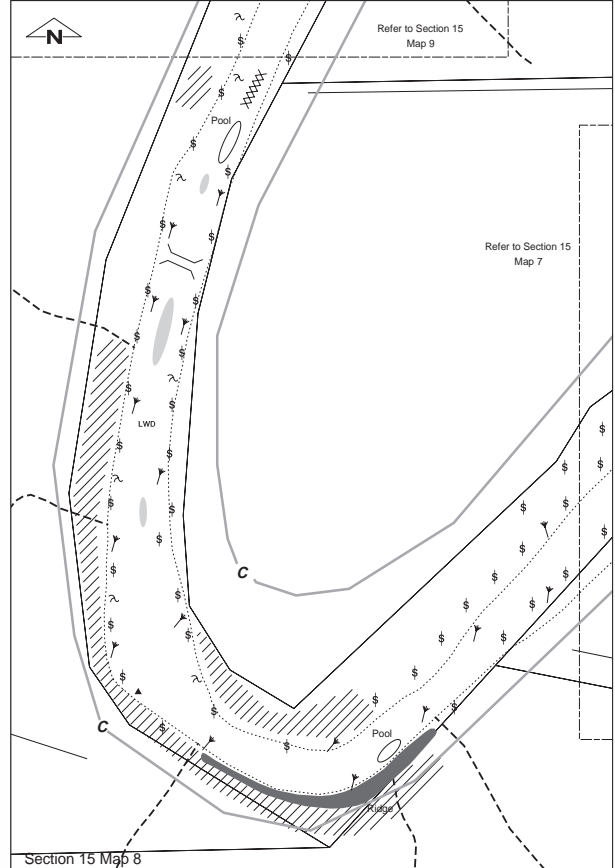
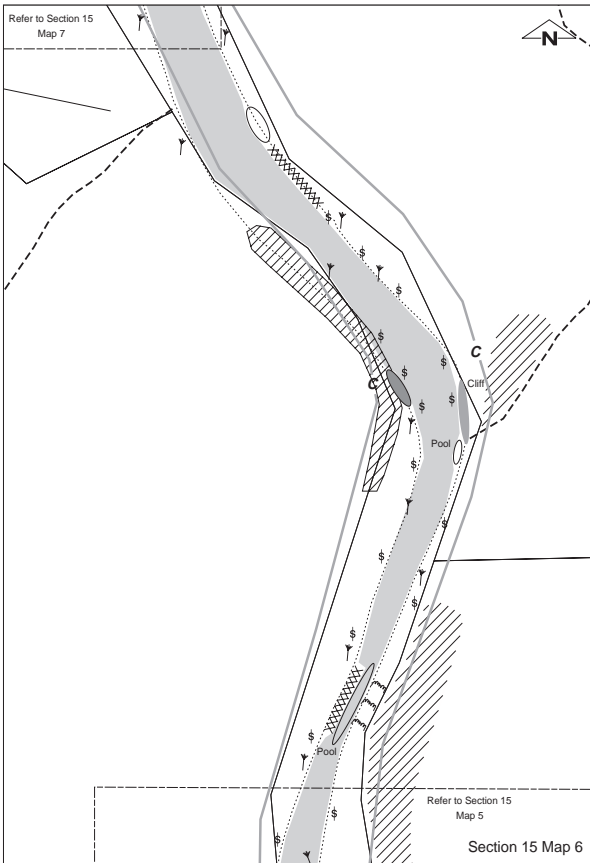
Other issues

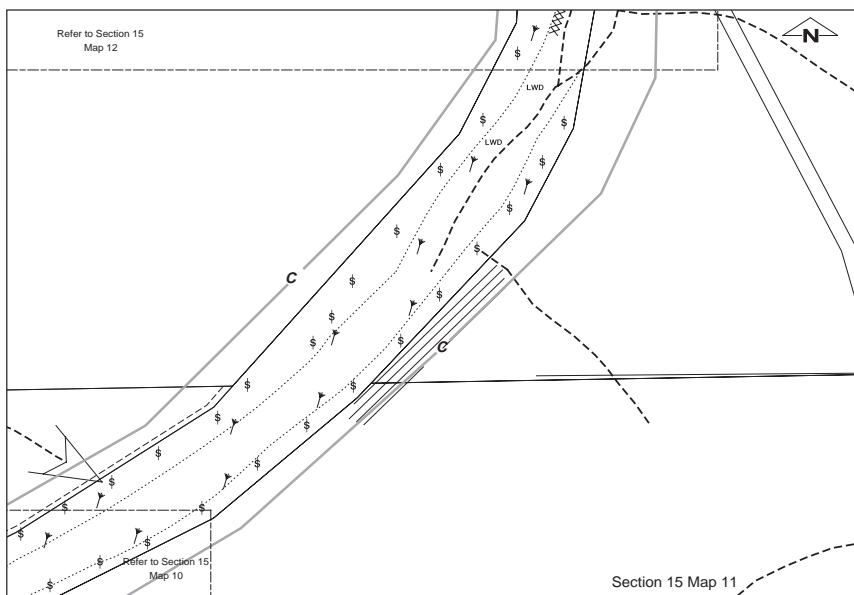
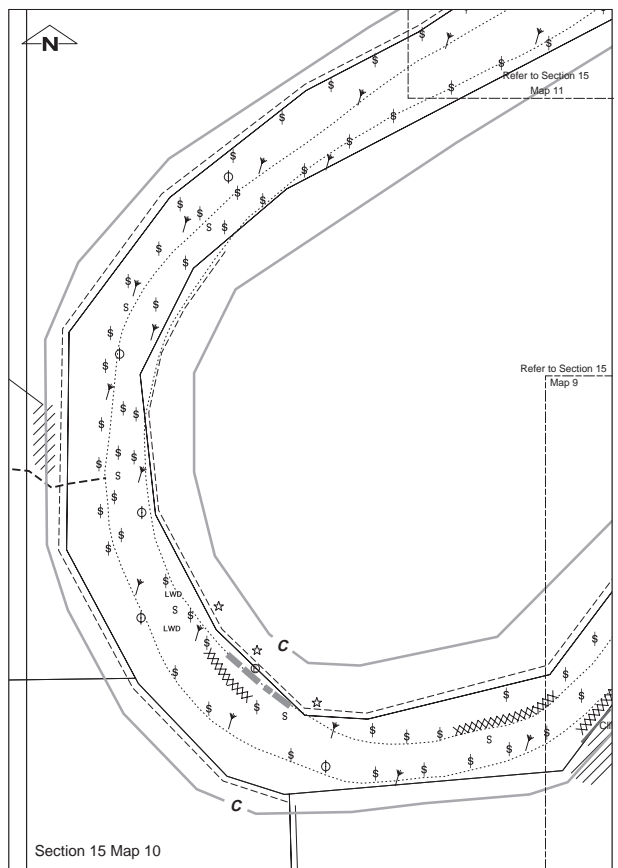
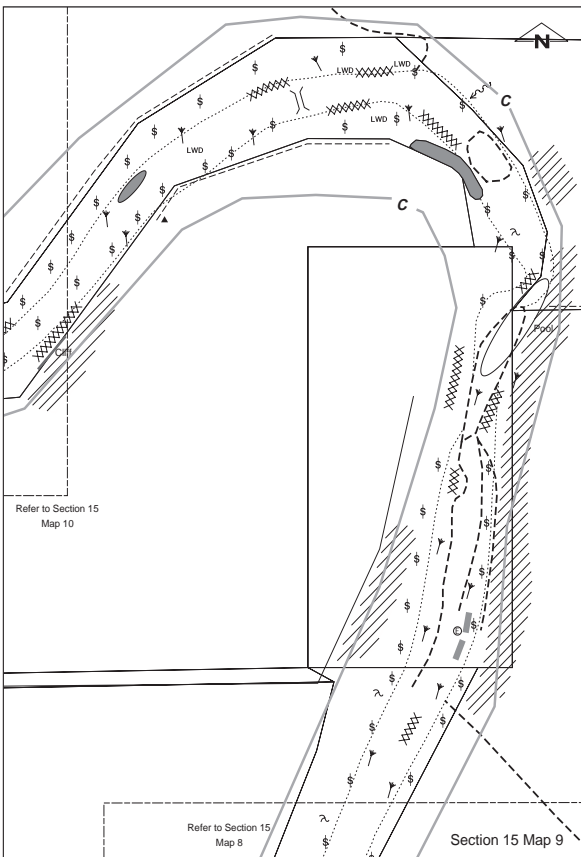
- O Continue fence maintenance programs, focussing on sections where increasing the extent of vegetation will help to reduce future erosion.
- O Ensure debris trapped in fences is removed between river flow events to reduce the frequency of fences being washed out.
- O Consider realigning fences above the river valley in sections where fences within the floodplain are washed away regularly.
- O Identify and mark the foreshore reserve, and discourage landholders from continuing to crop within the reserve.

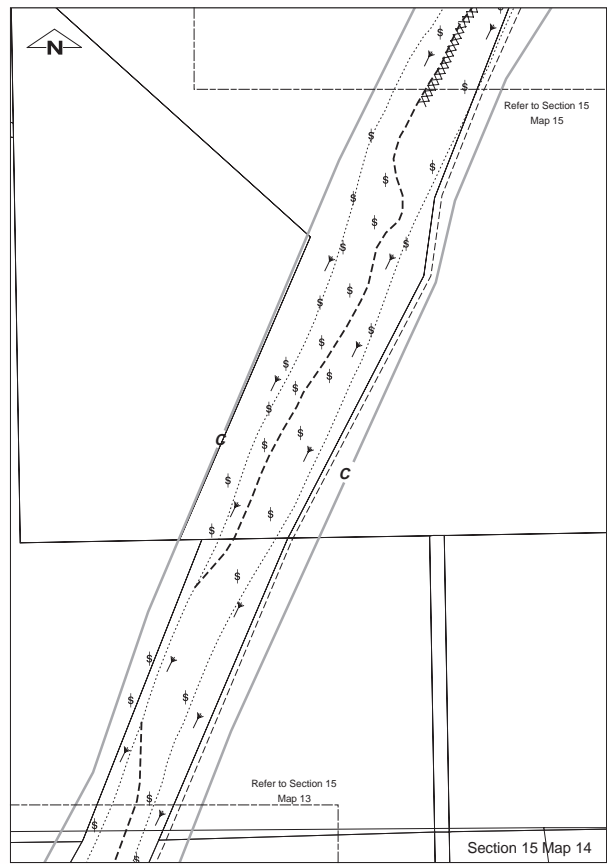
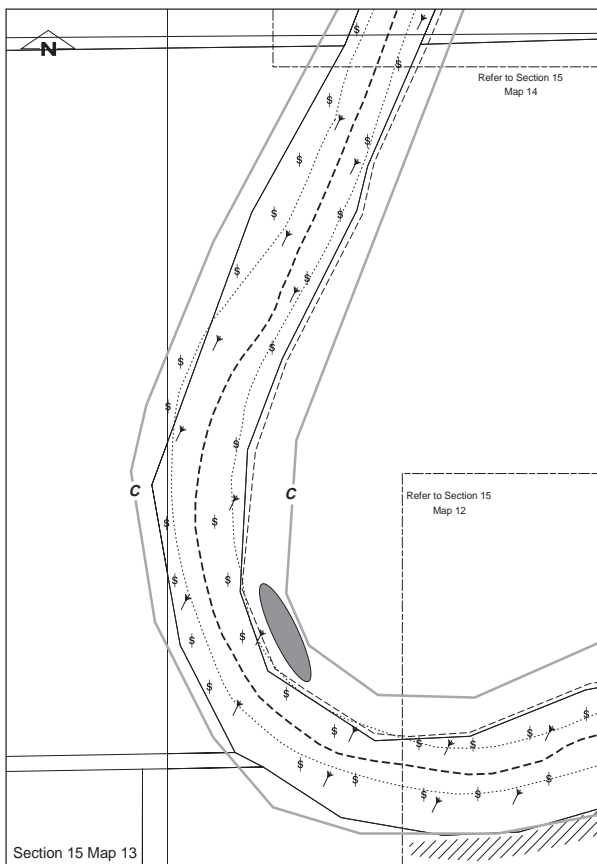
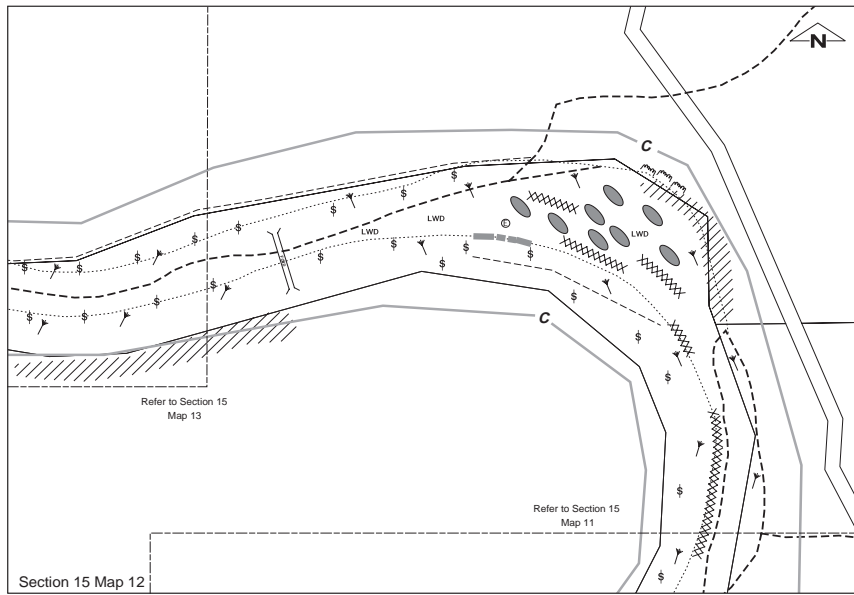


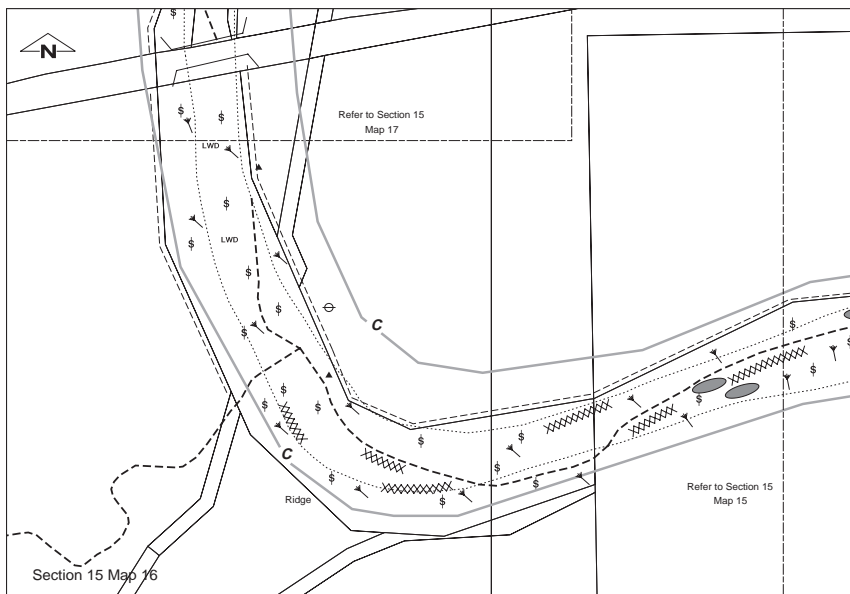
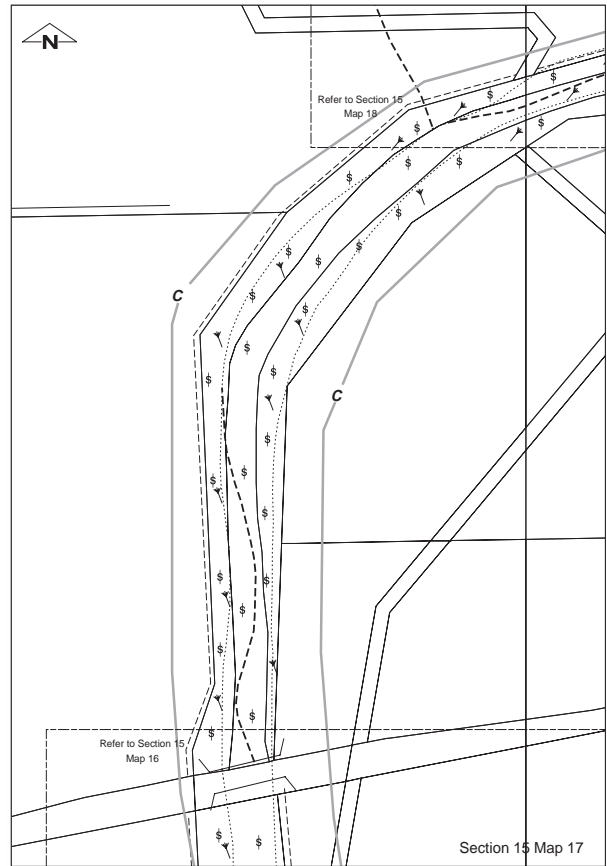
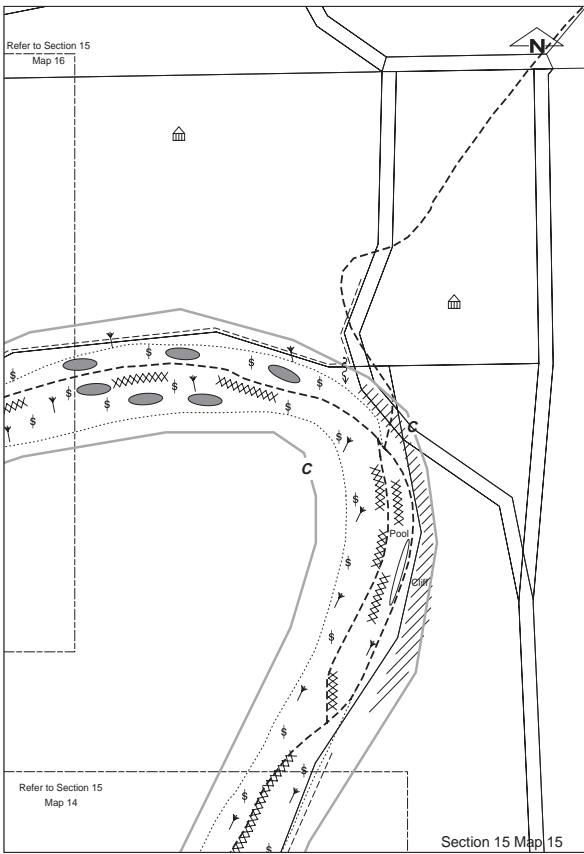


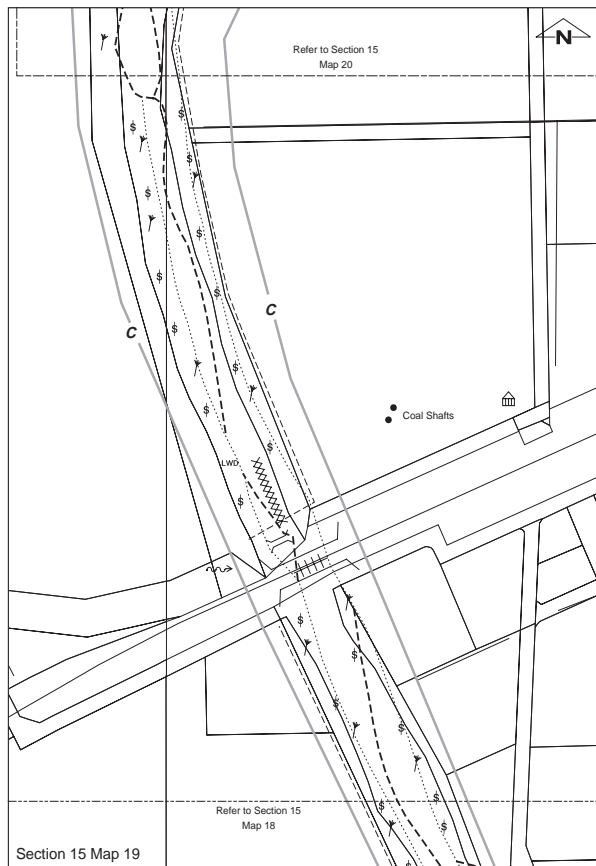
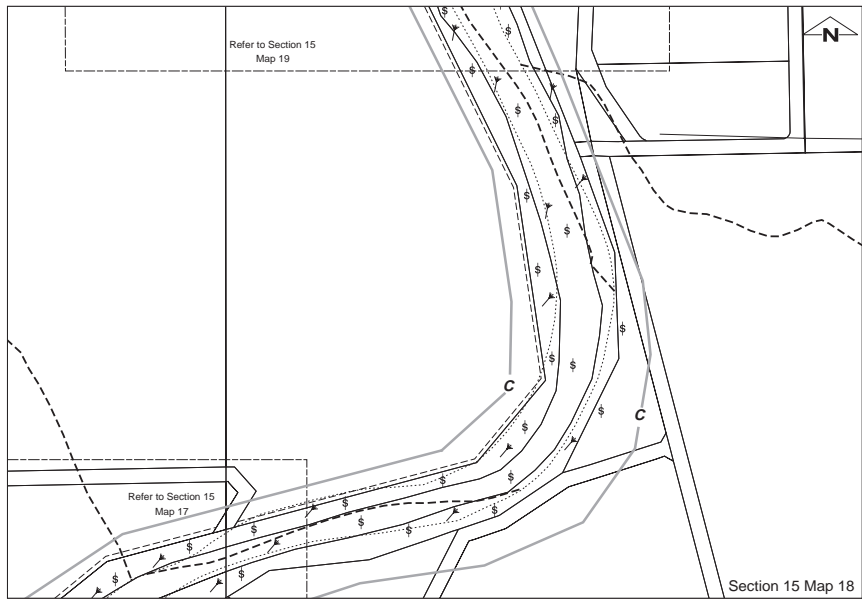


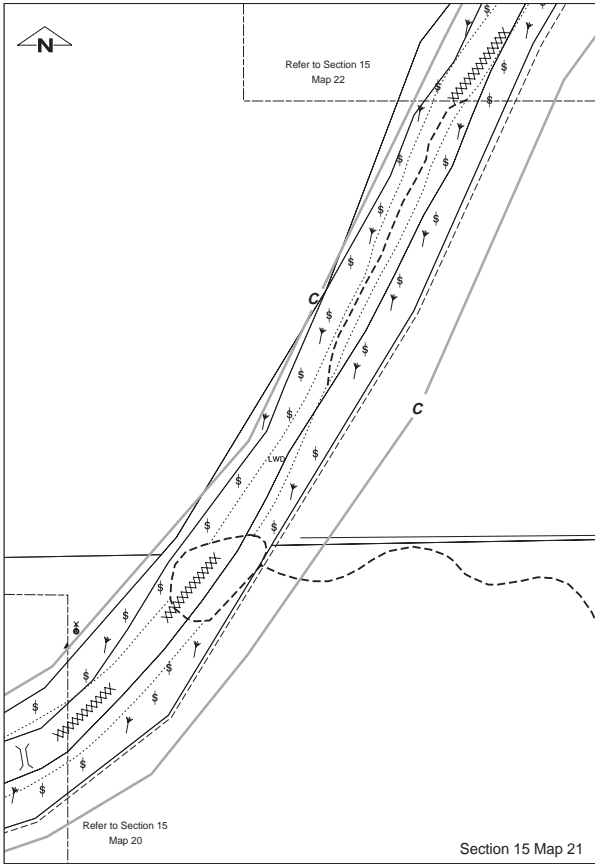
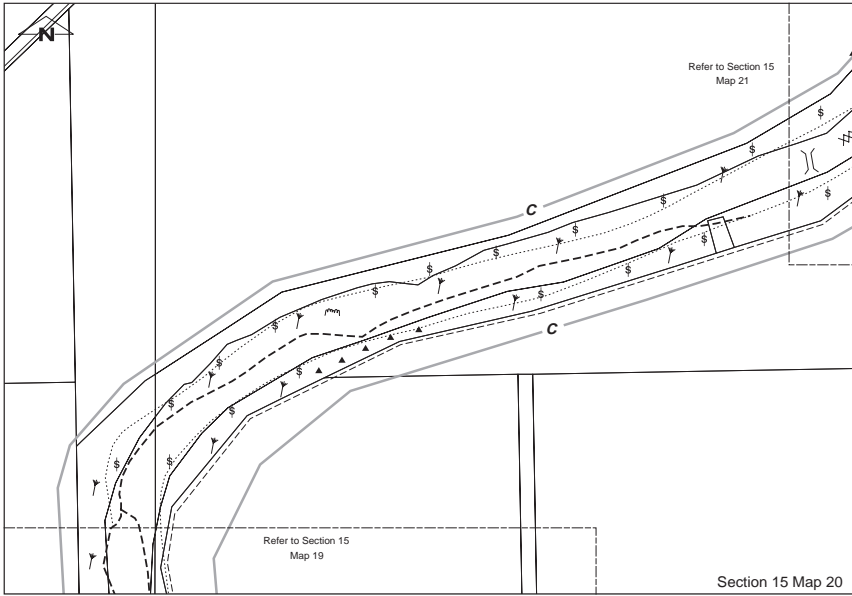


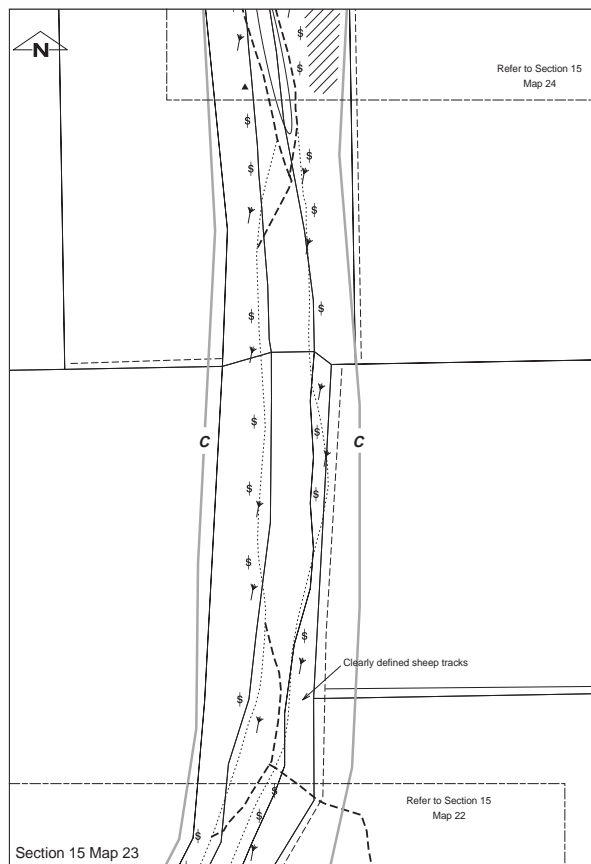
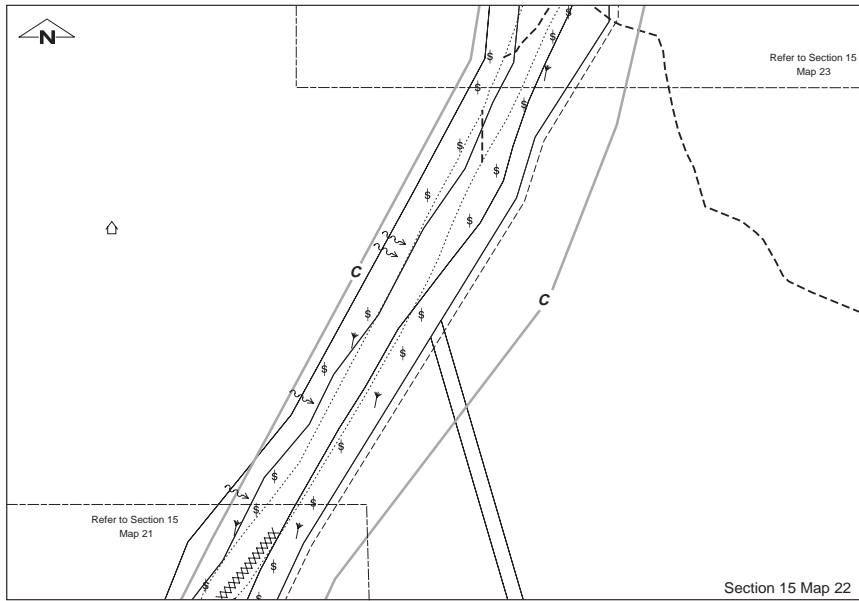


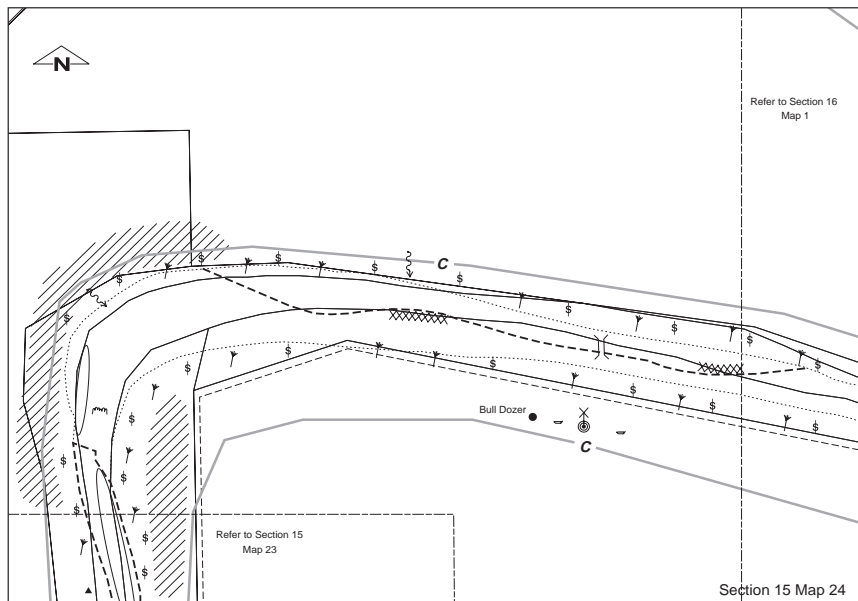












SECTION 16: GREENOUGH RIVER MAPS 1 – 12

Length of section (m): 12,410m

Recorders' names: N Siemon and T Rebola

Date surveyed: 12 June & 14 October 2000

Nearest road access: Burton – Williamson Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Poor C	Very Poor D	Poor C	Moderate B	Poor C

Bank stability

This section of the Greenough River is characterised by an almost entirely mobile sandy bed. The low flow channel at the time of survey ranged from 5 m to 15 m wide. The dominant channel averages at 60 m wide. The riverbanks retained patchy Couch cover, with some sparse Spiny flatsedge (*Cyperus gymnocaulos*). The bank gradients were slight with steep to very steep banks on the powerbends. The steep slopes were generally vegetated and, although there was evidence of stock at this point in time, the damage is minimal on the outcrops. There is a localised area of exposed granite rocks instream.

There were some severe erosion rills, predominantly on the left bank. There was evidence of changes to the riverbed characteristics that may impact on river flow in future events.

One 500 m section of the river has wider floodplain that has had considerable accretion (build up of sand) in the past. This has been stabilised by vegetation, however in some areas stock tracks have resulted in the creation of blowouts.

There is one large accumulation of woody debris.

Comments

There is insufficient vegetation cover to be sustainable in the long term, which is likely to contribute to poor bank stability in this section. The riverbed comprises mobile white sand, which is moved as a result of stock movement and flow events. Where vegetation is lost due to grazing, there are blowouts forming. Stabilising these will be difficult while stock continue to access the foreshores. The lack of shade throughout many of the paddocks adjoining the foreshore reserve makes the river an attractive location for stock to camp and rest.

Vegetation

The vegetation is very patchy (20 –80% cover) along the entire length. The riverbanks are characterised by being cleared to parkland. The dominant tree is River gum (*Eucalyptus camaldulensis*) usually limited to a single row, over an understorey of Couch (*Cynodon dactylon*) and occasional patches of Spiny flatsedge (*Cyperus gymnocaulos*). There is patchy middlestorey in the form of Coojong groves (*Acacia saligna*).



There were some small areas of verge vegetation periodically along the length, usually coinciding with clay-dominated rocky bluffs and low cliffs. The native overstorey was limited to occasional stands of York gum (*Eucalyptus loxophleba*). The middlestorey was patchy to sparse with a variable diversity. The vegetation diversity and cover on the steeper parts of the landscape was greater than on the low slope sections. Species occurring in small numbers consistently along this section include *Hakea cygna*, Honey bush (*Hakea lissocarpha*), Needles and corks (*Hakea obliqua*), Kurara (*Acacia tetragonophylla*), two *Melaleuca* species and occasional Manna gum (*Acacia. microbotrya*). Dwarf sheoak (*Allocasuarina humilis*), *Daviesia* spp., *Sphaerolobium* and *Dryandra* were also present occasionally. The understorey in the verge consists entirely of weeds. Annual grasses including Wild oats (*Avena fatua*) and Blowfly grass (*Briza maxima*) are present and flowering weeds such as Pie melon (*Citrullus lanatus*), Doublegee (*Emex australis*) and Cape weed (*Arctotheca calendula*) common.

Comments

Single rows of trees in the riparian zone are inherently unstable; as once localised erosion exposes the roots, the trees become increasingly likely to fall into the river. The lack of groundcover is a significant deterrent to native animals. The shrubs on the margins of the river, however, improve the habitat potential of the river. There is a need to control the annual grasses, Pie melon, Doublegee and Cape weed. The lower diversity of weeds present in this river section indicates that landholders take weed control seriously.

Stream cover

The stream cover is minimal in this river section. There was insufficient vegetation and woody debris to provide habitat.

Comments

The modifications to the channel characteristics have resulted in the loss of almost all stream cover. The stream cover is insufficient to support much aquatic life or enhance the length of time water stays in the shallow pools. By restoring vegetation to the margins of the channel and through the verge, additional detritus and leaf and branch litter may enter the watercourse. This will require additional stock control.

Habitat diversity

The habitat diversity was poor to moderate in localised areas. Generally it was considered to be poor due to the low density of remnant vegetation, lack of native understorey, minimal areas of permanent water and a lack of instream vegetation and debris. Two species of lizards (a skink and a dragon) were observed in the area, along with Port Lincoln parrots and a couple of Rock and Mulga parrots. These birds appeared to be commuting past this river section. The instream woody debris provides limited habitat for native animals.

Comments

Improving the remnant vegetation and modifying current stock management practices will assist in restoring habitat. The overall lack of cover limits the number of suitable habitats for terrestrial and aquatic life forms. Although occasional trees were present, there was no evidence of nesting or roosting by birds.

Other issues

There is a considerable volume of rubbish and discarded farm materials within and adjacent to the floodplain. This makes this site suitable for a CleanUp Australia Day working bee. The fencing status was variable with some fences needing maintenance. It is unknown if the fence alignment correlates with the reserve boundary. The presence of a foreshore reserve has implications for the management techniques used in the river zone.

There is some cropping occurring close to the top of the verge, which appears to be encouraging the formation of erosion rills in heavy rainfall events.

There is a river crossing and a railway bridge that was undergoing significant maintenance works at the time of survey. Drainage from an adjacent road is resulting in loss of soil from the roadside drains. This stormwater runoff needs to be managed more effectively.

There is a windmill and trough close to the top of the verge. This provides a focal point for stock movement across the foreshore, encouraging formation of tracks that may encourage scouring.



Suggestions

Bank stability

- B Liaise with landholders to determine their interest in active river management and provide training in large woody debris management. Alternatively investigate opportunities for landholders to work with members of the Greenough River Land Conservation District Committee (LCDC) to realign some of the debris and remove some of the fine suspended material.
- B Plant trees where stock can be excluded from the foreshore, particularly where there is only a single row of trees or no trees at all.

Vegetation

- V Encourage landholders to focus weed control on declared weed species and those that are a nuisance.
- V Continue revegetation works in sections where stock can be excluded from the foreshore.
- V Support natural regeneration by implementing localised weed control around any seedlings that appear.
- V Investigate opportunities for support and resources (tubestock or seed) that may become available through the Water and Rivers Commission and the Natural Heritage Trust.
- V Extend weed control activities within paddocks to the foreshore reserve, focussing around any native tree or shrub seedlings that have germinated or strips within the verge.
- V Focus weed control on plants that are toxic and present in low numbers such as Castor oil plants, particularly where stock accesses the foreshore.

Stream cover

- S Modify stock and foreshore management practices to encourage natural regeneration of trees and understorey rushes and sedges. The trees are likely to go through a natural selection process where only the most vigorous will survive. This natural culling of trees is likely to be sufficient to minimise blockage of peak flow events.

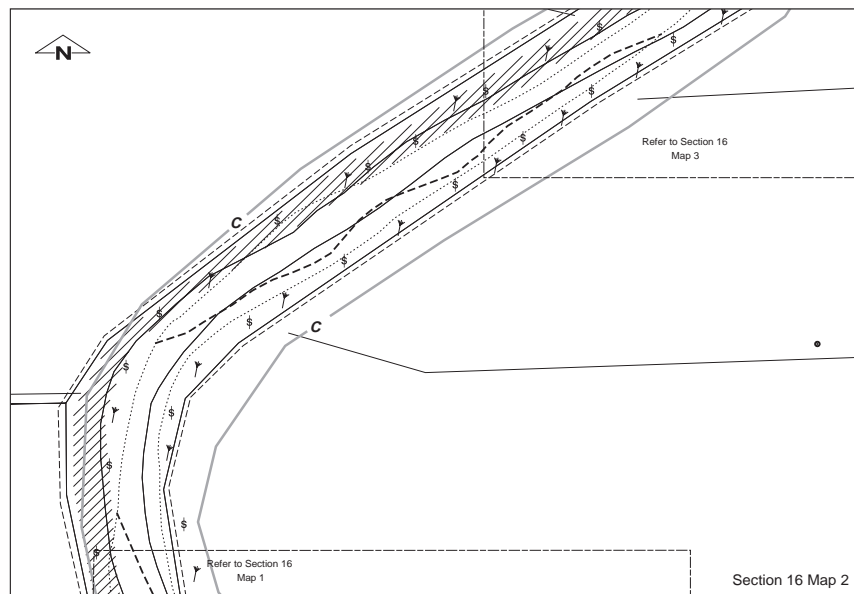
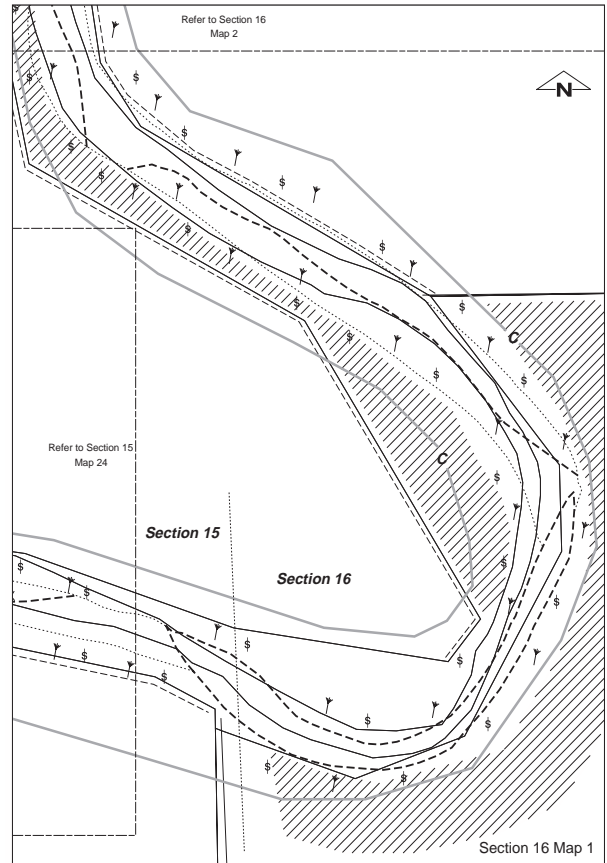
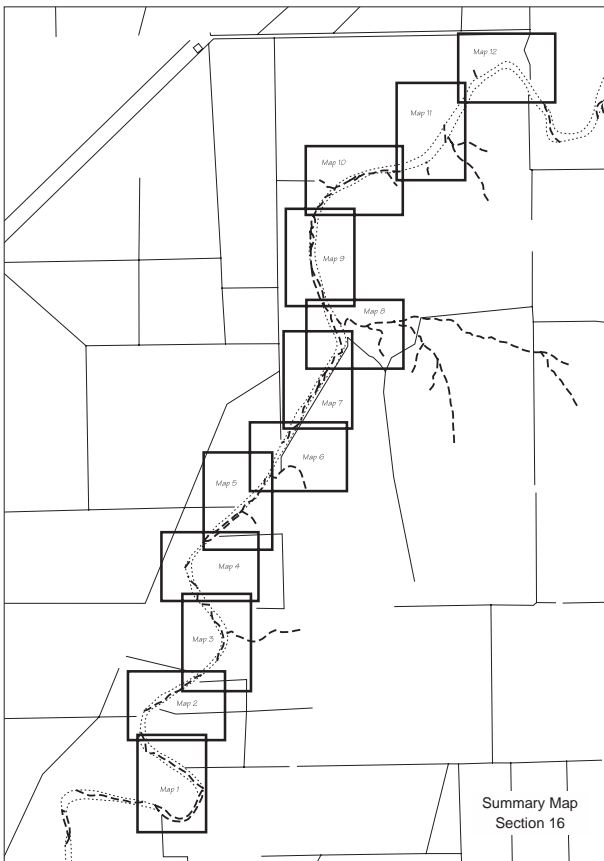
Habitat diversity

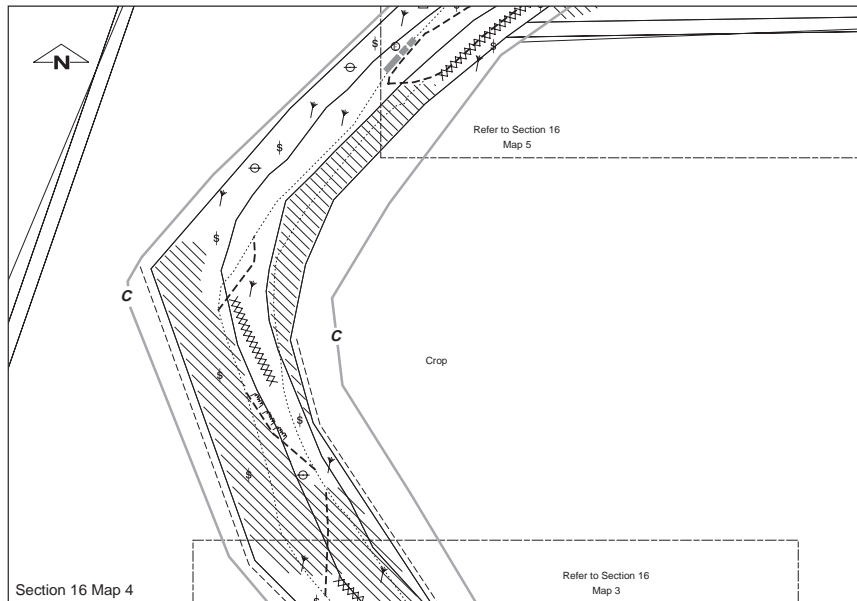
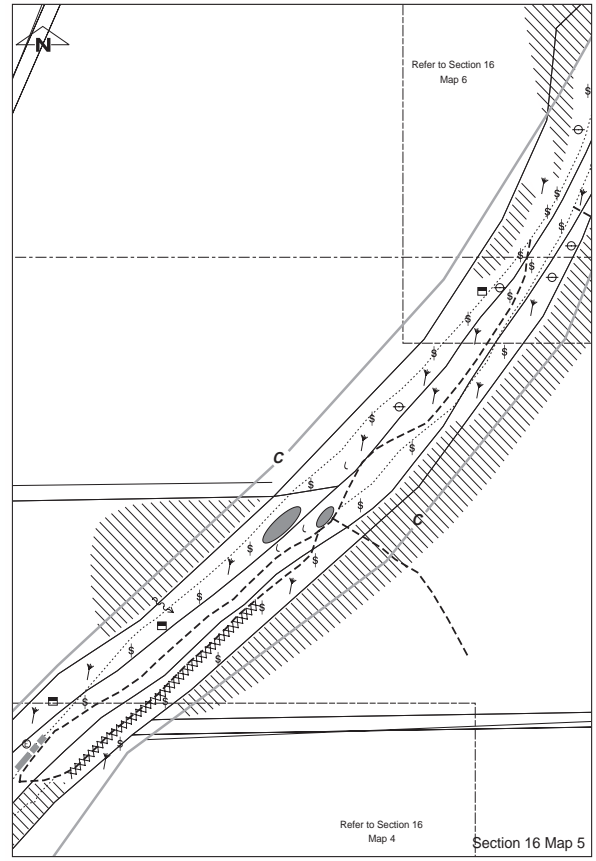
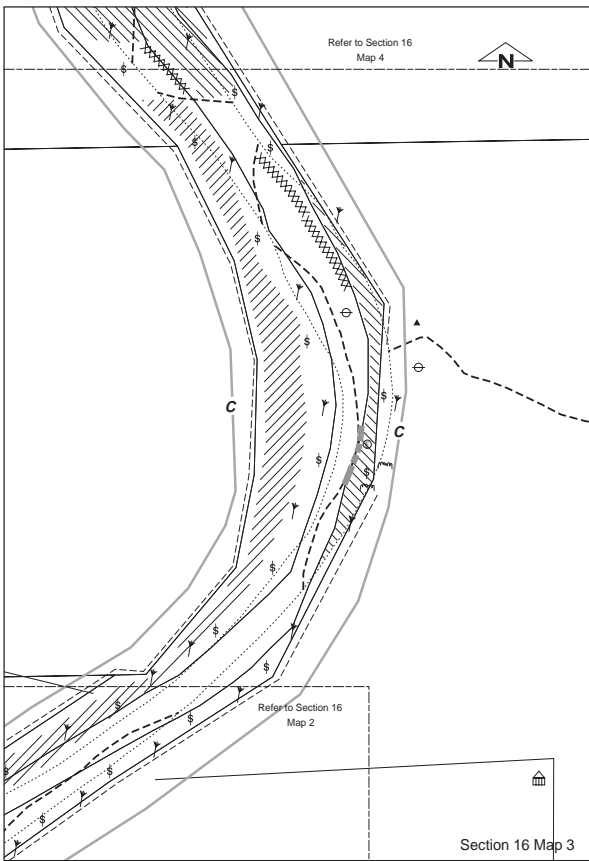
- H Work to restore vegetation and minimise disturbance to the soil structure for the length of the waterway.
- H Develop strategies to control water flow and sediment movement throughout this section length with the support and advice of relevant government agencies.

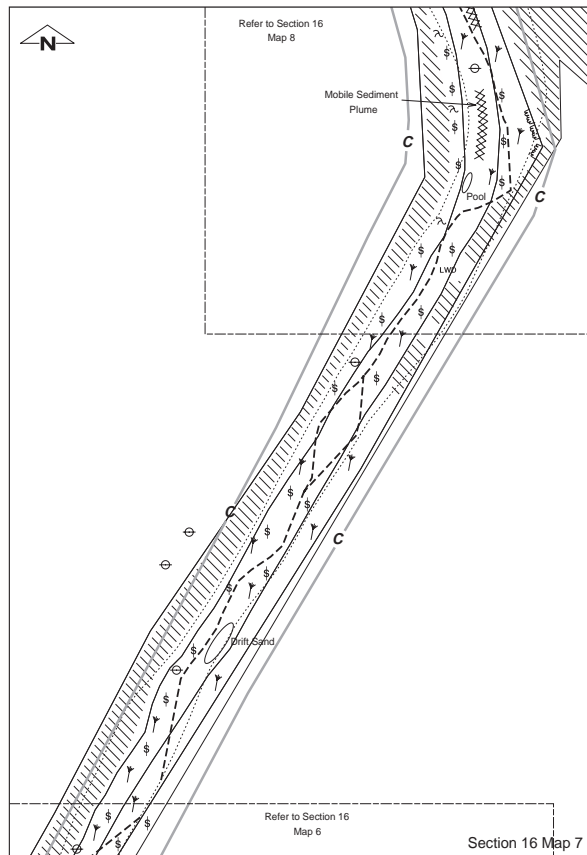
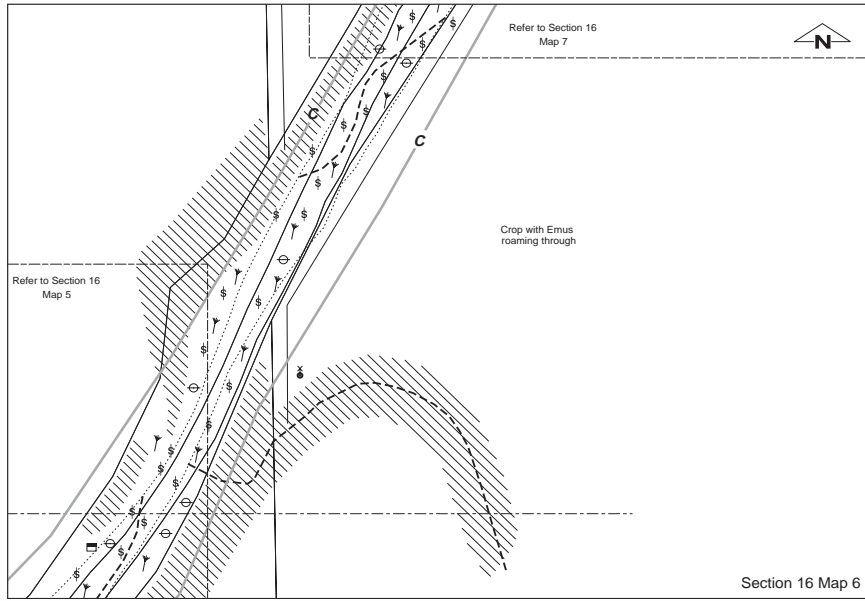
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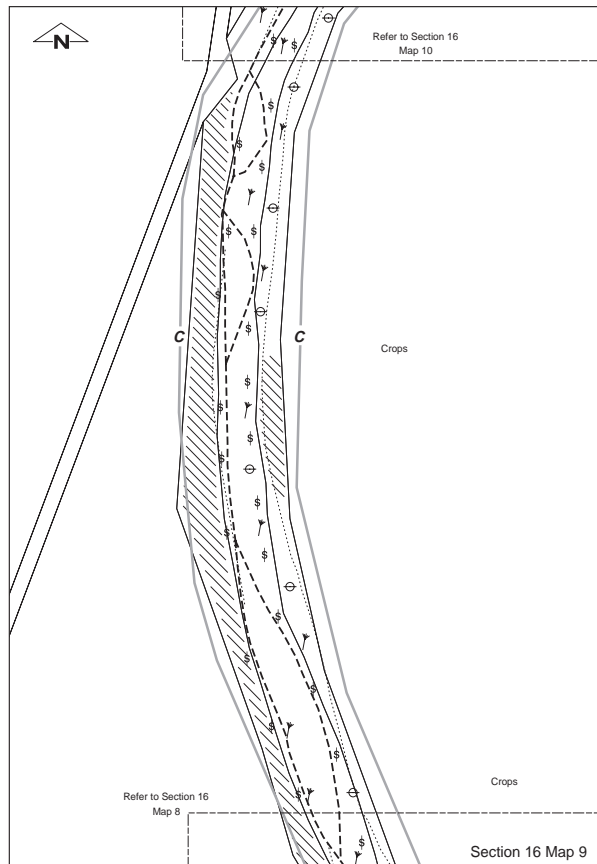
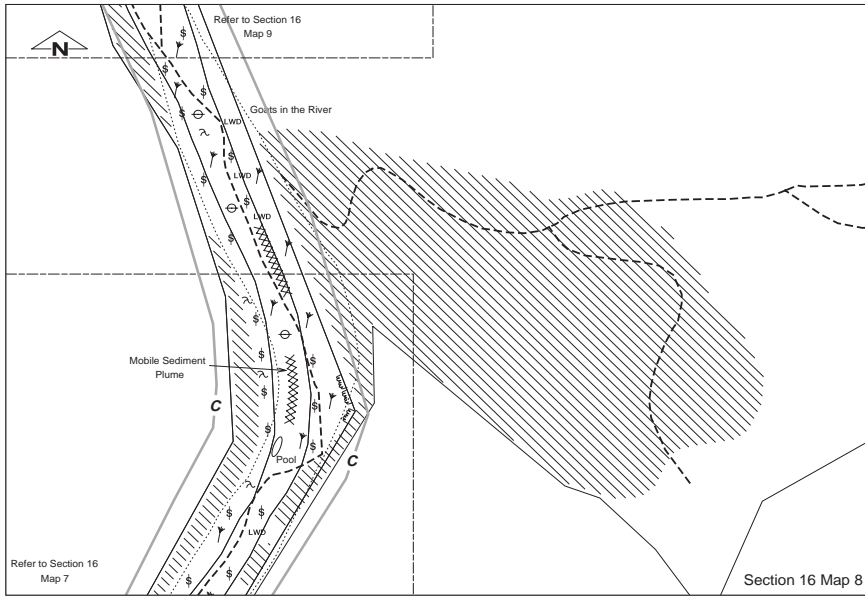
- O Realign tracks where they are eroding and/or formalise the tracks so that they do not disrupt the natural flow of water.
- O Locate and mark clearly the boundary between foreshore reserves and freehold land, and amend to reflect the natural landform if necessary.
- O Provide landholder with information packs about river processes and encourage discussion about modifying the channel characteristics.
- O Encourage the landholder to modify current cropping practices and aim to restore vegetation cover to this river section.
- O Investigate the feasibility of holding a CleanUp Australia Day working bee to help remove some of the discarded farm materials from the foreshore environment.

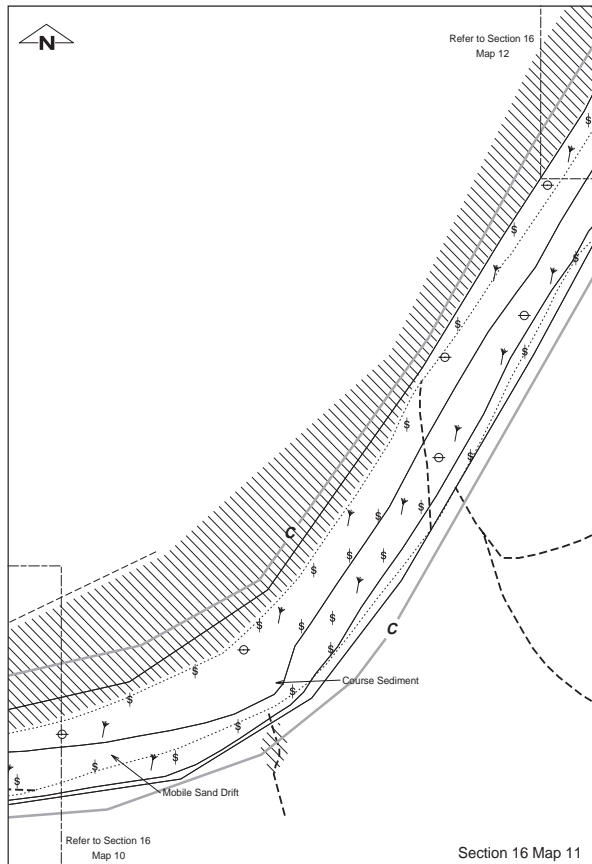
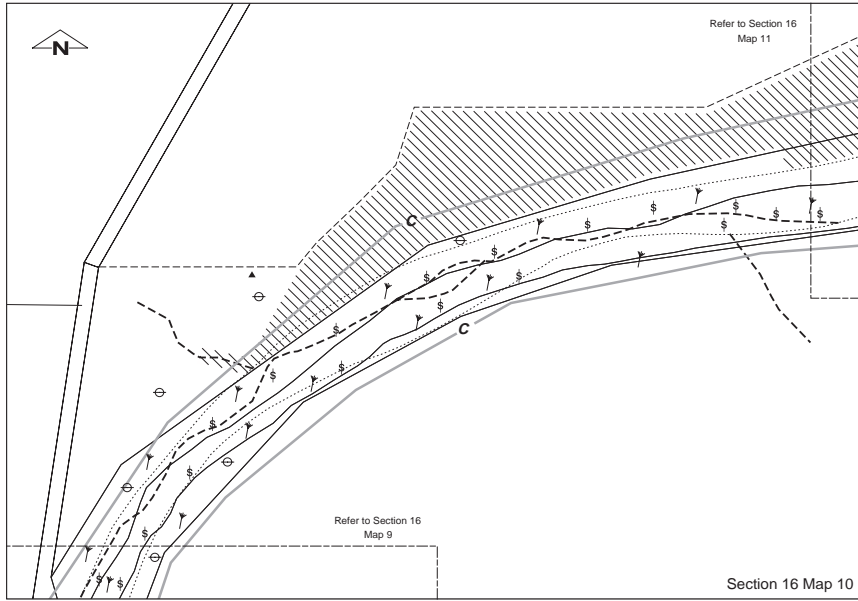


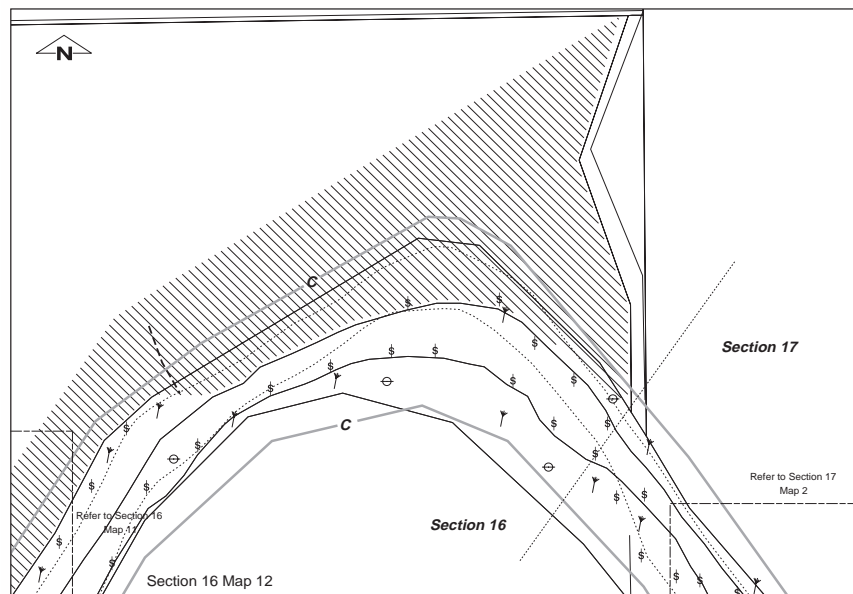












SECTION 17: GREENOUGH RIVER CONFLUENCE WITH KOCKATEA GULLY MAPS 1 – 11

Length of section (m): 10,510m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 8 April 2000

Nearest road access: Burton Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Poor C	Moderate B	Poor C	Poor C

Bank stability

This section of the Greenough River is characterised by an almost entirely mobile sandy bed. The low flow channel at the time of survey ranged from 5 m to 15 m wide. The dominant channel averages at about 60 m wide. The persisting rows of trees are at risk of being undermined. The riverbanks retained patchy Couch cover, with some sparse Spiny flatsedge (*Cyperus gymnocaulos*). The bank gradients are slight, with steep to very steep banks on the powerbends. The steep slopes grade rapidly into cliffs/ridges and are generally vegetated, and although there was evidence of stock at the time of survey, the damage is variable. There is a localised area of exposed granite rocks instream. Sedimentation is significant, occurring along 20 – 50% of the river section. There is one small pool and three erosion rills on the left bank. There are clearly defined sheep tracks along some parts of the foreshore that are being eroded.

Comments

This section is likely to continue to be relatively unstable until vegetation becomes re-established in the

river channel. This will be difficult to achieve because of the volume of mobile sand and the likelihood that any establishing plants will be covered as the sand is washed downstream. The river valley is clearly defined so there is minimal risk of further loss of arable land. It is likely that the pool will not be sustainable in the long term. Animals, probably kangaroos, had dug holes to find water in the riverbed.

Vegetation

The overstorey is sparse (<20% cover) and retains three rows of River gum (*Eucalyptus camaldulensis*). All of these trees are mature and there are no signs of regeneration. The middlestorey in the riparian zone is absent, and the understorey limited to patchy cover (20 – 80% cover), and dominated by weeds. Common plants include Couch (*Cynodon dactylon*) and Wild oats (*Avena fatua*) with sporadic clumps of the native Spiny flatsedge (*Cyperus gymnocaulos*).

The verge vegetation is also patchy (20 – 80% cover), however this is a reflection of the shallow soils and exposed rock and clay. The diversity is very good,



however annual grass weeds are starting to become prevalent. This includes Wild oats (*Avena fatua*) and Blowfly grass (*Briza maxima*).

Comments

Encouraging natural regeneration or assisting vegetation establishment through planting will be difficult due to the mobility of the substrate. Not only is the mobile sand likely to smother or undermine existing plants, it will also have an abrasive effect when mobilised during peak flow events.

Establishing assisted regeneration on the verge and the margins of the floodway is possibly a useful starting point, providing that stock can be excluded. Ensuring fences are installed and maintained along the length will help to control stock access, if stock are returned to paddocks adjoining the river.

Stream cover

There is minimal stream cover provided by the overhanging trees. The mobile sand has also smothered most of the instream debris and rocks, minimising cover.

Comments

Stream cover will be entirely dependent on the way in which the sand plumes are washed downstream and the regeneration of native vegetation. As mentioned above, plant establishment will be difficult due to the mobility of the substrate. Restoring woody debris into the river system may be an option to direct flow into large sediment plumes to encourage downstream movement of the sand.

Habitat diversity

There was no flow at the time of survey, however there is evidence that the sub-surface flow is close to the surface as there was evidence of animals digging for water. Habitat diversity is minimal and limited to localised use of tree hollows for nesting Corellas and Pink and grey galahs and use of the trunk by reptiles. The minimal groundcover makes movement between remnants difficult for small terrestrial animals. Kangaroos and Emus are likely to use this river section. Fox footprints were also seen. An unidentified lizard (orange headed dragon) was captured on the access

track adjoining the fence, and two types of skinks were observed.

Comments

Increasing the density and extent of native vegetation will help to increase habitat availability for terrestrial animals. The instream habitat diversity will continue to be minimal until the sand is colonised by plants, and the main channel is restored to a single channel. Increased vegetation cover on the riverbanks and across the floodway would help direct the flow to the path of least resistance (i.e. unvegetated main channel). This in turn may encourage scouring to occur and pools to re-form.

Other issues

There is a continuous foreshore reserve through this section.

Fencing is almost continuous on the north (left) bank, however the status of fencing was unclear on the right bank. There seemed to be gaps in the fences on this bank. There was no evidence of stock in the paddocks adjoining the river.

Gas pipelines cross the river.

Suggestions

Bank stability

- B Provide information to the landholder about preferred management techniques: encouraging protection of the foreshores and native vegetation, and techniques to minimise other potential impacts of poor management.
- B Monitor stock impact on the river system and implement periodic grazing standards if necessary.
- B Protect the remnant vegetation from disturbance to enable the vegetation to continue to stabilise the riverbed, banks and floodways.
- B Try to source external funds to develop a sub-catchment management plan for the Kockatea Gully as this waterway has a significant impact on sediment movement in the Greenough River.



Vegetation

- V Encourage natural regeneration by minimising disturbances to the substrate.
- V Restrict stock access to the river until 70% of the perennial native understorey vegetation is re-established. This may require supporting native seedlings by selectively spraying weeds around these plants and selective use of stock to reduce weed populations.

Stream cover

- S Restore instream woody debris and use this material to direct flows into mobile plumes to encourage downstream movement of the sediment.

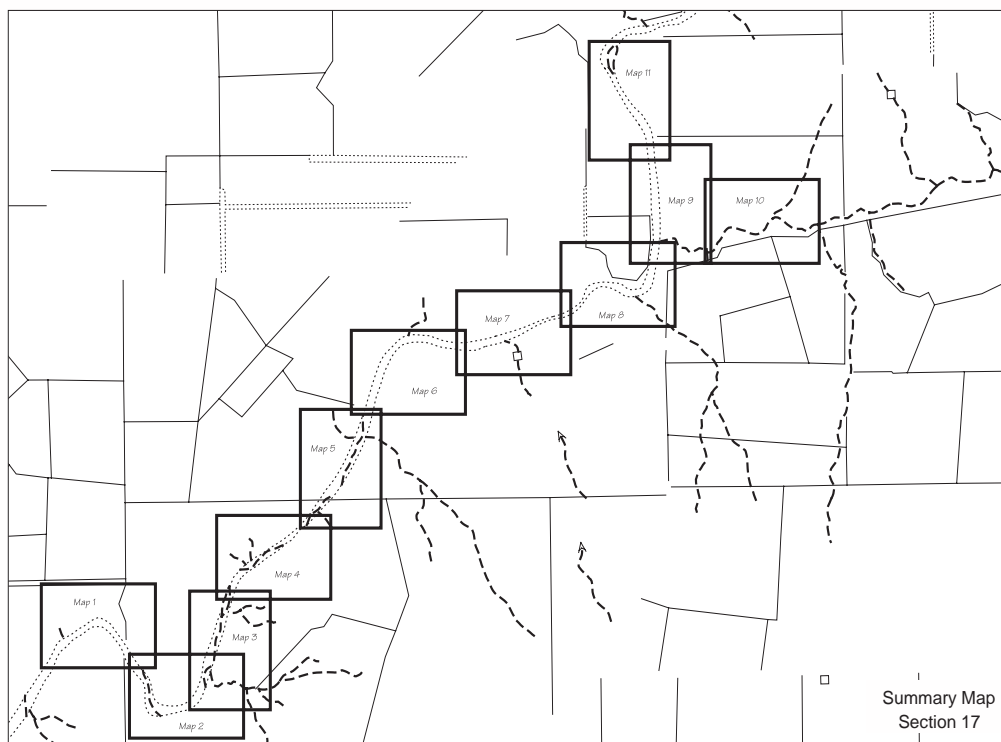
- S Monitor natural regeneration and if insufficient seedlings grow, commence a revegetation program to increase stream cover.

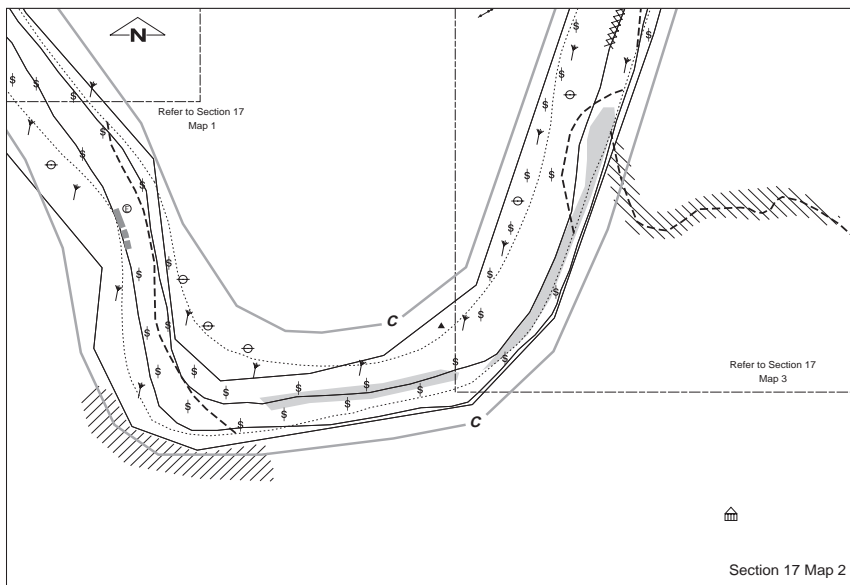
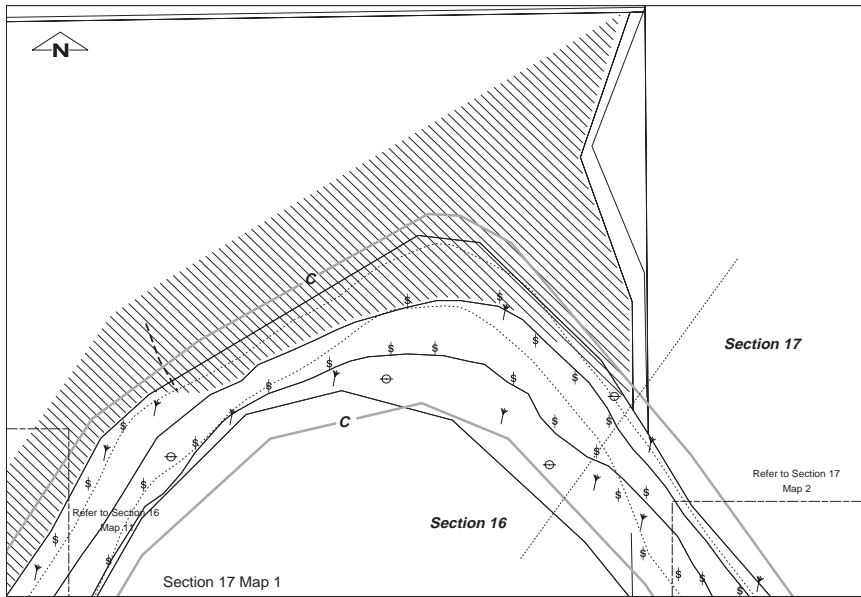
Habitat diversity

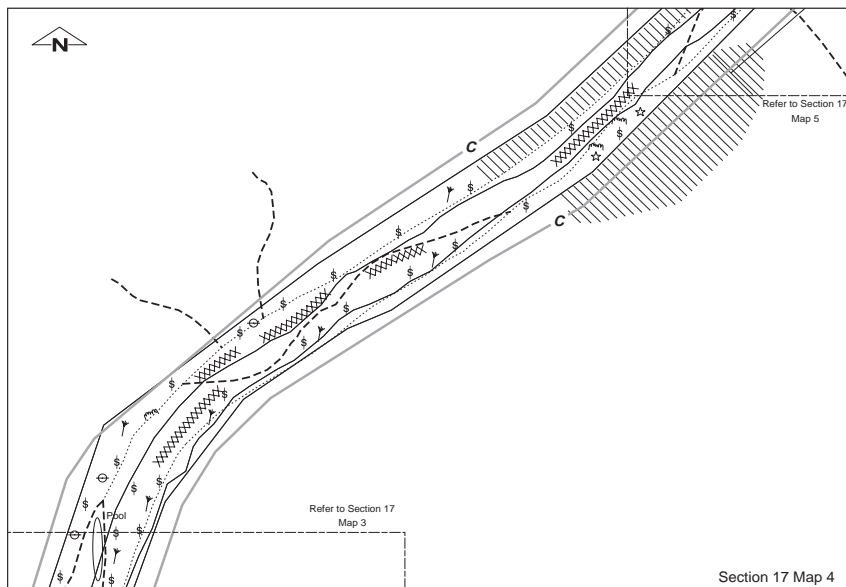
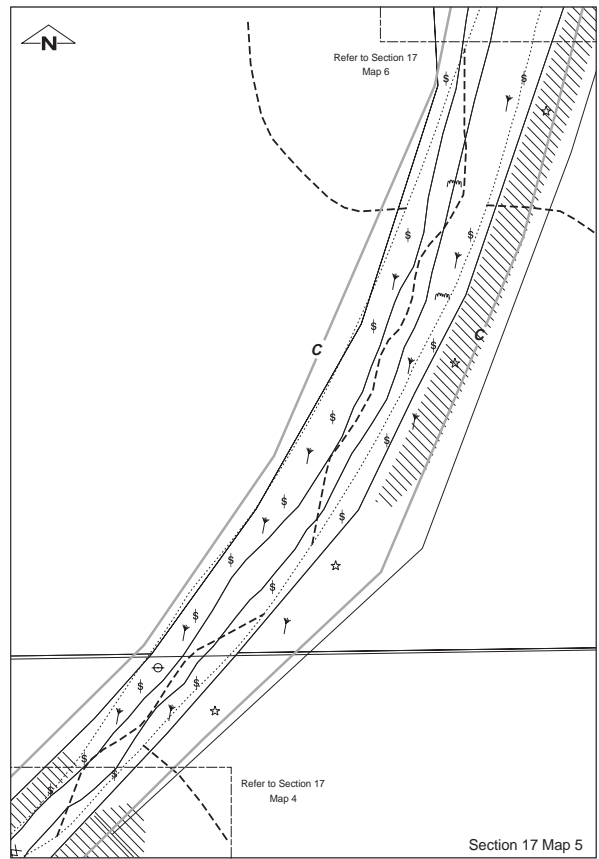
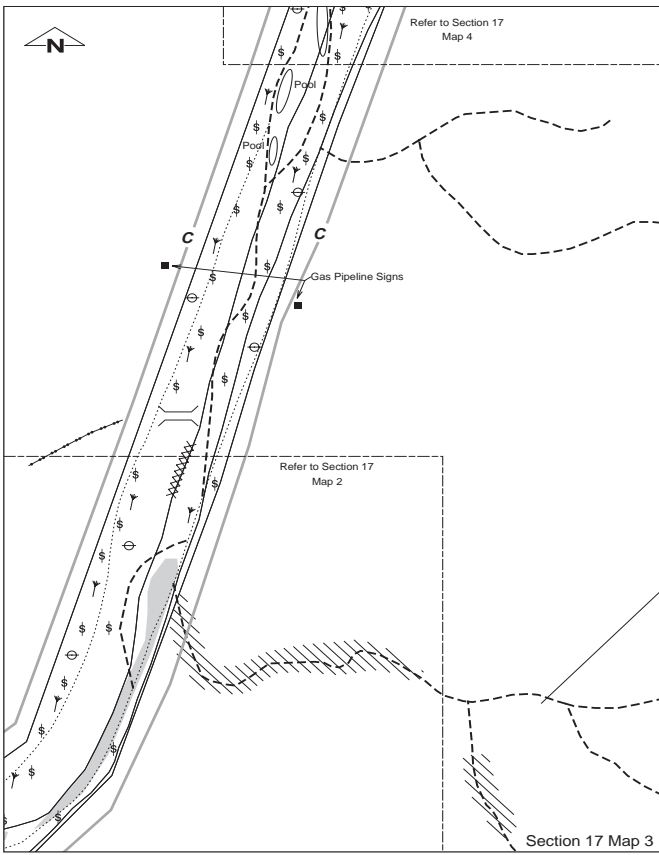
- H Monitor natural regeneration and if insufficient seedlings grow, commence a revegetation program to increase stream cover. Direct seeding is likely to be the most effective method.

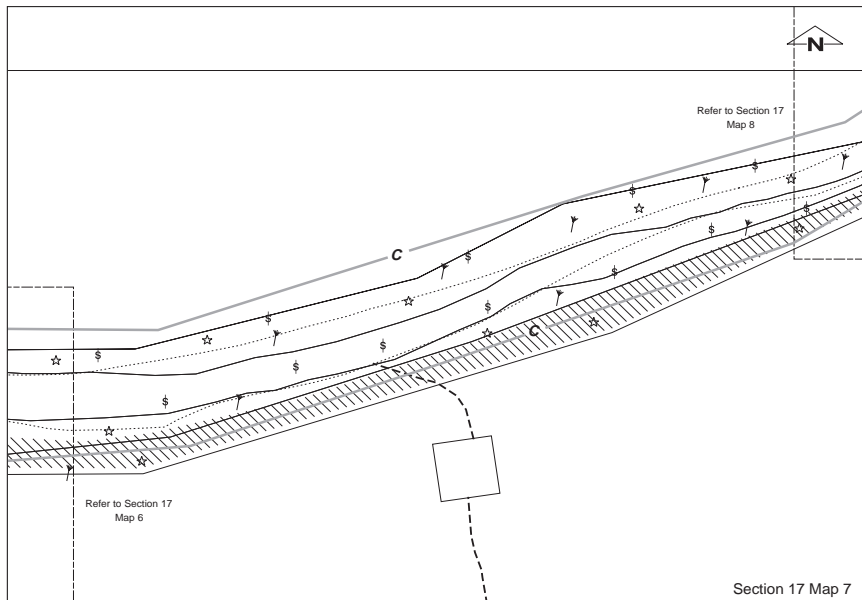
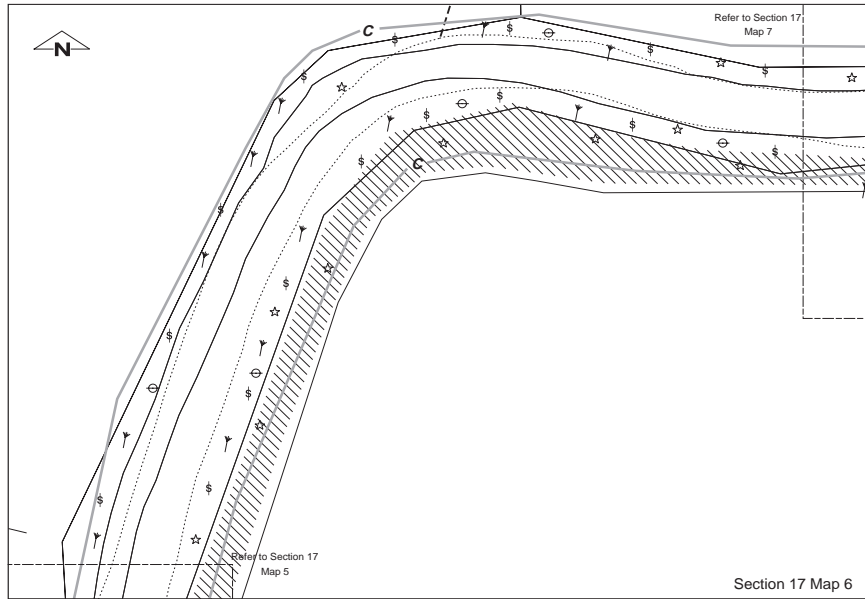
Other issues

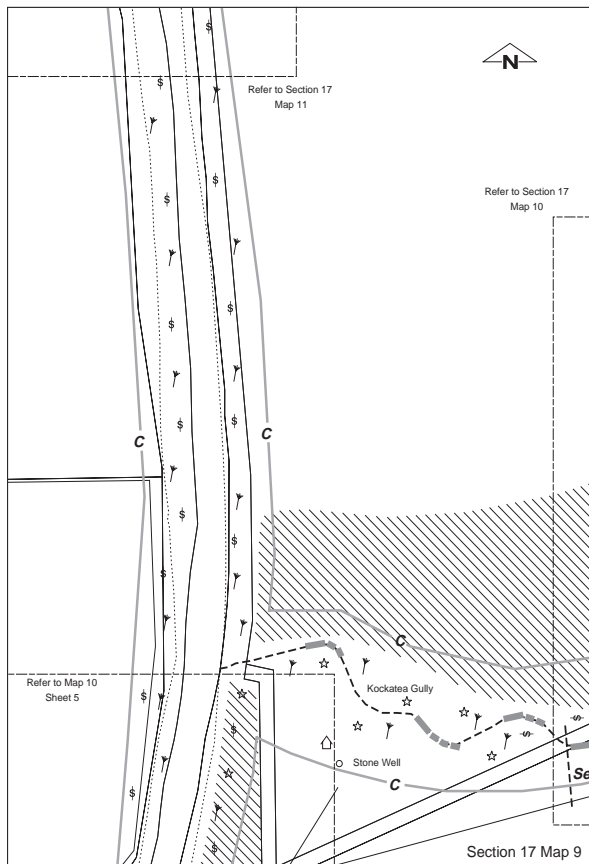
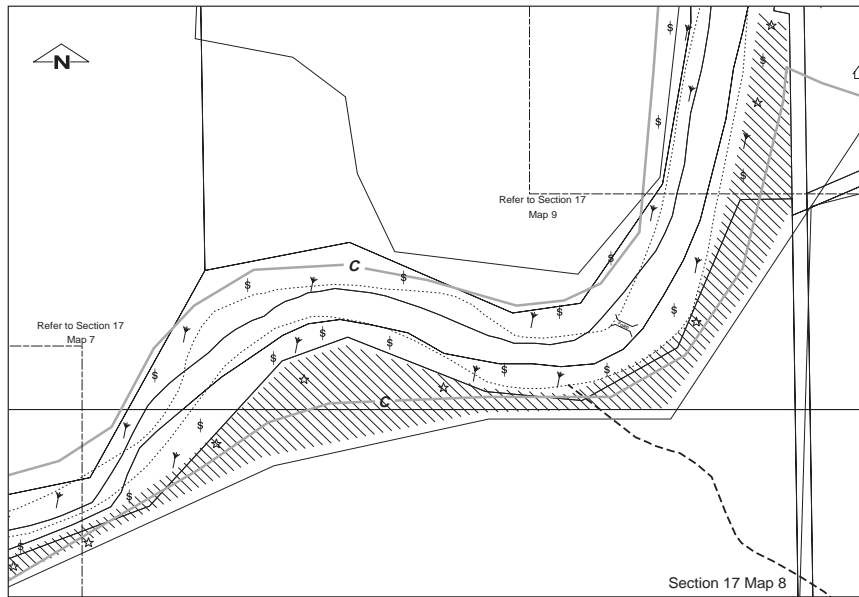
- O Ensure fences are maintained and used to define the foreshore reserve, if stock is rotated into the paddocks adjoining the river.

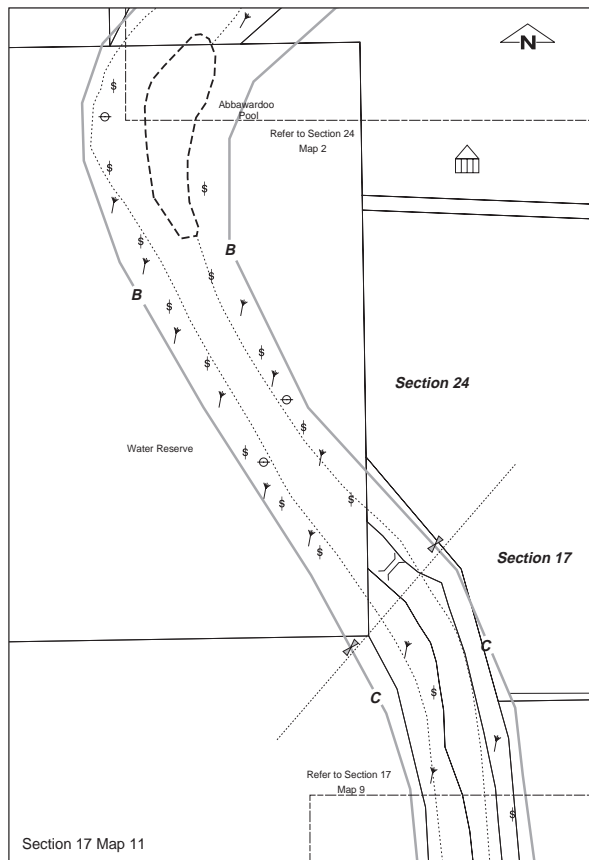
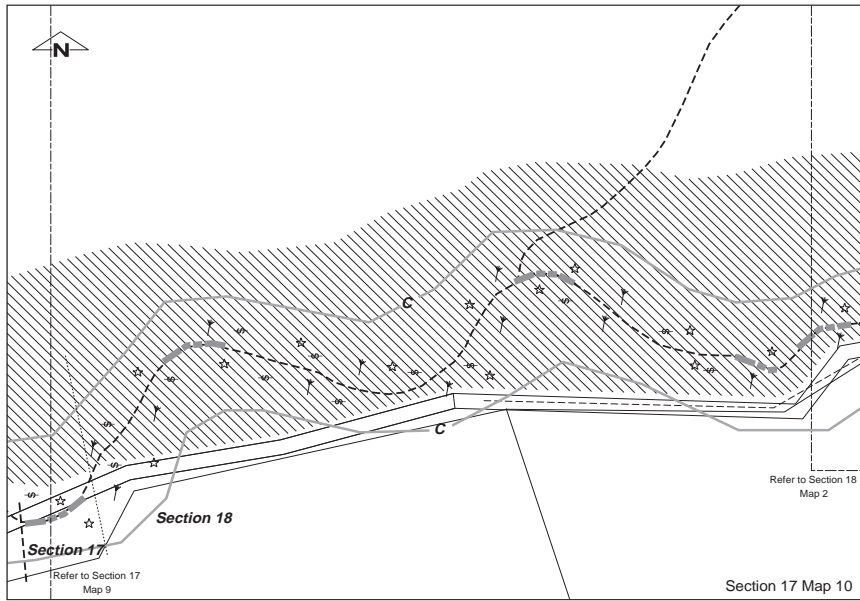












SECTION 18: KOCKATEA GULLY MAPS 1 – 6**Length of section (m):** 8,030m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 April 2000**Nearest road access:** Peter Road and Brenkley Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Poor D	Poor C	Very Poor D	Poor C	Moderate B	Poor C

Bank stability

The Kockatea Gully through this section is highly unstable due to a lack of perennial vegetation cover, limited exposed rocks and a steep fall in the riverbed. This section has significant amounts of mobile sand. The main river channel is between 4 and 17 m wide with a relatively narrow floodway. The surrounding landscape rises steeply on both sides of the river in the lower parts of this section with very steep (> 80°) slopes to 8 m high on the powerbends. Severe erosion is occurring on more than 50% of the river section, with significant sedimentation (> 50%) occurring along the entire length. Some of the steep banks have eroded back to stable clay marl, while others consist of poorly cohesive sand. Many of the tributaries are actively eroding and contain significant amounts of mobile sediment, and there are small gullies forming along much of this section length. There are some areas of exposed granite in the riverbed.

Comments

The lack of perennial vegetation cover, changing groundwater conditions and steep nature of the channel bed makes this reach susceptible to severe erosion. This inherent instability increases the difficulty in managing this environment, simply from natural river processes. Restoring vegetation in such unstable conditions is difficult and any rainfall events are likely to result in a peak flow occurring rapidly. Slowing water movement consistently within the catchment and the waterway itself is critical.

Vegetation

The overstorey is sparse (< 20% cover) with some mallee, occasional River gum (*Eucalyptus camaldulensis*) and Swamp sheoak (*Casuarina obesa*) and some revegetation lines in the upper reaches of this section. The middlestorey is patchy (20 – 80% cover) with some dense stands of remnant wattles (*Acacia* spp.) and *Hakea*. The understorey is also patchy (20 – 80%

cover) and dominated by annual grasses such as Wild oats (*Avena fatua*), Blowfly grass (*Briza maxima*) and occasional native Silky heads (*Cymbopogon obtectus*). Other weed species present include Doublegee (*Emex australis*), Wild turnip (*Brassica barrelieri*) and Wild radish (*Raphanus raphanistrum*).

Comments

Some of the landholders within this river section expressed an interest in gaining support to continue their revegetation works to help slow the water flow consistently through their property. This section appears to correspond with the zone in the river system where the riverbed gradient changes from a relatively steep system to a more moderate gradient near the confluence. Having sufficient perennial groundcover to help slow the water that has been moving rapidly up to this point, is critical to help minimise damage to the channel and floodplain during peak flow events.

Areas lacking vegetation cover particularly during the cyclone season (December to April) are at the greatest risk of causing erosion either locally or further downstream. Annual grasses help to protect the riverbanks and floodplain between August and November, after which they contribute little to bank stability. The rivers tend to have a boom and bust cycle, and their unpredictability is the main reason for needing perennial groundcovers. Similar processes occur if there is insufficient groundcover to protect the topsoil from wind erosion. The need for perennial groundcovers to minimise excessive change to the river environment cannot be emphasised enough.

The lack of dense vegetation consistently on this river section is contributing to the loss of coarse material and increased abrasion by the mobile sand. The scale of the blowouts occurring >1.5 m above the channel bank height are of concern. It is likely that the course of river flow will migrate to the right floodway in future flood events if the density of vegetation is not improved. Large woody debris is exacerbating erosion in some



areas. The remaining single row of trees is likely to be undermined in the future. Advice on river crossing design and maintenance may be useful.

The large amounts of sedimentation evident cannot be exclusively linked with degradation processes in this river section. In some areas, sandbars have become stabilised and vegetated. The significant levels of sedimentation indicate that erosion is occurring further upstream. This highlights the need to understand processes occurring upstream of any waterway and demonstrates that no site can be considered in isolation.

Stream cover

The stream cover is minimal in this section and is limited to three regions where overhanging trees provide some shade. The narrow overstorey is insufficient to meet stream cover needs. There are intermittent rocks, logs and branches and some vegetative material present in the river channel that also provide localised areas of cover.

Comments

The lack of continuous shading of the water increases the rate at which the pools dry up, and also the rate of deterioration in water quality particularly as it relates to algal growth. Anecdotal evidence suggests that filamentous algae are becoming increasingly prevalent. Shade reduces water temperature, which in turn discourages the growth of algae. By increasing the availability of shade, it is possible to minimise the growth of nuisance algae.

Habitat diversity

The habitat diversity is limited due to the minimal native vegetation cover and lack of continuity of vegetation cover. The sections retaining vegetation provide some habitat for woodland and shrubland birds, small reptiles and occasional herbivorous invertebrates. The diversity and abundance of these animals is low. The waterways were flowing at the time of survey, however no aquatic life was observed or heard. Further, flying insects with aquatic stages in their lifecycle were not observed during the survey.

Comments

The overall lack of cover limits the number of suitable habitats for terrestrial and aquatic life forms. Although

occasional trees were present, there was no evidence of nesting or roosting by birds. The dense shrublands on some of the rocky marl slopes support large goannas and some shrubland birds, although the number was limited.

Other issues

The fences are generally well set back from the top of the river valley in the upper reaches of this river section, while much of the lower section is unfenced. One road crosses the river and has been washed out in the past. A large block of bitumen has been moved downstream approximately 12 m from the current road alignment. This is now directing peak flows up the riverbanks and is resulting in a new erosion zone. The coarse conglomerate material used as road base is present in plumes until the confluence with the Greenough River.

Suggestions

Bank stability

- B Focus on restoring vegetation cover to improve bank stability, keeping in mind that the rate of plant establishment is likely to be slow.
- B Liaise with Agriculture WA, Mullewa LCDC and Water and Rivers Commission to try to develop a catchment management plan for this sub-catchment.
- B Try to source external funds to assist in managing this sub-catchment as it has a significant impact on sediment movement in the Greenough River.

Vegetation

- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Encourage the landholders to fence off the persistent native remnant vegetation within their properties and establish shelterbelts of deep-rooted trees to provide shade and shelter for stock.
- V Protect the riparian zone from grazing and trampling for some time to enable the vegetation to recover. Periodic crash grazing may be useful to control fire hazard and limit the production of weed seed.



Stream cover

S Fence off tributaries and protect the remaining vegetation along the length of the waterways.

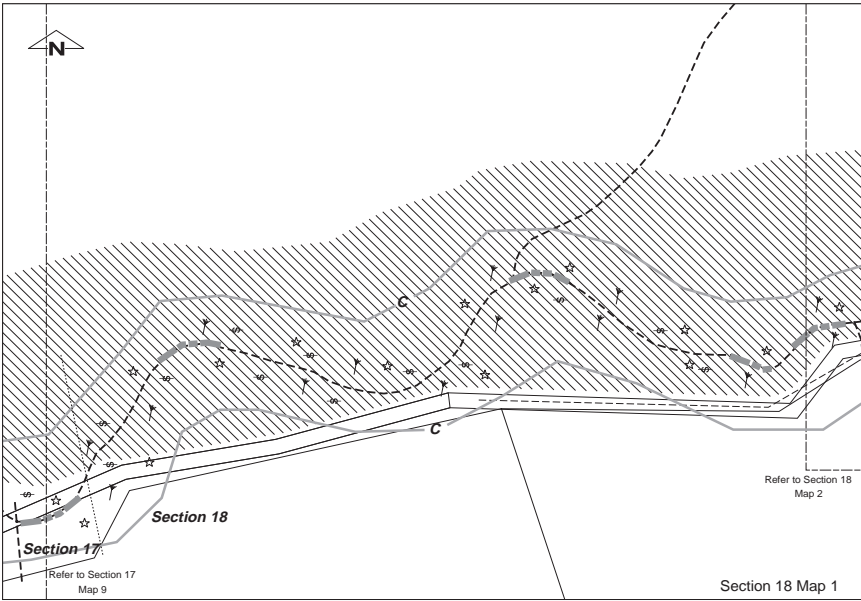
Habitat diversity

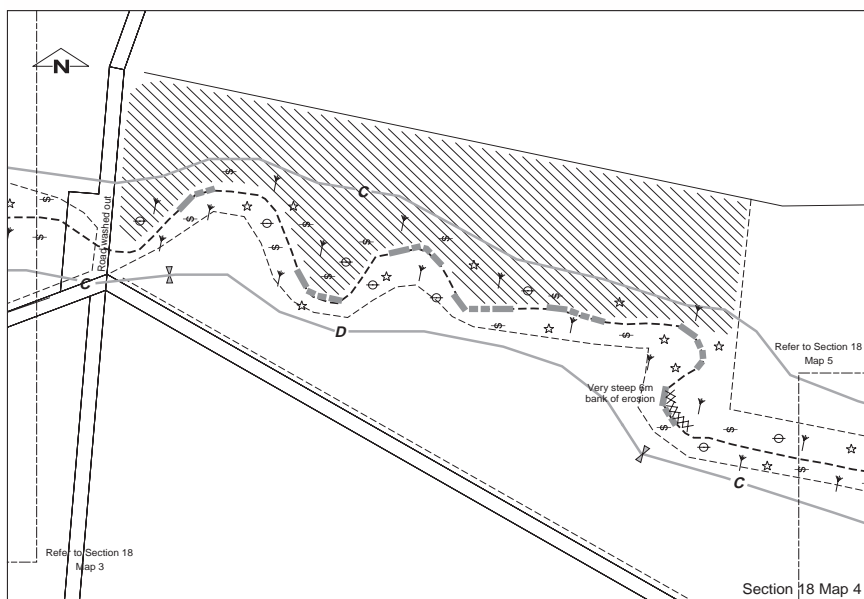
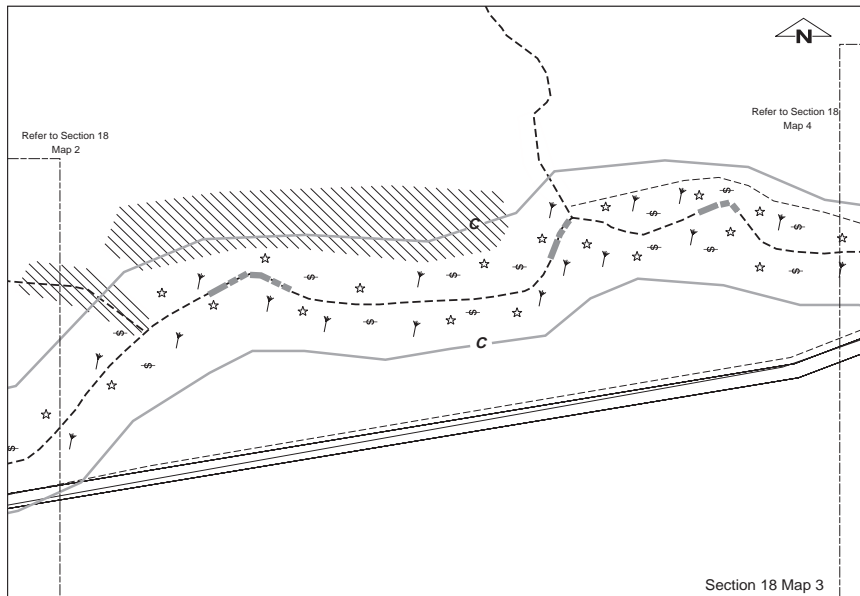
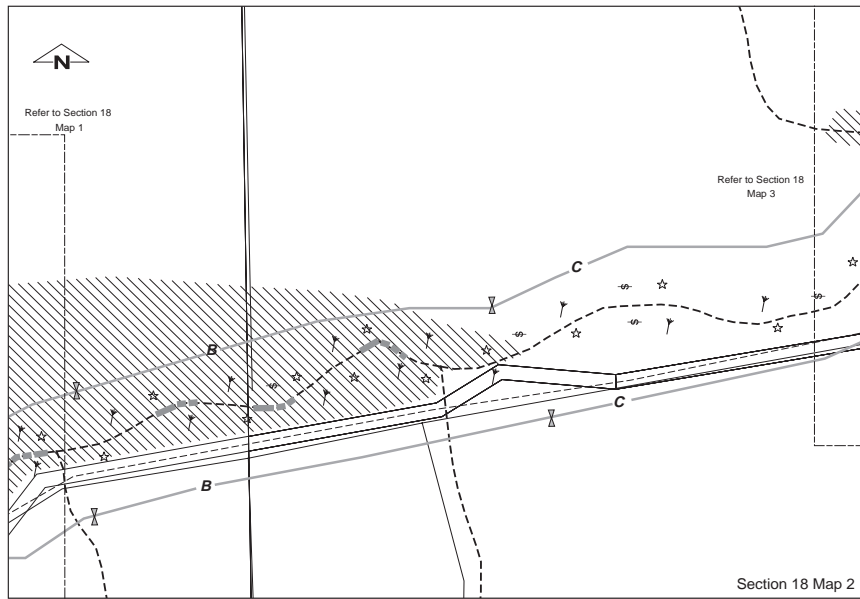
H Work to restore vegetation and minimise disturbance to the soil structure for the length of the waterway.

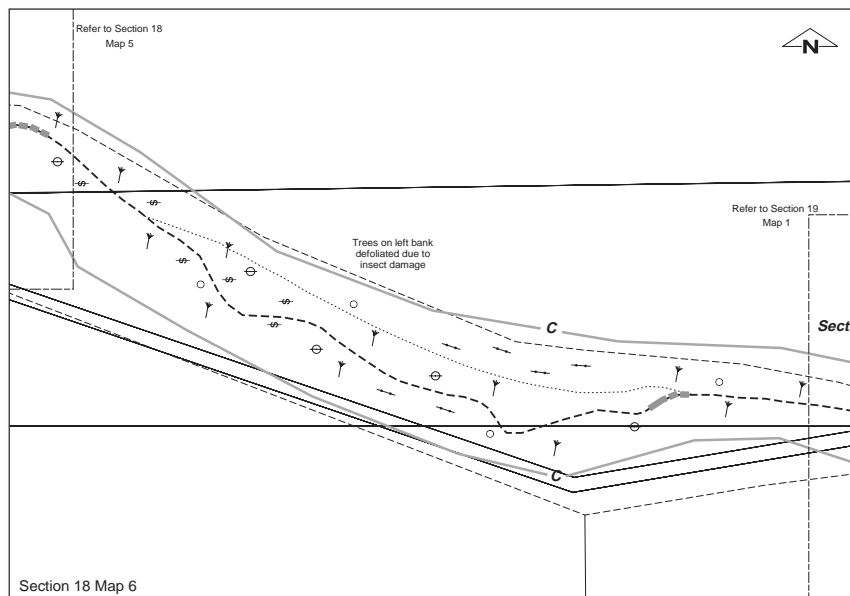
H Develop strategies to control water flow and sediment movement throughout this section length with the support and advice of relevant government agencies.

Other issues

O Modify current stock management practices to exclude stock until 70% perennial vegetation is achieved, if practical. Some short-term grazing may be useful to control weed species and fire hazard.







SECTION 19: KOCKATEA GULLY MAPS 1 – 5

Length of section (m): 6,100m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 4 April 2000

Nearest road access: Brenkley Road and Tenindewa Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Poor C	Very Poor D	Poor C	Poor C	Poor C

Bank stability

The main river channel spills down from a sandy loam dominated substrate to one with exposed granite periodically. The main channel ranges from 1.5 to 2 m with steep channel banks on the right bank and the floodplain on the left. The bank stability within this section is moderate, due to the rocky nature of the

substrate and frequently exposed clay soils. At the downstream end of this section, the dominant river channel ranges from single channel sections 8 – 15 m wide to braided channel sections. The channel banks rise on a moderate to very steep gradient to a height of between 1.5 and 3 m. The river valleys rise on a moderate slope to a height of between 4 and 6 m. The main course of river flow has changed in the recent



past. There is minimal sedimentation along this river section, which is a function of the gradient of the riverbed. Small erosion rills are evident, and there are localised areas of stock damage to the soil stability. There is a noticeable reduction in foreshore health in the last 600 m of this river section.

Comments

The exposed granite boulders instream and on the channel banks are significant features of the landform that are protecting the tributaries and Kockatea Gully from severe erosion damage from all flow conditions. Further, the soil types and geology help to confine the flow to the river valley. The riverbed is very steep. Stock movements on the valley banks are compacting the soil and leaving it denuded, making it more susceptible to erosion. These stock tracks have lower friction than vegetated areas, which allows the water to move more quickly across these areas. This is resulting in bank collapse and the erosion along many of the river sections.

Vegetation

The overstorey is sparse (< 20% cover) and dominated by mature York gum (*Eucalyptus loxophleba*), occasional Swamp sheoak (*Casuarina obesa*) and trees that have been planted by the landholder. The middlestorey is sparse while the understorey is continuous (> 80% cover). The understorey is dominated by weeds although there are some stands of native vegetation that are retaining their integrity. Saltmarsh species including *Sarcocornia* and *Atriplex* dominate along with a range of annual grasses, Lupins (*Lupinus* spp.), Pie melon (*Citrullus lanatus*) and Roly poly (*Salsola kali*).

Comments

Some of the weeds present are declared noxious and landholders are required to control these species on their properties. The revegetation works have had variable success, ranging from < 5% to approximately 50%. There may be opportunities to continue this work, supported through a regional funding application.

Stream cover

Infrequent patches of permanent shade are present in areas where the fringing vegetation is extensive and dense, and overhangs the main channel. There were

small pools persisting at the time of survey that are unlikely to be permanent. There is leaf litter and frequent rocks and branches also providing instream cover. Roly poly skeletons that blow into the river system are trapped in the vegetation and against instream woody debris, providing cover and a substrate for filamentous algae.

Comments

The stream cover is relatively poor, and the continuing decline of native vegetation will continue to reduce the quality of this feature in the future. The need to maintain good vegetation cover and therefore good stream cover cannot be emphasised enough.

Habitat diversity

Water flow is not permanent along this river section. Riffle zones and cascades aerate the water as it flows over exposed instream rocks. Large boulders periodically slow water flow. There are large concentrations of sheep droppings at stock crossing points that are causing localised reductions in water quality. There is little fine suspended sediment, however there are large volumes of mobile white sand that are starting to infill these pools. The minimal diversity and extent of native vegetation minimises the habitat diversity for aquatic and terrestrial invertebrates. The patchy shrubs were homes for finches, wrens and fantails, while Willy wagtails and Port Lincoln parrots frequented the remaining trees. Mountain ducks also use this area. Burrows of some lizards were seen during the survey. There were few flying insects that have a water-dependent part of their lifecycle. Kangaroos were observed.

Red-tailed black cockatoos are abundant on two properties. This species has expanded its range in the wheatbelt because an introduced pasture weed, Doublegee, makes up the bulk of their diet. These birds also eat a wide range of native seeds and some insects. The massive beak is sometimes used to strip bark and break small branches to get wood boring insect larvae. There is considerable evidence of stripping the leaves and bark from trees, which is impacting on the level of success of revegetation works.

Comments

Protecting the remaining vegetation is one of the keys to maintaining and possibly improving habitat



availability and diversity for native animals. Reducing disturbance to the substrate will also help. Stock movement along the riverbed keeps the mobile drift sand uneven and able to be more readily moved during the next flow event.

Other issues

Fencing is present and in variable condition along this section. There are some areas where the fencing would require less maintenance if realigned. There is a fenced stock crossing that is catching debris during flow events. There are some discarded farm materials in the riparian zone. Stock access on the powerbends is increasing the susceptibility of the channel banks to erosive forces. Culverts beneath river crossings would benefit from some minor extraction of sediment, and a possible variation to the design to improve the rate of flow beneath the road.

Suggestions

Bank stability

B Reduce stocking rates and length of time spent in the river reserve to reduce the formation of tracks on the valley slopes and help the vegetation to recover. This will help reduce erosion and broadscale changes to the shape of the valley.

Vegetation

V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.

V Implement a combined planting tubestock and direct seeding program ensuring that the plants are protected from stock, rabbits and birds where feasible.

V Reduce the length of time stock spend within the foreshore reserve to encourage natural regeneration.

Stream cover

S Exclude stock from river reserve to allow the vegetation to recover. Consider stocking for brief periods to achieve weed control.

S Monitor the accumulation of woody debris instream and determine where it is causing a greater problem than benefit as habitat. Realign or move upslope if necessary.

Habitat diversity

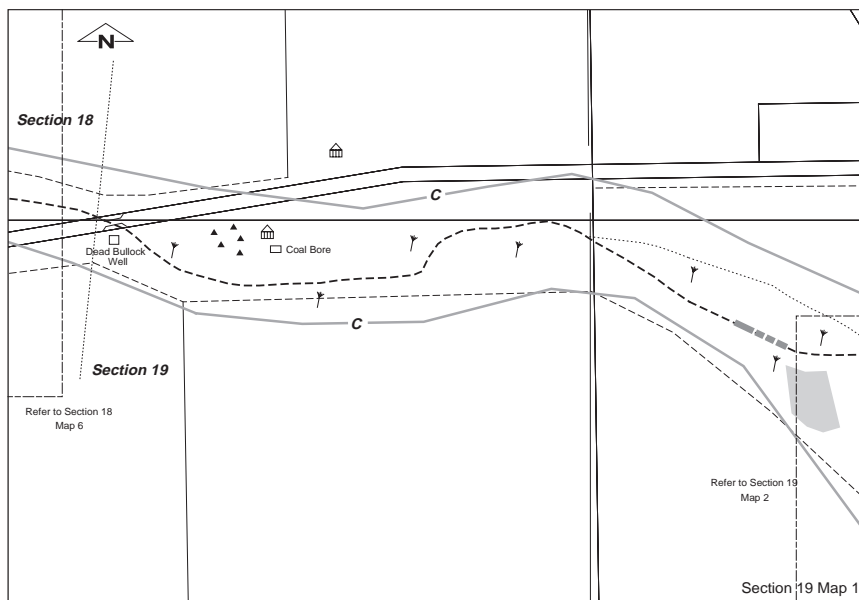
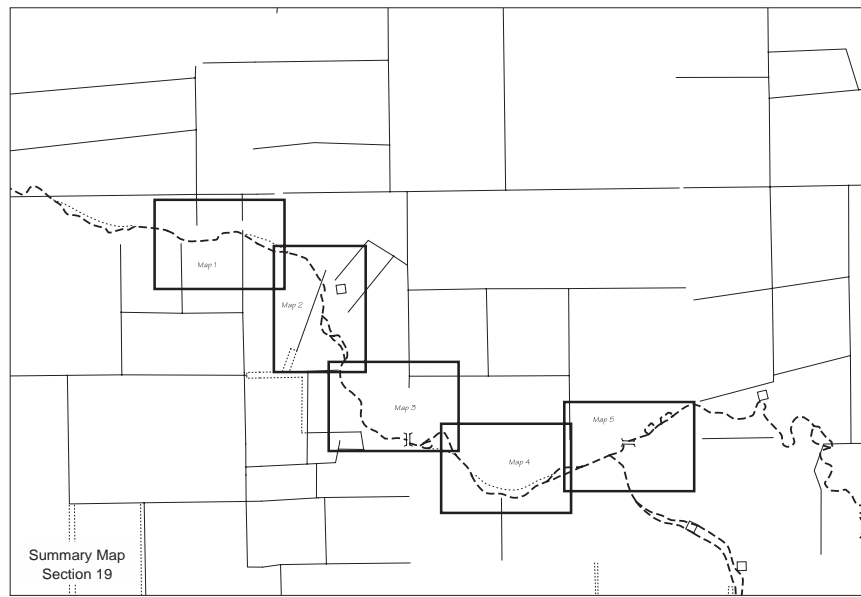
H Review current stock management practices and endeavour to keep stock from accessing the foreshore reserve until there is sufficient vegetation cover to protect the banks from erosion during the next flow event.

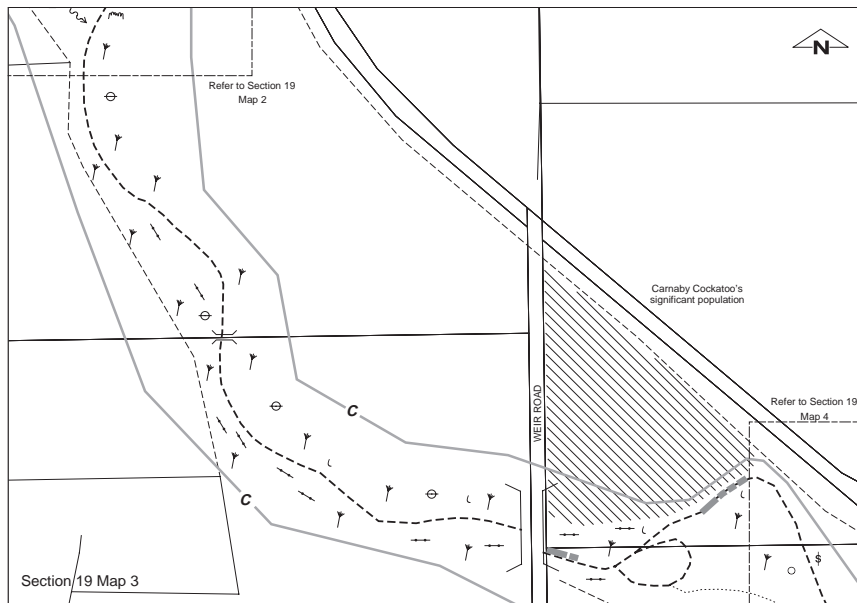
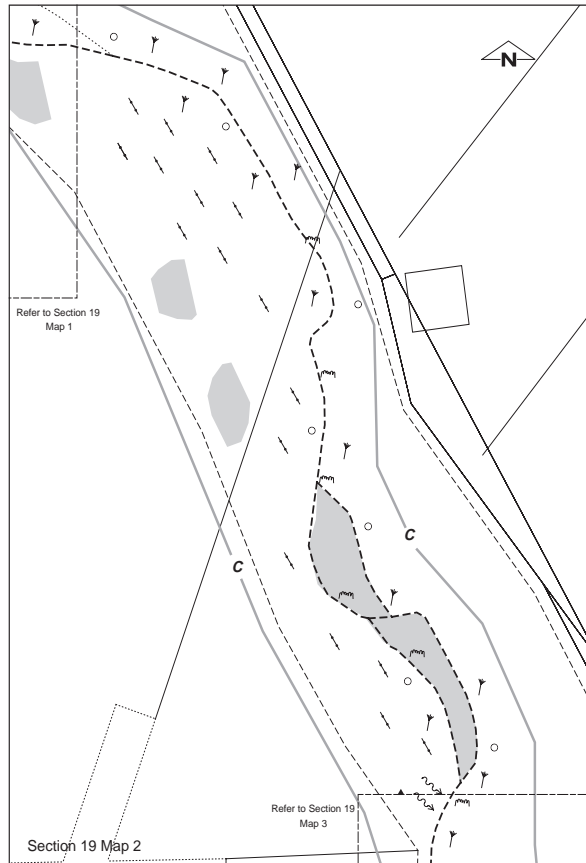
H Monitor the level of natural regeneration and if insufficient, plant tubestock in areas where stock exclusion can be guaranteed until the plants are established. These would be best in nodes that are a manageable size.

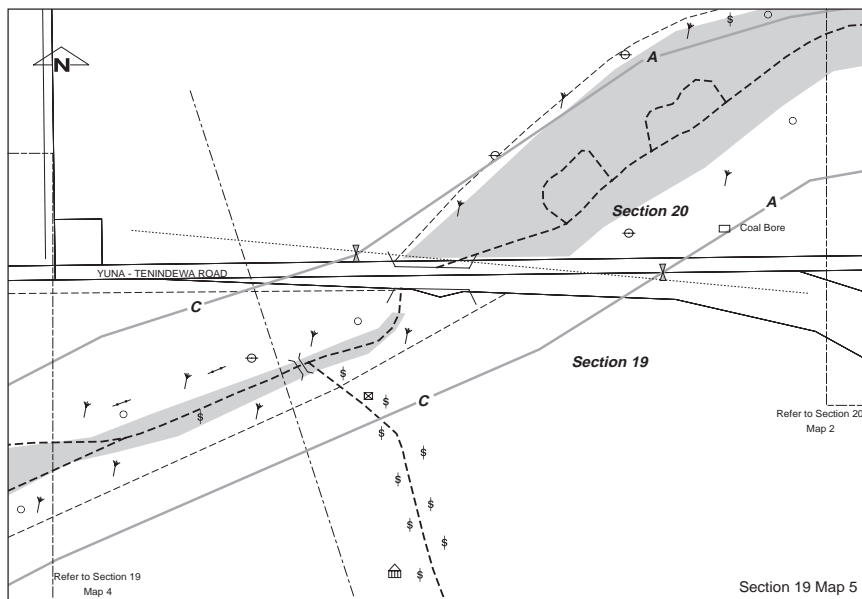
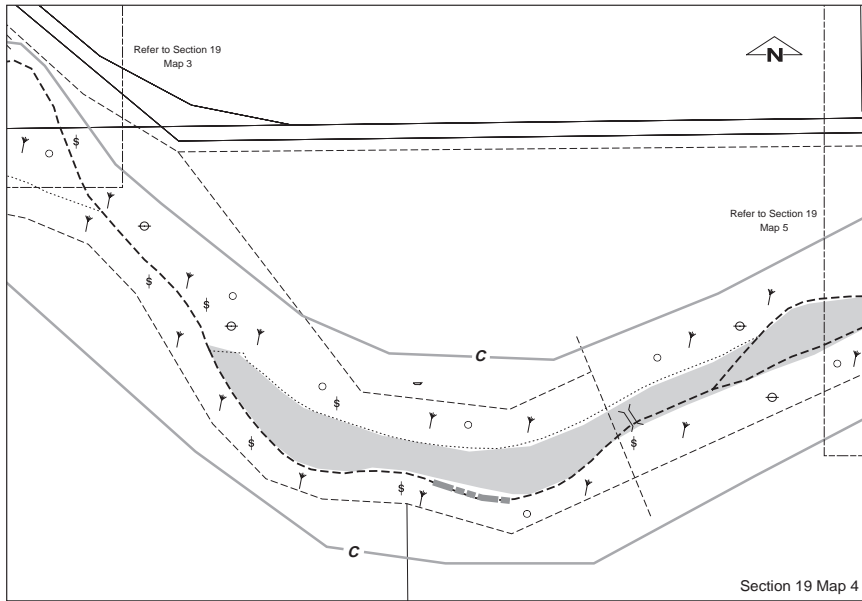
Other issues

O Review the foreshore reserve boundary alignment and suitability, and clearly mark any current amended or revised boundary.









SECTION 20: KOCKATEA GULLY MAPS 1 – 2**Length of section (m):** 800 m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 4 April 2000**Nearest road access:** Byron Road crossing and Tenindewa Road crossing**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Good A	Very Good A	Very Good A	Very Good A	Moderate B	Very Good A

Bank stability

The main waterway channel ranges from < 1 to 2 m wide through this section. The channel banks rise on a moderate gradient to a height of less than 1 m and the landform rises on a slight gradient to about 3 m over a 50 m distance. There is localised erosion close to the river crossings and also localised sedimentation in these areas. The banks are quite stable and well vegetated to the waterline. The peak flows inundate the area with the bulk of the flow on the south bank (right bank).

Comments

Provided there is no significant loss of vegetation due to trampling, grazing or prolonged inundation, the channel banks should remain stable. Monitoring of the impact of the causeways over time will help to detect a decline in vegetation.

Vegetation

There is no overstorey or middlestorey in this river section, which is characteristic of samphire dominated communities. The understorey is continuous (> 80% cover) and dominated by a range of *Halosarcia*, *Sarcocornia* and *Frankenia*. There is some Annual beardgrass (*Polypogon monspeliensis*) interspersed within the saltmarsh. *Atriplex* becomes common on the saltmarsh margins.

Some trees have been planted on the verge. Lupins (*Lupinus* spp.), Roly poly (*Salsola kali*) and a range of annual grasses dominate the verge.

Comments

The vegetation is in very good health in this section, although changes to water flow or quality may result in a reduction of health. Increasing the density of verge vegetation would help trap weed seed upslope, increase habitat values and reduce pressure on the saltmarsh.

Stream cover

The overhanging saltmarsh vegetation provides good stream cover, and there is some instream woody debris and leaf material that also contributes shade. Green filamentous alga is present.

Comments

The stream cover is very good, reflecting the health of the vegetation. The cover will be retained as long as the vegetation thrives.

Habitat diversity

The water is unlikely to be permanent and was clear in colour. The water depth varies but is shallow, ranging between 0.1 and 0.4 m in depth. The instream vegetation and scattered rocks and branches also provide good habitat. Waterbirds feeding in the mudflats also have access to trees in which they can roost and nest. The instream vegetation provides protection for aquatic invertebrates.

Comments

As outlined above, it is important to monitor the saltmarsh health to ensure that it is not left to decline with increasing waterlogging.

Other issues

Fences are present along this river section. Debris is suspended in the fencelines approximately 70 m from the main channel, indicating the extent of floodwaters. There is some rubbish within the foreshore area.

Suggestions

Bank stability

- B Link with groundwater monitoring programs and review the status of the levels regularly to determine



if there is a threat of increased fluctuations in the course of river flow.

- B Ensure surface water management and disposal is considered when upgrading access roads and causeways.

Vegetation

- V Eradicate Wild radish and Fleabane and control annual grasses while their populations are manageable.
- V Control weeds along access tracks and roadsides leading to the river.
- V Monitor natural regeneration processes within the saltmarsh and verge vegetation, and if necessary reinforce with overstorey, middlestorey and understorey species.
- V Control introduced annual grasses using flouzifop-butyl or slashing to reduce the fire risk associated with these species.
- V Review river flow through this section and upgrade to increase culvert capacity during low flow conditions if feasible.
- V Encourage landholders to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.

Stream cover

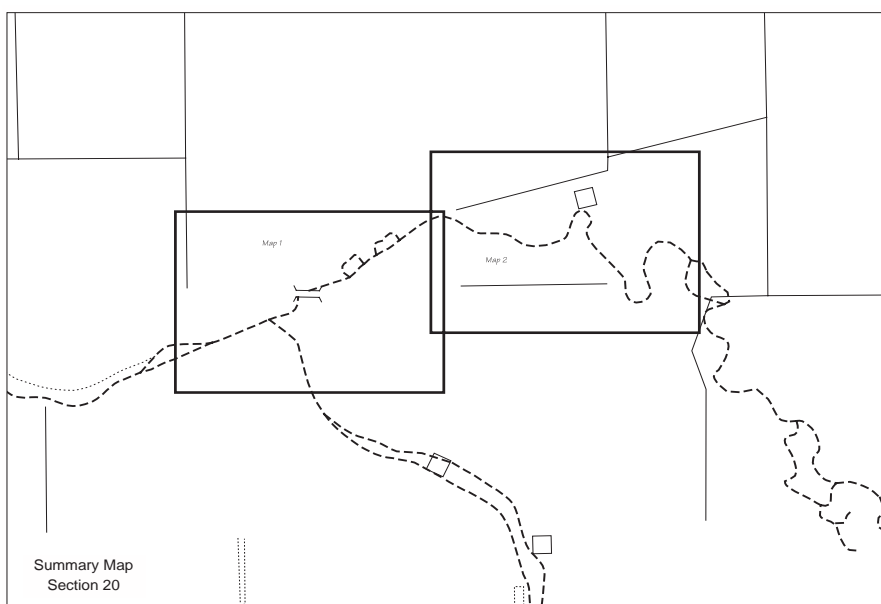
- S Maintain instream branches where these features do not exacerbate stream erosion.
- S Monitor plant health in the floodway with an aim of preventing any widespread loss of samphire species.

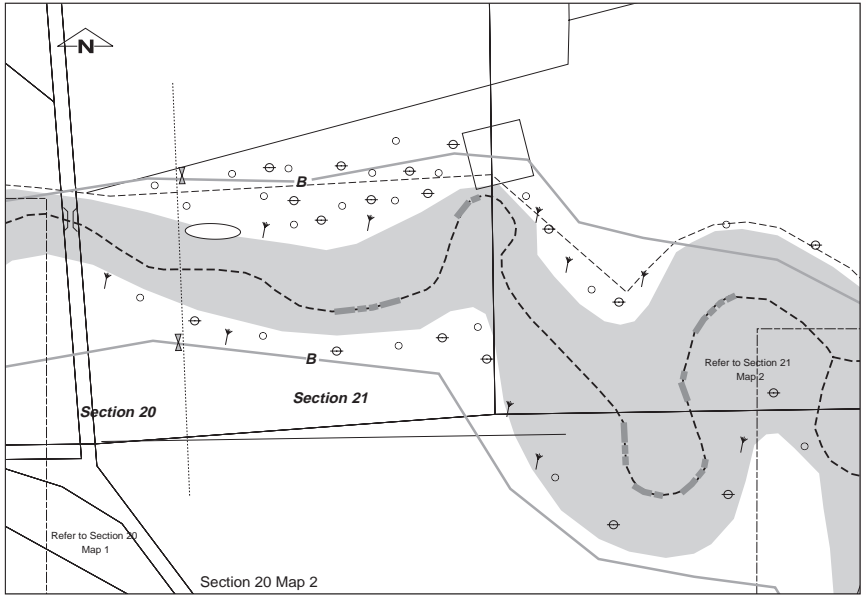
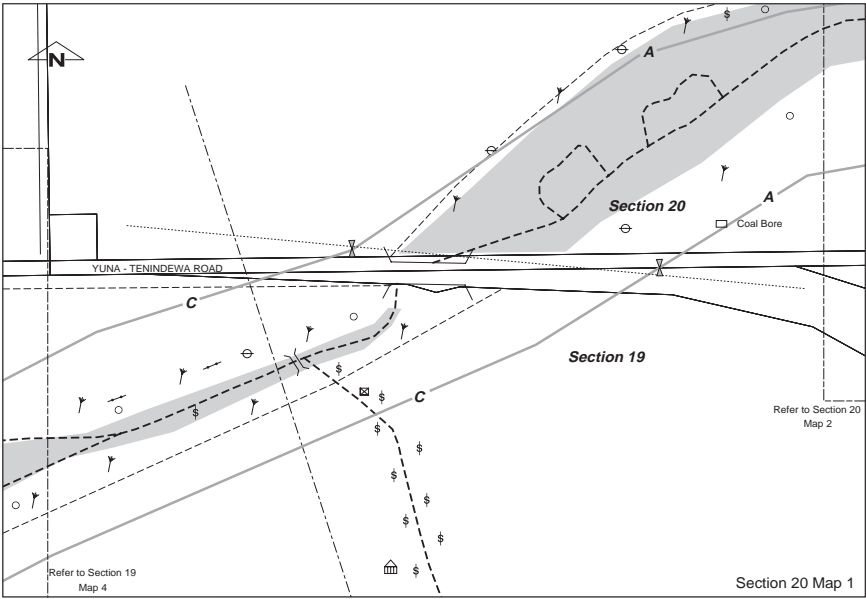
Habitat diversity

- H Control weeds, especially those that increase the fire risk, along the margins of the verge vegetation.
- H Reinforce the overstorey if required by planting tubestock where weeds are effectively controlled.
- H Monitor the health of vegetation in the floodway and on the verge over time, and liaise with Water and Rivers Commission, Department of Conservation and Land Management and Agriculture WA if a decline is noted. This will enable a strategy to be developed to sustain vegetation cover in the long term.

Other issues

- O Review flows beneath all of the crossings in this section under different flow conditions to develop a strategy to reduce ponding.





SECTION 21: KOCKATEA GULLY MAPS 1 – 4

Length of section (m): 5,800m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 4 April 2000**Nearest road access:** Yuna-Tenindewa Road and Byron North crossing**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Moderate B	Moderate B	Moderate B	Moderate B	Moderate B

Bank stability

The channel and floodway banks are characteristically moderately steep and reflect expected river patterns with a wide floodplain and erosion on the powerbends. The low flow channel varies in width from 2 m to 5 m wide, and the channel banks range from less than 1 m to 3 m high. The floodplain is generally on the right bank. About 40% of the entire section has some erosion, undercutting and subsidence on the powerbends of the creek. The river has changed course in the distant past with defined former channels acting to carry peak flows. There are five severe blowouts, sections with considerable accumulation of coarse sediment and localised erosion rills forming where stock have congregated.

There is also evidence of wind erosion exacerbating minor blowouts formed following peak flow events. The revegetation works are helping to reduce the effect of the wind.

Comments

The lack of perennial or annual vegetation cover and high levels of stock access have resulted in this section becoming highly unstable and erosion prone. The steep banks defining the river valley will continue to erode unless there is considerable effort to control water movement down these slopes. The considerable sedimentation observed can be linked to the water slowing as the two rivers meet. Because the instream vegetation is not continuous upstream of this point and many tributaries are contributing both water and sediment, the rivers tend to carry large amounts of soil during large peak flow events. Increasing vegetation cover and slowing river flow will help reduce the formation of blowouts and effects of wind erosion in this section.

Vegetation

The characteristic vegetation in this section continues to be samphire species from the main channel to the full extent of the floodway. The dominant species are Shrubby samphire (*Halosarcia halocnemoides*), Beaded samphire (*Sarcocornia quinqueflora* and *S. blackiana*), Bluebush (*Atriplex* spp.) and introduced annual grasses. The health of these plants is very good, however the density of vegetation generally decreases with increasing distance from the main channel. There has been considerable effort towards revegetating the creekline and restoring tree and shrub cover. Species planted include eucalypts, melaleucas, Swamp sheoak (*Casuarina obesa*), mallee and wattles. There are occasional relic River gum (*Eucalyptus camaldulensis*). Tree and shrub cover is generally less than 5% of the total river section. Beyond the floodplain there are annual grasses, Box weed, Pie melon (*Citrullus lanatus*), Doublegee (*Emex australis*), a weed that is a member of the mint family weed and a range of clovers and medics. These become increasingly prevalent beyond the floodway.

Comments

Continuing revegetation works will benefit the landholders and the waterway by ultimately reducing the management effort required. The wind erosion is a significant management issue and increasing turbulence will help reduce its impact. Ensuring that revegetation works are not limited to the waterway would assist this process further. Establishing networks of corridors from the rivers, across paddocks to remnant bushland would benefit native fauna. It would also benefit introduced fauna, particularly foxes.



Stream cover

There is very little stream cover which is characteristic of samphire flats. There is some instream debris providing shelter and evidence of deeper pools.

Comments

Stream cover in the pools is important to provide shelter and shade for fauna as they prepare to hibernate. Without cover, the water temperature can rise rapidly, triggering a range of bacteria and algae to grow. These can kill or interfere with the remaining fauna.

Habitat diversity

The instream and floodway habitats were poor to moderate in some sections. Little aquatic life was seen apart from filamentous algae (*Spirogyra*). The water was very clear and saline. The survey was undertaken on a cool day, which is likely to have impacted on fauna movements. There were considerable numbers and diversity of bird fauna in this section. Birds observed included Emus, Pink and grey galahs, crows, hawks, falcons, harrier, Wood swallows and Magpie larks. Kangaroos were also present.

Other issues

Fencing is generally set back from waterway at least 3 m and up to 200 m in places on both banks. Where the fence was aligned close to the waterway, there were significant amounts of stubble and other debris entwined around the wire. This debris indicates the extent of the floodplain required during flood events. In some locations, the fence occurs well within this level.

There has been considerable effort to deep rip and plant trees. The trees are a number of years old. The canopy cover ranges from 70% within revegetation area to less than 10% depending on success rate. There is evidence of reinforcement plantings in areas with lower success rates.

There are two stock and vehicle crossings that appear to function well. There is considerable build up of sheep droppings at these crossings. There are extraction points to feed water tanks and water troughs set in the paddock outside the floodplain.

The stock yards are set well back from the river and high water mark, which is an effective management technique to retain excreta in the paddocks and minimises soil damage.

Stock continue to graze in the area, to keep understorey/ fire hazard down. There are localised areas where stock are compacting the clay soils, increasing the soil susceptibility to collapse and erosion. There is a dam within the floodplain. There is an off-line salt pan. There is minimal shelter for stock beyond the floodplain.

Suggestions

Bank stability

- B Link with groundwater monitoring programs and review the status of the levels regularly to determine if there is a threat of increased fluctuations in the course of river flow.
- B Ensure surface water management and disposal is considered when upgrading access roads and causeways.

Vegetation

- V Eradicate Wild radish, Pie melon, Roly poly and Saffron thistle while their populations are manageable.
- V Control weeds along access tracks and roadsides leading to the gully.
- V Monitor natural regeneration processes within the saltmarsh and verge vegetation, and if necessary reinforce with overstorey, middlestorey and understorey species.
- V Control introduced annual grasses using flauzifop-butyl or slashing to reduce the fire risk associated with these species.
- V Encourage landholders to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.



Stream cover

- S Maintain instream branches where these features do not exacerbate stream erosion.
- S Monitor plant health in the floodway with the aim of preventing any widespread loss of samphire species.

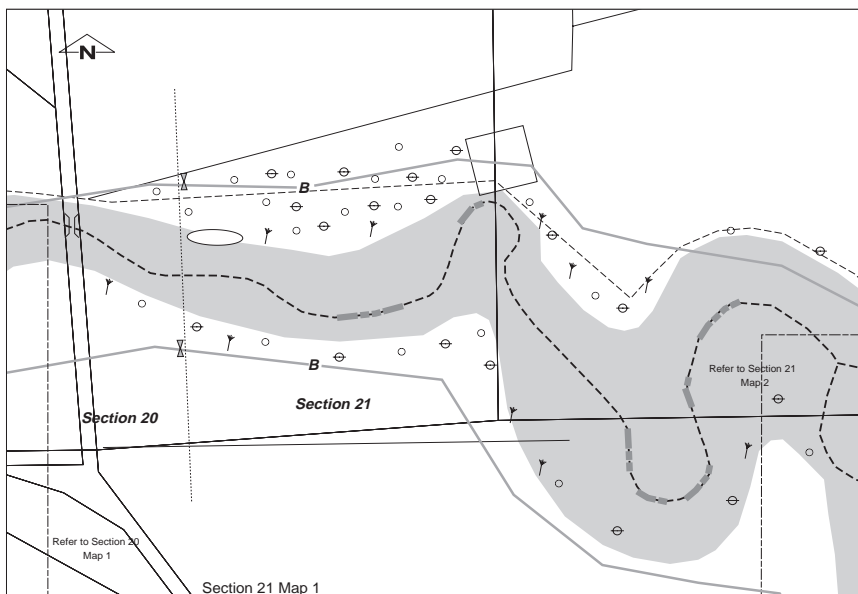
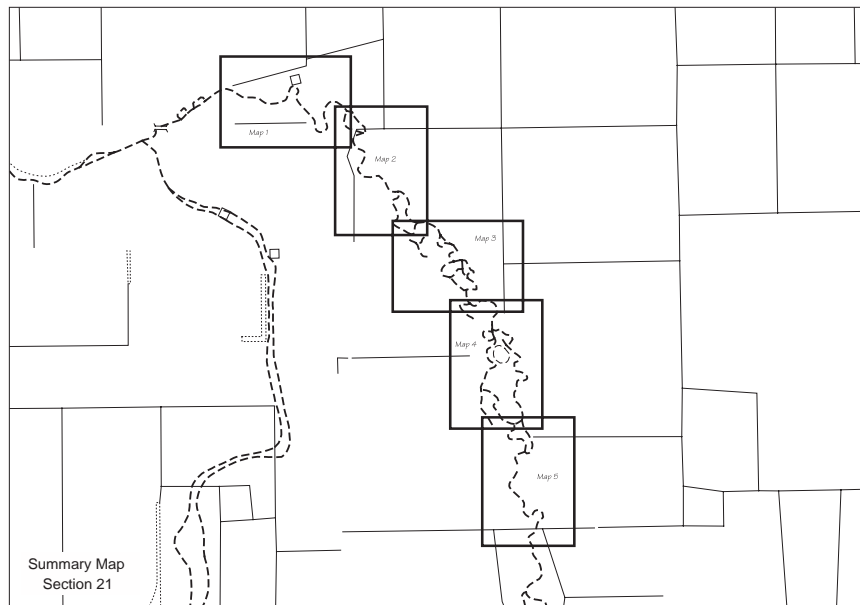
- H Monitor the health of vegetation in the floodway and on the verge over time, and liaise with Water and Rivers Commission, Department of Conservation and Land Management and Agriculture WA if a decline is noted. This will enable a strategy to be developed to sustain vegetation cover in the long term.

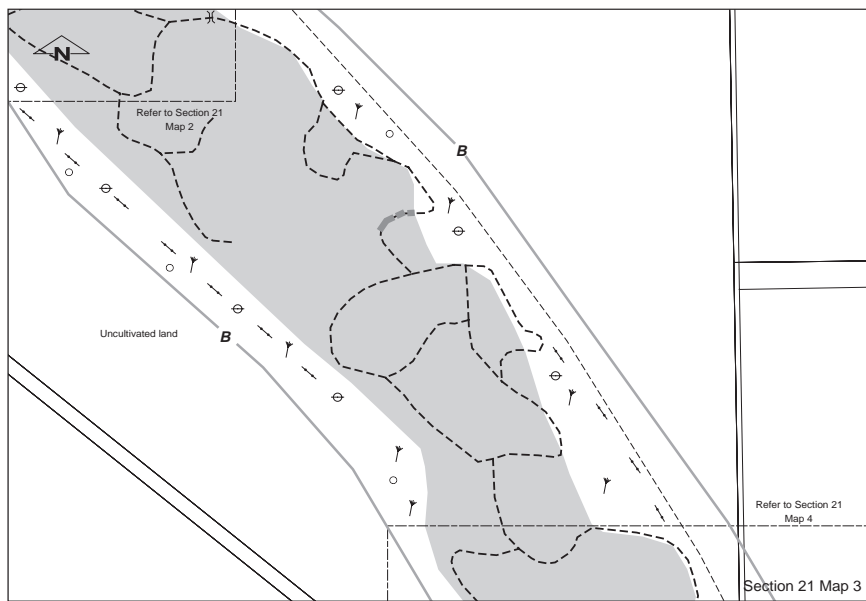
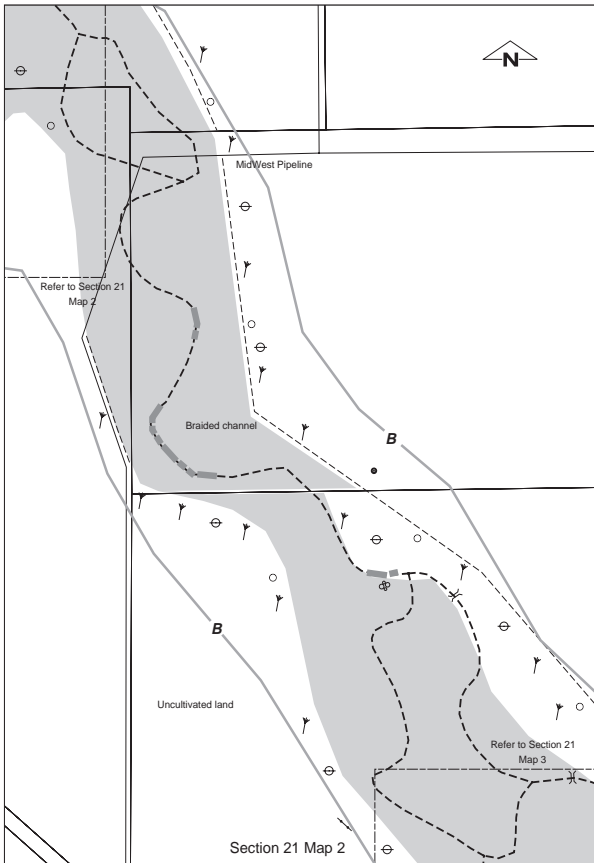
Habitat diversity

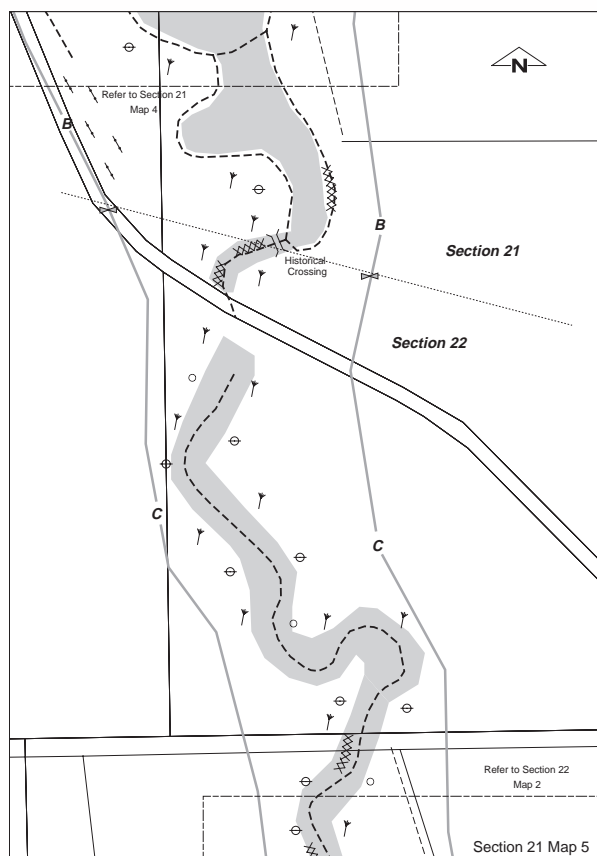
- H Control weeds, especially those that increase the fire risk, along the margins of the verge vegetation.
- H Reinforce the overstorey if required by planting tubestock where weeds are effectively controlled.

Other issues

- O Review flows beneath all of the crossings in this section under different flow conditions to develop a strategy to reduce ponding.







SECTION 22: KOCKATEA GULLY MAPS 1 – 7

Length of section (m): 8670m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 4 April 2000

Nearest road access: Yuna-Tenindewa Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Poor C	Very Poor D	Poor C	Very Poor D	Poor C

Bank stability

There is considerable variation in bank stability. The channels vary in width from 2 m to 15 m wide, and the channel banks range from less than 0.5 m to 2 m high. Secondary channels are forming along approximately 15% of the river length during peak flows. About 30% of the entire section has severe erosion, undercutting and subsidence on the powerbends of the creek. There is minimal vegetation within the bank full section of the river, with the samphire mostly limited to areas above high water mark. Coarse river sand is accumulating in large plumes in the middle of the river along about 20% of the section.

Comments

The volume, rate and frequency of flow is resulting in changes to the stability of the bed and banks. This is

likely to be linked with the changes to the flow regime resulting from the construction of the Geraldton-Mullewa Highway and the railway line. Both of these features have culverts to enable flow, however the poor bank stability downstream suggests that the current arrangement is insufficient. The coarse sediment is arising from the local area, with some of the abrasive power of the water contributing to loss of sediment from the channel banks. The lack of vegetation close to the main river channel is another indicator of poor health.

Vegetation

The characteristic vegetation in this section is samphire. The dominant species are Shrubby samphire (*Halosarcia halocnemoides*), Beaded samphire (*Sarcocornia quinqueflora* and *S. blackiana*), Bluebush (*Atriplex* spp.) and others. The health varies. There



has been considerable effort put into revegetating the creekline and restoring trees to the environment. Species planted include Eucalypts, Melaleucas, Saltwater sheoak (*Casuarina obesa*), mallee and One-eyed wattle (*Acacia cyclops*). Some of the species are not locally indigenous. Beyond the floodplain there are annual grasses, Box weed, Pie melon (*Citrullus lanatus*), Doublegee (*Emex australis*), a weed that is a member of the mint family weed and a range of clovers and medics. In addition the native Wallaby grass (*Danthonia setacea*) is common. There are some dead trees within the main channel.

Comments

The effort put into re-establishing trees and shrubs is highly commendable and will ultimately contribute to improved river health. Reviewing the manner of flow beneath the major road and rail link will help to determine the impact of changing hydrologic conditions. Restoring the flow of Kockatea Gully will protect persistent native vegetation and encourage natural regeneration processes.

Stream cover

There is very little stream cover which is characteristic of samphire flats. There is some instream debris providing shelter. The tree and shrub replacement process is improving the habitat values of the floodway considerably, however there are few large shrubs.

Comments

Stream cover is gradually improving and with continuing effort into revegetating the foreshore, greater cover is achievable. Leaf litter, branches and woody debris will become more common in the environment as the trees grow, die back and follow their natural cycle.

Habitat diversity

The saltmarsh has less cover than Section 23 of Kockatea Gully, and has more extensive mudflats. Fox footprints were noted along with some rabbit droppings. Willy wagtails, Port Lincoln parrots and a type of finch were observed in the revegetation areas.

Comments

The habitat diversity is minimal. The modifications to the channel characteristics have resulted in the loss of

almost all stream cover. By restoring vegetation to the margins of the channel and through the verge, additional detritus and leaf and branch litter may enter the watercourse. The occasional green filamentous alga present has a limited capacity to provide habitat.

Other issues

The creek passes beneath the Geraldton-Mt Magnet Road and rail line. Fencing is generally set back from waterway at least 10 m and up to 100 m in places. In the upstream parts of this section, the fence is limited to a single side. There has been considerable effort to deep rip and plant trees along most of the length. The trees are likely to be more than 4 years old. Stock continues to graze the area, to keep understorey/fire hazard down, however they are impacting on regeneration of native understorey plants. The success rate of overstorey plantings has resulted in vegetation cover ranging from less than 10% to 70% within the revegetation area. There have been additional reinforcement plantings in areas with lower success rates. The stock and vehicle crossing has not been improved and appears to function well. There is considerable build up of sheep droppings at these crossings.

Suggestions

Bank stability

- B Continue deep ripping and revegetation works to trap sediment upslope from the river.

Vegetation

- V Monitor samphire deaths and work to modify the drainage patterns to increase flow and reduce banking back of water.
- V Continue planting program and start to include more shrubs and groundcovers, along with reinforcement trees.

Stream cover

- S Focus attention on restoring vegetation cover to the riparian and verge zones along this entire section.
- S Consider stream cover if a strategy to restore the river channel is developed.



Habitat diversity

H Continue revegetation program to improve habitat values within the floodway and on the verge.

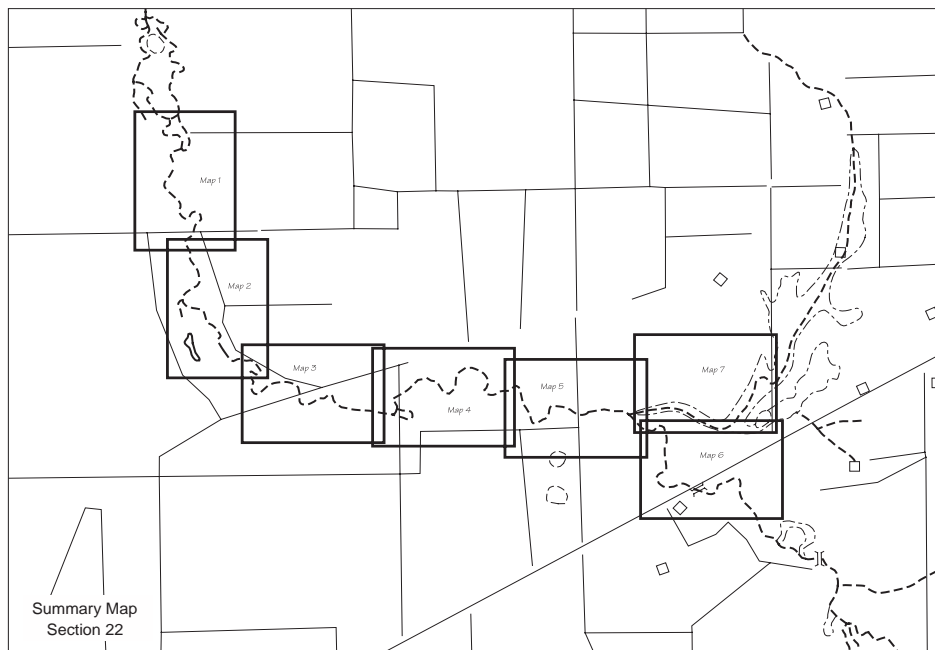
H Link the existing remnant vegetation with revegetation works in the floodplain.

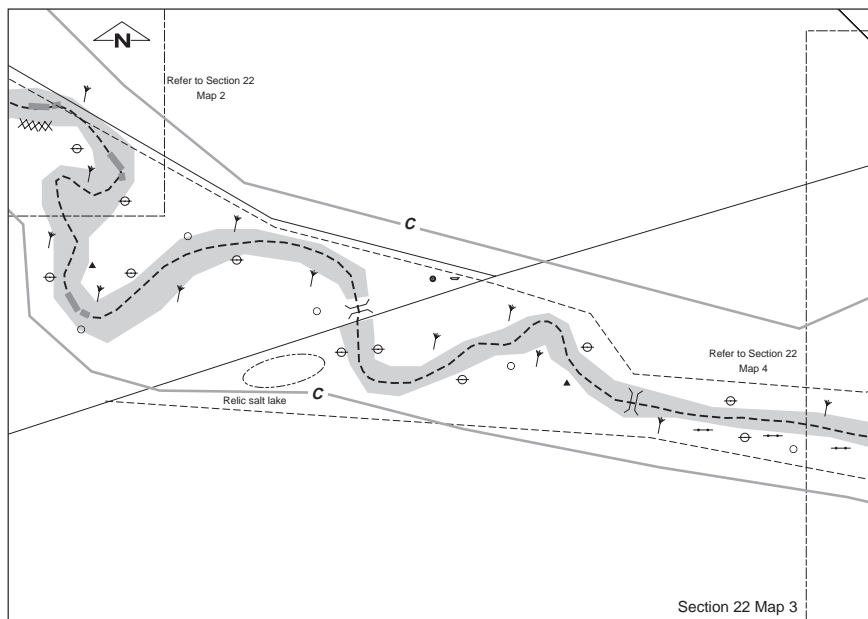
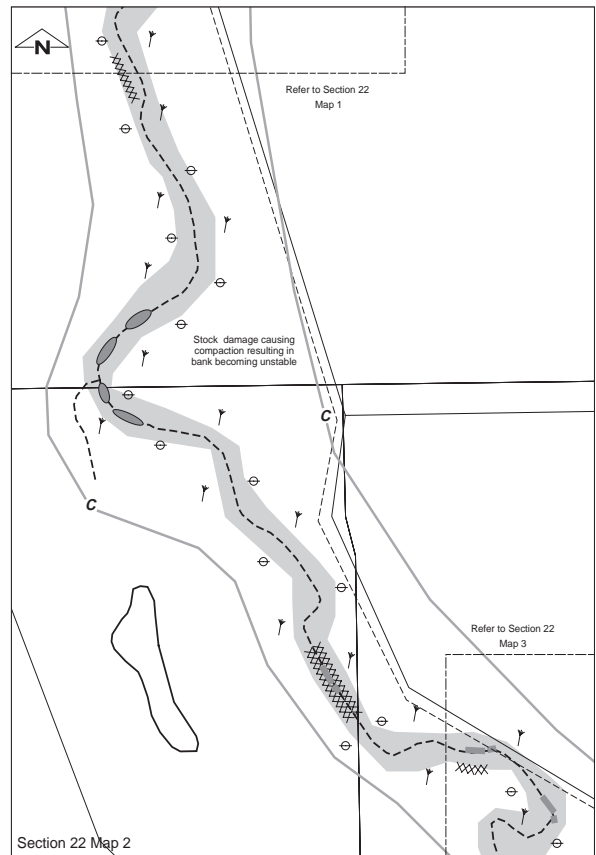
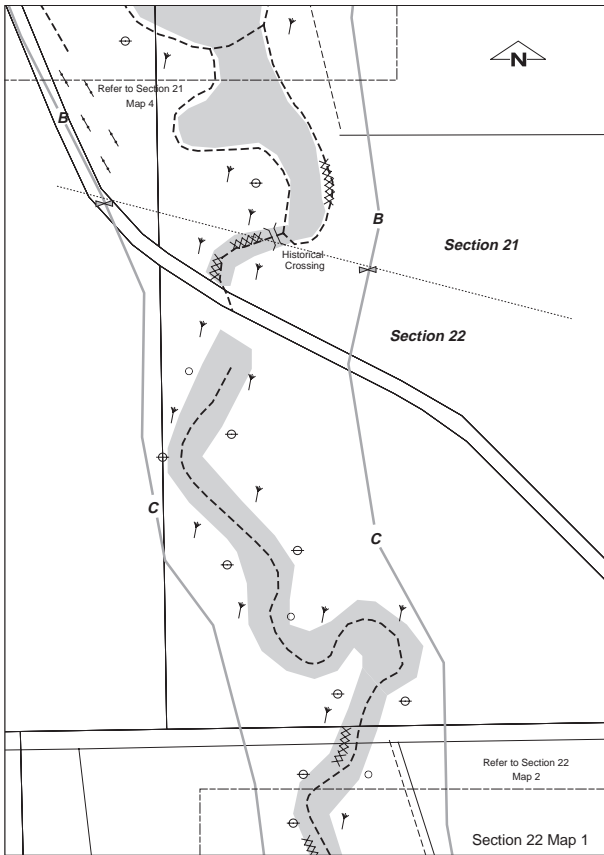
Other issues

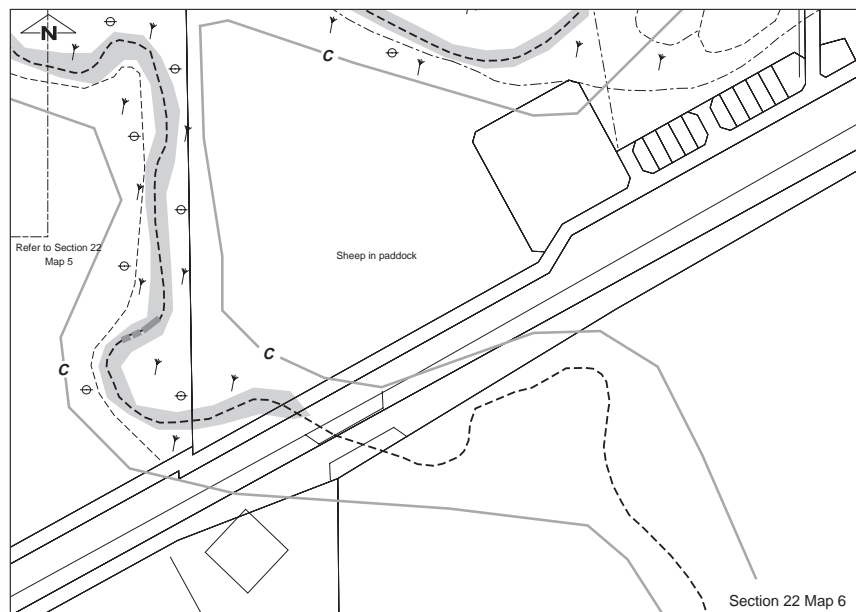
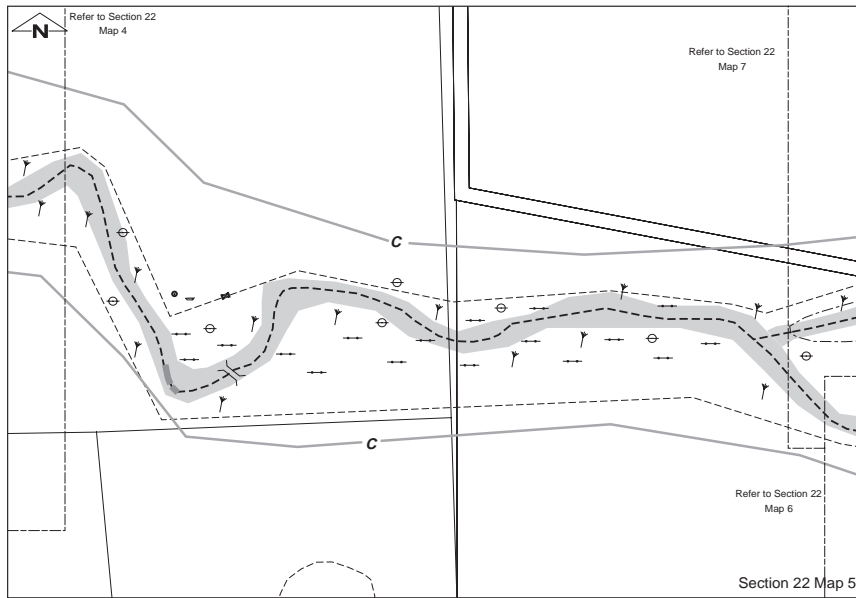
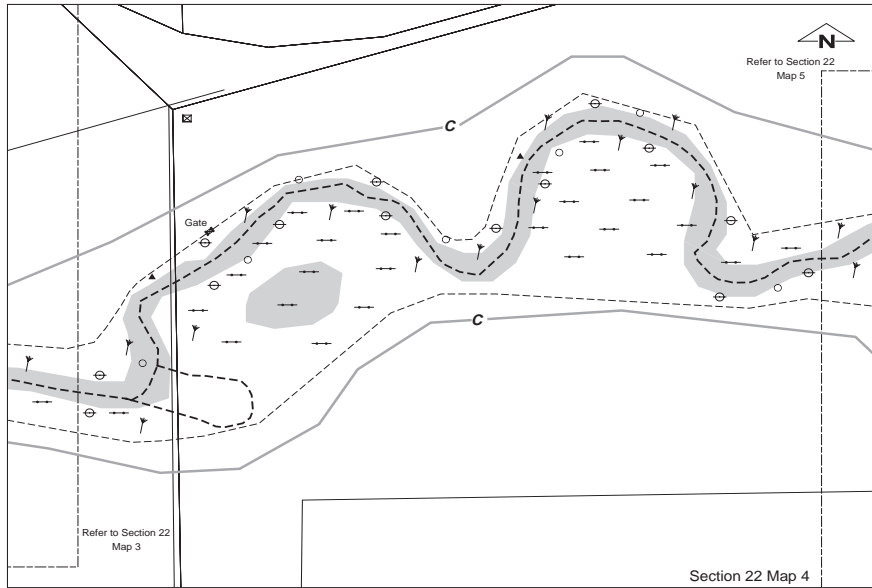
O Continue revegetation works within fenced off stream area and minimise stocking for as long as possible.

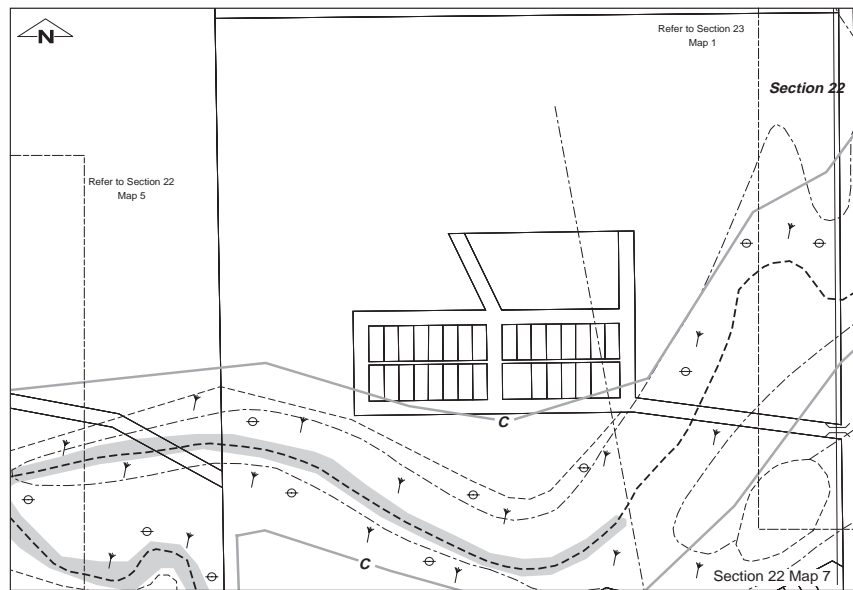
O Maintain current fence alignment on left bank to protect the bank and encourage the landholder to fence off a section of the foreshore on the right bank where fencing is currently absent.

O Liaise with emergency crews to develop a disaster response strategy including a holding area to maximise the containment of any pollutants that may arise in the event of a traffic or rail accident in the vicinity of the creekline.









SECTION 23: KOCKATEA GULLY MAP 1

Length of section (m): 910 m

Recorders' names: N Siemon and T Rebola

Date surveyed: 4 April 2000

Nearest road access: Yuna-Tenindewa Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
A Very Good	A Very Good	B Moderate	B Moderate	A Very Good	A Very Good

Bank stability

The Kockatea Creek passes through a well-vegetated saltmarsh in this section and there is little variation in bank stability. The creek channel varies in width from 2 m to 5 m, and the channel banks range between 0.1 m to 0.5 m high. Secondary channels are forming along approximately 15% of the river length during peak flows. About 10% of the entire section has some accumulation of fine clays. The floodplain extends up to 80 m either side of the channel. The Yuna-Tenindewa crossing is causing the water to bank back as the culverts do not meet the full channel width. This is starting to cause a decline in vegetation health, as the plants are unable to cope with increased inundation.

Comments

This section is a relatively minor tributary of the Kockatea Gully with the bulk of flow originating to the south of this site. These relatively low flow conditions help to protect the bed and banks from erosion. The clay - loam nature of the soil in the riverbed also minimises the volume of coarse sediment contributed to this waterway. This helps protect the vegetation from abrasion that often is a result of mobile

sand in water. The greatest threat to the longevity of vegetation in this section is related to inundation issues.

Vegetation

The characteristic vegetation in this section is samphire species. The dominant species are *Halosarcia*, *Sarcocornia*, *Atriplex*, *Frankenia pauciflora* and Bluebush (*Maireana*). The health varies depending on the level of waterlogging. Beyond the saltmarsh, weeds, with occasional *Atriplex* and wattles, dominate the understorey. Beyond the floodplain there is a diverse range of annual grasses, Roly poly (*Salsola kali*), Pie melon (*Citrullus lanatus*), Doublegees (*Emex australis*) and clover amongst remnant mallee woodland. The native Wallaby grass (*Danthonia setacea*) is common. There are some dead trees within the main channel.

Comments

The healthy saltmarsh community is at risk from changes to the surface and groundwater movements in the area. The salt levels in the riparian zone minimise the availability of habitat for many weed species. Those that grow are adapted to these conditions. The verge vegetation is limited, probably reflecting the changing hydrologic conditions.



Stream cover

There is very little stream cover, which is characteristic of samphire flats. There is some instream debris providing shelter and also deeper pools. There are patches where filamentous algae are prevalent, indicating high nutrient levels particularly nitrogen based compounds. This alga provides good cover for native fish and the introduced Mosquito fish (*Gambusia holbrooki*). Anecdotal evidence suggests that the proliferation of filamentous algae is a reasonably recent occurrence.

Comments

The changing water quality conditions increases instream substrate (algae) and therefore cover, but may result in changes to the oxygen loading of the water as the flow decreases and the river dries back to pools. The cover is limited, and is unlikely to provide habitat throughout the year.

Habitat diversity

The samphire flats provide feeding grounds for mountain and black ducks, and a range of invertebrates. There are a number of small burrows into the channel banks. The vegetation beyond the floodway provides variable cover for birds, reptiles and mammals. Native pigeons, Willy wagtails and Port Lincoln parrots were observed in the area.

Comments

The habitat diversity is moderate with the shallow saltmarsh likely to provide seasonal habitat for migratory wading birds such as dotterels and plovers, and the surrounding open shrubland providing some patchy cover for birds. There is minimal habitat for terrestrial fauna, particularly reptiles in the saltmarsh.

Other issues

This section is not fenced and there is no evidence of livestock grazing. The floodway is well vegetated and is currently stable. The headwaters of the catchment beyond the extent of the survey area should be assessed

using this process to enable identification of any potential degradation processes.

Suggestions

Bank stability

- B Investigate the feasibility of modifying the crossing to restore stream flow to its natural width to prevent further loss of vegetation. This may only be feasible in the event of the existing structure being damaged during a peak flow event.
- B Continue foreshore assessment survey work upstream to assess any potential threats from the uppermost section of the catchment.

Vegetation

- V Monitor samphire deaths and work to modify the drainage patterns to increase flow and reduce banking back of water (see above).
- V Maintain current status of the shrubland and woodland beyond the floodplain.

Stream cover

- S Monitor for any loss of vegetation, particularly adjacent to the channel.
- S Continue to monitor water quality particularly for available nitrogen based compounds which can impact on samphire health.

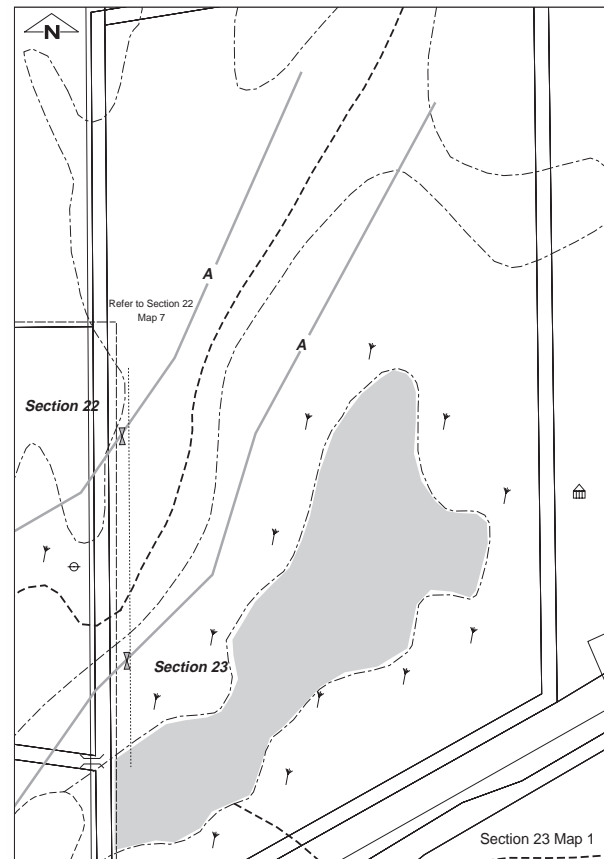
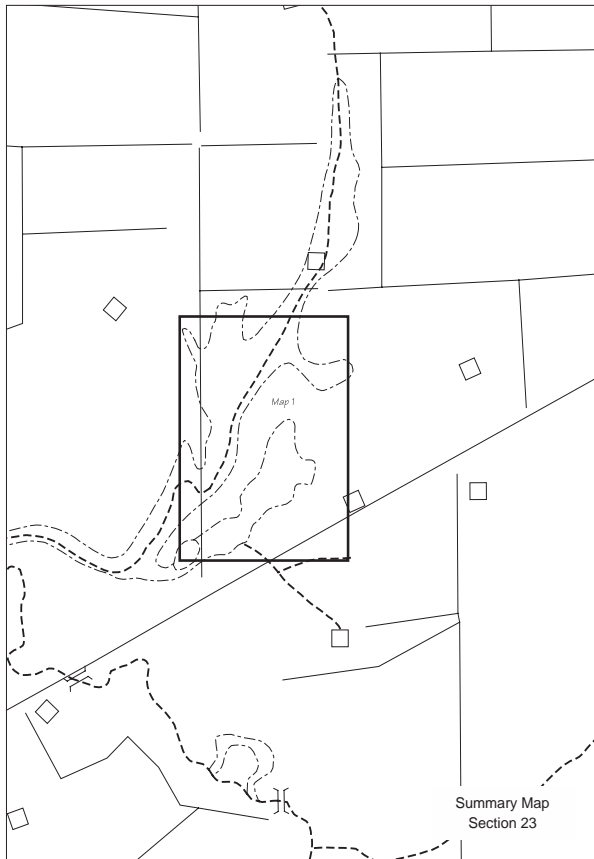
Habitat diversity

- H Use this site to show landholders what healthy saline waterways should look like and the level of vegetation cover that is sufficient to protect bank stability in low-lying areas.

Other issues

- O Determine land ownership and tenure of the saltmarsh and adjoining remnant vegetation and work to ensure long-term protection for this area.





SECTION 24: GREENOUGH RIVER MAPS 1 – 11

Length of section (m): 12,520m

Recorders' names: N Siemon and T Rebola

Date surveyed: 17 October 2000

Nearest road access: Noondamurra Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Moderate B	Poor C	Poor C

Bank stability

The main river channel ranges from < 5 to 12 m wide with moderate channel banks to an average height of 1.8 m, grading into a steep left valley bank and moderate right bank. Erosion is localised (20 – 50%) and occurs principally on the margins of the floodway and in shallow graded areas that are prone to flooding. These blowouts range from minor to severe. The river channel banks are generally stable, however future peak flow events may result in changes in the river course. There are frequent beds of exposed rocks in the riverbed.

Sedimentation is significant (>50%) and the result of sand removed from the floodway being deposited downstream when water flow is slowed by vegetation. There are several long, narrow pools that are at risk of

being in-filled by the mobile sand. Some of these have rocky substrates and the channel bed gradient is relatively steep. These pools are likely to be sustained in the long term. Others though are unlikely to have sufficient flow through, as the vegetation cover is insufficient to direct water flow preferentially along the main river channel. Therefore it is unlikely that these pools will self-clean and be maintained in perpetuity.

Some of the steep valley banks are unstable with numerous erosion rills forming, while others are relatively stable.

Comments

Many of the erosion rills are forming in areas lacking vegetation cover. This paucity of vegetation can be associated with either stock or feral animals such as goats, or ant activity. Managing the formation of these



rills may be achieved relatively easily by selective placement of granite rocks to form small riffle structures to slow sheet runoff. This is labour intensive, however, once installed the structures are likely to require minimal maintenance. They will also reduce the rate of formations of head cuts into the river system.

Vegetation

The overstorey is patchy (20 – 80% cover) and dominated by River gum (*Eucalyptus camaldulensis*) interspersed with dense stands of Swamp sheoak (*Casuarina obesa*). There is another unidentified sheoak present that may or may not be native. There was significant evidence of regeneration and a range of trees of different ages. The middlestorey is Swamp paperbark (*Melaleuca raphiophylla*) and some species of *Acacia*. The understorey is patchy (20 – 80% cover) and is dominated by mosaic of weeds or dense stands of Spiny flatsedge (*Cyperus gymnocaulos*) or saltmarsh species such as *Halosarcia*, *Sarcocornia*, *Atriplex* and an annual *Scaevola*. Common flowering weeds include Paterson's curse (*Echium plantagineum*), Ruby dock (*Acetosa vesicaria*), Wild radish (*Raphanus raphanistrum*), Pie melon (*Citrullus lanatus*) and Roly poly (*Salsola kali*). Annual grasses including Wild oats (*Avena fatua*), Annual Wimmera ryegrass (*Lolium rigidum*) and occasional clumps of the native Silky heads (*Cymbopogon obtectus*) persist among the weeds.

There is minimal verge vegetation along this length, however the persisting stands retain moderate diversity.

Comments

The considerable regeneration is a good indicator that this section can be sustained and improved in the long term, with careful management and continued minimal use of the area by stock. The foreshore reserve boundary generally reflects the landform, so the riparian zone is well protected. The sections with < 20% vegetation cover are vulnerable to erosion and the trees are being undermined. Selective weed control would be beneficial to encourage regeneration. The right bank has the greatest potential for supportive revegetation works.

Stream cover

Stream cover ranged from excellent to good through this section, and reflected the extent of native vegetation

and instream woody debris. The native vegetation frequently overhangs the narrow river channel providing patches of permanent shade. The large rocky pools also retained good stream cover.

Comments

Current stock and fire management practices are helping to protect this section of foreshore from disturbance that may result in degradation. The remnant vegetation, while showing considerable weed infestation, is sufficient to provide cover both instream and on the floodway. Maintaining these values while tackling the weeds should be the focus.

Habitat diversity

The diversity of habitat is good. The water is clear and light brown, and was flowing at the time of survey. The river channel varies in depth from < 0.1 to 0.8 m where pools occur beneath rocks. The instream logs and rocks provide suitable substrates for aquatic invertebrates, although the salinity levels may limit the diversity of this group of fauna. The streamside vegetation is dense in some parts and weed dominated in others. This discontinuity impacts on the number of suitable habitats for terrestrial animals. Western grey kangaroos were observed.

Large numbers of rabbits and a considerable number of burrows were seen in the area.

Comments

The habitat diversity is good as the diverse landform and wide riparian zone provide for different substrates for a range of fauna.

Other issues

Eight tributaries feed into this section of river, including Wandin Creek. The creek mouth is highly eroded. Additional studies of this creek using a foreshore assessment technique in conjunction with water load studies may be useful. The upper reaches have had a range of agricultural drainage techniques applied to the main channel, and there was evidence that the water is saline. It is likely that there have been changes to the groundwater characteristics of this sub-catchment.

The foreshore reserve is continuous along this section and is fenced for the most part. The alignment of



fencing is generally very good and appropriately located. Some sections have no evidence of recent stock access. The steep left bank restricts stock movement.

One landholder has excellent gate designs, which may be a marketable commodity. There are tanks and troughs close to a ford. An informal crossing has been re-formed by machine and the sand stockpiled on the floodway margins.

Suggestions

Bank stability

- B Exclude stock from the riparian zone and reduce general stock numbers to allow the land and vegetation to recover.
- B Liaise with Water and Rivers Commission and Agriculture WA to investigate options to stabilise erosion rills.
- B Initiate direct seeding and tree planting projects from the top of the verge to the valley floor in manageable nodes.
- B Develop a farm plan that addresses the impact of stock on this unstable environment.

Vegetation

- V Undertake weed control in manageable nodes and focus on reinforcing shrubs and trees on the margins of the floodway where cover is lower. Assisting regeneration of understorey species should occur in nodes where weeds have been eradicated.
- V Monitor germination and support native plant seedling establishment by focussing weed control around natural and assisted regeneration sites. Undertake assisted regeneration if required, by planting overstorey and middlestorey species.

- V Treat Pie melon, Paterson's curse and Ruby dock to reduce the spread of these species.
- V Encourage landholders to meet statutory requirements to control declared weed species.

Stream cover

- S Protect existing remnant vegetation by controlling weeds and reinforcing native vegetation through planting or facilitating natural regeneration.
- S Continue to exclude stock or use minimal stock numbers to control weeds periodically, as this management pattern is reflected in foreshore health.
- S Protect instream branches from removal where they do not obstruct water flow or exacerbate erosion.

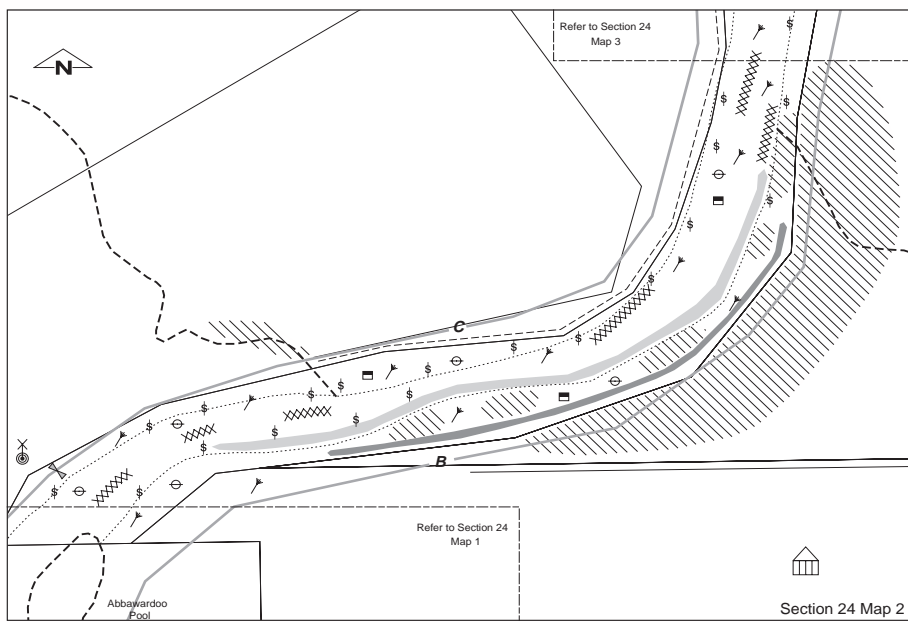
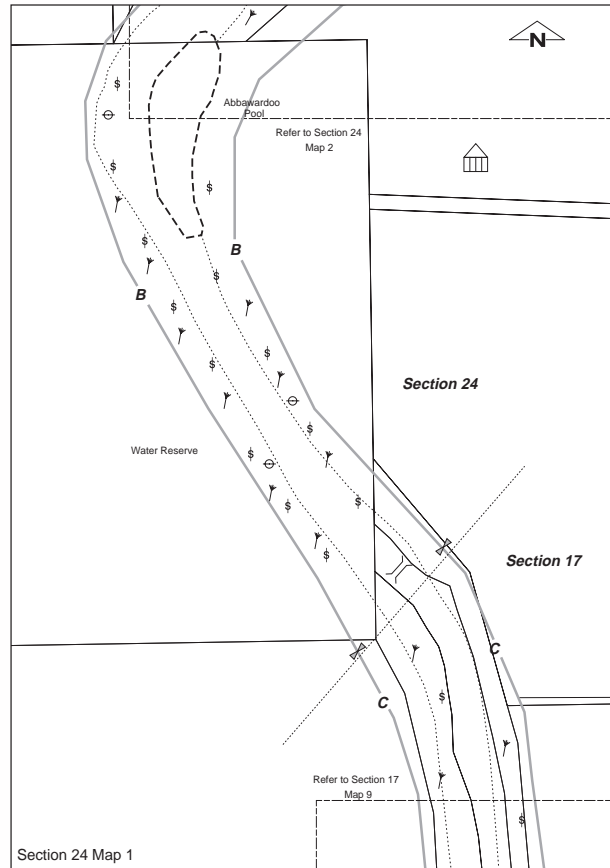
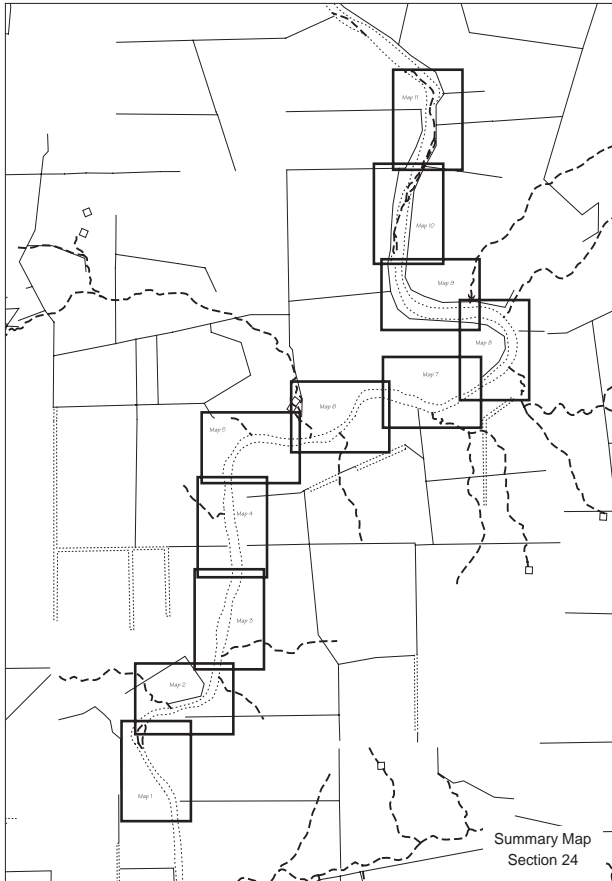
Habitat diversity

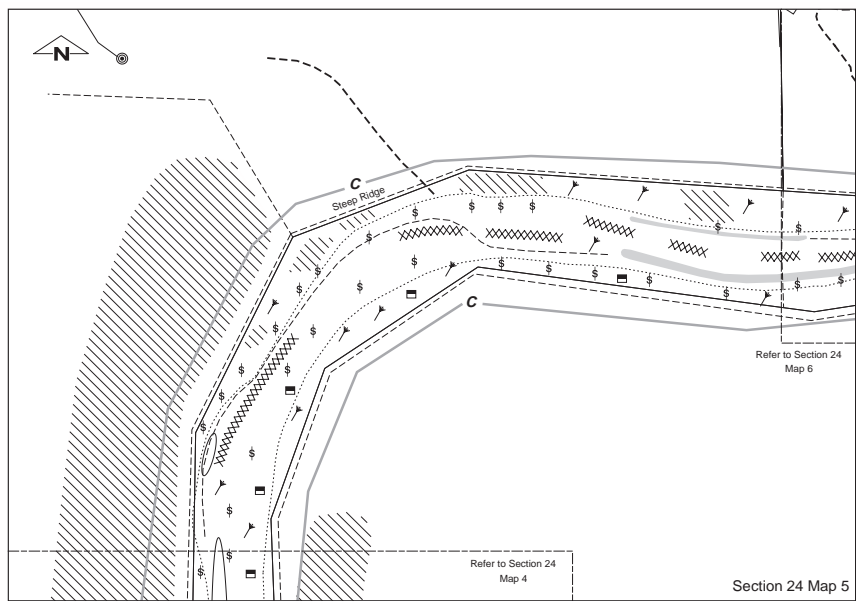
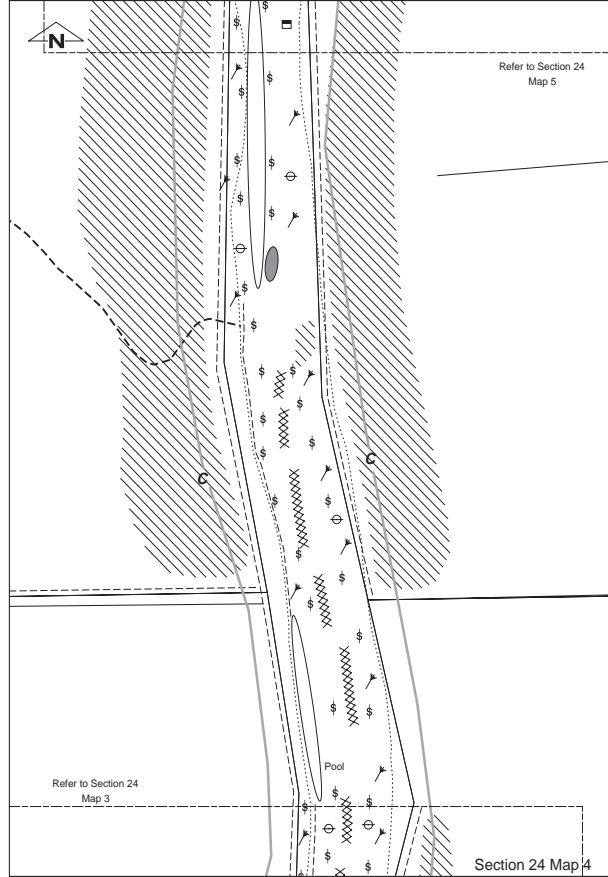
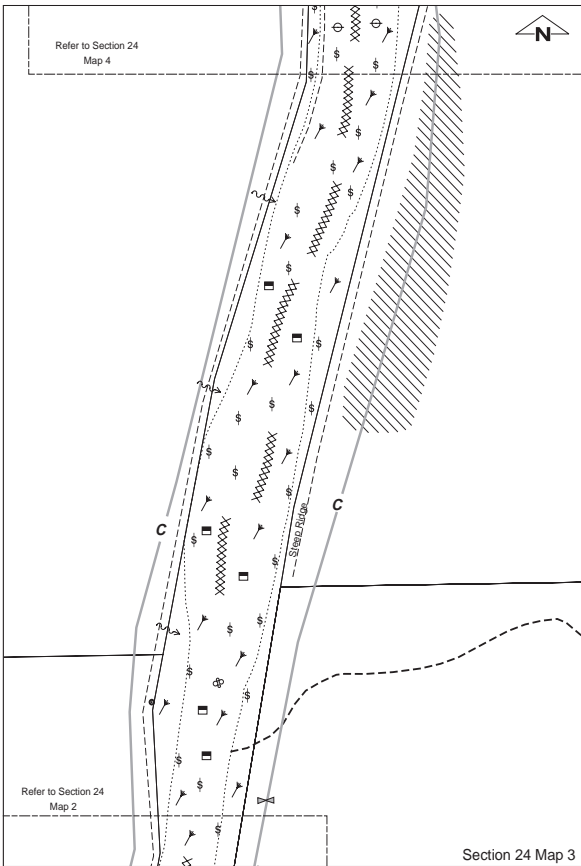
- H Retain debris within the river to maintain habitats for instream organisms.
- H Undertake a fauna survey in this section and immediately upstream of Wandin Creek to gain a comparative understanding of water quality and diversity of aquatic fauna.
- H Improve the condition of the native vegetation providing cover by undertaking weed control activities outlined above.
- H Continue to undertake rabbit control activities.

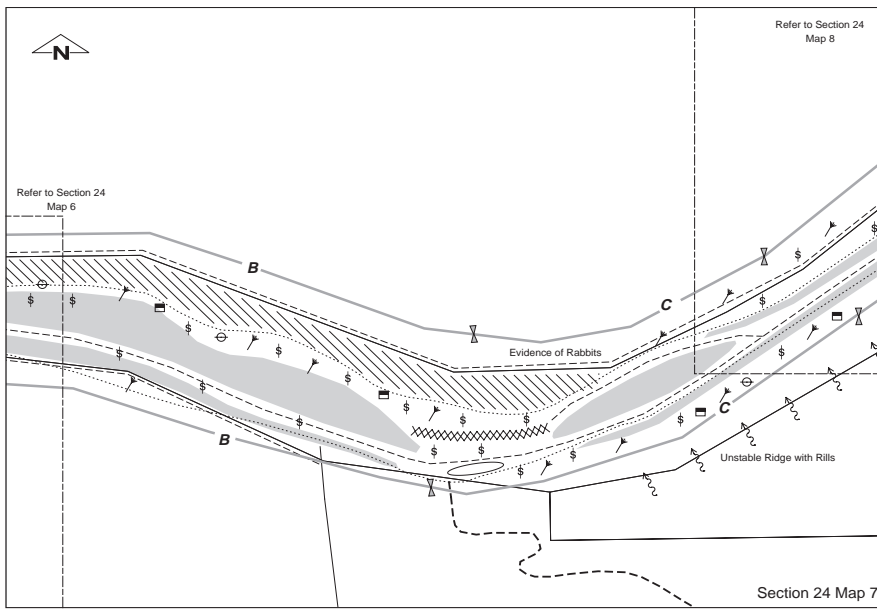
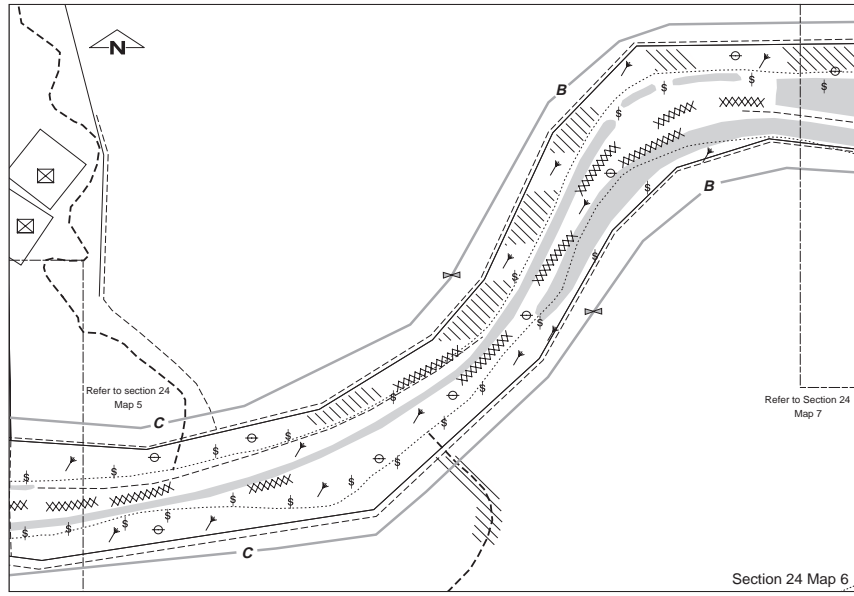
Other issues

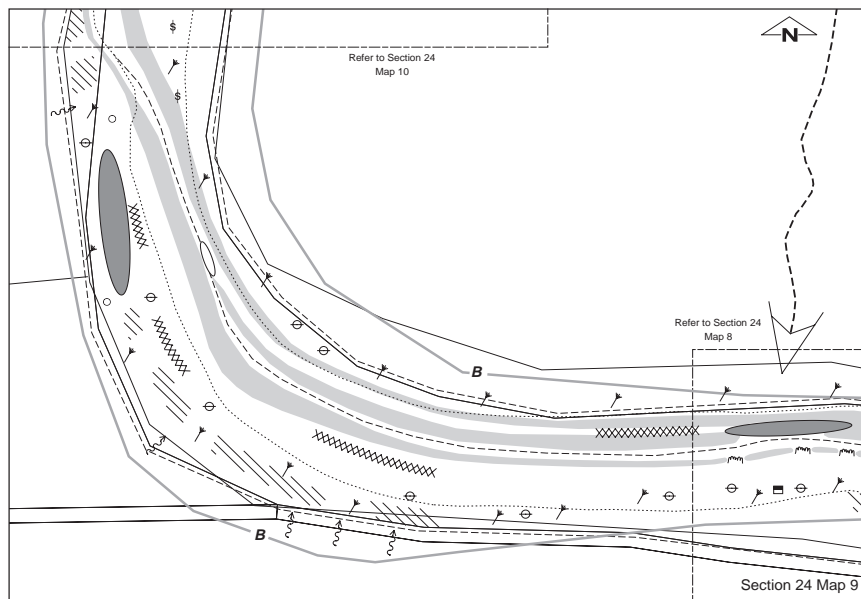
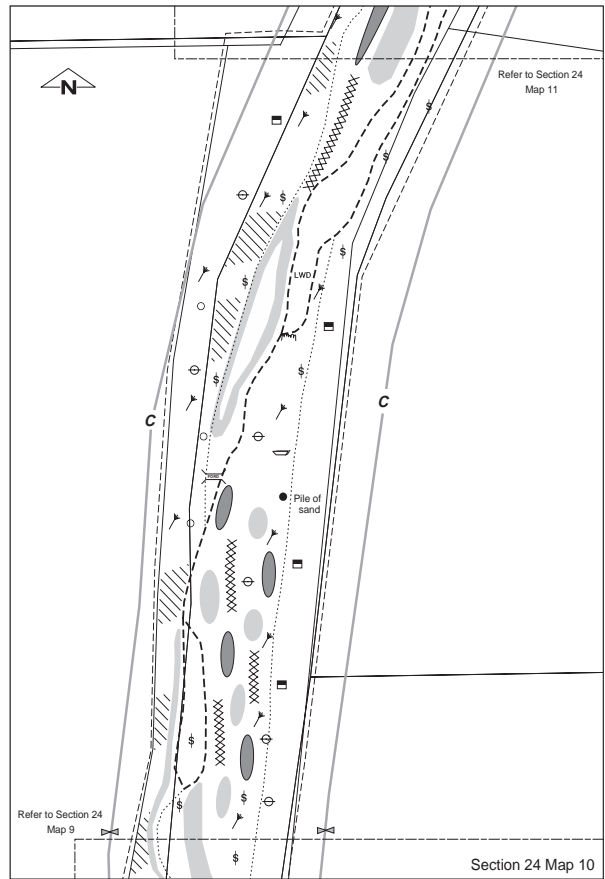
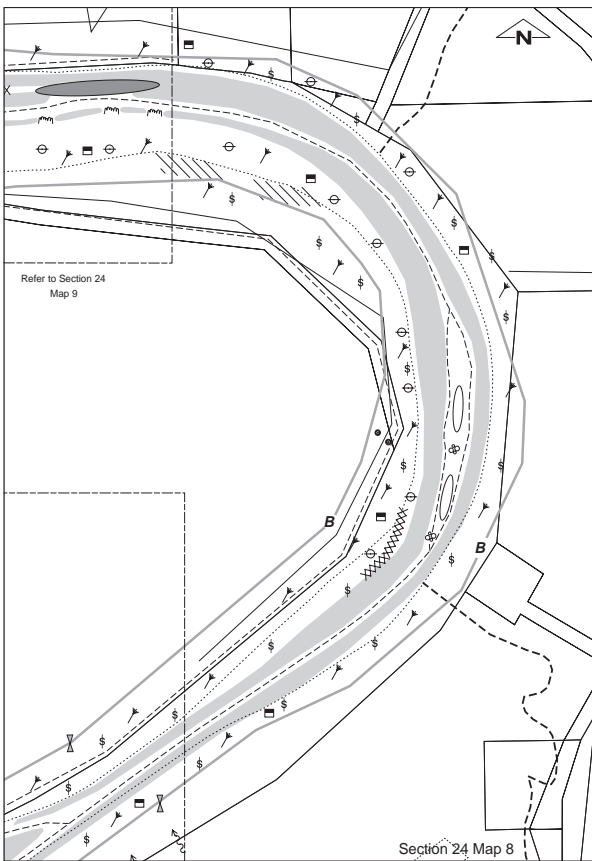
- O Investigate Wandin Creek water quality, quantity and flow characteristics and review techniques used to manage water flow. Document the level of success achieved with current works.
- O Provide all landholders with an information pack about rivers, weed control and ancillary information.

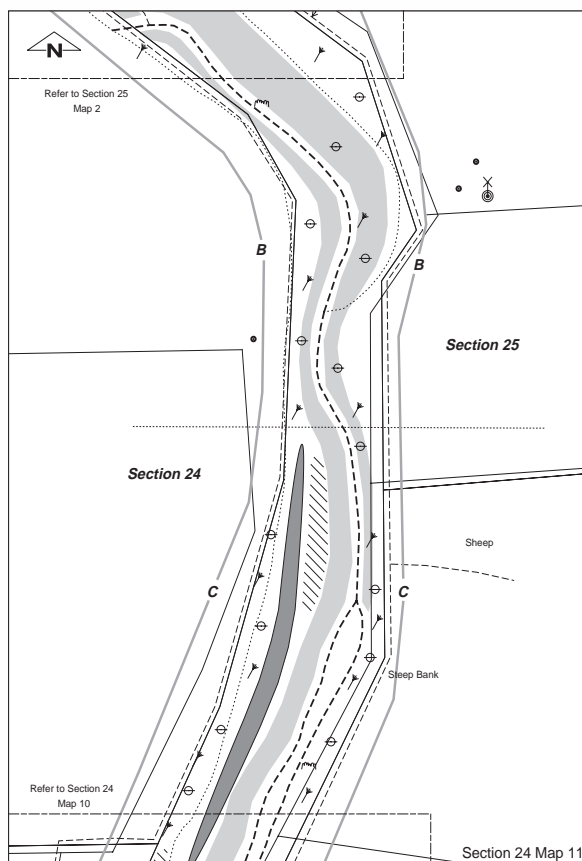












SECTION 25: NOONDAMURRA CROSSING UPSTREAM MAPS 1 – 10

Length of section (m): 10,300m

Recorders’ names: N Siemon and T Rebola

Date surveyed: 17 October 2000

Nearest road access: Noondamurra crossing

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B

Bank stability

The main channel ranges from < 2 m wide to approximately 70 m wide in some of the pools. The banks are generally very steep (rising to 2 m) where there is a narrow channel dropping to slight to moderate slopes where the channels widen (< 1.2 m). Erosion and undercutting are localised, occurring along 5 – 20% of the foreshore section. Focus points of erosion occur at the base of trees growing along the channel banks and where there has been considerable trampling by recreational users. Sedimentation is also localised (5 – 20%) with accretion focussed in sections that have been vegetated since previous flow events. Accumulation of sediment also occurs where the course of river flow has changed as a result of differences in the level of vegetation.

Exposed granite occurs periodically down the river channel, and some has associated sediment deposition immediately upstream of these rocks. There are large quantities of large woody debris in this section.

There is a road crossing defining the downstream end of this section and an access road to the Noondamurra Pools present on the right bank. There is a small offline road to a picnic spot.

Comments

Some of the large woody debris is likely to exacerbate erosion by acting as natural dams during the next major flow event. It also constitutes a significant fire hazard, particularly as there is evidence of campfires. Selective removal of debris that is likely to cause an erosion problem is suggested to minimise both of these risks.



Planning for use of this foreshore reserve may help to protect this area from widespread disturbance by enabling definition of access points and control of activities that may reduce the environmental values of these pools.

Vegetation

The overstorey is continuous along each bank and is broken by large pools. Dominant species are Swamp sheoak (*Casuarina obesa*) and Mohan and Swamp paperbark (*Melaleuca viminea* and *M. raphiophylla* respectively). River gums (*Eucalyptus camaldulensis*) are present in the upstream parts of this section. The middlestorey is limited to occasional Black berry nightshade (*Solanum nigrum*) and two native plants, Coojong (*Acacia saligna*) and the emergent Lake club rush (*Schoenoplectus validus*). Native plants dominate the understorey, although the length of time this dominance can be maintained is unknown under the current management systems. Diverse native rushes and sedges including Bare twig rush (*Baumea juncea*), Shore rush (*Juncus kraussii*) and Saw sedge (*Gahnia* sp.) are present. The introduced annual grass Wild oats (*Avena fatua*) is common, while there are patchy occurrences of Wild radish (*Raphanus raphanistrum*) and Flatweed (*Hypochaeris radicata*).

Dodder laurel (*Cassytha* sp.) is present periodically.

There are some significant stands of verge vegetation extending to the top of a small rocky hill on the left bank.

Comments

Managing and reducing disturbance factors is important to enable protection of the riparian and verge vegetation in the long term. Processes that encourage degradation of the foreshore need to be minimised through increased monitoring of use of the area. Selective removal of weeds, designating access to reduce indiscriminant trampling and possibly installing signage to encourage visitors to enjoy this area but protect its values would help.

Stream cover

The stream cover for most of this section is poor with mature River gums and Swamp sheoaks overhanging the narrow river channel, and frequent large woody

debris. The pools have a lower rate of cover, however there is significant instream material to effectively provide stream cover. Filamentous and upright algae and emergent macrophytes such as the Lake club rush (*Schoenoplectus validus*) are present in this section. Large amounts of instream detritus such as leaves, branches and bark also contribute to cover.

Comments

Protecting native vegetation close to the channel banks and minimising fire risk are two guiding principles to maintain stream cover. Monitoring regeneration will be important over time to ensure that there are plants of all age categories present in the foreshore reserve.

Habitat diversity

The water was clear and stained dark brown due to the presence of tannins leached from plant material. The water depth ranges from <0.2 to >1.5 m deep through the clearly defined narrow river channel joining the pools, and is likely to be permanent. Eight species of dragonflies were common and brief observations of the waterway resulted in numerous aquatic invertebrates being counted. Invertebrates seen were beetle larvae, dragonfly nymphs, aquatic beetles, snails and others. The diversity appeared to be excellent. The dense terrestrial vegetation provides excellent habitat for fauna. Snakes and lizards were seen in the area and there was evidence of possums using the mature River gums. The dense and variable canopy and proximity to good areas for wading birds increases the diversity of birdlife. Further, the continuity of verge vegetation facilitates animal movement across the landscape, increasing the value of this area.

Comments

The Noondamurra Pools support diverse aquatic and terrestrial plant and animal life. The continuity of cover and linkage with extensive shrubland areas increases these values. Protecting these values while maintaining recreation use of the area is possible provided there is some effort to manage impacts.

Other issues

This is a Council managed foreshore reserve, and there is evidence that the site is a popular recreation area for local residents and visitors to the mid-west region. Evidence of campsites was noted. The access road to



the Noondamurra Pools was being upgraded at the time of survey and there may be continuing difficulties in managing roadside drainage. The road provides an excellent fire access track.

A property upslope of the road has one of the most extensive infestations of Pie melon seen throughout the Chapman and Greenough Rivers.

There is a group of four windmills and five tanks approximately 400 m from the river.

The foreshore reserve is partially fenced.

Suggestions

Bank stability

- B Consider the feasibility of developing a small foreshore management plan to manage access, camping and recreation use of this part of the Greenough River.
- B Undertake selective removal of woody debris from the floodplain and the main channel, only where it is likely to exacerbate erosion. This should occur with the approval and advice of the Water and Rivers Commission. The woody debris could be chipped and spread out to form informal pathways, to encourage indiscriminant access to the entire area.

Vegetation

- V Commence a selective weed control program focussing on Black berry nightshade, Wild radish and Wild oats.
- V Develop a foreshore management plan that includes vegetation management.
- V Determine if there is a need to undertake selective control of Dodder laurel. Implement if necessary.

Stream cover

- S Reduce indiscriminate access to the foreshore to limit trampling and loss of stream cover.
- S Encourage natural regeneration by undertaking weed control in localised nodes around persisting native plants.

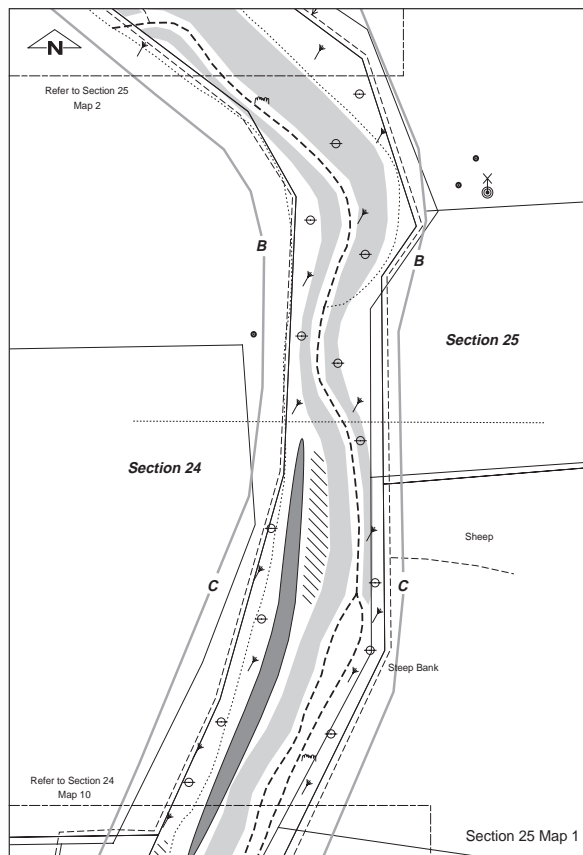
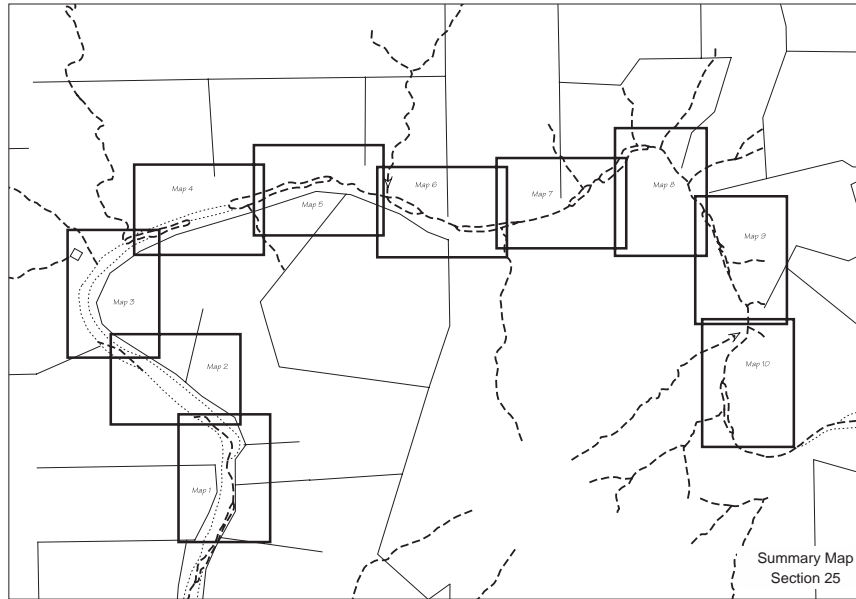
Habitat diversity

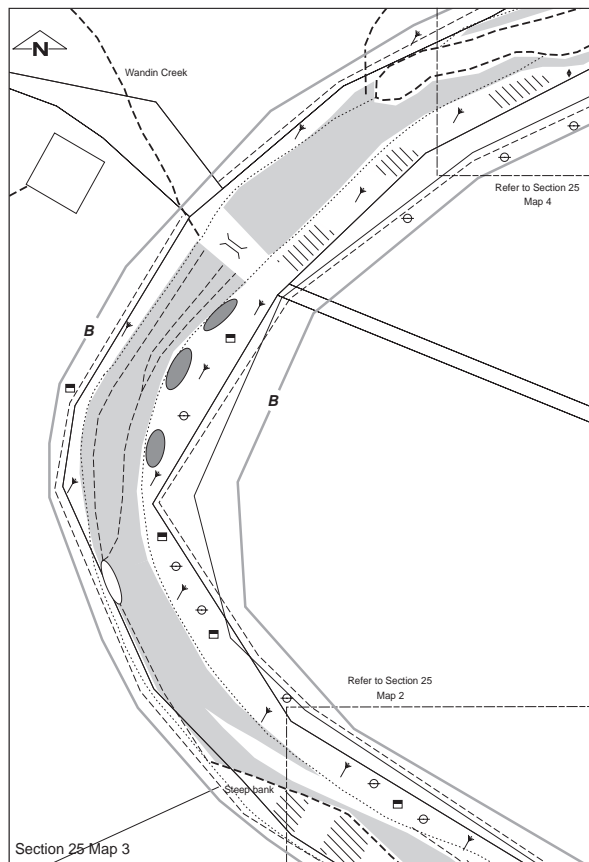
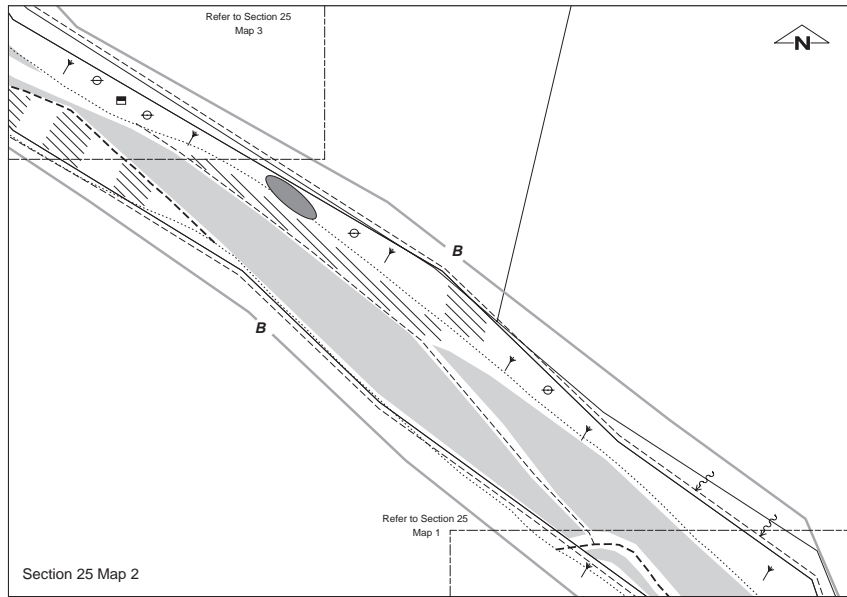
- H Protect existing native vegetation by controlling weeds and access, and possibly reinforcing native vegetation along roadsides and in areas where weeds have been successfully controlled or eradicated.
- H Encourage regeneration of rushes and sedges by controlling weeds around persisting plants.
- H Protect instream branches from removal where they do not obstruct water flow or exacerbate erosion.
- H Manage weed control in nodes and ensure fauna corridors are maintained to facilitate movement of any animals present in the reserve and surrounding land.

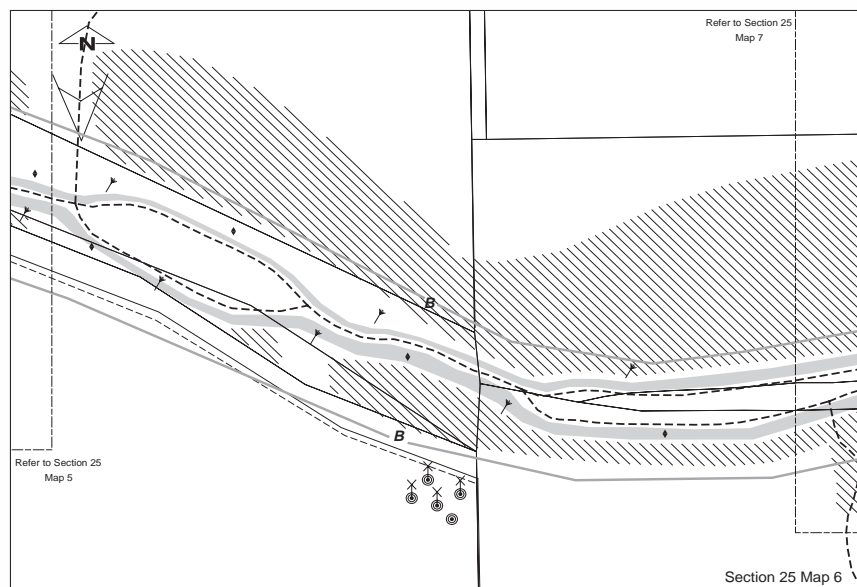
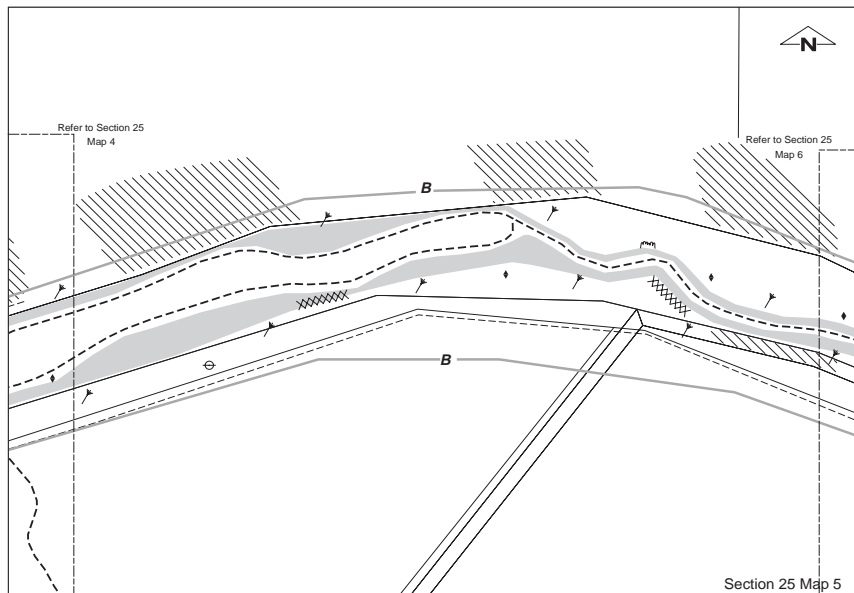
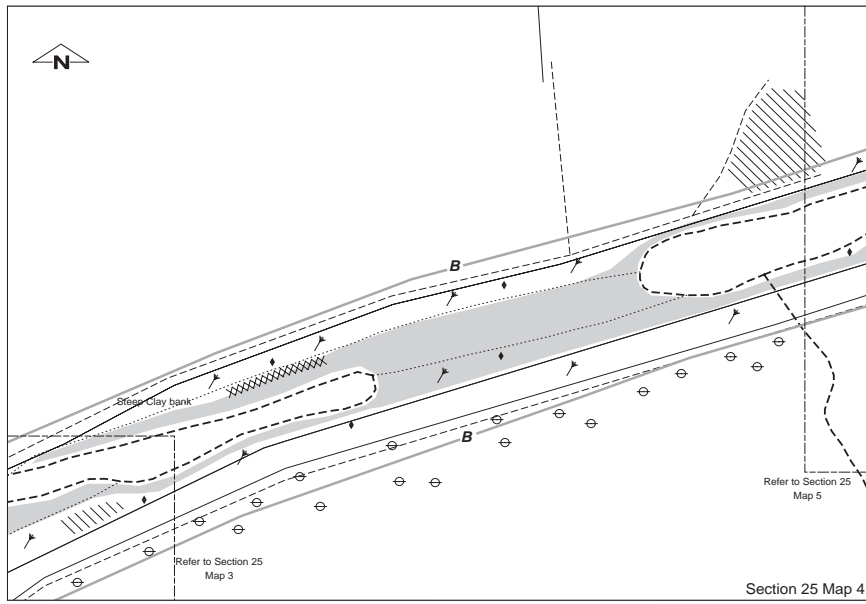
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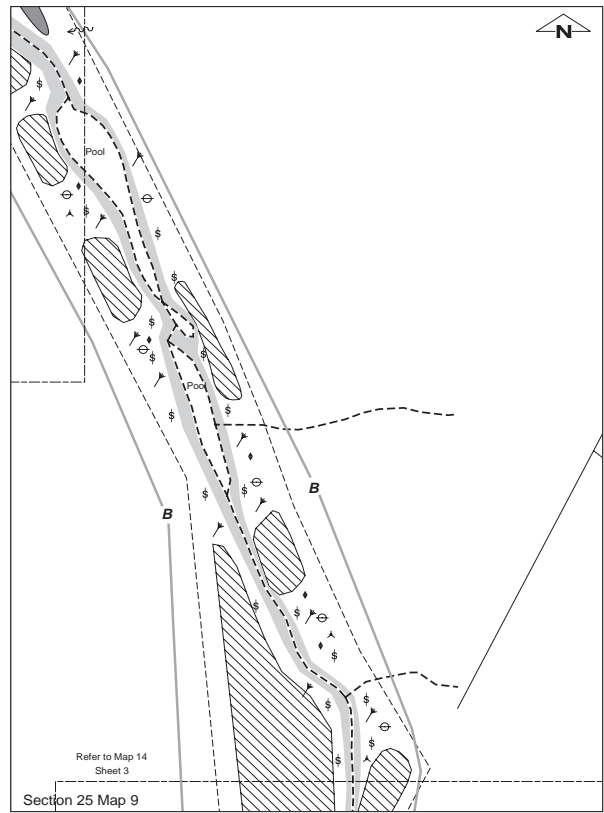
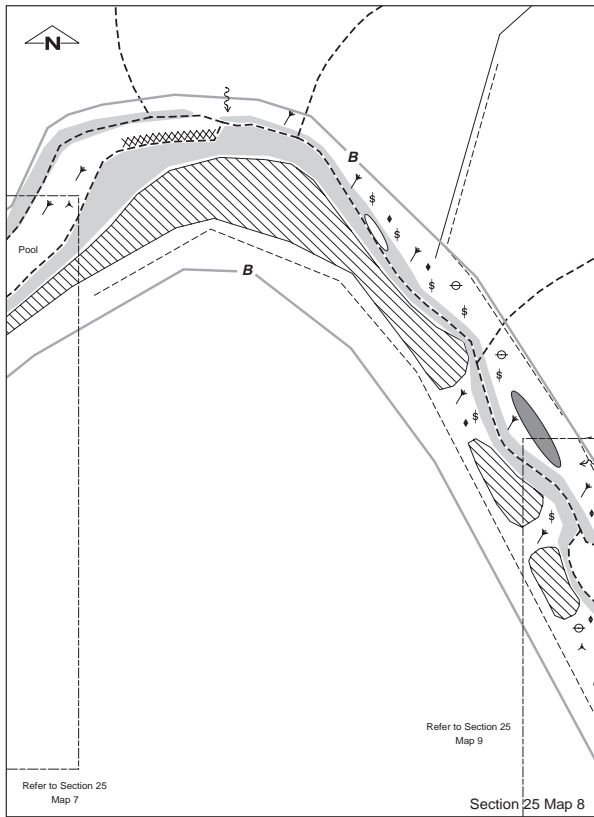
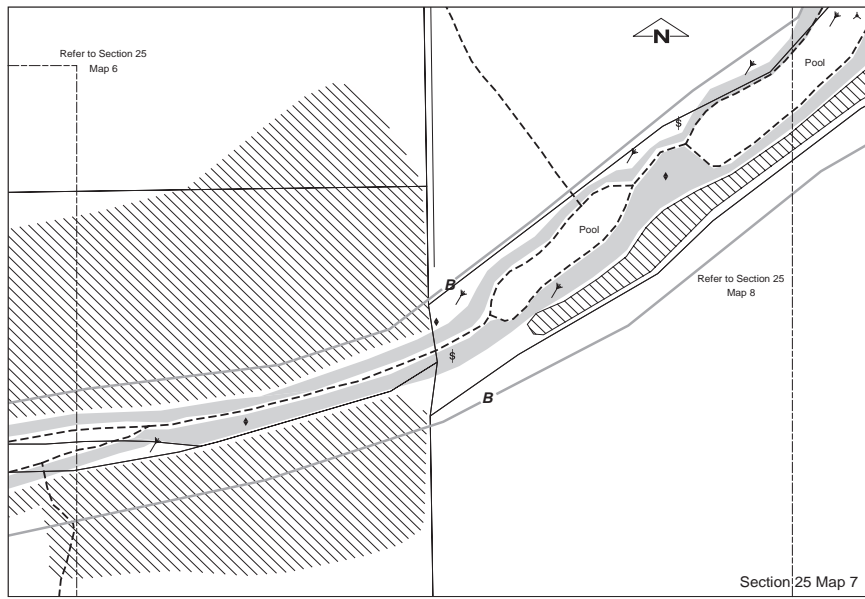
- O Develop a reserve management plan, which assesses community needs, defines access points, determines surface water issues and develops recommendations to improve and enhance native vegetation and control exotic weed species.
- O Encourage visitors to the pools to participate in local management of this area.
- O Increase rubbish bin availability to reduce the quantity of litter entering the river.

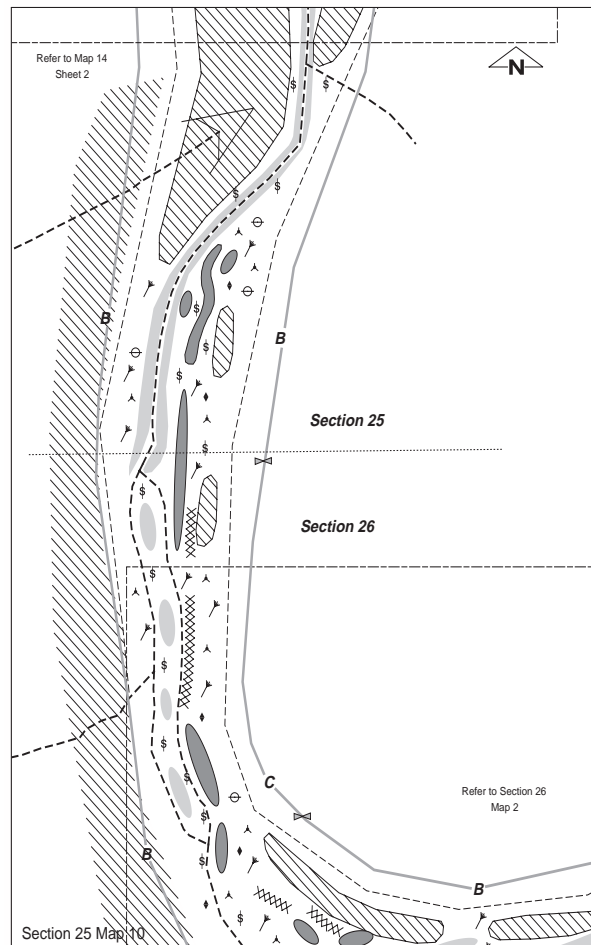












SECTION 26: ENANGALNOOGOO TO POOTEN MAPS 1 – 4

Length of section (m): 3,000m

Recorders' names: N Siemon and T Rebola **Date surveyed:** 4 June 2000

Nearest road access: Tenindewa North Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Moderate B	Moderate B	Poor C

Bank stability

The main channel is < 5 m wide and the foreshore bank grade is moderate to steep, rising to about 1.5 m. There are some braided sections where significant erosion events have occurred on the floodway. Erosion is significant, occurring along 20 - 50% of the foreshore. There are numerous blowouts on the floodway throughout this section, occurring in areas dominated by annual weeds. There is a stable low cliff that has been undercut, comprising clay with interspersed rock. A long narrow pool occurs beneath the cliff. There is some evidence of bank collapse. Sedimentation is also significant (20 – 50%). There are substantial mobile plumes at the downstream end of this section. Small pools occur periodically beneath steep, rocky banks.

There are also instream boulders periodically, and the riverbed has eroded back to a stable base in some sections.

Woody debris was trapped up to 4 m above the main channel, even though the floodplain is up to 100 m wide. The secondary (overflow) channel is 15 – 18 m wide.

Comments

The exposed granite boulders instream and on the channel banks are significant features of the landform that are protecting the tributaries and the Greenough River from severe erosion damage from all flow conditions. Further, the soil types and geology help to confine the flow to the river valley. The riverbed is very steep. Stock movements on the valley banks are



compacting the soil and leaving it denuded, making it more susceptible to erosion. These stock tracks have lower friction than vegetated areas, which allows the water to move more quickly across these areas. This is resulting in bank collapse and the erosion along many of the river sections.

Vegetation

The overstorey is patchy (20 – 80% cover) and is dominated by Swamp sheoak (*Casuarina obesa*) with occasional River gum (*Eucalyptus camaldulensis*). The middlestorey is also patchy (20 – 80% cover) and comprises Lesser bottlebrush (*Callistemon phoeniceus*) and infrequent Castor oil plant (*Ricinus communis*) and Black berry nightshade (*Solanum nigrum*). Weeds with occasional persistent native rushes and sedges in the riparian zone dominate the understorey. Sporadic clumps of Spiny flatsedge (*Cyperus gymnocaulos*) occur periodically, amongst relic saltmarsh plants such as *Atriplex* and *Sarcocornia*. Cape weed (*Arctotheca calendula*), Annual Wimmera ryegrass (*Lolium rigidum*), Doublegee (*Emex australis*), Pie melon (*Citrullus lanatus*) and Wild radish (*Raphanus raphanistrum*) are the dominant species. There are isolated occurrences of Saffron thistle (*Carthamus lanatus*) periodically. The perennial grass Couch (*Cynodon dactylon*) occurred occasionally.

The verge comprises almost exclusively annual grasses with occasional persistent shrubs such as *Hakea*, *Allocasuarina* and *Acacia* spp. *Statice* (*Limonium*) is present on the shallow soils at the top of the verge.

Comments

Weed control efforts should aim to reduce fire hazard and focus on currently uncommon weeds such as Castor oil plant, Ruby dock, Black berry nightshade and Saffron thistle that are either toxic to stock or reduce the value of produce.

Stream cover

Stream cover is patchy and provided by overhanging branches from mature trees. There is some instream woody debris and boulders providing limited cover. Infrequent patches of permanent shade are present in areas where the fringing vegetation is extensive and dense, and overhangs the main channel. There were

small pools persisting at the time of survey that are unlikely to be permanent.

Comments

The stream cover is relatively good, however continuing loss of native vegetation will reduce the quality of this feature shortly. The need to maintain good vegetation cover and therefore good stream cover cannot be emphasised enough.

Habitat diversity

The water through this section ranged from clear and light brown in colour to cloudy, and is unlikely to be permanent. There was some evidence of springs arising between clay and sandy parts of the steep banks that coincide with shallow pools (< 0.4 m deep). Few aquatic invertebrates were observed in the clear water at the time of survey, however there was diverse instream fauna where the water was milky. The patchy native understorey provides some discontinuous cover for terrestrial animals, and the extent of weed infestation reduces the habitat diversity. Spiders and similar large predators occurred infrequently. One dead frog was present. The blowouts provide almost no cover and effectively limit animal movement from the riverbank to the top of the verge. The occasional shrubs provide habitat for scrubland birds and where the remnant verge vegetation is more extensive there is a noticeable increase in birdlife. Red-breasted robins, Blue wrens, Rufous whistlers and two types of honeyeaters were observed. Woodland birds such as Willy wagtails, Magpie larks and Butcherbirds roost and nest in the sheoak stand.

Comments

The slightly milky/cloudy colour of water may arise as the river flows over a stable white clay base. The discontinuous nature of the colouration is unusual. The occasional shrubs along the riparian verge are the subject of fierce competition between scrubland birds seeking habitat. The large reserve adjoining this river section is likely to support large populations of these animals, but dispersal of new generations is limited due to a lack of similar shrubs along the waterways and minimal corridors through neighbouring properties. Occasional small pools are present, however it is unknown whether the seep is sufficient to maintain the pools as summer refuges.



Other issues

This foreshore section adjoins a large sandplain reserve that is extremely well vegetated. It is likely the Department of Conservation and Land Management has vesting and management responsibility for the reserve.

A number of animal traps (likely to be fox and feral cat traps) were present in the foreshore reserve. These had been baited with kangaroo meat.

A number of small creeklines are not present in the baseline data provided by Department of Land Administration.

This property had one of the few chickpea crops seen during the survey. Interestingly, native animals were not seen foraging on the margins of the crop, nor was there evidence of prior foraging.

The fences are set well back from the high water mark, usually at the top of the verge. There has been little maintenance of these fences in recent times. Considerable repairs are required prior to re-stocking these paddocks.

There is a water tank close to the foreshore. Further investigation is needed to determine the source of water (groundwater or surface water), quality and depth to the groundwater to allow officers of the Water and Rivers Commission to estimate the pool longevity.

Suggestions

Bank stability

- B Monitor the level of large and small woody debris and remove or realign if forming natural dams. The realignment should aim to support sediment movement downstream.
- B Reduce stocking rates and length of time spent in the river reserve to reduce the formation of tracks on the valley slopes and help the vegetation to recover. This will help reduce erosion and broadscale changes to the shape of the valley.

Vegetation

- V Encourage landholders to continue to meet their statutory requirements to control declared weeds, extending their work into the foreshore reserve where practical.
- V Focus weed control effort on declared species and those that are toxic to stock or reduce the value of produce.
- V Reduce the length of time stock spend within the foreshore reserve to encourage natural regeneration.

Stream cover

- S Exclude stock from river reserve to allow the vegetation to recover. Consider stocking for brief periods to achieve weed control.
- S Monitor the accumulation of woody debris instream and determine where it is causing a greater problem than it is in the form of habitat. Realign or move upslope if necessary.

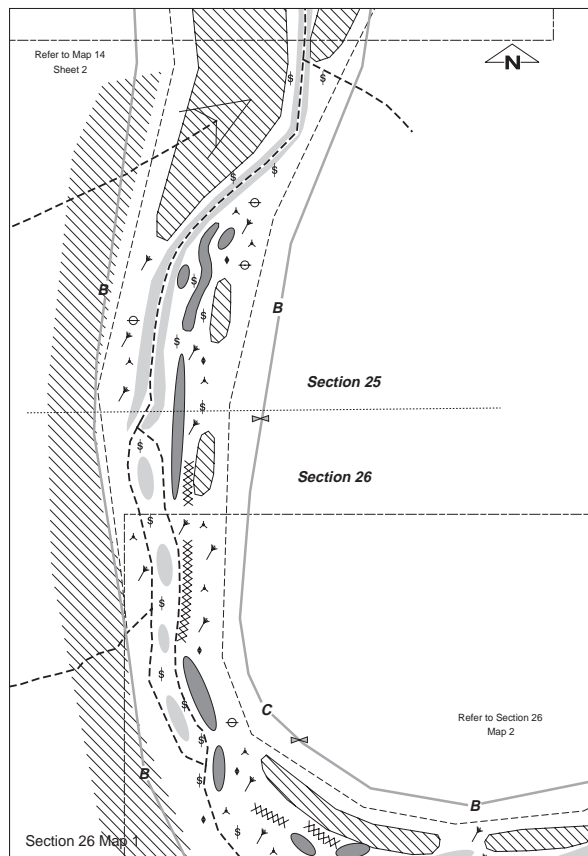
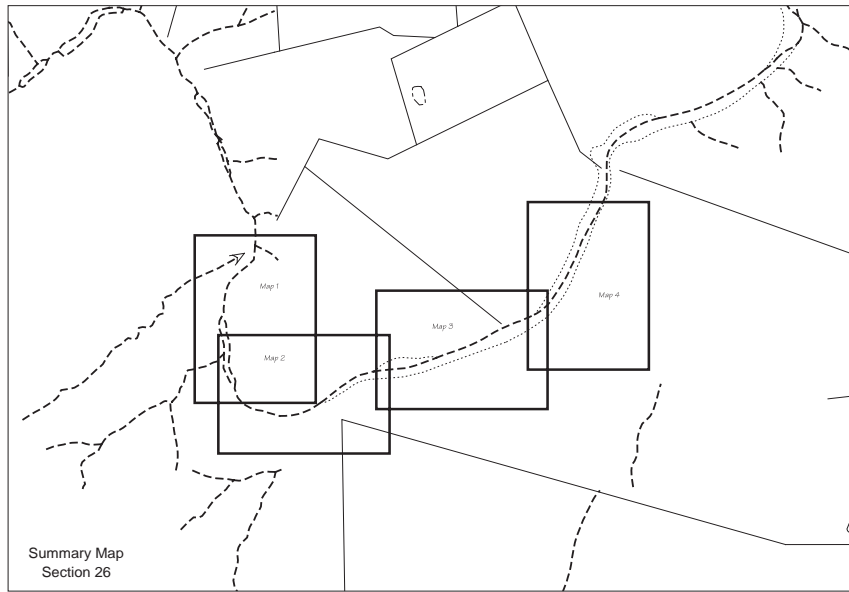
Habitat diversity

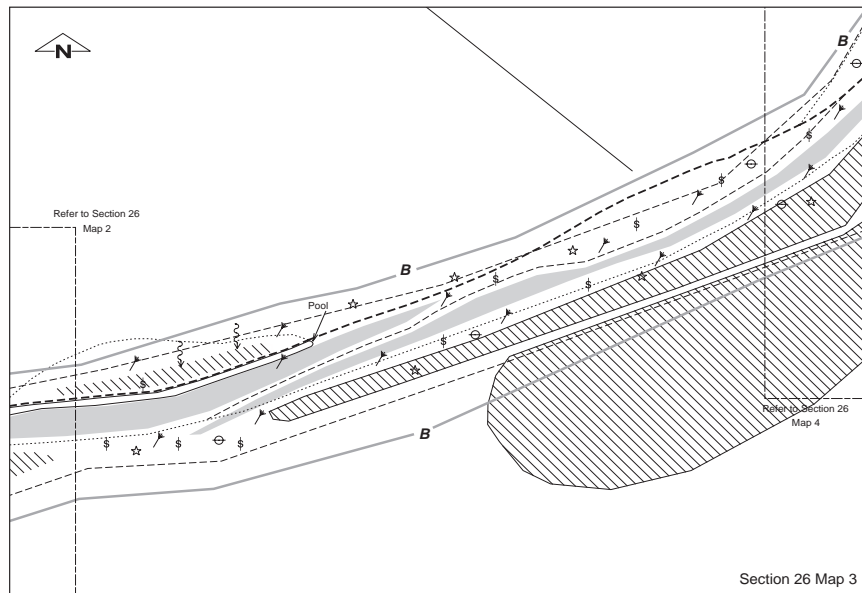
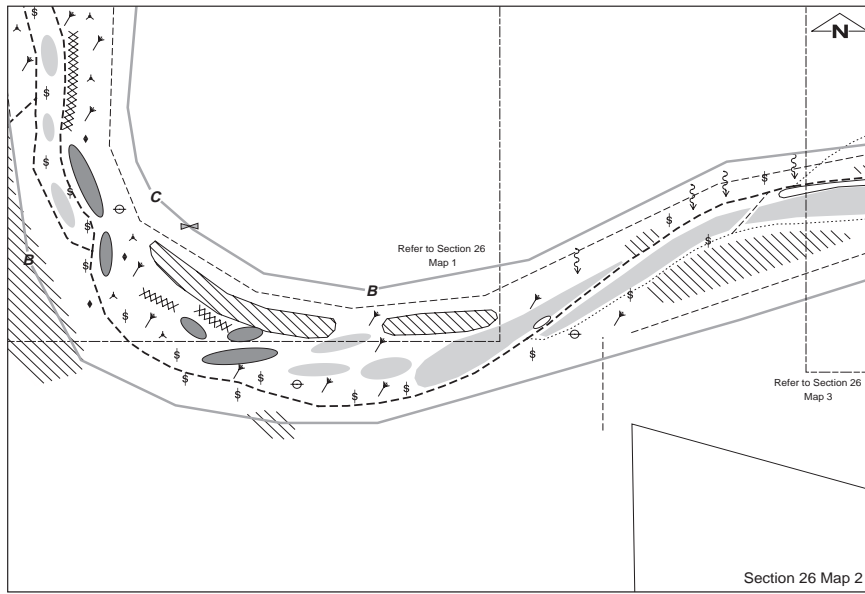
- H Continue revegetation works and increase plant diversity to encourage a wider range of fauna to inhabit the area. Link the existing remnant vegetation with revegetation works in the floodplain.
- H Continue to control feral animals as resources permit.
- H Continue revegetation works across the channel and floodway. Plantings may need to be protected from peak flows.

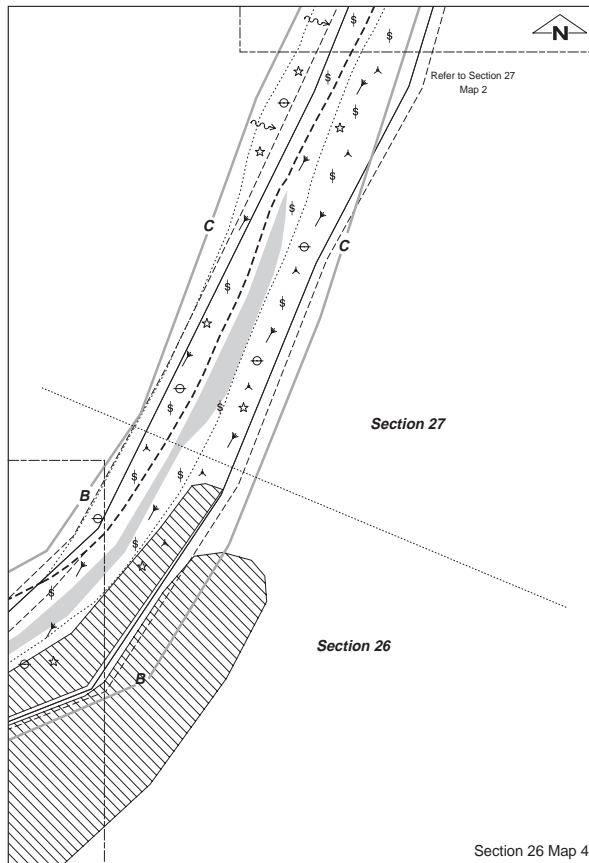
Other issues

- O Continue feral animal control program.
- O Encourage landholders to ensure that fences are repaired prior to the introduction of stock to the adjoining paddocks.
- O Provide landholders with information about river processes, the impacts of burning and related issues to assist them to manage this resource.









SECTION 27: ERARANYU TO POOTEN MAPS 1 – 6

Length of section (m): 8,070m

Recorders’ names: N Siemon and T Rebola

Date surveyed: 17 October 2000

Nearest road access: Pooten Road

Summary of river health:

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Poor C	Poor C	Poor C	Poor C	Very Poor D	Poor C

Bank stability

The river channel is 6-12 m wide with the foreshore banks rising on a medium to steep gradient to a height of 1-1.5 m. The left bank is characterised by steep banks with the floodplain extending on the right. Significant levels of erosion are occurring along 20-50% of the foreshore area particularly where there is minimal foreshore vegetation. There is little evidence of broadscale bank collapse and slumping. Sedimentation and the volume of mobile drift sand are significant. Deposition is occurring along > 50% of this section. Generally the material is poorly sorted. There are two pools persisting, however it is unknown if they are permanent. A natural spillway has formed where the bed has eroded back to a stable clay base. This occurs immediately upstream of a rocky ford (crossing). There is evidence of machinery working in

the river.

Comments

The lack of dense vegetation consistently on this river section is contributing to the loss of coarse material and increased abrasion by the mobile sand. The scale of the blowouts occurring >1.5 m above the channel bank height is of concern. It is likely that the course of river flow will migrate to the right floodway in future flood events if the density of vegetation is not improved. Large woody debris is exacerbating erosion in some areas. The remaining single row of trees is likely to be undermined in the future. Advice on river crossing design and maintenance may be useful.

The large amounts of sedimentation evident cannot be exclusively linked with degradation processes in this river section. In some areas, sandbars have become



stabilised and vegetated. The significant levels of sedimentation indicate that erosion is occurring further upstream. This highlights the need to understand processes occurring upstream of any waterway and demonstrates that no site can be considered in isolation.

Vegetation

The overstorey is patchy (20-80%) and generally limited to very narrow strips extending a few metres either side of the river channel. Along some sections the overstorey is reduced to almost single tree width. The most frequent overstorey species is Swamp sheoak (*Casuarina obesa*) with occasional River gum (*Eucalyptus camaldulensis*). Infrequent Castor oil plants (*Ricinus communis*) are present along the foreshore. The middlestorey is sparse < 20% cover and dominated by Saltbush (*Atriplex* spp.) The understorey is patchy (20-80%) and dominated by weeds. Frequent species include Prickly paddy melon (*Cucumis myriocarpus*) and Pie melon (*Citrullus lanatus*), Doublegee (*Amex australis*) and Wild oats (*Avena fatua*) and one group of Saffron thistle (*Carthamus lanatus*). The only native species present are Spiny flatsedge (*Cyperus gymnocaulos*) and a Beaded samphire (*Halosarcia* sp.).

The verge vegetation is limited to less than 20% of this section. Isolated shrubs over dense Wild radish is characteristic of the vegetation community.

Comments

The lack of continuity of vegetation is resulting in floodwaters spreading widely across the floodway causing scouring of the floodway margins. Where the vegetation is denser the flow is generally confined to the main river channel. The dominance of annual weed species increases the susceptibility of the floodway to erosion.

Stream cover

The patchy narrow overstorey provides little permanent shade along the river channel. Instream cover is intermittent and limited to areas retaining instream rocks and woody debris.

Comments

Encouraging the natural regeneration of native vegetation will help to improve stream cover. By protecting instream woody debris where it is not exacerbating erosion, landholders can support instream aquatic invertebrate populations.

Habitat diversity

Water is unlikely to be permanent and water present at the time of survey had a slightly milky appearance. The intermittent pools vary in depth from <0.25 to 0.6 m. There are woody debris and occasional rocks within the river providing suitable substrates for aquatic invertebrates. The streamside vegetation is weed dominated, limiting the number of suitable habitats for terrestrial organisms. The trees provide some suitable nesting and roosting sites for woodland bird species. Evidence of snakes was observed.

Comments

The lack of healthy native vegetation and mobility of sand in the river and on the floodway limits habitat availability. Sections dominated by weeds provide some protection for terrestrial animals, however the habitat diversity is low.

Other issues

There are seven creeklines and three gullies contributing water and sediment to this section. Coarse material and rocks up to 0.2 m diameter occur at the confluence at one of these creeks. There has been some use of discarded farm materials to control the rate of gully incision. Some farm machinery and parts have been left in the floodway. There are two tanks and windmills in this section. Fencing is not continuous along the foreshore reserve boundary and is in variable condition. There is minimal evidence of stock so, in the event of restocking farmlands, fences should be repaired.

Suggestions

Bank stability

- B Provide all landholders with a Water and Rivers Commission Water Notes information pack.



- B Undertake localised realignment or removal of woody debris only where the debris is exacerbating erosion.
- B Continue weed control activities focussing on buffer establishments around native seedlings and plants.
- B Develop strategies to manage two erosion rills so they do not become a greater management problem in the future.

Vegetation

- V Encourage private landholders to undertake weed control and revegetation works where resources permit. This should be undertaken in manageable sized nodes aiming to establish a buffer around native plants.
- V Ensure the impact on bank stability is considered before weed control works are undertaken.
- V Focus weed control on Castor oil and Saffron thistle that are relatively uncommon.
- V Investigate opportunities to provide support or material assistance to landholders willing to implement rehabilitation activities.
- V Focus any assisted revegetation works on re-establishing verge vegetation.

Stream cover

- S Support natural regeneration of native plants by managing stock access to the foreshore reserve to enhance stream cover.

- S Protect instream branches from removal where they do not obstruct water flow or exacerbate erosion.

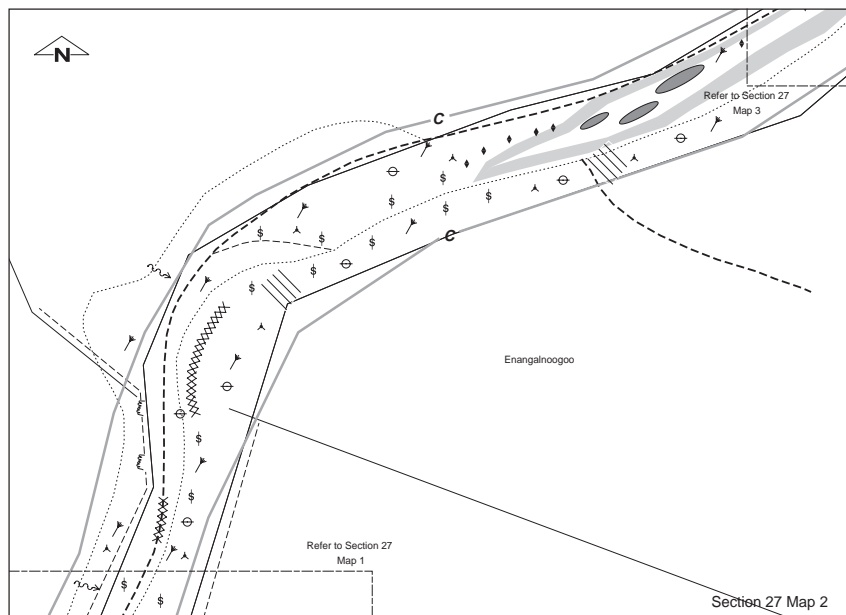
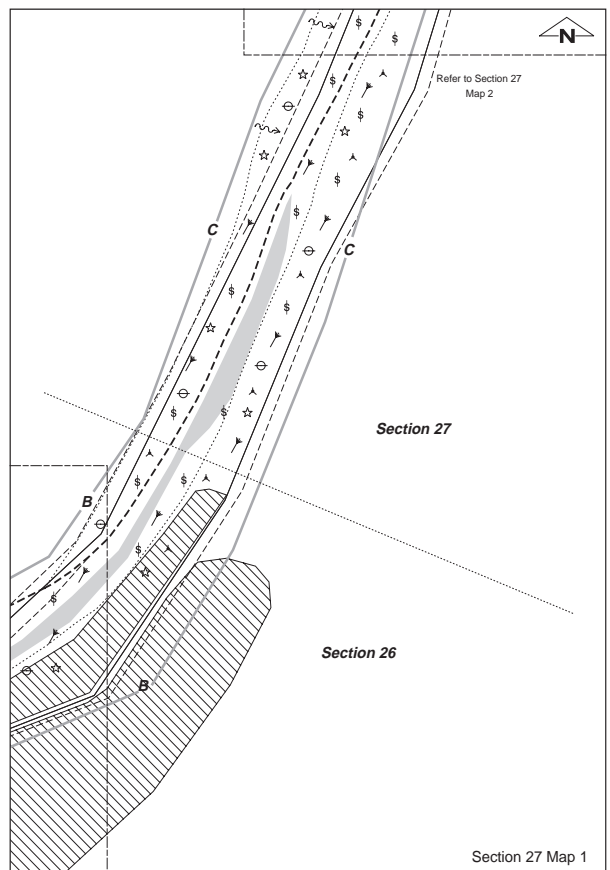
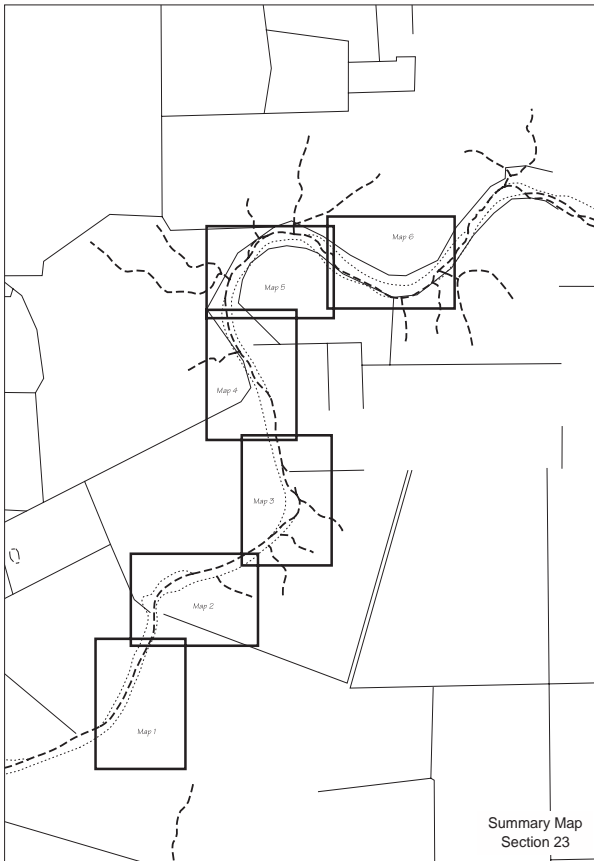
Habitat diversity

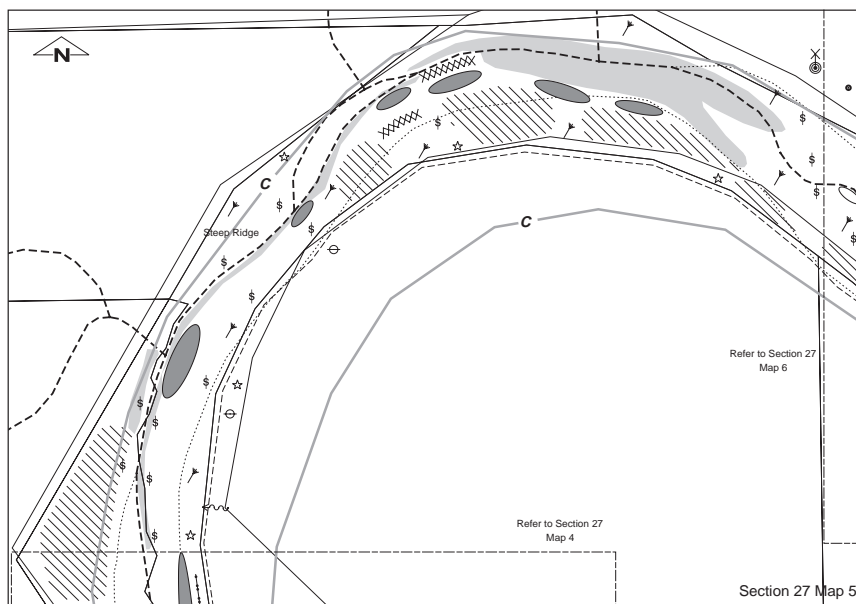
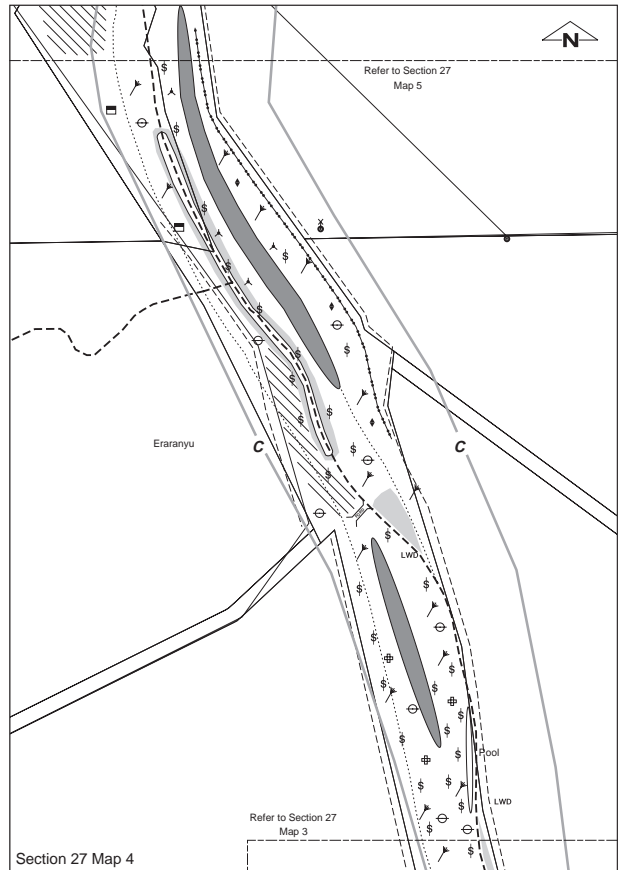
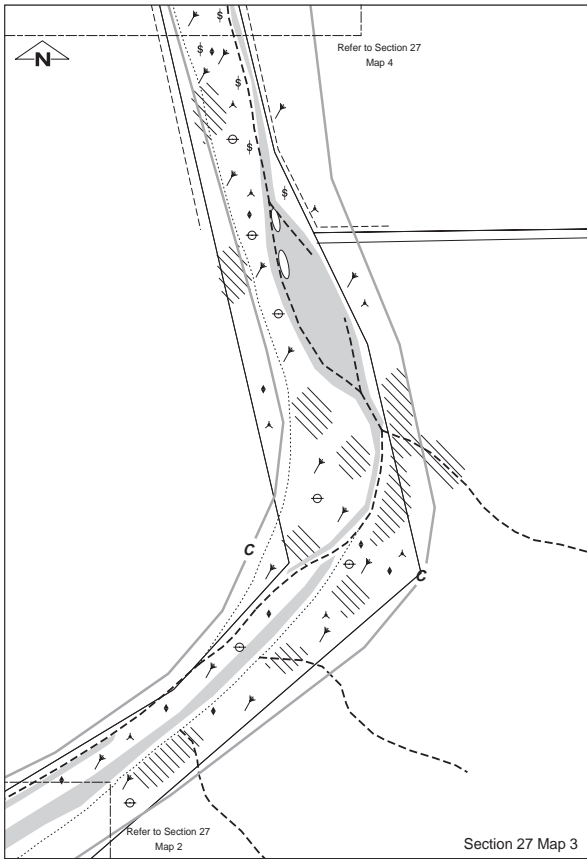
- H Retain debris in the river to maintain habitats for instream organisms.
- H Encourage landholders to monitor natural regeneration in the floodway and on the verge, and if inadequate regeneration occurs then implement more intensive weed control and tube stock planting.

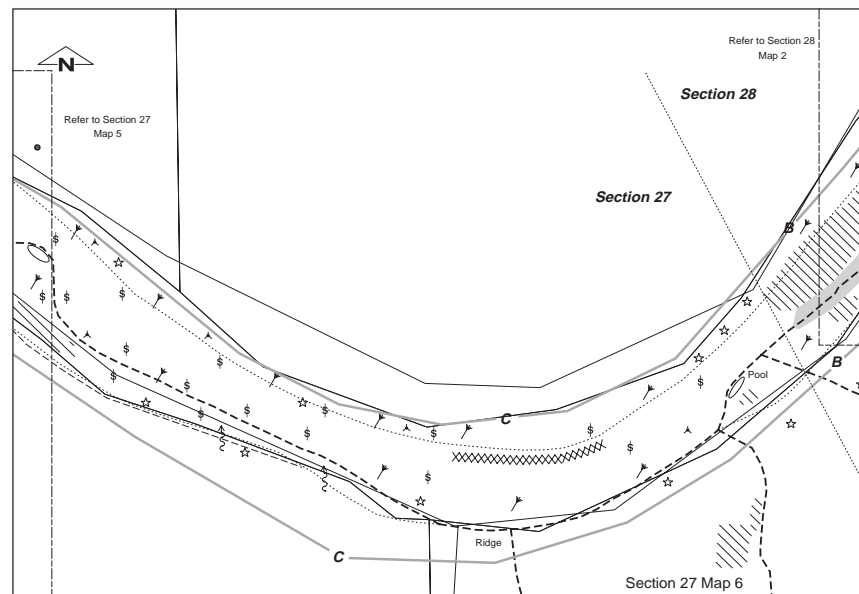
Other issues

- O Remove unsightly machinery and parts from the floodway. Farm machinery collectors could be approached to remove these materials.
- O Ensure that fences are repaired prior to restocking. Grazing within the foreshore reserve should be limited to occasional heavy rotational grazing to achieve weed control. Close monitoring of stock impacts is important to protect remnant native plants.
- O Obtain advice from Agriculture WA and/or Water and Rivers Commission about techniques to arrest the gully erosion.









SECTION 28: POOTEN MAPS 1 – 2

Length of section (m): 1,440m

Recorders' names: N Siemon and T Rebola

Date surveyed: 16 – 17 October 2000

Nearest road access: Pooten Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Moderate B	Very Good A	Moderate B	Moderate B

Bank stability

The main river channel is 2 – 8 m wide with steep banks rising to 1 m. Erosion along the foreshore banks is localised at the base of trees growing along the foreshore bank and where large woody debris is acting as a natural dam. This occurs along 5 - 20% of the foreshore. Sedimentation is also localised (5 - 20%) and occurs immediately downstream of a causeway.

Comments

The channel banks through this section are relatively stable due to the continuity and density of remnant vegetation. The extent of riparian vegetation is relatively narrow and is surrounded by verge vegetation. This vegetation cover is sufficient to stabilise the floodway during peak flow events. The causeway is causing some disruption to river flow characteristics. Some of the large woody debris is exacerbating erosion.

Vegetation

The overstorey is predominantly Swamp sheoak (*Casuarina obesa*) with occasional River gum (*Eucalyptus camaldulensis*). It is patchy (20-80%) and

generally narrow. The middlestorey is sparse (<20% cover) and is limited to regenerating tree species. The understorey is continuous >80% cover and is dominated by Saltbushes (*Atriplex* spp.) with weed species becoming dominant in the verge. Common flowering weeds include Statice (*Limonium sinuatum*), Caltrop (*Tribulus terrestris*), Paterson's curse (*Echium plantagineum*) and Roly poly (*Salsola kali*). There are isolated Saffron thistle (*Carthamus lanatus*) and Prickly paddy melon (*Cucumis myriocarpus*) plants in the adjoining paddocks.

The verge vegetation is relatively extensive and retains a moderate diversity of wattles (*Acacia* spp.), hakea (*Hakea* spp.) and infrequent native grasses such as Silky heads (*Cymbopogon obtectus*).

Comments

The vegetation in this section is relatively intact and represents an example of a vegetation community which is salt tolerant. There is minimal evidence of physical disturbance such as trampling by stock. Maintaining current management practices may be sufficient to protect this vegetation community in the long term.



Stream cover

The overstorey is narrow, however good stream cover is present. Overhanging Saltbushes provide some shade. Scattered leaf material, rocks and branches provide instream cover.

Comments

Stream cover is generally very good and is likely to be sustainable in the long term provided there is no additional disturbance.

Habitat diversity

The water depth is shallow ranging from 0.15 to 0.4 m. The water is very clear and light brown in colour with little suspended material evident in the water column. The instream woody debris within the main channel helps to aerate the water. Due to the shallow water and the narrow width of the river it is unlikely that invertebrates requiring permanent water are present in this section. The presence of healthy native vegetation, particularly the closed understorey, provides for a diverse range of terrestrial organisms. The overstorey trees provide some habitat for birds, however Corellas strip the bark and leaves from the canopy and cause considerable damage.

Comments

The voracious appetite of the Corellas threatens the long-term survival of the mature gums. As their habitat becomes diminished these birds may cause the death of the trees and having removed this food source they may migrate to new areas in search of food or decimate agricultural crops. Aquatic instream fauna or animals requiring water as part of their breeding cycles were rarely seen in this area. Predators such as spiders and frogs were not observed during this survey. The lack of some components of the food chain may indicate this section is in the early stages of decline.

Other issues

There is a river crossing that impacts on stream flow. Fencing is continuous and generally in good repair. The alignment of fences appears to correlate with the foreshore reserve boundaries. There is no evidence of recent stock access.

Suggestions

Bank stability

- B Continue current management practices that are maintaining good vegetation cover.
- B Investigate the design of the causeway to determine the feasibility of restoring the flow dynamics.
- B Assess the impact of branches on stream dynamics and remove where they are causing excessive scouring or sedimentation.

Vegetation

- V Protect native vegetation from disturbances that may reduce the survival of the plant community in the long term.
- V Undertake selective weed control in manageable sized nodes to reduce the potential of erosion due to loss of vegetation cover.
- V Monitor natural regeneration as it will provide an indication of river health over time.
- V Remove isolated occurrences of Saffron thistle and Prickly paddy melon before these species become widespread and require greater resources for their control.
- V Encourage landholders to meet their statutory requirements to control declared weeds such as Paterson's curse.
- V Encourage landholders to continue weed management in the foreshore reserve as resources permit. Alternatively seek funding to provide this support.

Stream cover

- S Monitor vegetation structure and density on the foreshore banks and if necessary undertake weed control or replanting of native tubestock to maintain stream cover.
- S Protect instream debris from removal if it is not exacerbating erosion.

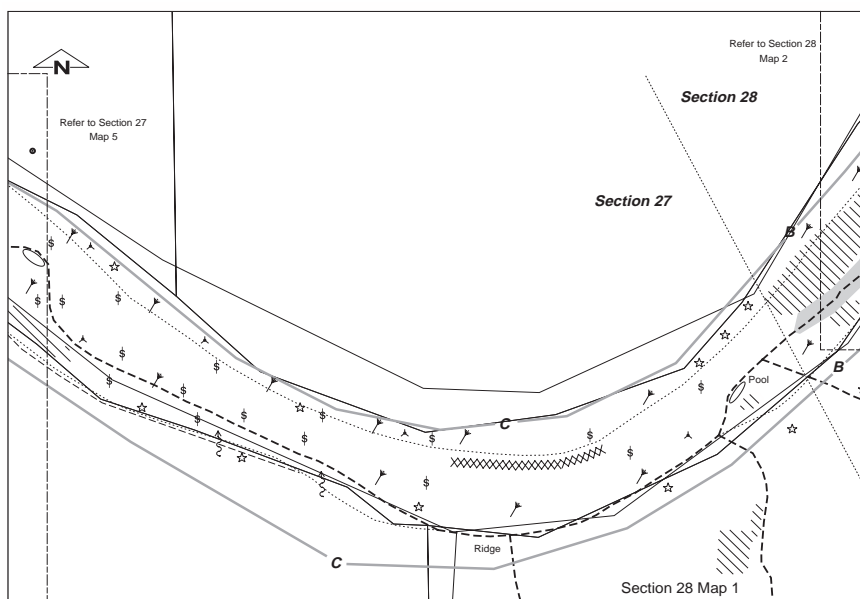
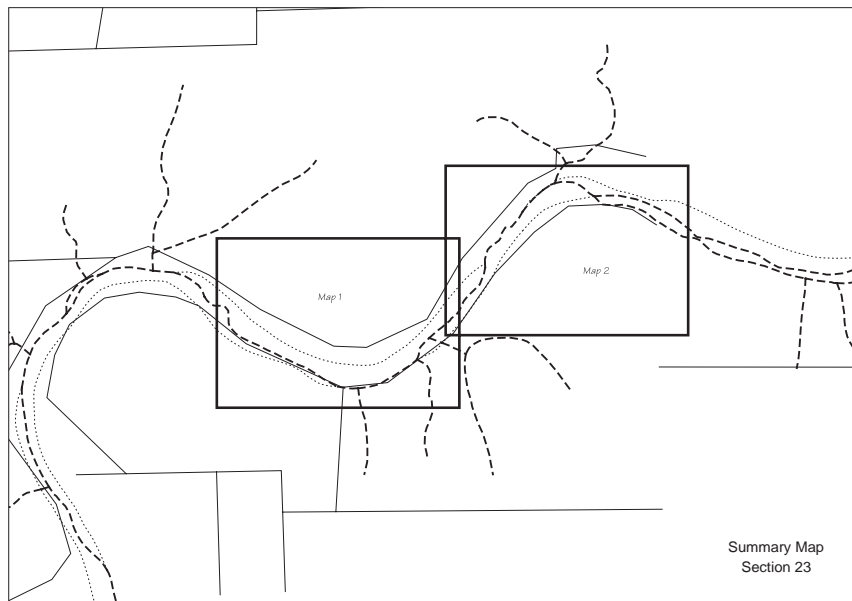


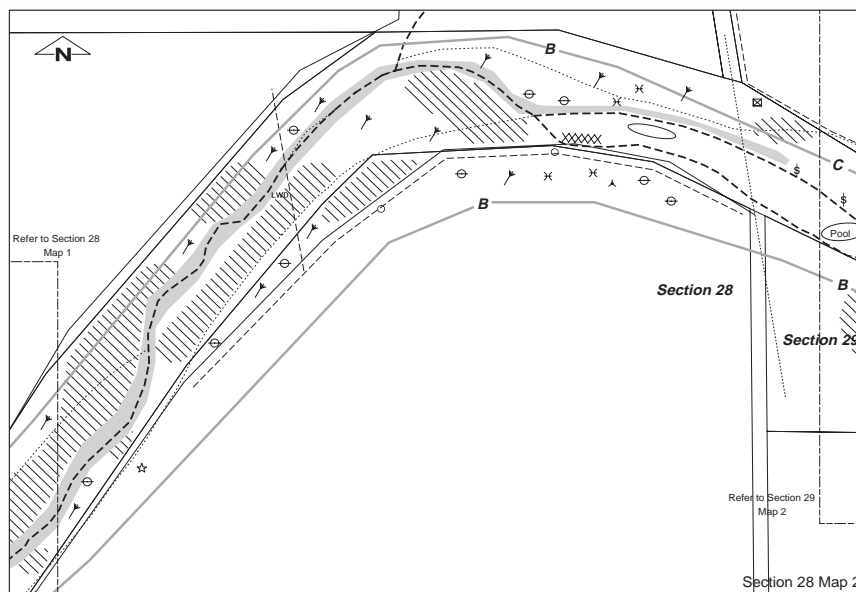
Habitat diversity

- H Leave the woody debris instream and in the floodway where it is not exacerbating erosion of the foreshore banks.
- H Replant the verge with tree stock ensuring protection from Corellas, rabbits and livestock.

Other issues

- O Ensure that fences are repaired if necessary, prior to restocking paddocks adjoining the foreshore reserve.





SECTION 29: POOTEN TO COONAWA MAPS 1 – 16

Length of section (m): 15,580m

Recorders’ names: N Siemon and T Rebola **Date surveyed:** 16 October 2000

Nearest road access: Coonawa Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Very Poor D	Poor C	Very Poor D	Poor C	Moderate B	Poor C

Bank stability

The main river channel of the Greenough River ranges from 5 to 70 m wide, depending on the nature of the soil. The foreshore banks generally rise on a steep grade to between 1.5 to 3 m in height. Erosion is severe, affecting > 50% of the foreshore. The erosion occurs both on the channel banks and within the floodway, resulting in braided sections forming. There are 17 blowouts ranging from moderate to severe and it is likely that the course of river flow will fluctuate into these blowouts in the future. There are some significant and minor pools periodically along this section and these tend to be associated with exposed rocks and the presence of clay. Slumping is localised along 5 - 20% of the foreshore. Sedimentation is significant with more than 50% of the bed and floodway being mobile. Large deposits of sediment contribute to the formation of braided channels. There are some plumes of coarse material periodically.

Comments

At the time of survey there was almost no groundcover vegetation within the floodway and the overstorey is generally limited to single, double or triple rows of

trees. The decrease in the extent of vegetation is resulting in erosion occurring during every flow event, rather than only during peak flows. As the soil is scoured away, the tree roots are exposed and the trees become less supported. Subsequently there is an increased likelihood of trees collapsing and exacerbating the erosion problem.

The poor bank stability seen in this section of the river can be partially attributed to large numbers of stock in the foreshore reserve. The lack of grazing control is resulting in the acceleration of degradation processes. Stock trampling, camping and grazing were conspicuous contributors to the loss of vegetation and soil from the riparian zone.

Vegetation

The overstorey vegetation is patchy to sparse in the riparian zone (ranging from < 20% to 20 – 80% cover). As mentioned above, the vegetation is generally limited to single rows and up to three rows of River gum (*Eucalyptus camaldulensis*) with occasional Swamp sheoaks (*Casuarina obesa*). There are infrequent Broom ballart (*Exocarpos sparteus*). Many of the



overstorey trees are sick or dying with little evidence of seedling regeneration. Frequent Castor oil plants (*Ricinus communis*) are present along this river section. The middlestorey is patchy (20 – 80% cover) in the upper reaches of this section, and sparse at the downstream end. Wattles (*Acacia* spp.), Native hibiscus (*Alyogyne* spp.), a Paperbark (*Melaleuca* sp.) including Saltwater paperbark (*Melaleuca cuticularis*) and a type of Waxflower (*Chamelaucium micranthum*). Black berry nightshade (*Solanum nigrum*) occurs periodically. A species of *Nicotiana* was present. It is unknown if this species is native. The understorey is patchy (20-80% cover) and is dominated by weeds interspersed with large areas of bare ground due to stock accessing the river. Abundant weeds include annual grasses such as Wild oats (*Avena fatua*) and Annual Wimmera ryegrass (*Lolium rigidum*). Frequently occurring flowering weeds include Statice (*Limonium sinuatum*), Saffron thistle (*Carthamus lanatus*), Doublegee (*Emex australis*) and Roly poly (*Salsola kali*). The only relic native species are infrequent Spiny flatsedge (*Cyperus gymnocaulos*), Saltbush (*Atriplex* spp.) and *Chenopodium* sp.

The verge vegetation is in variable condition and is patchy (20-80% cover).

Comments

The extent and condition of native remnant vegetation in this river section are of concern. The river channels are likely to become less clearly defined and wider with more land becoming prone to flooding during peak events. It is likely the existing mature vegetation will be undermined and lost in future flood events. The minimal natural regeneration currently observed is probably the result of grazing by livestock, feral goats or rabbits. The current vegetation level is not sustainable in the long term. The diversity and extent of weeds is also limited by grazing pressure, however control is required to prevent populations increasing.

Stream cover

Stream cover is very poor in this section due to the limited extent of vegetation. The overstorey provides some patches of shade. While there are occasional sections of large woody debris these do not provide instream cover, as they do not correspond with the persisting pools. Stock movement enables the

mobilisation of sediments throughout the year, causing many natural pools to disappear.

Comments

Stream cover can be improved by allowing natural regeneration processes to occur, and increasing the density and extent of native vegetation. Realigning selected pieces of debris where it is exacerbating erosion may also contribute to improved stream cover.

Habitat diversity

Water is not permanent in this river section, although the sub-surface moisture is likely to be close to the surface. The water is clear, salty and light brown in colour due to the presence of tannins leached from vegetation detritus. The river channel is very shallow due to sediment deposition. Water depth varies from <0.15 to 0.4 m. The lack of instream logs, branches and rocks limits the number of suitable substrates for aquatic invertebrates. As the streamside vegetation is highly degraded and there is minimal groundcover, leaf litter or plant material, there are almost no suitable habitats for terrestrial fauna including frogs and reptiles. The patchy overstorey provides some nesting and roosting sites for birds, although the diversity was generally low. Wildlife seen was restricted to the areas retaining verge vegetation and exposed granite outcrops on breakaway slopes.

Comments

The significant use of most of this section for grazing has contributed to the reduction of habitat diversity, due to widespread loss of vegetation, mobility of the sand in the riverbed and floodway and the loss of leaf litter and groundcover materials. There is little cover for animals to move around safely. The lack of permanent water reduces use of this area as a summer refuge, however as mentioned above there is evidence that the sub-surface water is palatable.

Other issues

Large numbers of drums are present in the river reserve downstream of Mungo. The source appears to be along the significant tributary - Wooderarrung Creek. The reserve boundary is not entirely fenced. A CALM reserve is present and large numbers of feral goats were observed in this area. The fence lines are generally in



good condition but livestock and feral animal access to the foreshore is not prevented. The surrounding landuse is rural and conservation reserve. Some paddocks are cropped, while others are uncropped for broadacre grazing.

Suggestions

Bank stability

- B Remove stock from the foreshore reserve immediately where the foreshore is close to being completely denuded, and exclude until at least 70% vegetation cover is achieved. Supported revegetation may be necessary, as the degradation is severe.
- B Ensure that fence maintenance is sufficient to exclude stock and enable effective stock control in the future.
- B Liaise with landholders to develop and implement strategies to manage and if possible reduce the erosion processes occurring in this river section, as soon as possible.
- B Develop an agreement relating to access to the foreshore reserve, if deemed appropriate to ensure that current management practices are modified to reduce degradation of the river system.

Vegetation

- V Undertake selective removal of Black berry nightshade and Castor oil plants, as these are toxic to livestock. Saffron thistle should also be a priority as it can be a problem in wool production.
- V Modify current stock management practices (remove stock from the foreshore reserve) until there is sufficient vegetation cover to protect the riverbed and its bank.
- V Encourage landholders to fence the unfenced sections and ensure all fences are kept in good repair to control stock.
- V Encourage all landholders to undertake rabbit and feral goat control taking care that the impact on native animals is minimised.

Stream cover

- S Realign woody debris where it is exacerbating erosion, with the aim of improving stream cover as well as reducing erosion.
- S Ensure fences are well maintained and exclude stock as a priority.
- S Undertake selective weed control of the grasses in small nodes to encourage natural regeneration.
- S Monitor whether or not any natural regeneration is occurring and if not, plant trees within the fenced foreshore reserve.

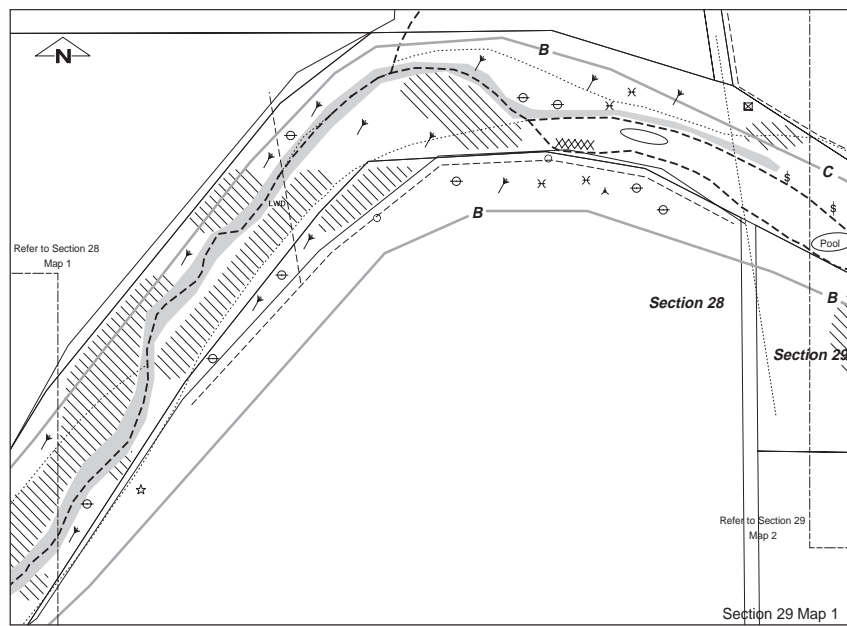
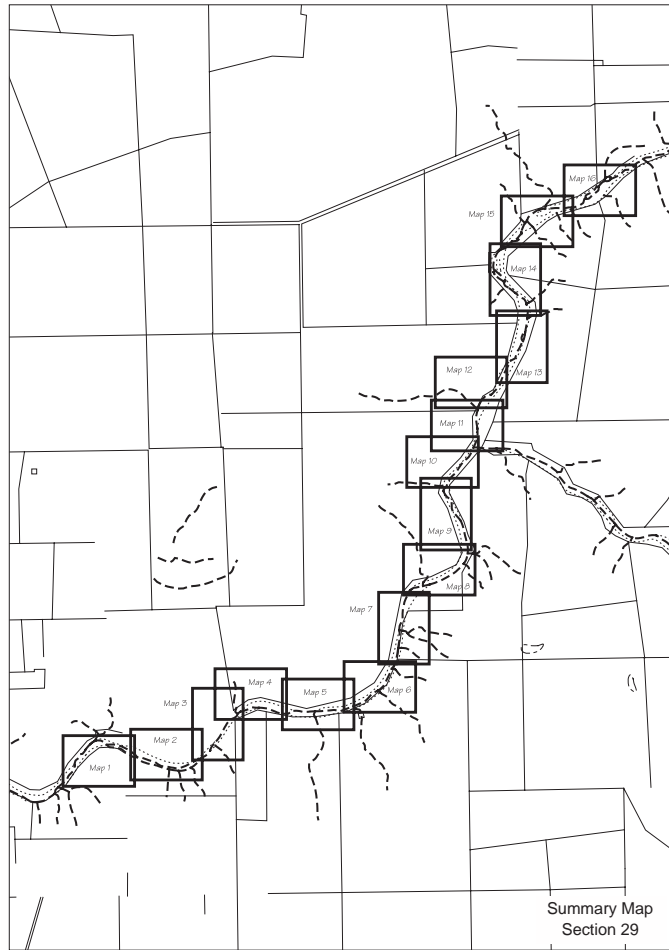
Habitat diversity

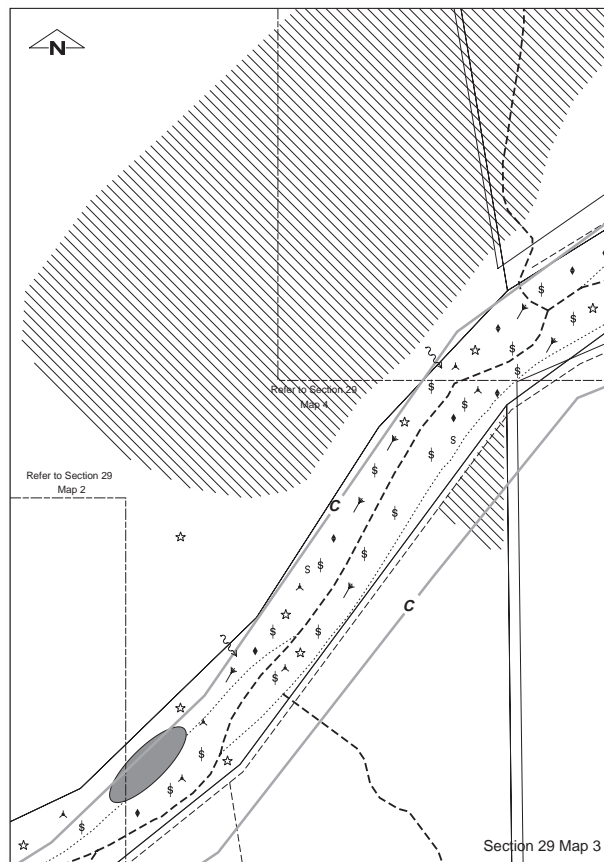
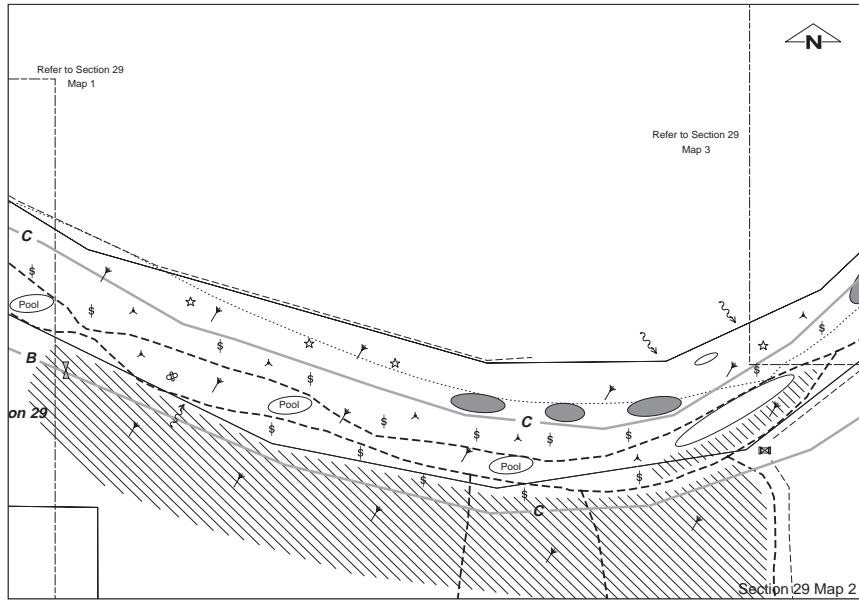
- H Support natural regeneration within the riparian zone to reduce the mobility of sediment, by fencing the foreshore banks to limit the impact of stock.
- H Support landholders in achieving all of these objectives.
- H Provide landholders with Water and Rivers Commission Water Notes information packs.
- H Protect any instream woody debris present that is not exacerbating erosion.

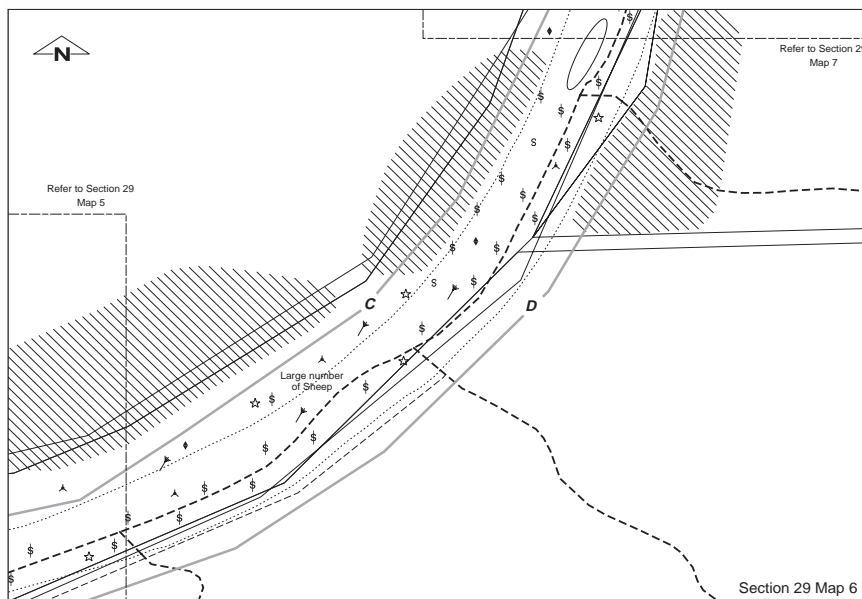
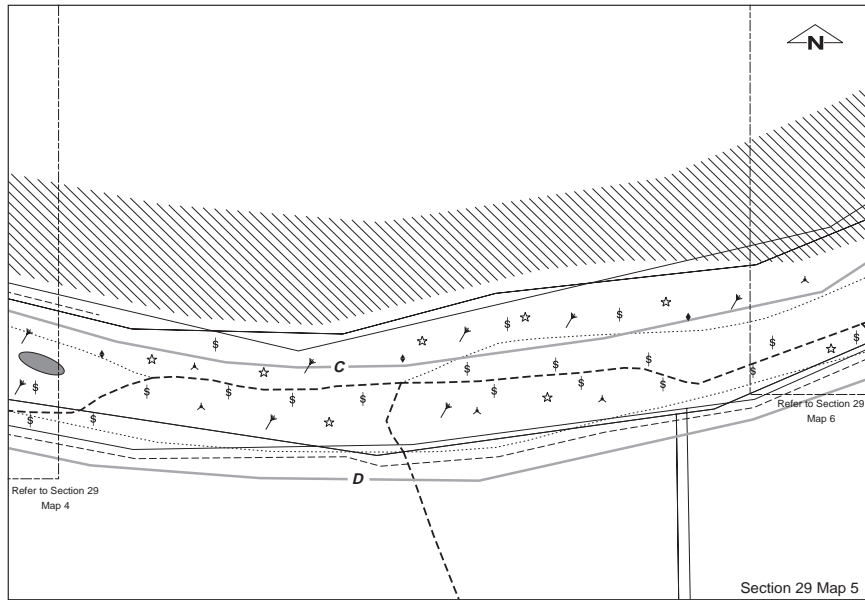
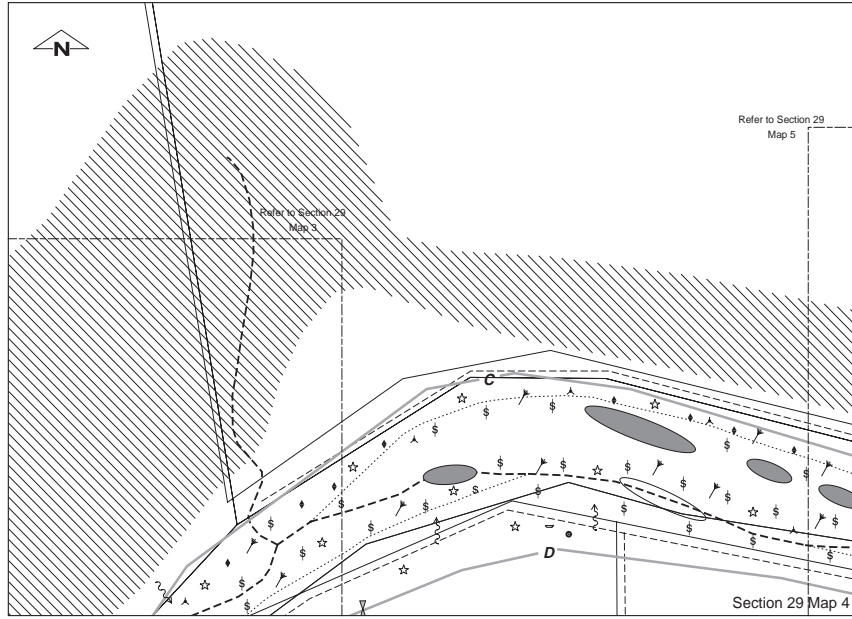
Other issues

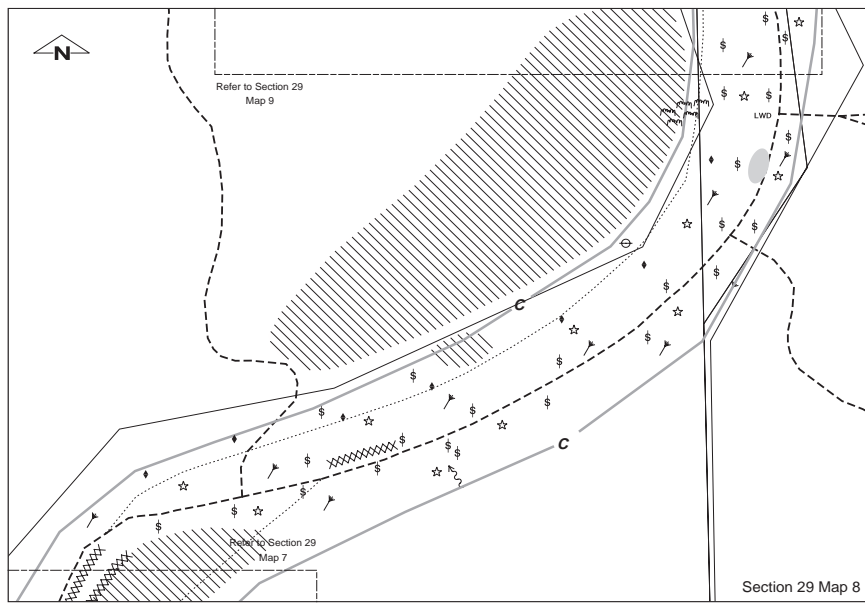
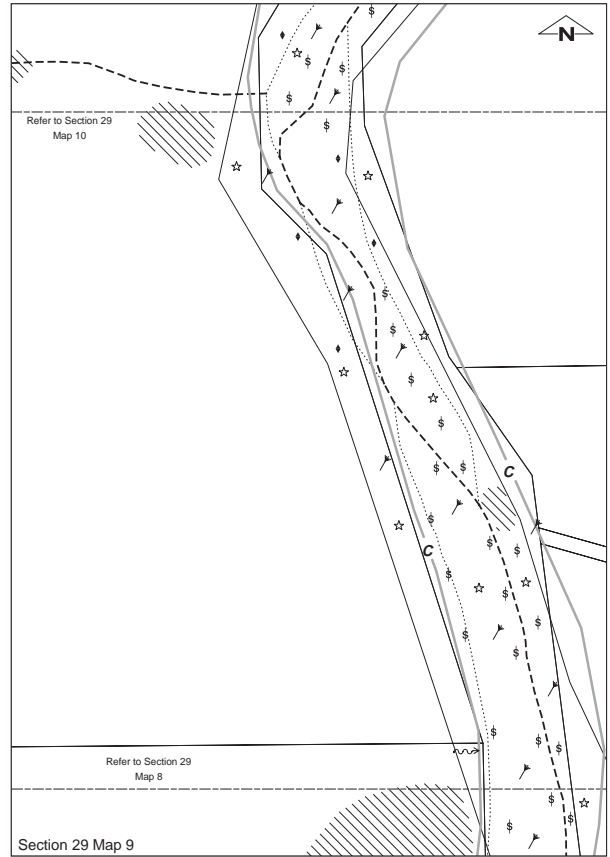
- O Provide information to the landholder about the benefits of undertaking the above listed activities.
- O Support landholders in achieving the outlined objectives, possibly through the provision of materials or labour.
- O Write to all landholders adjoining Wooderarrung Creek advising them of the findings of the foreshore assessment survey, detailing concern about the number of chemical drums in the floodway and encouraging further weed control – particularly of Saffron thistle and Castor oil plants.

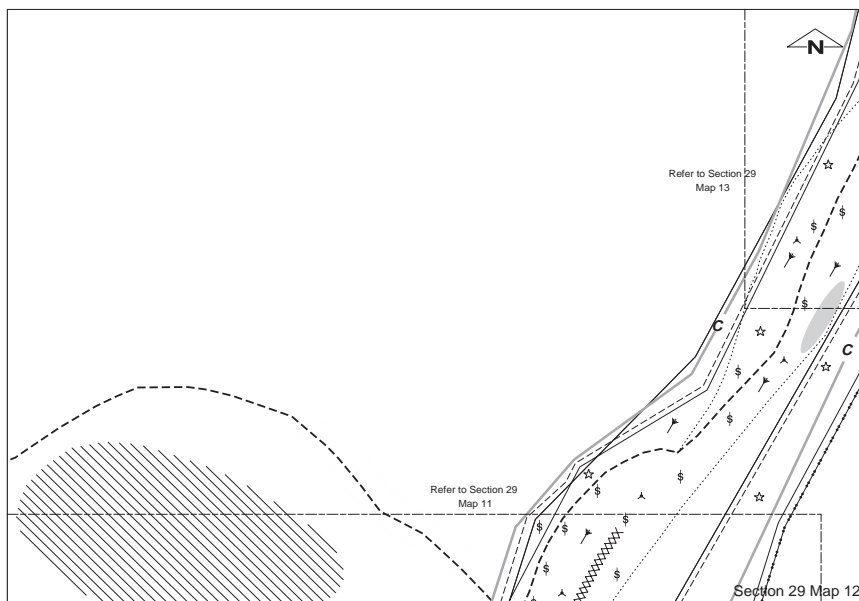
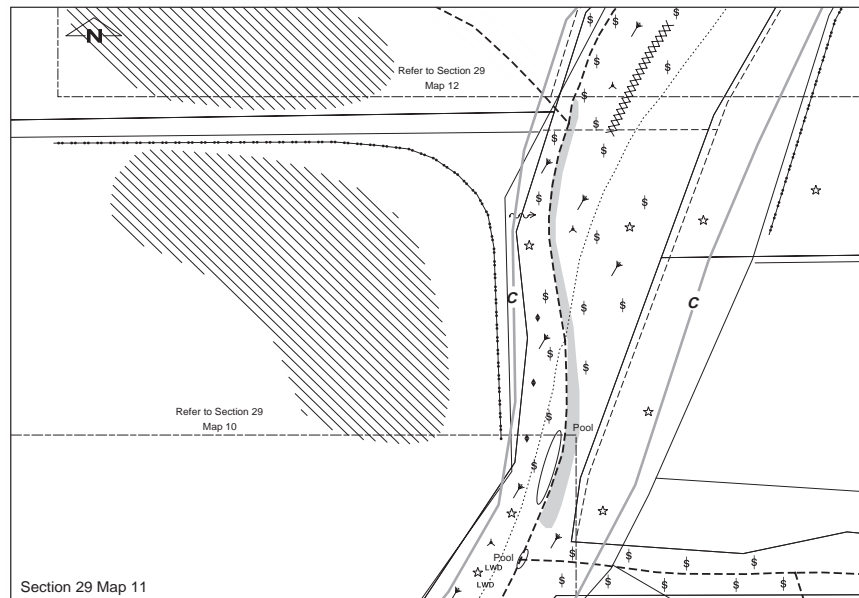
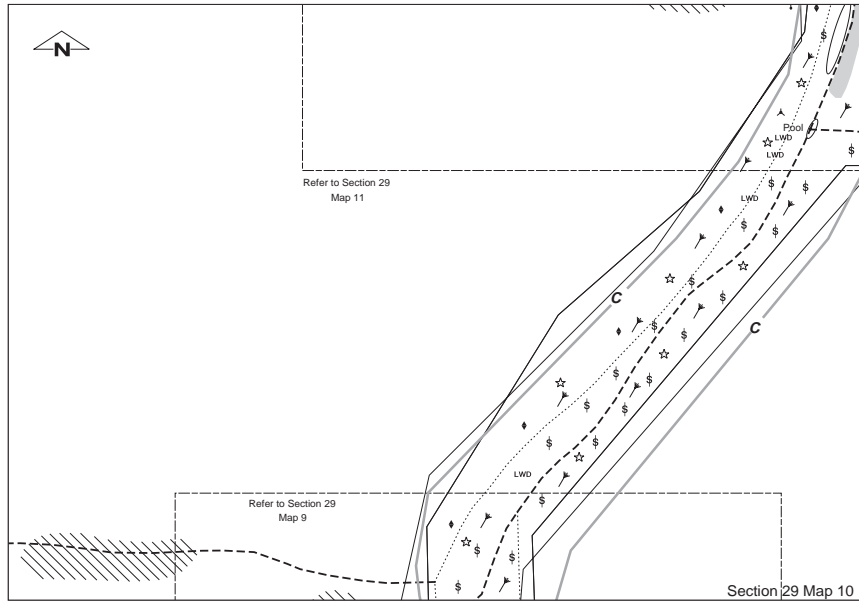


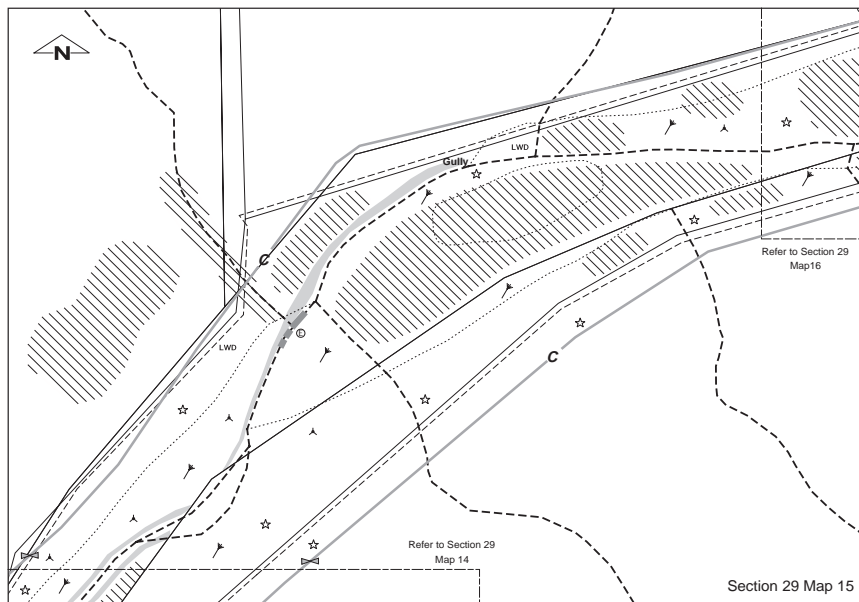
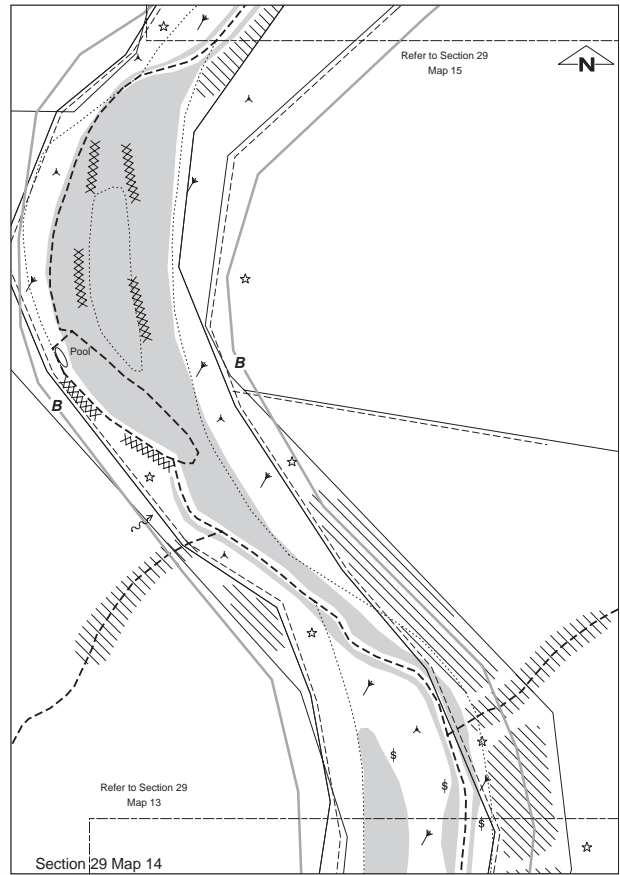
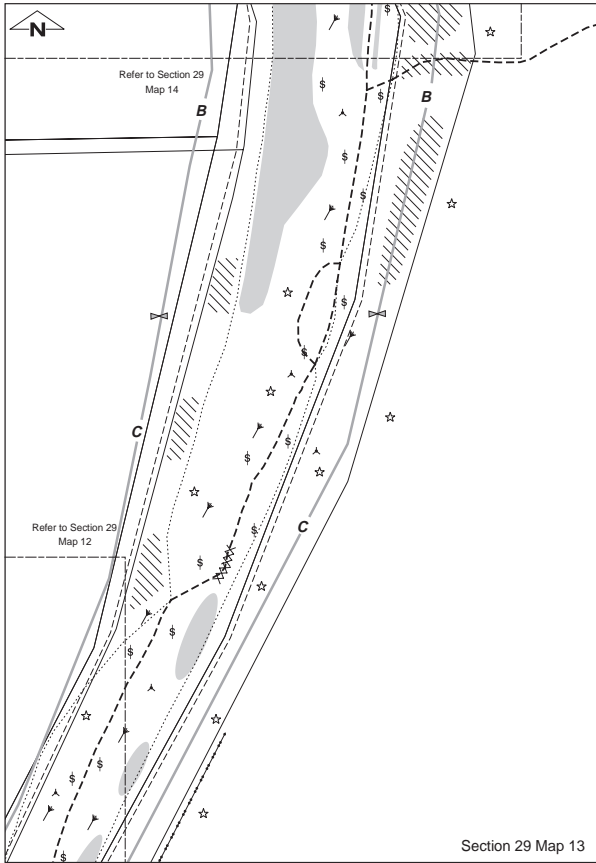


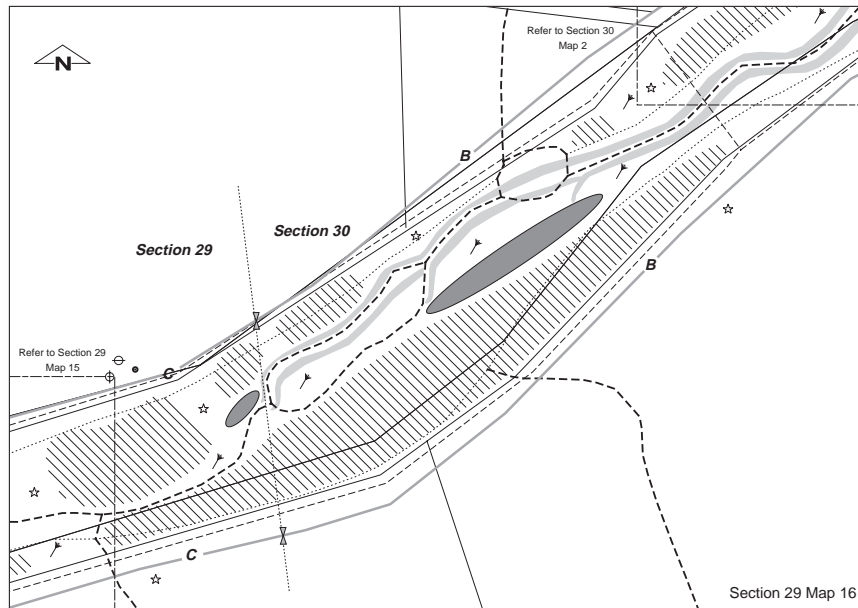












SECTION 30: COONAWA AND BARRAWHEELBARRA HILL REGION MAPS 1 – 13

Length of section (m): 13,830m

Recorders' names: N Siemon and T Rebola Date surveyed: 13 and 16 October 2000

Nearest road access: Coonawa Road and Nubberoo Roads

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Poor C	Moderate B	Moderate B	Very Good A	Moderate B	Moderate B

Bank stability

The main river channel ranges in width from 3 to 8 m. The foreshore bank gradients are highly variable and reflect the different soil types throughout this section. The floodway extends up to 200 m on each side of the main channel. There are small rocky cliffs (3 m high) on the right bank. Occasional steep breakaways occur along this section, helping to define the river valley. The erosion evident along the foreshore ranges from minimal (0-5% of the area) to localised on the floodway (5 - 20%). The erosion on the floodway is associated with areas lacking dense understorey. There is little evidence of slumping, however sedimentation is severe. Sand deposits and corresponding blowouts are present where river processes are forming braided channels. Twenty-three tributaries join this section of the Greenough River. There are four pools with depths ranging up to 1.5 m.

Comments

The actual channel banks through this section are relatively stable. At the time of survey the channel bed ranged from dry to 0.4 m of flowing water. There is considerable mobile sediment originating from within

and beyond this section. The range of sediment types suggests that the sediment from the Upper Greenough is yet to be transported to this river reach. The bulk of the material within the floodway appears to originate in Kolanadgy Creek. Assessing the soil structure in the plume led to these conclusions. Upstream of Kolanadgy Creek the bed materials tend to be pure silica, coarse materials of conglomerate origin, large stones and pieces of granite. Downstream the bed contains mostly red loam from which the fine clays have not yet been leached.

The blowouts are occurring between existing vegetation clumps and correspond with poor understorey vegetation. Managing grazing pressure will help to allow natural regeneration of plants to stabilise these blowouts.

Vegetation

The overstorey is continuous (> 80% cover) and ranges in width from 10-70 m wide on either side of the channel. Swamp sheoak (*Casuarina obesa*) is dominant with occasional Weeping pittosporum (*Pittosporum phylliraeoides*) and Lesser bottlebrush (*Callistemon*



phoeniceus) where there is exposed granite in the main channel or across the floodway. There is significant regeneration of these trees with frequent seedlings present. The middlestorey is patchy (20-80% cover) with frequent stands of a wattle (*Acacia* sp.), Broom ballart (*Exocarpos sparteus*) and uncommon Mohan (*Melaleuca viminea*). The understorey is patchy (20-80% cover) with dense stands of native plants interspersed with areas of bare sand. The floodway is dominated by homogeneous stands of Spiny flatsedge (*Cyperus gymnocaulos*), Saltbush (*Atriplex* spp.), Samphire (*Halosarcia*) and Marine couch (*Sporobolus virginicus*). The floodway margins have continuous cover and are dominated by Corkscrew grass interspersed with Ruby dock (*Acetosa vesicaria*), Doublegee (*Emex australis*), Saffron thistle (*Carthamus lanatus*), Pie melon (*Citrullus lanatus*), Annual barbgrass (*Polypogon monspeliensis*), two species of Statice (*Limonium sinuatum* and *L. lobatum*) and Wild oats (*Avena fatua*). Cape weed (*Arctotheca calendula*) is present in the upper part of this section.

The verge vegetation is patchy (20-80% cover) and is characterised by mature York gums (*Eucalyptus loxophleba*), *Hakeas*, *Grevilleas*, wattles (*Acacias* sp.) and infrequent Sandalwood (*Santalum spicatum*).

Comments

The vegetation is relatively intact in this section although there is some loss of vegetation due to flood damage. The level of weed invasion is of concern as it greatly increases the fire risk and may ultimately lead to the loss of remnant vegetation. There is some evidence of rabbit damage to regenerating seedlings. Selective management of declared weeds and Ruby dock should be a priority.

Stream cover

The overstorey and instream vegetation provides areas of permanent shade. The presence of vegetation detritus, scattered branches and instream rocks also provides instream cover.

Comments

The stream cover is generally good with most pools being well protected. This is reflected in fauna diversity.

Habitat diversity

The water depth ranges from dry to 1.5 m deep. The instream cover provides diverse habitats for aquatic

invertebrates. The water appeared to be less saline than adjoining river sections, which may indicate that springs feed this section. Diverse aquatic fauna was observed in the shallow channels and deeper pools. These included fish, four types of water beetle, three types of aquatic snails and larvae of dragonfly and caddisfly. Aerial insects such as cicadas, dragonflies, grasshoppers and damselflies are abundant. The terrestrial habitats are diverse reflecting improved vegetation cover and diversity. Predators such as spiders are plentiful. Birdlife was prolific in the river, on the floodways and in the surrounding shrublands. Of particular interest was the presence of three species of water birds: Banded stilts, dotterel and plovers. Black cockatoos, Corellas, Willy wagtails and Magpie Larks are common.

Reptiles observed in this section included one Perentie (*Varanus giganteus*), Sand monitor (*Varanus gouldii*), several Central netted dragons (*Ctenophorus nuchalis*), a Gwardar (*Pseudonaja nuchalis*) and two King browns (*Pseudechis australis*).

Comments

The habitat value of this region is excellent. The diversity of fauna observed during the course of this survey is likely to represent only a small part of the total fauna.

Other issues

The Coonawa River crossing is causing localised sedimentation and minor disruption to the river flow characteristics. The Barraweelbarra Hill is an interesting landscape feature. The hill comprises a diverse range of rocks. A powerline crosses the river. The surrounding landuses include grazing, cropped and uncropped paddocks. Feral goats are present in this area. There are two disused wells on the floodway margin. The water level in these wells appeared to be approximately 0.2 m below the riverbed level.

Suggestions

Bank stability

- B Assess the flooding characteristics and surface water hydrology at the junction of Kolanadgy Creek and the river to determine the feasibility of managing runoff and peak flows.



B Undertake a foreshore assessment survey of Kolanadgy Creek with a focus on assessing sediment mobility and identify mechanisms to reduce particulate load if required.

B Monitor the pools to determine whether or not they are self-cleaning with each flow event. Protecting these summer refuges from sedimentation will help to maintain animal populations.

Vegetation

V Continue stock management that is minimising degradation of the foreshore vegetation.

V Undertake selective weed control of Saffron thistle, Ruby dock and Pie melon.

V Monitor the river section and eradicate any new weeds before numbers increase.

V Encourage all landholders to develop fire management plans that enable ready access along the foreshore reserve.

Stream cover

S Protect vegetation from disturbance by fire, livestock and infrastructure development to maintain cover.

S Maintain instream vegetative material and do not remove debris unless it is causing significant damage to the riverbanks and bed.

Habitat diversity

H Continue the minimal use of the foreshore reserve to protect the persisting flora and fauna.

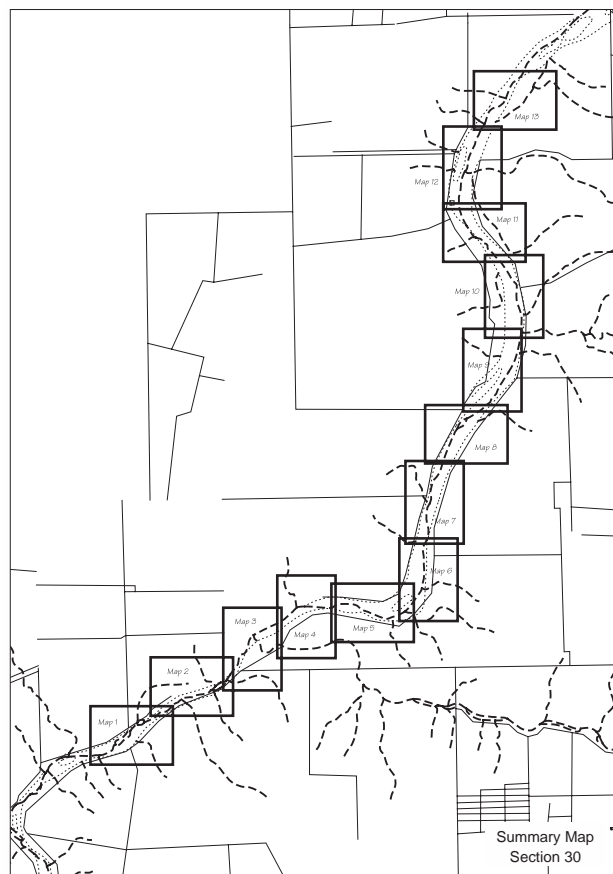
H Protect the remnant vegetation in the area from clearing and/or other activities that could cause degradation.

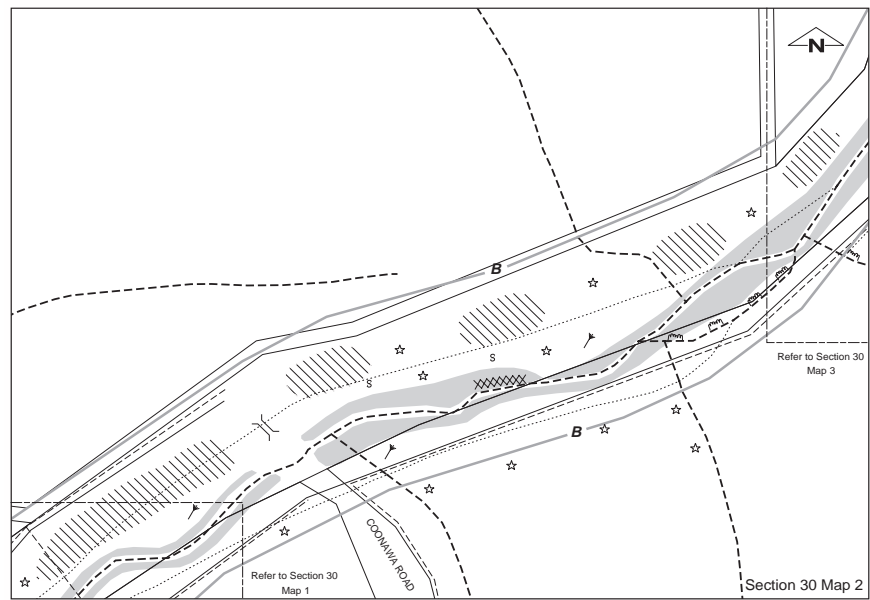
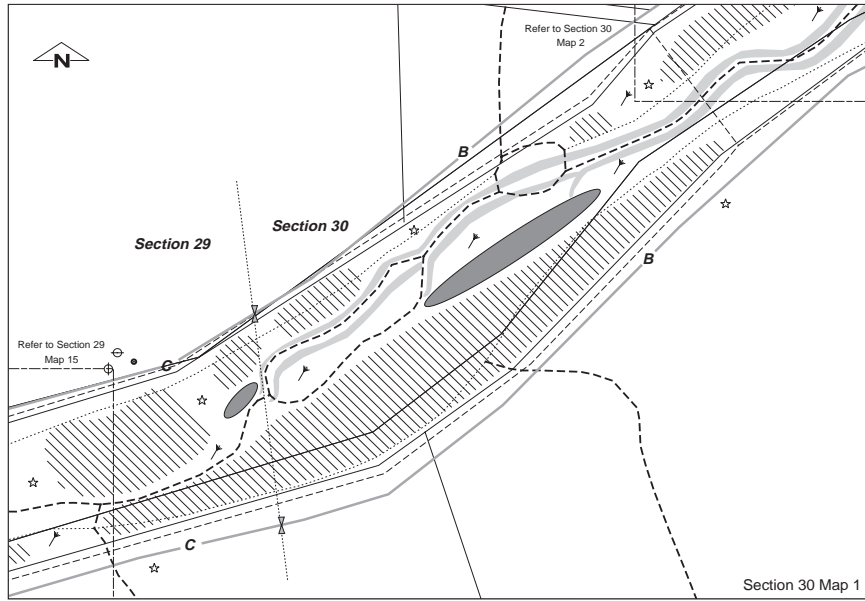
H Monitor river pool health and obtain advice for management of these features from officers of the Water and Rivers Commission.

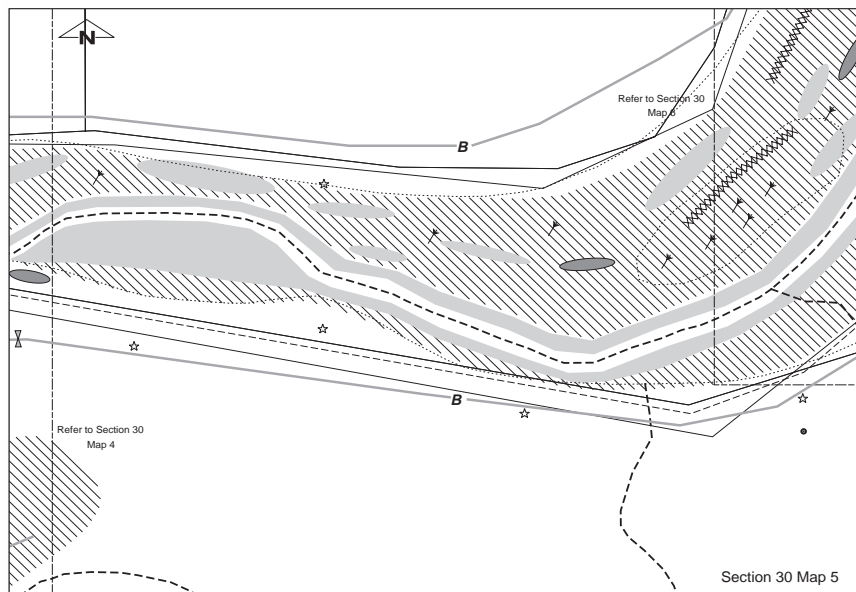
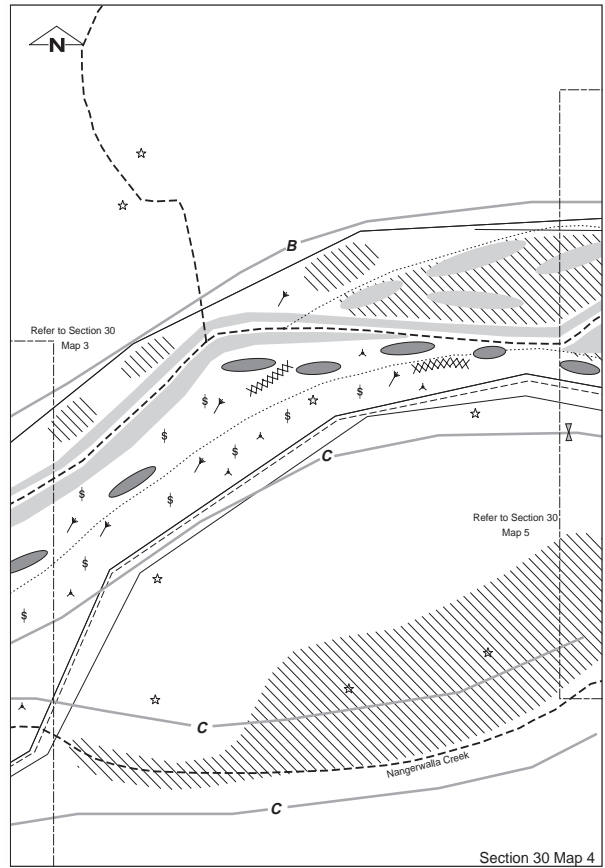
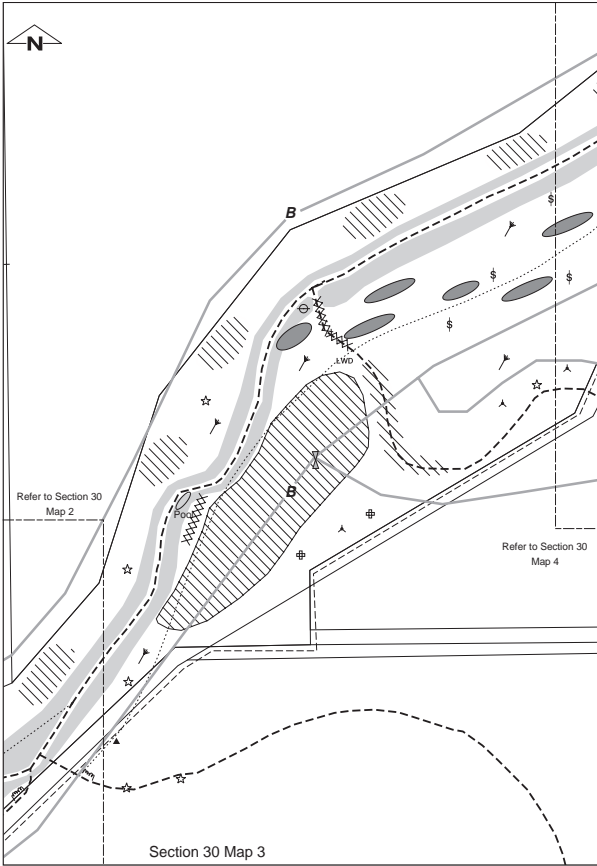
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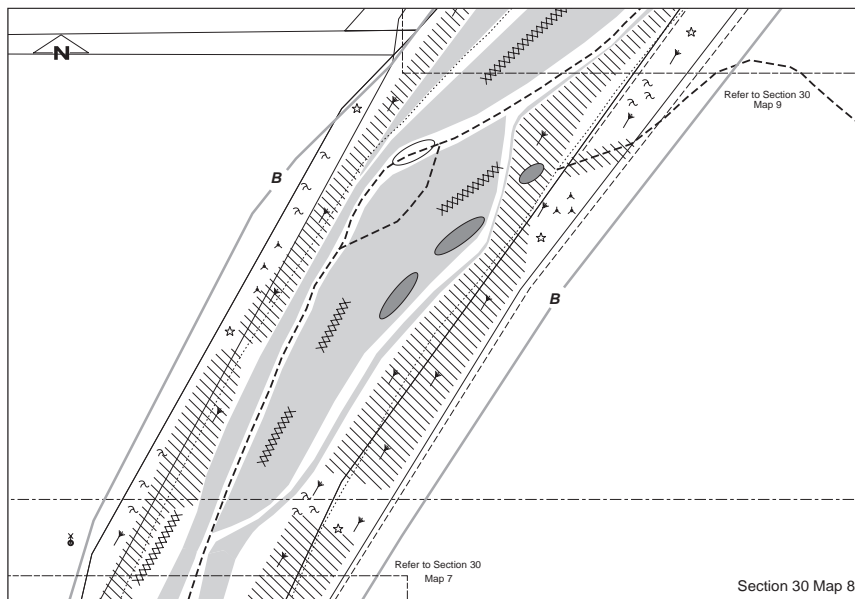
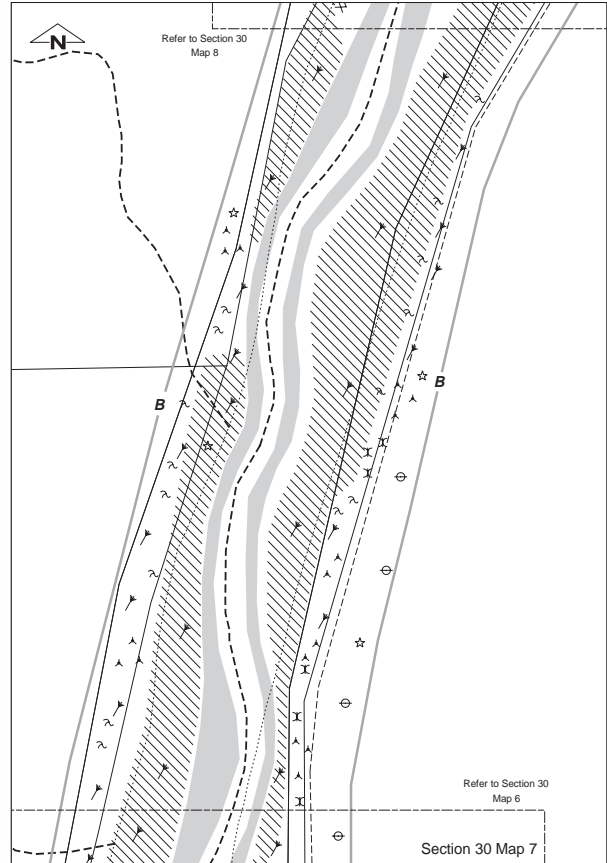
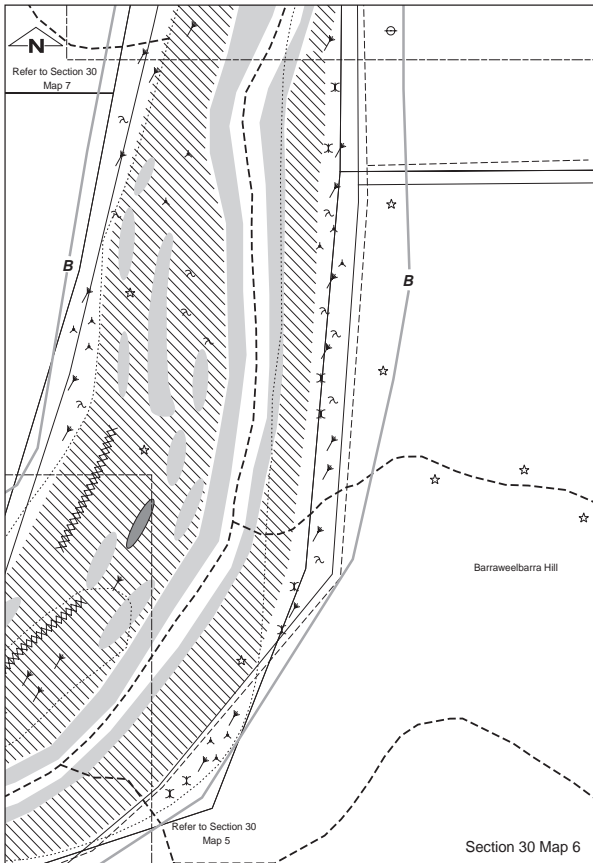
O Implement feral goat control, which may involve trapping and selling them for export or for Australian gourmet markets.

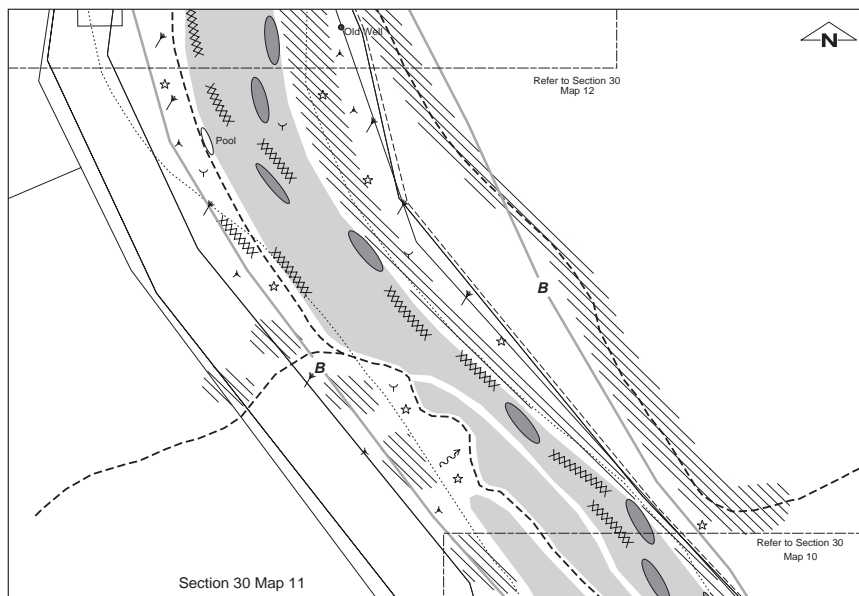
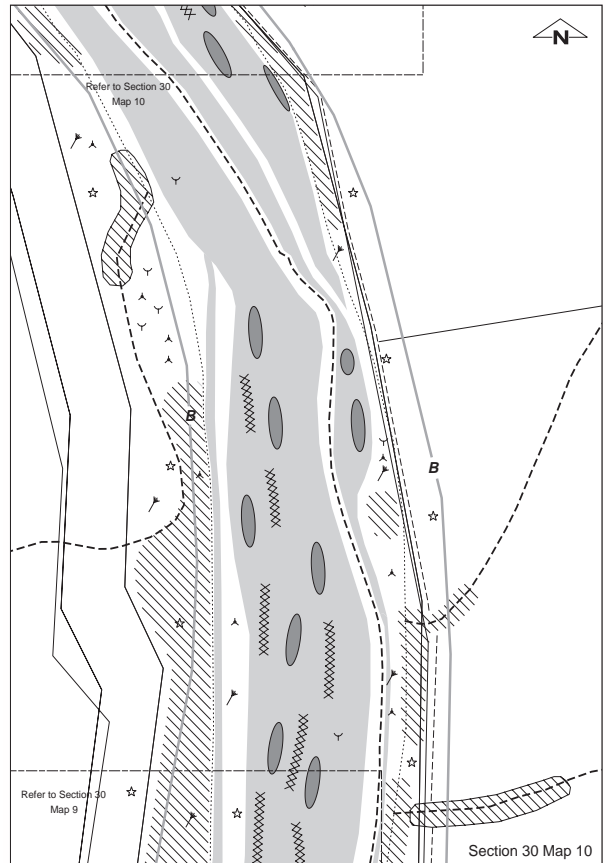
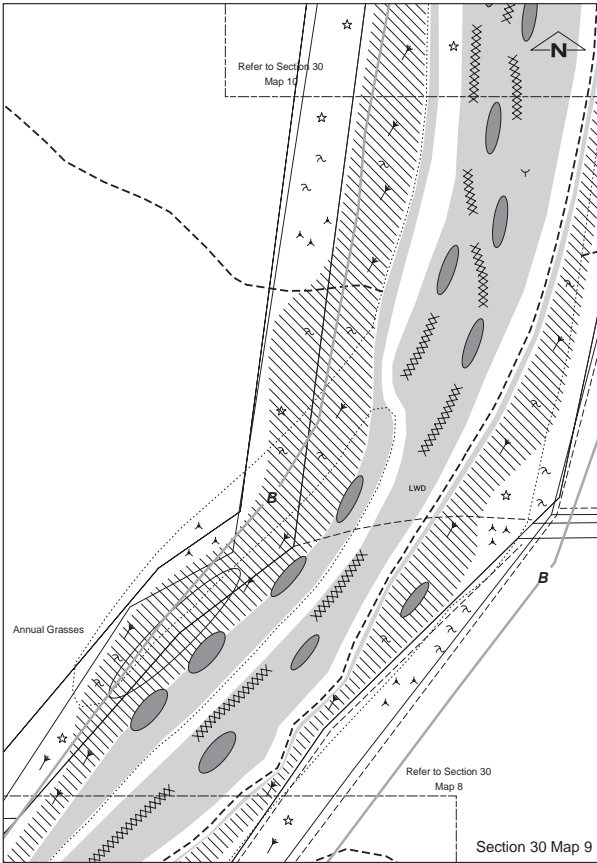
O Investigate the history and geological processes that formed Barraweelbarra Hill.

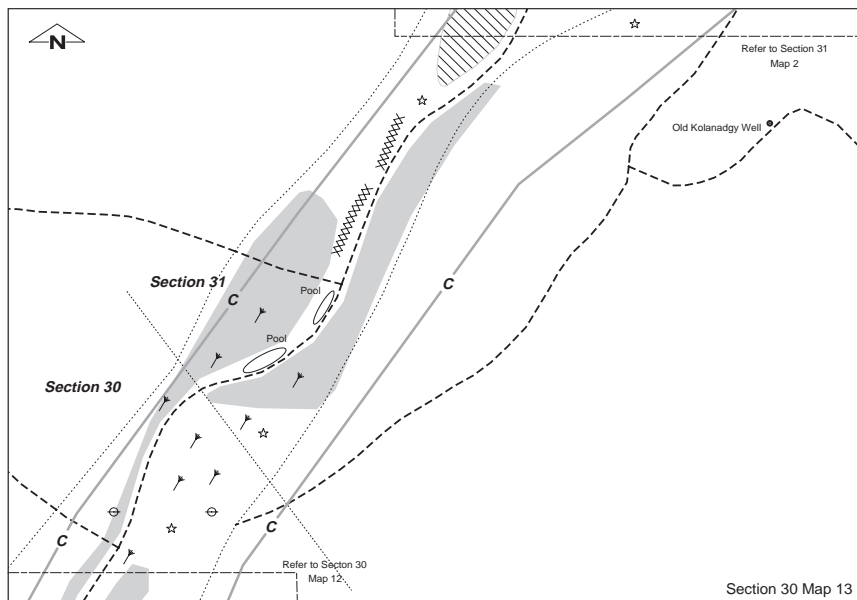
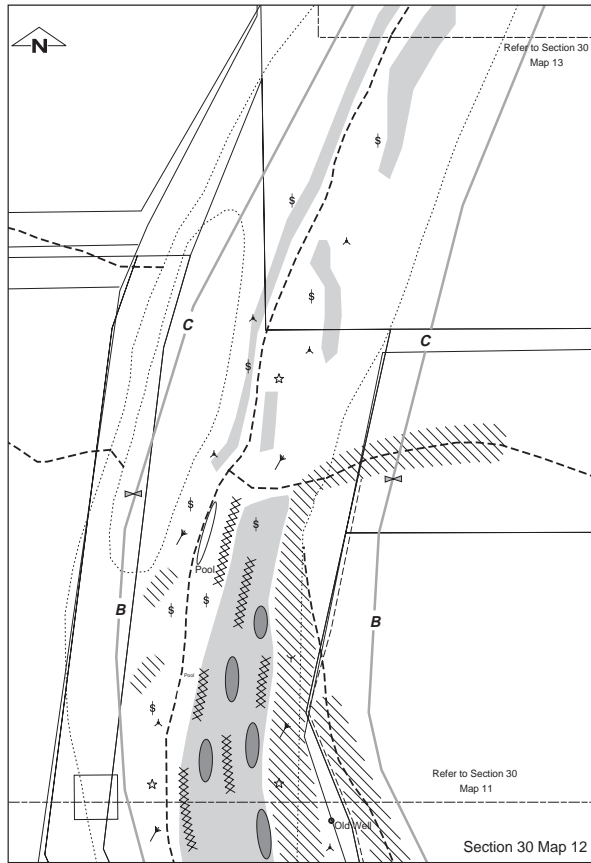












SECTION 31: OLD KOLANADGY WELL TO CONFLUENCE OF URAWA RIVER MAPS 1 - 7**Length of section (m):** 6,170m**Recorders' names:** Mullewa CLC, N Siemon and T Rebola**Date surveyed:** 4 October 2000**Nearest road access:** Mullewa – Carnarvon Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Very Poor D	Poor C	Poor C	Poor C	Poor C	Poor C

Bank stability

The main channel of the Greenough River ranges between 8 and 20 m wide. The foreshore banks rise on a medium gradient to a height of 1 - 4 m. There are some sections where the main channel is braided. Erosion is severe, occurring along > 50% of the foreshore section. The main overflow channels are approximately 20 m wide. Sedimentation is significant, occurring along > 50% of the floodway. Mobile sand and coarse conglomerate material increase the abrasive force of the flow in peak events. In limited areas the main channel bed has eroded back to a hard stable base. Exposed granite boulders appear periodically along this section. There are sections characterised by numerous sand plumes. At the time of survey four small pools were present. Ten tributaries contribute water to this river section, including the Urawa River.

Comments

The right bank is generally more stable than the left bank in this section. There is insufficient riparian vegetation to protect the riverbed and banks from erosion. Large amounts of woody debris are forming natural dams in the open sheoak woodlands, causing scouring beneath and around the remaining trees. The exposed granite boulders instream and on the floodway margins are insufficient to slow the rate of flow.

Vegetation

The overstorey is patchy (20 - 80% cover) extending 10 - 50 m from the river. The overstorey consists of abundant Swamp sheoak (*Casuarina obesa*) and occasional Weeping pittosporum (*Pittosporum phylliraeoides*), Lesser bottlebrush (*Callistemon phoeniceus*) and Swamp paperbark (*Melaleuca raphiophylla*). The middlestorey is sparse (< 20% cover) being limited to occasional groups of wattles including Coojong (*Acacia saligna*), Broom ballart (*Exocarpos sparteus*), Saltbushes (*Atriplex* spp.) and

infrequent *Chamelaucium micranthum*. The understorey is patchy (20-80% cover) and dominated by weeds. Persistent native species present include Spiny flatsedge (*Cyperus gymnocaulos*), Samphire (*Halosarcia* spp.) and Yellow autumn lily (*Tricoryne elatior*). The prevalent weed species include Saffron thistle (*Carthamus lanatus*), three species of Statice (*Limonium sinuatum*, *L. lobatum* and *L. companyonis*), Pie melon (*Citrullus lanatus*), Pimpernel (*Anagallis arvensis*) and Doublegee (*Emex australis*). Widespread annual grass species include Wild oats (*Avena fatua*), Annual barbgrass (*Polypogon monspeliensis*) and the native Windmill grass. Infrequent patches of Couch (*Cynodon dactylon*) are present.

The verge vegetation is limited to occasional stands of York gum (*Eucalyptus loxophleba*) over an understorey of annual grasses. Shrubs occur infrequently.

Comments

The native vegetation is likely to be unsustainable in the long term because of the current land management practices. Future flow events are likely to result in loss of vegetation from the floodway. There was evidence of livestock and feral animal damage. The lack of natural regeneration of native plants is of concern because as the mature plants die of old age there is nothing to replace them.

Stream cover

There is some native vegetation overhanging the main channel and few areas of permanent shade across the remaining open water. The presence of scattered logs, branches and boulders provides some instream cover.

Comments

Stream cover is classed as minimal and insufficient to slow the rate of evaporation of river pools. Facilitating the natural regeneration of native plants will help to improve the cover.



Habitat diversity

Water is unlikely to be retained in pools over summer. It is possible however that sub-surface water occurs close to the surface of the riverbed. There is some evidence of this as kangaroos and other fauna have dug for water. The river channel ranges from dry to 0.6 m deep. The few instream logs, branches and frequent rocks provide limited numbers of suitable substrates for aquatic invertebrates. As the streamside vegetation is highly degraded and there is very little leaf litter evident, the number of suitable habitats for terrestrial fauna particularly reptiles is limited. The patchy overstorey and verge vegetation provides some nesting and roosting sites for birds. Emus and kangaroos were observed in the foreshore reserve.

Comments

The degradation of the foreshore limits the usefulness of this section as habitat. Controlling livestock and feral animals is important to assist natural regeneration.

Other issues

Woody debris is suspended up to 2.5 m above the low flow channel bed. Urawa Creek drains a large catchment area. Foreshore reserves occur along this entire section and some parts are fenced whilst others are unfenced. The relationship between the existing fencelines and the foreshore boundary is unknown. Continued feral animal control will also help to restore the river environment.

Suggestions

Bank stability

- B Undertake selective realignment of woody debris where it is exacerbating erosion.
- B Assess the surface water hydrology and hydraulics of the Urawa River along its entire length to determine the feasibility of slowing the rate of flow and volume of water contributed by this sub-catchment.
- B Implement a foreshore assessment survey of the Urawa River and relate back to catchment issues.

Vegetation

- V Protect remnant vegetation from access by livestock to support natural regeneration processes.
- V Undertake selective weed management in the foreshore reserve and adjoining lands focussing on Saffron thistle, Pie melon and Doublegee.
- V Encourage landholders to establish an access track along the foreshore reserve boundary to enable access for weed and fire control.
- V Undertake weed control in manageable nodes and focus on establishing buffers around native seedlings to encourage growth.
- V Fence off the foreshore reserve as a priority to enable stock management.

Stream cover

- S Fence off currently unfenced zones as a priority and undertake selective weed control around native seedlings.
- S Monitor whether or not any natural regeneration is occurring and if not, plant tree tubestock within fenced areas. It may be necessary to protect these from grazing by rabbits.

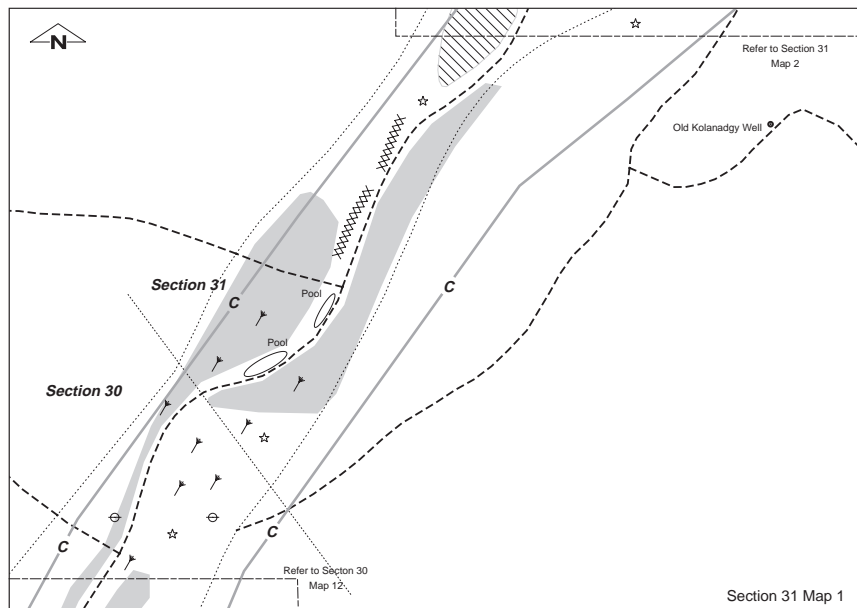
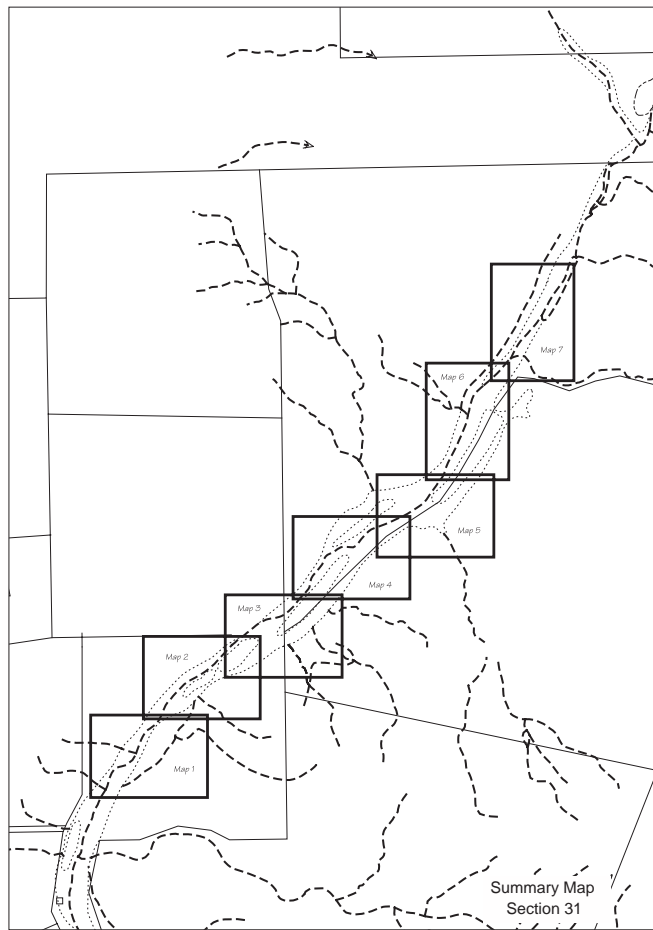
Habitat diversity

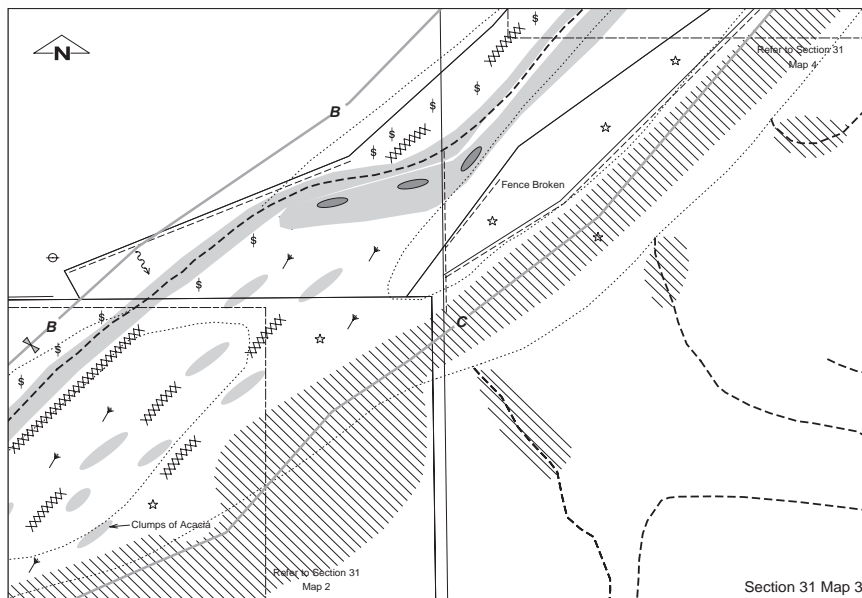
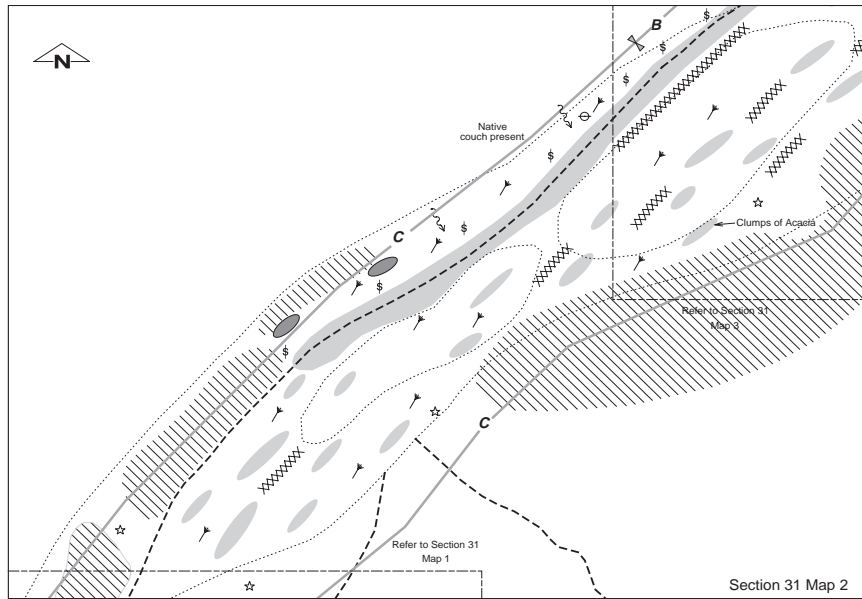
- H Install fencing along the foreshore reserve boundary to enable more effective control of stock.
- H Protect any instream debris present that is not exacerbating erosion.
- H Implement localised weed control within the reserve as resources permit.

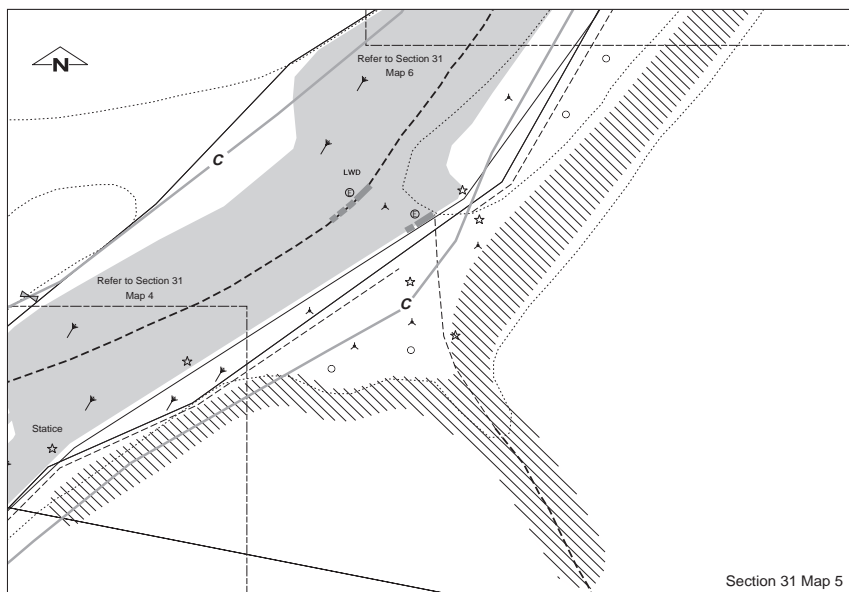
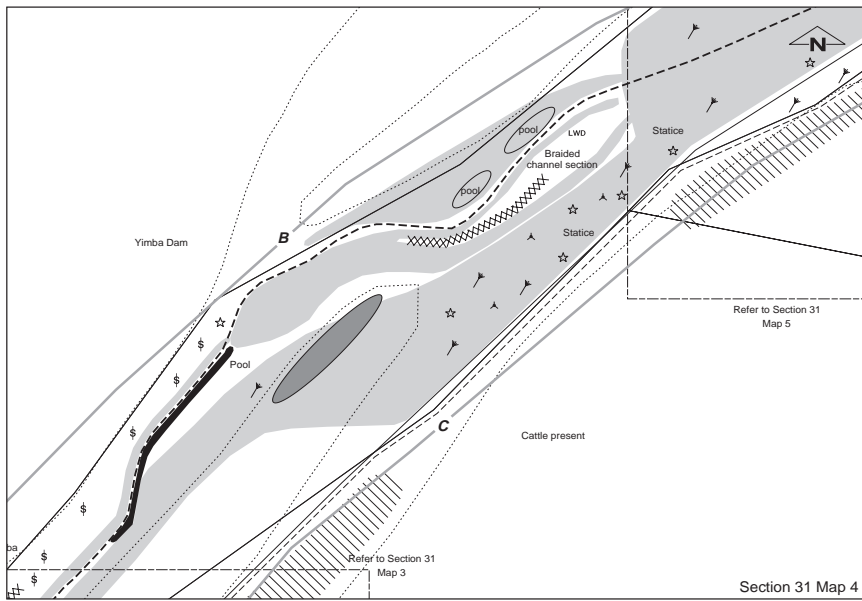
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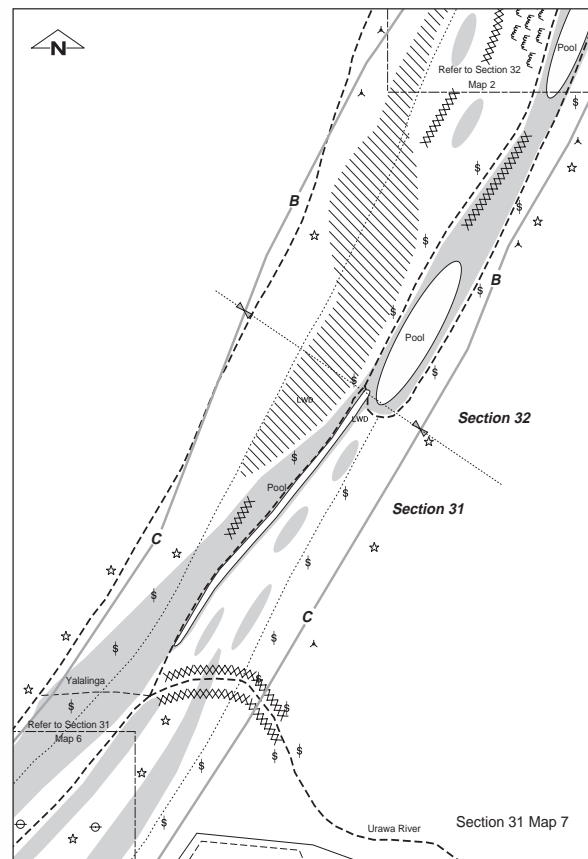
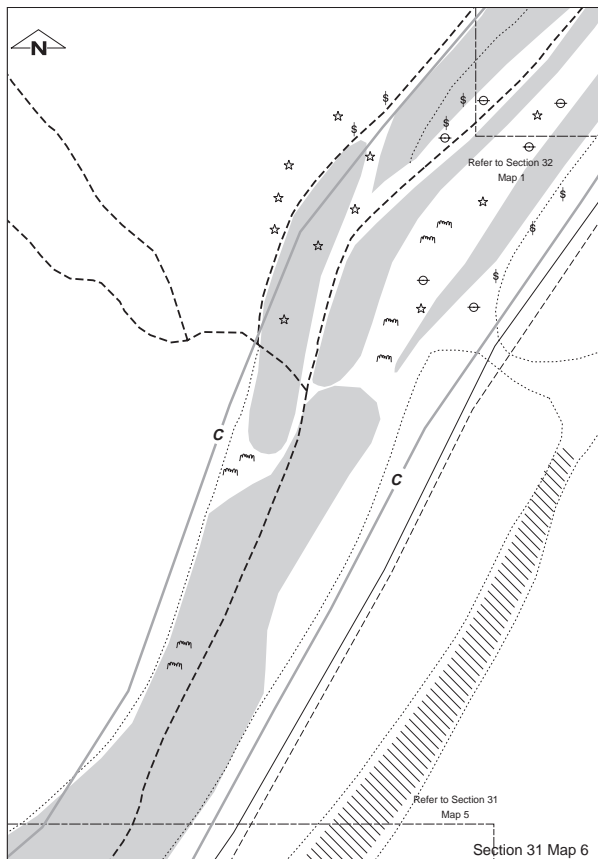
- O Investigate the Urawa Creek foreshores and the catchment to determine the feasibility of controlling water flow and volumes contributed.
- O Ensure that fences are established along the entire foreshore reserve boundary, using landform contours to determine the alignment rather than necessarily using the actual boundary.











SECTION 32: MURGUNDIE, NUNIERRA CREEK TO CADJACOOThERRA MAPS 1 – 14

Length of section (m): 14,310m

Recorders’ names: N Siemon and T Rebola **Date surveyed:** 4 October 2000

Nearest road access: Mullewa – Carnarvon Road

Summary of river health:

Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Verge Vegetation	Stream Condition
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B

Bank stability

The main river channel has a single channel or braided form, as it flows through a series of granite spillways and mobile sandy sections. The main channel ranges in width from 15 to 70 m wide. The channel banks range from slight through to very steep, although the sections that are very steep are typically characterised by stable sediment types. Erosion is localised (5 – 20%), principally due to the river valley geology. The dominance of granite boulders along this river system, and the steep bed gradient impacts on sediment movement and distribution. Slumping and undercutting is also localised (5 – 20%) in areas characterised by clay dominated riverbanks. These sections are eroding slowly. Sedimentation is significant (> 50%), with plumes deposited in banks up to 1.5 m above the low flow channel height. These plumes are generally

deposited on the upper reaches of the floodway. There are a number of substantial pools amongst the granite boulders. These are important landscape features and provide an important refuge. The salinity in these pools seems to be relatively high, due to evaporation and the consequent concentration of salts. Twelve substantial pools were present at the time of survey. Many of these pools have stable rocky beds and may retain water throughout the year.

Comments

The riverbed, banks and floodway are relatively stable due to the frequency of granite and stable clay riverbanks along this river section. In the river sections with a slight bed gradient, there is significant sediment accumulation, while in the steep rocky sections this deposition does not occur. The volume of mobile sediment through the well-vegetated sandy sections is



of concern. There is also a risk that many of the river pools may be infilled by mobile sediment. Where there are significant steps in riverbed height this threat is small. Managing sediment load will become important in the future to protect these summer refuges. Some of the sand plumes are moved throughout the year by the movement of stock accessing pools for water and use of the pools by feral animals, particularly goats and native animals such as emus and kangaroos.

There is a semi-formal river crossing leading to the small airstrip near the Nunierra Well.

Vegetation

The overstorey is patchy (20 – 80% cover) to sparse (< 20% cover) depending on the soil type. Where the soils are shallow, trees are understandably limited in extent and frequency. Some stands of trees have established on large sandbars in the middle of the river channel. The dominant species is Swamp sheoak (*Casuarina obesa*) with infrequent Weeping pittosporum (*Pittosporum phyllarioides*). The middlestorey is patchy (20 – 80% cover) and dominated by Coojong (*Acacia saligna*), an unidentified wattle (*Acacia* sp.) and (*Olearia muelleri*). The understorey is also patchy (20 – 80% cover) and dominated by weeds with occasional persistent native grasses and rushes/sedges. Occasional stands of Spiny flatsedge (*Cyperus gymnocaulos*), Samphire (*Halosarcia* spp.), (*Sarcocornia* spp.), (*Atriplex* spp.), (*Frankenia* spp.) and (*Rhagodia* spp.) occur in the floodway. Abundant flowering weeds include Pimpernel (*Anagallis arvensis*), Doublegee (*Emex australis*), Saffron thistle (*Carthamus lanatus*), Pie melon (*Citrullus lanatus*) and Black berry nightshade (*Solanum nigrum*). Another weed species present is Dandelions (*Hypochaeris glabra*). The native small leaf Roly poly (*Salsola kali*) occurs periodically.

The verge vegetation is patchy (20 – 80% cover) and is characterised by occasional York gum (*Eucalyptus loxophleba*) close to tributaries, and low shrublands dominated by *Maireana* spp. There are frequent stands of native hibiscus (*Alyogyne* spp.).

Comments

It is anticipated that native vegetation cover will be patchy in these low rainfall zones. Further, where there

are shallow soils plant establishment is often limited. The impact of weed invasion on these communities can be severe as they compete with native plants for soil moisture and nutrients. Maintaining sufficient vegetation cover is an important part of keeping riverbeds, banks and floodways stable.

Stream cover

Stream cover provided by overhanging vegetation is patchy, however the erosion of the channel bed in the pool zones provides excellent cover. Filamentous algae occur in the river pools providing cover and substrate for aquatic animals. The presence of boulders, rocks and branches is sufficient to ensure cover is available in instream pools.

Comments

There is sufficient stream cover provided by instream rocks, boulders and woody debris in the pools remaining in the river channel. Protecting the longevity of the pools by facilitating sediment movement is an important aspect of protecting the stream cover.

Habitat diversity

Water is possibly permanent in some of the river pools in this section, and likely to be groundwater fed. The water is saline, clear and lacks tannins that are apparent where chemicals are leached from instream vegetation. There is evidence that the nitrogen levels are higher than natural levels due to the prolific growth of a species of filamentous algae. Floating sheep and goat faeces were evident in many pools. This is expected where stock congregate to drink. The channel depths range from dry to pools with water depths up to 2.5 m. These were well stocked with large fish (probably grunters), aquatic snails, water beetles and related fauna. All of these species are able to tolerate hypersaline conditions that occur in the pools. Waterbirds including Dotterels, Spoonbills, Great egrets and White-faced heron were observed using pools in this section.

The patchy vegetation provides habitat for a range of woodland and shrubland birds. Orioles, fantails and cuckoos were identified in the area. Swallows and bees inhabit the cracks between collapsing conglomerate. A fledgling Wedge-tailed eagle and its parents were seen in the area.



Emus and kangaroos utilise the foreshore and have dug for water on the margins of the pools. Foxes and feral goats are present in the foreshore and neighbouring land. The condition of some of the animals is poor.

Comments

The habitat diversity is excellent in this river section, even though the vegetation is patchy. This reflects the rangeland. The weed invasion and grazing by both feral animals and livestock is impacting on river health.

Other issues

There is a landing strip for light aircraft in this section. Foreshore reserves are continuous but there is no fencing or other visual identification of the location of this boundary. The property boundaries are often fenced across the river, perpendicular to river flow and often with large quantities of debris trapped.

Suggestions

Bank stability

- B Monitor pools and sediment movement annually or following any peak flow events, to determine whether or not additional support of the river process is required.
- B Discourage activities that result in additional mobilisation of bank sediments such as overgrazing of the foreshore reserve.

Vegetation

- V Undertake selective weed control of weed species such as Saffron thistle, Pie melon, Black berry nightshade and Doublegee, as resources permit.
- V Encourage landholders to fence the foreshore reserve to enable more effective control of rangeland grazing as the opportunity arises. This may be difficult but will help to reduce sediment contributions from these upper reaches.

Stream cover

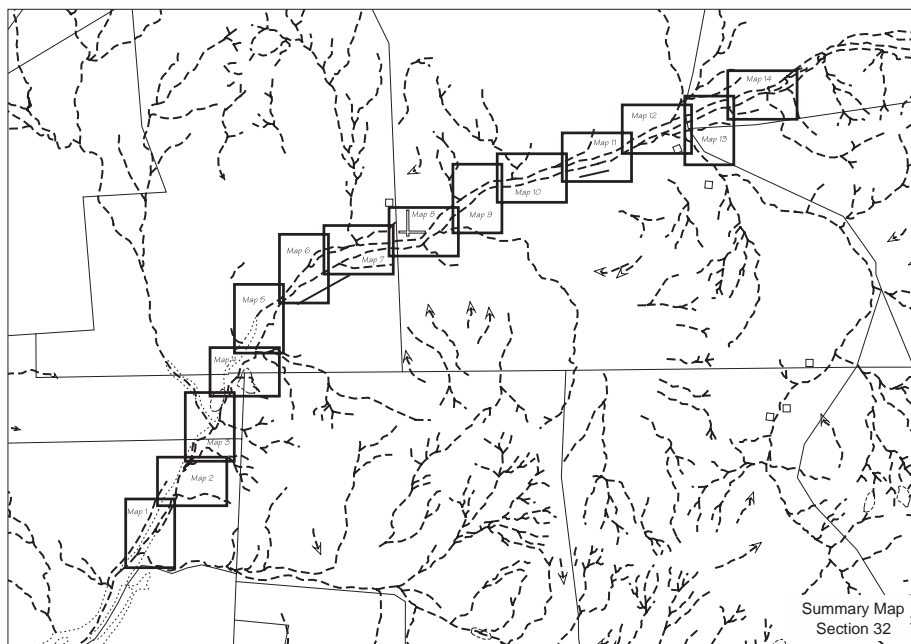
- S Monitor pool health and sediment mobility close to these pools following future flood events.
- S Encourage livestock management practices that exclude stock periodically from the foreshore environment to enable the instream vegetation to recover.

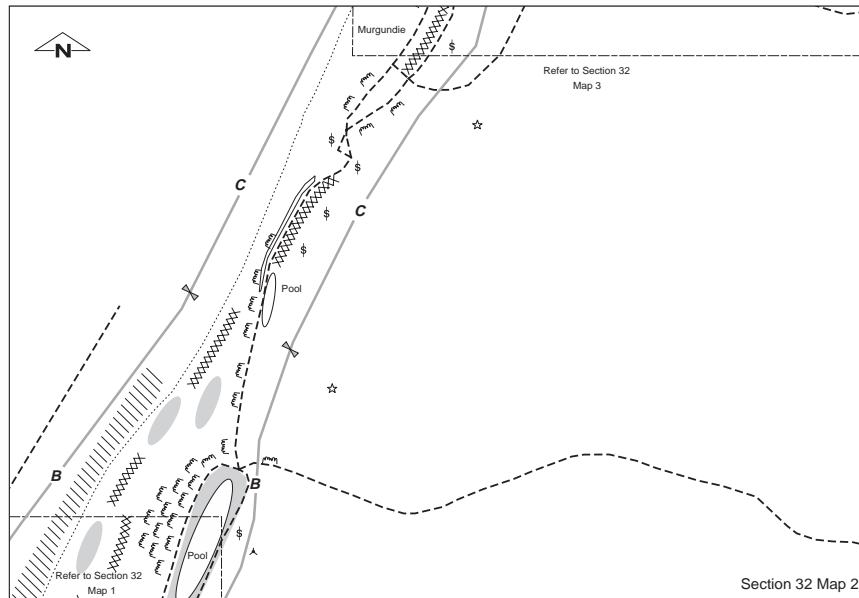
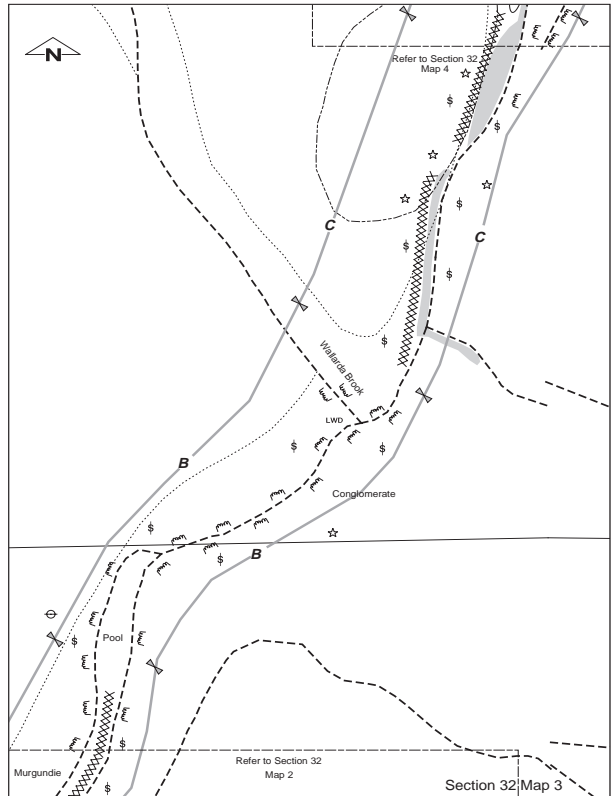
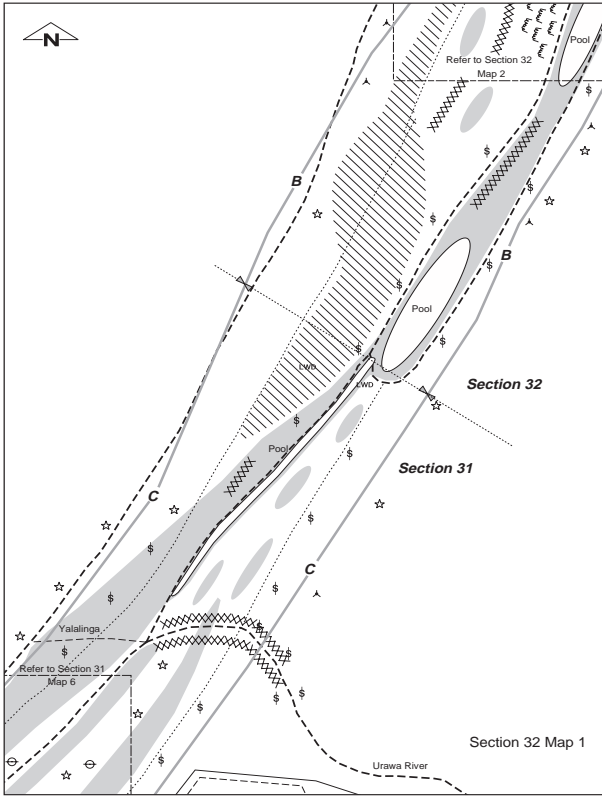
Habitat diversity

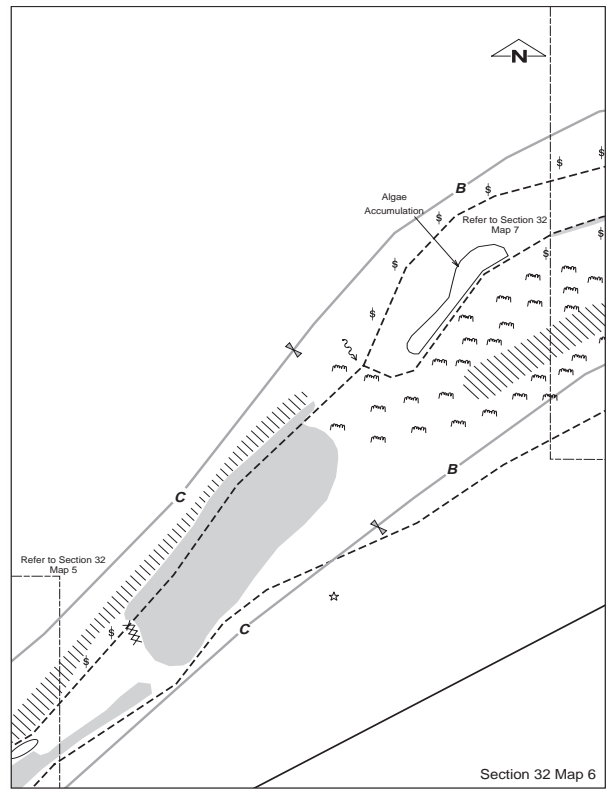
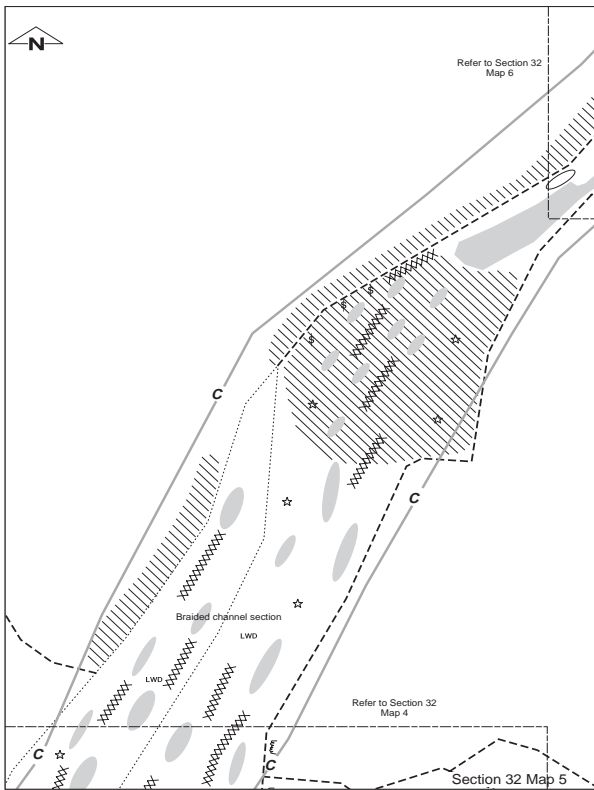
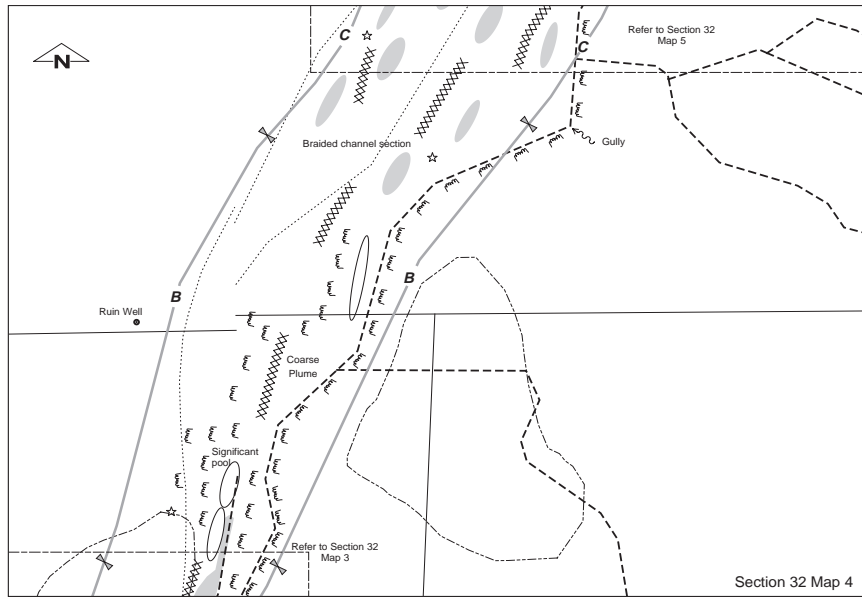
- H Protect river values to encourage native animals.

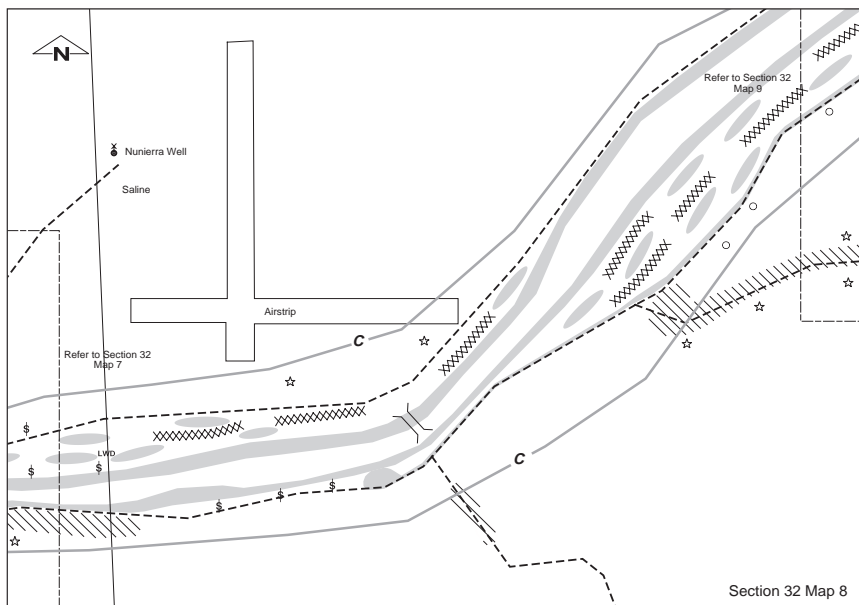
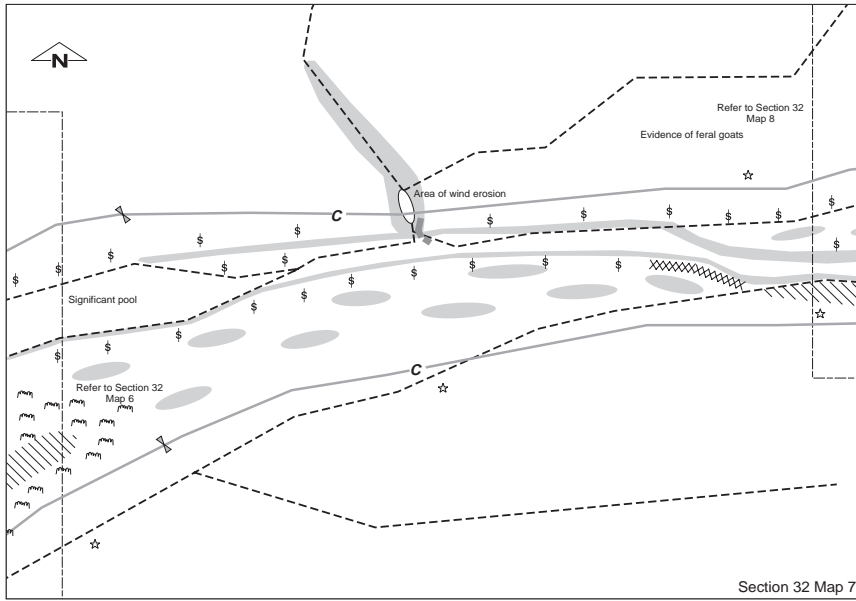
Other issues

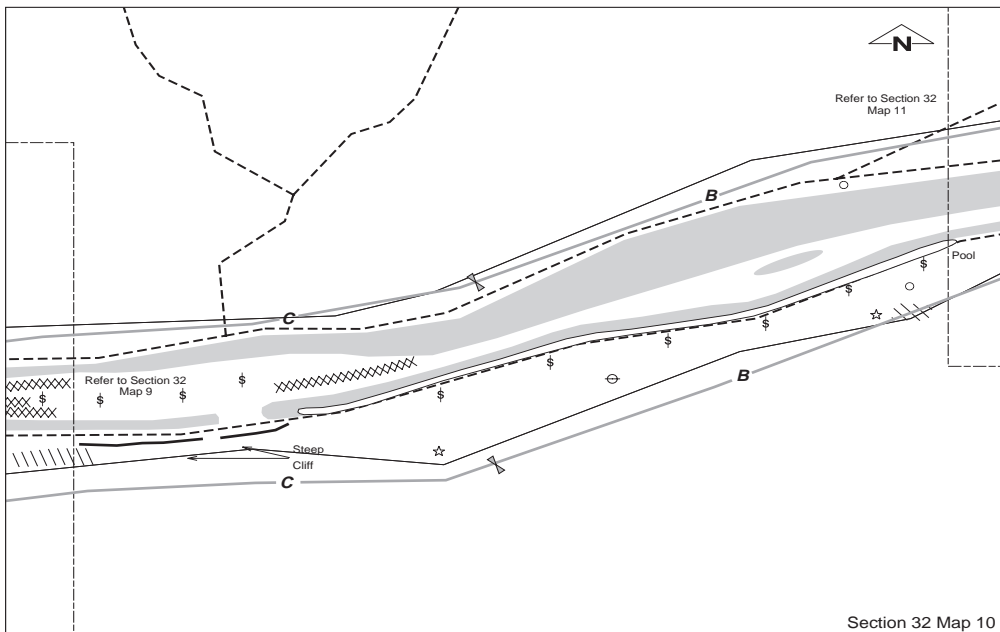
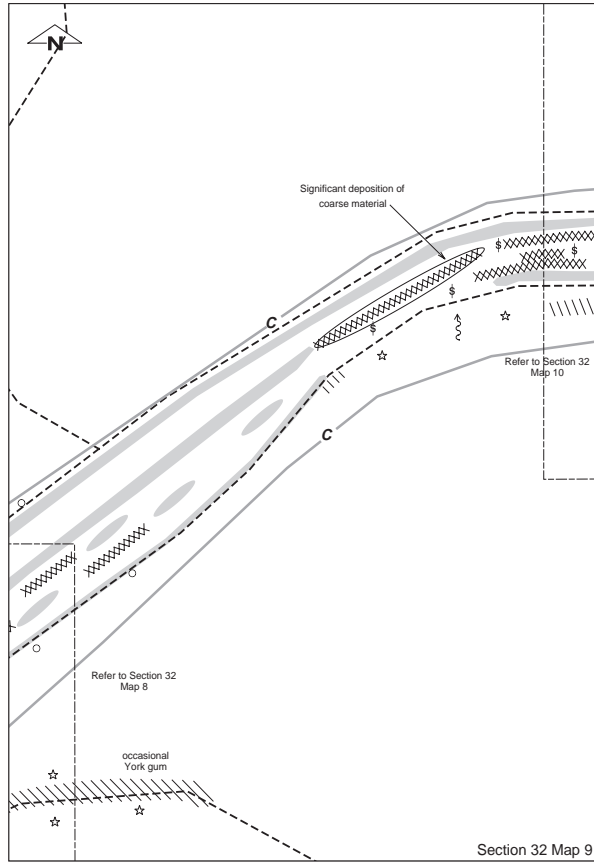
- O Increase monitoring of grazing stock to ensure that basic needs such as regular shearing, crutching, louse control and other animal husbandry practices are met.

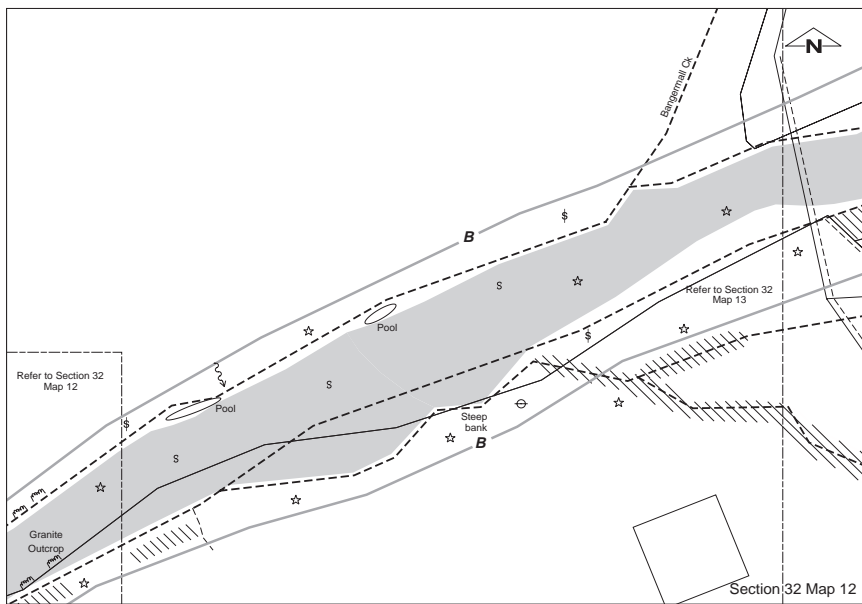
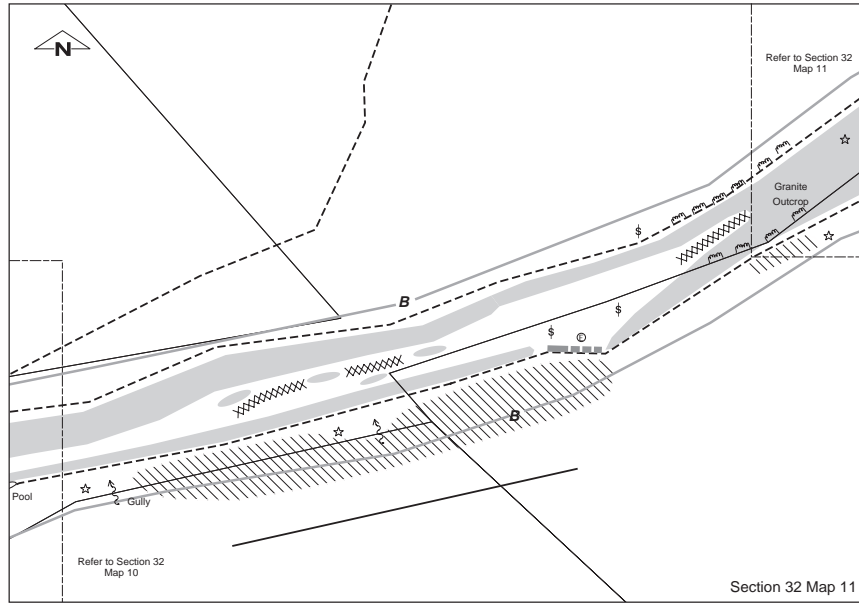


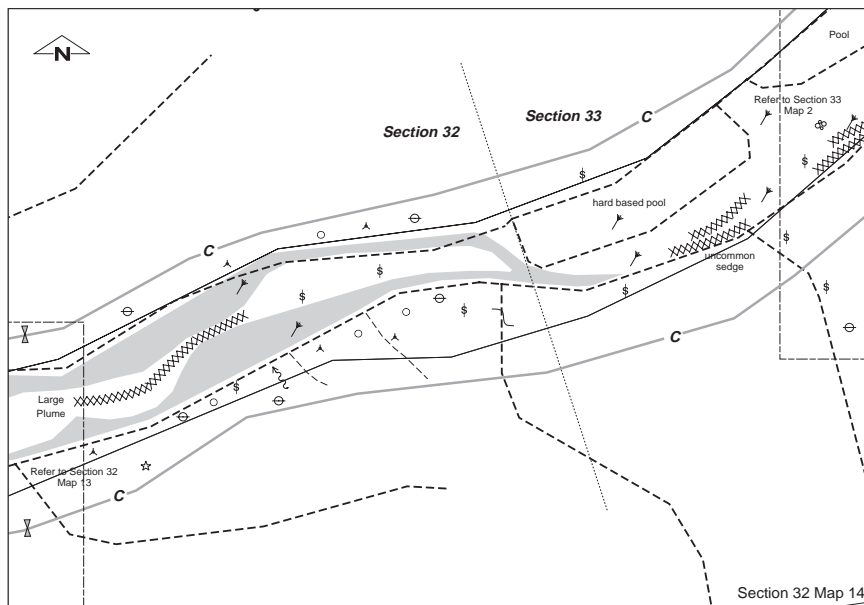
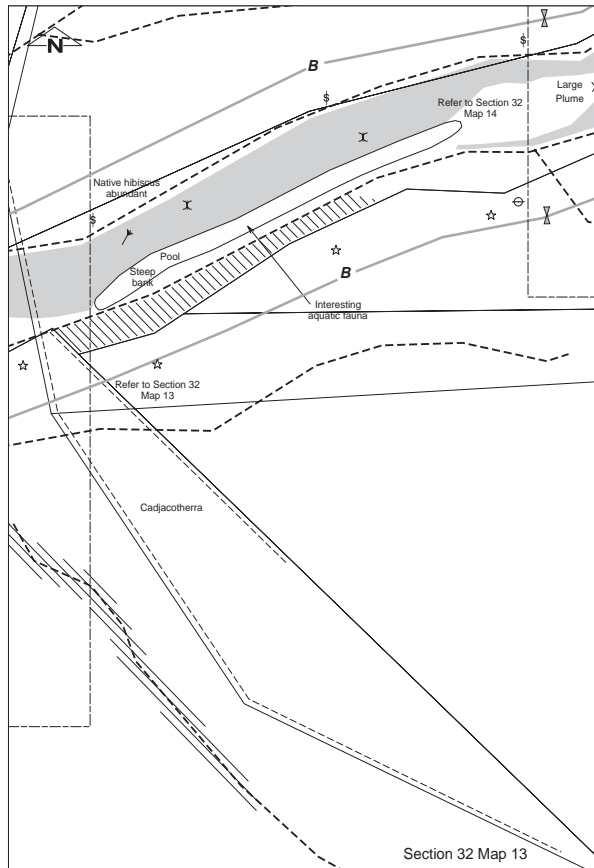












SECTION 33: GREENOUGH RIVER MAPS 1 – 12**Length of section (m):** 13,440m**Recorders' names:** N Siemon and T Rebola **Date surveyed:** 7 – 8 June & 9 October 2000**Nearest road access:** Mullewa – Carnarvon Road**Summary of river health:**

<i>Bank Stability</i>	<i>Foreshore Vegetation</i>	<i>Stream Cover</i>	<i>Habitat Diversity</i>	<i>Verge Vegetation</i>	<i>Stream Condition</i>
Moderate B	Moderate B	Poor C	Moderate B	Moderate B	Moderate B

Bank stability

The main river channel is between 4 to 12 m and 15 to 25 m depending on the soil type in the riverbanks. At the time of survey, the water depth ranged from 0.15 m deep to pools retaining water to 0.8 m deep. The banks are generally steep to very steep, rising up to 10 m in height. The river flows through a series of cascades and small granite waterfalls, and the composition of the riverbanks is highly variable. The channel banks on the left bank are generally steeper. Erosion is localised (5 – 20%) and the riverbanks have eroded back to stable clay in some places.

Undercutting and slumping are also localised (5 – 20%) on the foreshore. These faults tend to occur where there is a change in soil type, and are particularly common where there is clay conglomerate or calcareous rock formation. Sedimentation is moderate (20 – 50%) along this section. Coarse sand plumes occur periodically.

There are a number of erosion rills forming at the top of the valley banks. These are associated with sections where vegetation cover is minimal, and stock traverses the banks. Some have evolved into deep gullies, and the track alongside the river has been realigned several times to enable vehicles to pass these gullies.

The floodplain averages between 60 and 80 m wide through this section.

The geology of this region is very interesting. There are areas where the rock diversity along with assorted conglomerate and alluvial material is difficult to explain. There has been a suggestion from nearby landholders that this material may have been dumped in a glacial process. The substrate is highly unusual with rocks of every size, shape and colour.

Comments

This river section is relatively stable due to the materials comprising the riverbed and banks. There are some

spectacular landforms that evolved as a result of severe erosion events, however these are now stable. The stock movement across the valley slopes and on the riverbanks themselves is contributing to an increase in the formation of erosion rills. This may become an issue in future events, with gully formation becoming more difficult to manage.

Vegetation

The overstorey is patchy (20 – 80% cover) and dominated by Swamp sheoak (*Casuarina obesa*). Trees are present either in single rows or dense stands, depending on soil depth. There is one isolated African boxthorn (*Lycium ferocissimum*) that is likely to have been brought in by a vehicle. The middlestorey is limited to occasional Jam (*Acacia acuminata*), *Lasiopetalum* and some Lesser bottlebrush (*Callistemon phoeniceus*) where there are shallow soils and exposed rocks. Middlestorey cover is generally < 20%. The understorey is patchy (20 – 80% cover) and characterised by saltmarsh herbs and low shrubs including Samphire (*Halosarcia* spp.), Sarcocornia and occasional Marine couch (*Sporobolus virginicus*). Patchy Spiny flatsedge (*Cyperus gymnocaulos*) are present and a type of *Frankenia* occurs periodically. Weeds present include Pie melon (*Citrullus lanatus*), Doublegee (*Emex australis*), Wild oats (*Avena fatua*), Saffron thistle (*Carthamus lanatus*).

Rangeland species predominate the verge and reflect the soil types. Jam (*Acacia acuminata*), *Allocasuarina campestris*, Kerosene bush (*Eremophila*), large stands of native hibiscus (*Alyogyne*), some *Hakea* and a few species of acacia occur periodically. Of interest, is that one paddock is covered consistently by *Allocasuarina campestris*. No other shrub species co-occurs and the understorey is limited to widely spaced grasses.

Comments

Selective weed control, particularly of difficult to manage species such as Pie melon and Saffron thistle,



would be useful in this river reach. At the moment the extent of these populations is relatively limited, although the scale and distance between populations will mean control efforts will take time. Further, removing the isolated African boxthorn should be a priority to prevent this species from spreading in the future. Controlling grazing by native animals, livestock and feral goats is another aspect of minimising damage to the river foreshore. Historically, pressure on native vegetation was from kangaroos, Emus, Perentie and physical events such as heavy downpours. Fencing may be useful but could be difficult to establish in the hard soils. Recognition of the foreshore reserve and the sensitivity of the river environment to disturbance may help to stabilise some of the river.

Broadscale clearing was noted in accessing these river sections. It is likely that some of this was unauthorised under the Soil and Land Conservation Act. Fire access would be difficult because while there is a track parallel with river flow, there are few gates or fence structures that enable vehicles to cross between properties.

Stream cover

Overhanging vegetation provides minimal cover, however instream cover is excellent in areas retaining saltmarsh and where the riverbed has eroded back to a series of ledges. The granite boulders, cascades and pools trapped in the waterfalls are afforded some stream cover by the rocks themselves. There is minimal dead vegetative material instream to provide additional cover.

Comments

The stream cover is generally sufficient in the remaining pools to ensure that they remain good habitat. Protecting the pools from infilling and sedimentation processes associated with animals accessing the pools is difficult. There is little that can be done apart from fencing to exclude stock from accessing the river system.

Habitat diversity

The water is unlikely to be permanent, however it is likely that the groundwater occurs close to the riverbed. It appears to be saline, although indicators of low salinity levels such as Cape weed occur. The water

was clear with no tannin staining. The instream rocks and boulders effectively aerate the water even in low water conditions. There is some evidence of significant amounts of available nutrients in the water column. Stock camps, principally sheep and goats close to the pools and river's edge, retained high levels of faecal material. While considerable aquatic life was observed, there were few aerial insects with part of their life cycle based in water such as dragonflies and caddisflies.

Higher order predators such as spiders are abundant in the low saltmarsh vegetation and many of the shrubs in this area. Reptiles, particularly members of the dragon family, were frequently sighted in the course of this assessment.

A variety of birds including dotterels, Willy wagtails, White-faced heron, kingfishers, plovers, Wedge-tailed eagles were observed. Swallows are nesting in the riverbanks where the hard clay banks have been undercut and large sections of bank have slumped into the main river channel.

Foxes appear to be relatively common and conspicuous elements of the environment.

A large cigar shaped piece of faecal material was seen, however it is unknown what animal produced it.

Comments

The diversity of habitat is relatively good, given the comparatively limited vegetation cover. The damage by feral animals however, puts the usefulness of this river section as a summer refuge at risk. Many of the animals utilising this section obtain food from the river pools, and assessing the sustainability of these pools may provide an indication about longer term habitat values. There is considerable pressure placed on the remnant vegetation by not only livestock and feral goats, but native animals as well.

Other issues

The export feral goat market may provide a useful alternative income stream and help to protect the rangelands from increasing degradation pressure. There is minimal fencing of the foreshore reserve boundary in this river section. It may be useful to consider fencing if resources become available, to



enable more effective stock management in and along the river. There are some windmills and bores in this river section.

There are some significant landscape features and some very attractive potential picnic spots in this river section. Pindaring Rocks close to a Water and Rivers Commission gauging station is one such location. This gauging station provides information about water flow, its rate and height remotely to Water and Rivers Commission officers in Geraldton. This provides valuable data about potential flood events.

Suggestions

Bank stability

- B Endeavour to control feral animals to reduce their impact on the bed and banks of the river, and reduce grazing pressure that often results in reduction in bank stability.
- B Investigate the feasibility of alternative landuses such as Sandalwood growing or culling of native animals to further reduce pressure on the landscape.

Vegetation

- V Investigate the feasibility of providing marked access points for fire control, to enable some level of control to be afforded.
- V Discourage further clearing of the rangeland due to the potential to increase sheet runoff following removal of vegetation material to shield the ground from rainfall.
- V Undertake selective control of Pie melon, Saffron thistle, the single African boxthorn and any declared

weeds present on a regular basis to prevent their populations becoming more extensive.

- V Consider using mobile electric fencing to close off 1 - 10 ha blocks to encourage natural regeneration and protect small areas from stock, native animals and feral goats. Regeneration could be monitored to determine the potential for moving the fence around to try to encourage vegetation establishment.

Stream cover

- S Protect remaining vegetation and instream woody debris to maintain stream cover in the pools.
- S Encourage natural regeneration by modifying stock management practices and implementing a feral animal control program.

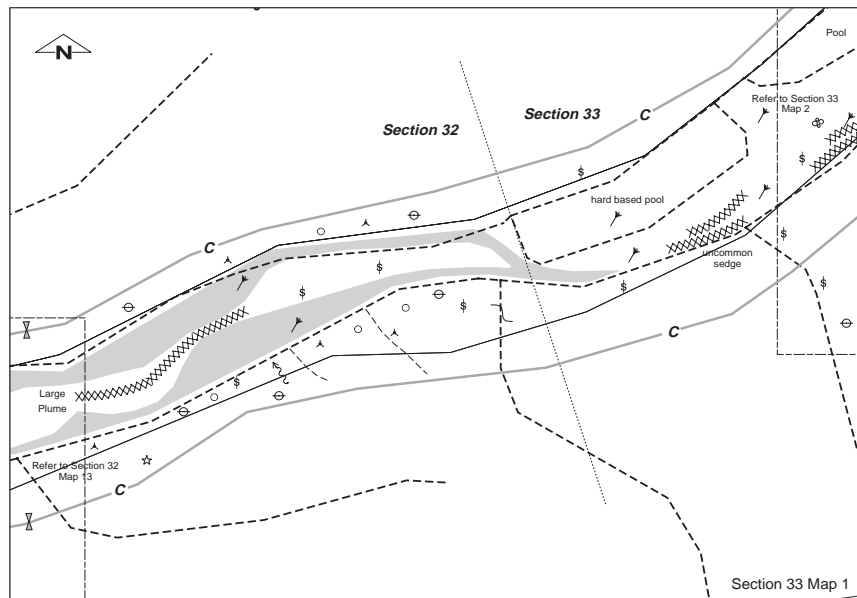
Habitat diversity

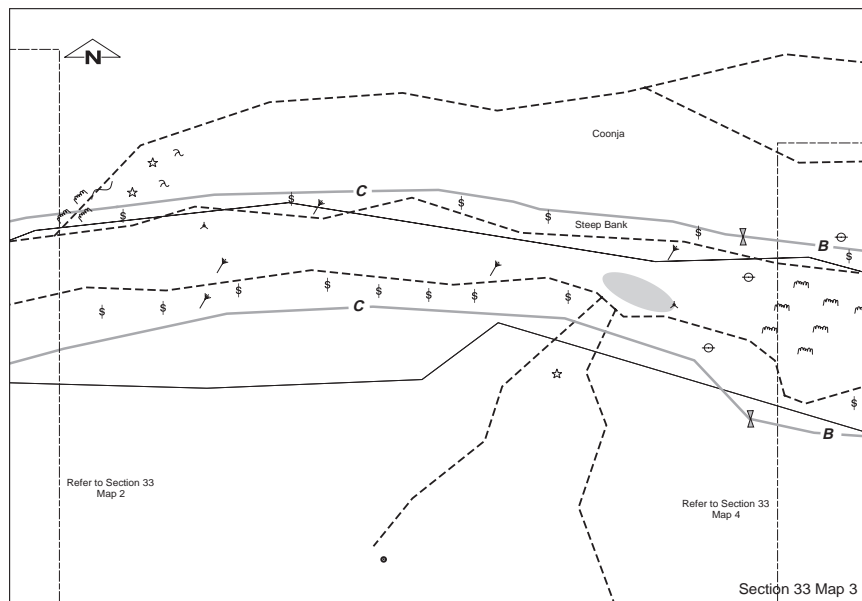
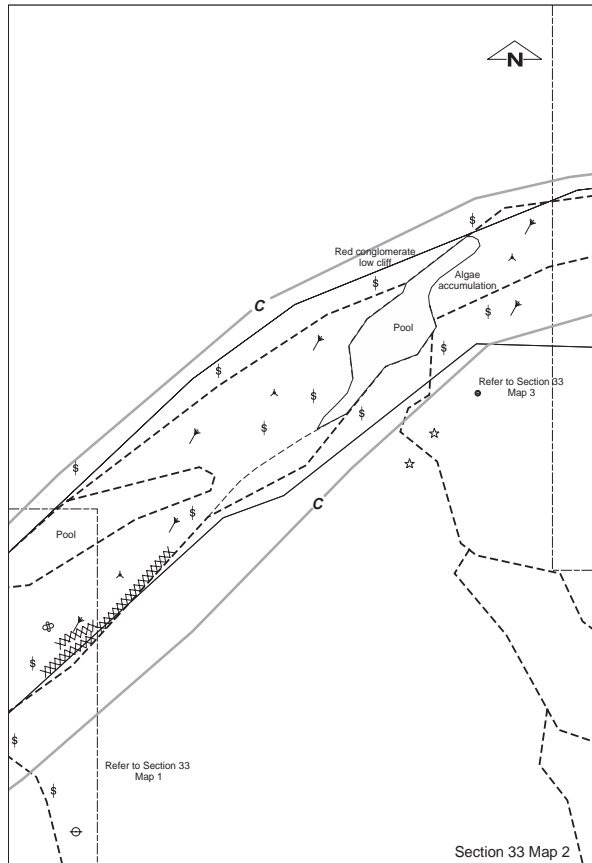
- H Continue relatively low stocking practices and aim to encourage natural vegetation to regenerate.
- H Try to create islands of dense native vegetation by fencing off 500 m by 500 m areas using mobile fencing, then moving it once vegetation has recovered to a reasonable density.

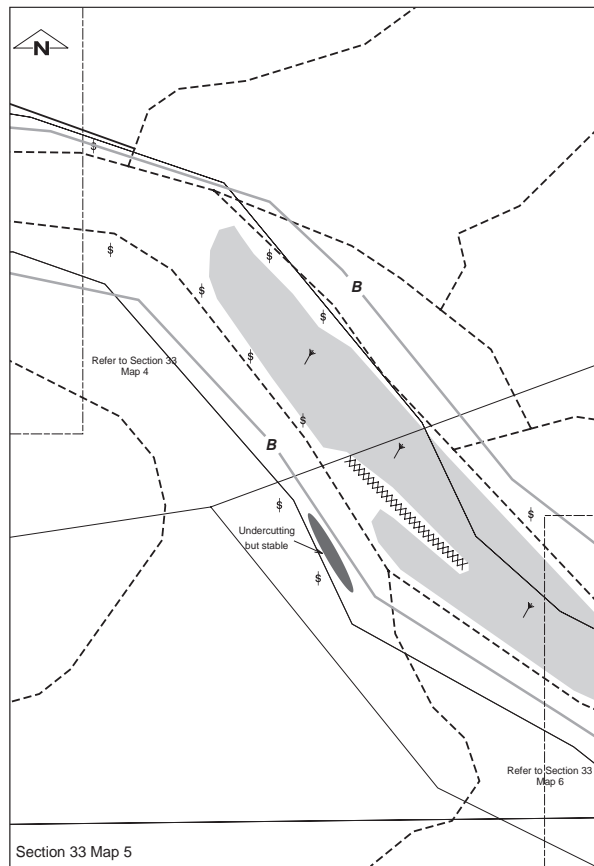
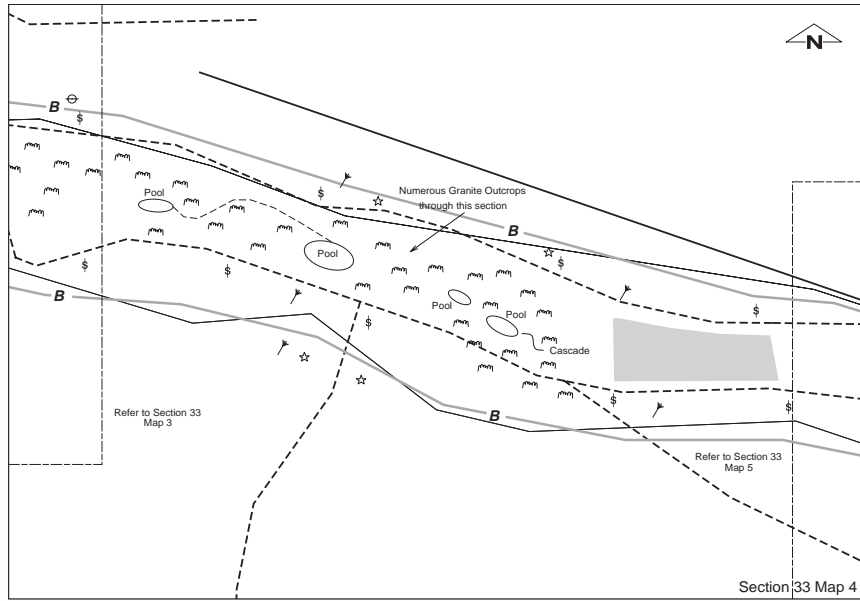
Other issues

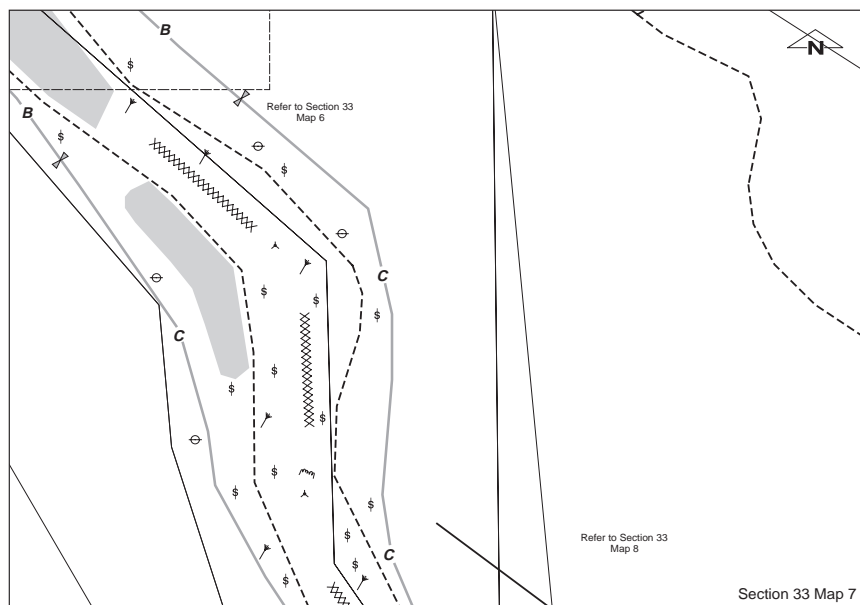
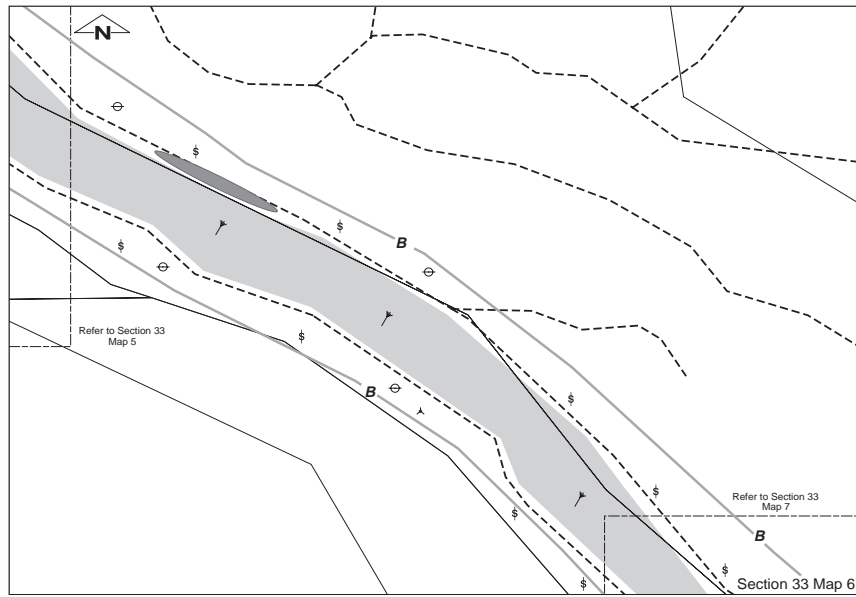
- O Consider establishing limited picnic facilities in the foreshore reserve close to the Mullewa-Carnarvon Road.
- O Consider installing signage advising visitors of the role of the Water and Rivers Commission and the information that is collected at this site.

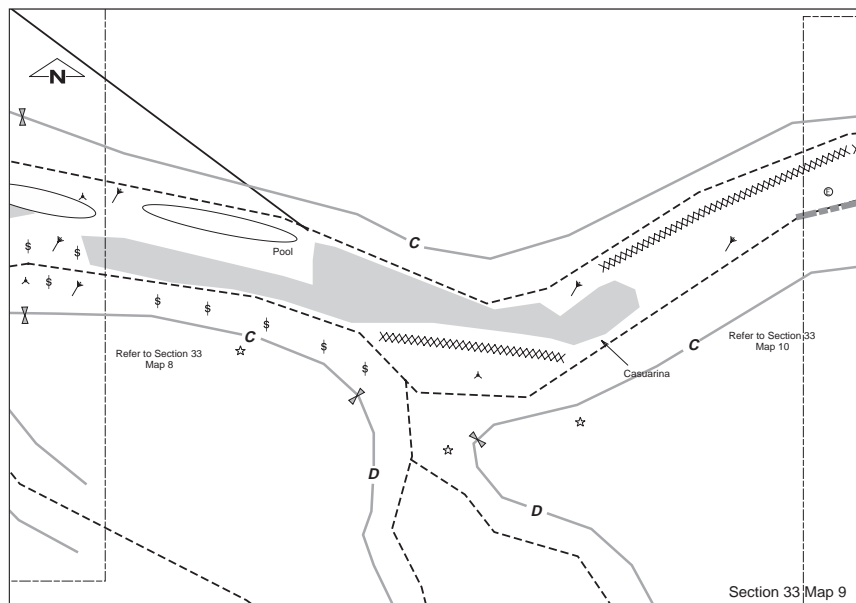
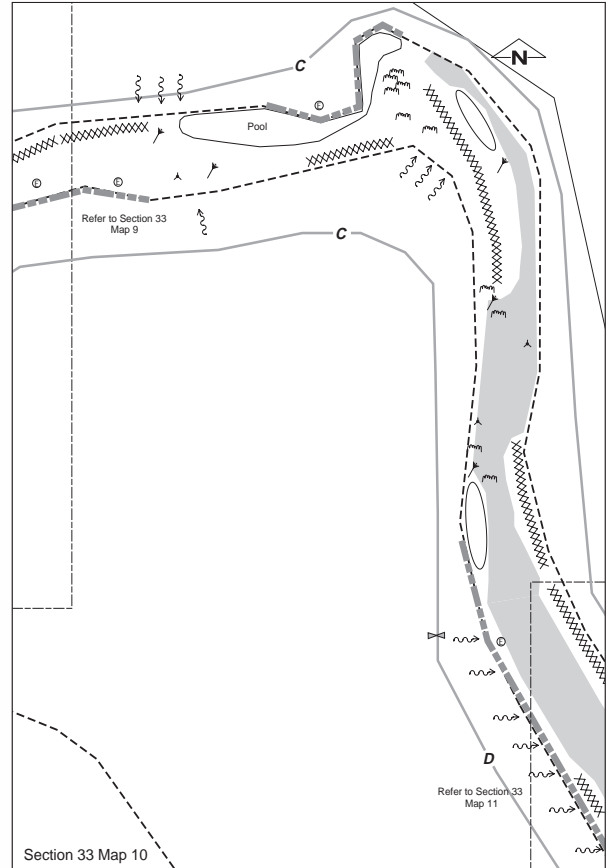
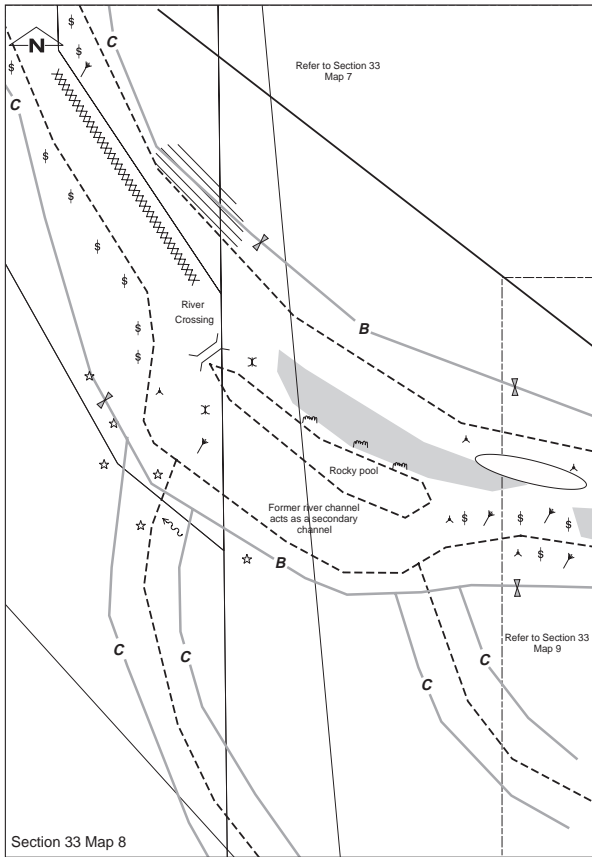


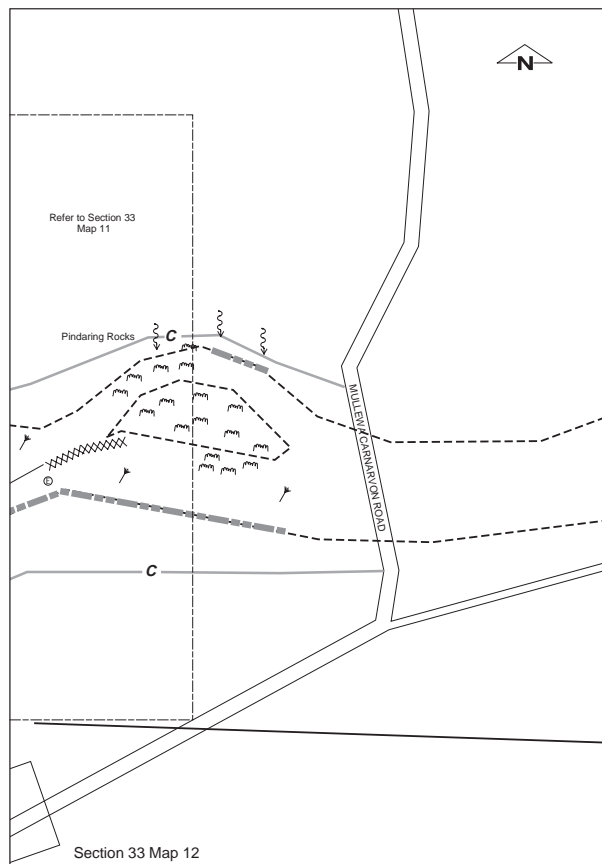
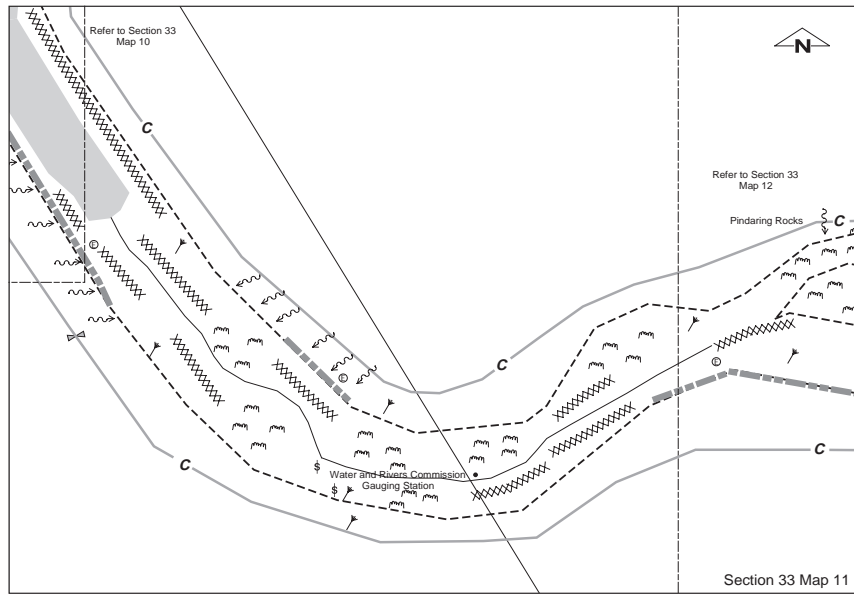












6. Common issues

5.1 Rights and responsibilities of owning land adjoining the river and foreshores

Foreshore reserves

Along sections of the Greenough River, Foreshore Reserves have been demarcated, ceded to the Crown and are vested with the local government authority or WRC for on-going management. Any activities or works within foreshore reserves, such as development of access tracks, requires authorisation from the management body.

Interference

The Greenough River is a proclaimed watercourse. Under Section 17 of the *Rights in Water and Irrigation Act 1914 (reprinted as at 10 January 2001)* it is an offence for any person to obstruct, destroy or interfere with the waters, bed or banks of any watercourse, race, or drain flowing through or over, or wetland situate wholly or partly on, land that has not been granted or demised by the Crown.

Any interference with a watercourse, race or drain that is not on freehold land requires approval from the Water and Rivers Commission. Approval is granted by the issuance of a permit by the WRC that will include conditions to ensure that interference poses minimal impact on the integrity of the water, bed or banks of the watercourse.

Riparian rights

The rights of landholders with watercourses through their properties include:

- Domestic and ordinary use of that water;
- Stock watering; and
- The use of the river while ensuring that the flow of the water in the watercourse is not sensibly diminished.

A surface water licence issued by the Water and Rivers Commission is required for extraction of water from the Greenough River for uses that do not relate to riparian rights.

Obstruction of flow

Landholders cannot convey or discharge, or cause or permit any sludge, mud, earth, gravel, or other matter likely to obstruct the flow of the current to be conveyed or discharged into any surface water or wetland.

6.2 Foreshore reserves

The foreshore reserve extends along much of the river. The reserve boundaries are rarely clearly defined. The current alignment of fencing may not necessarily be consistent with the actual river boundary. Some examples, where landholders applying for subdivisions were required to survey the boundary, showed that sections of reserves lie up to 80 m within existing paddocks, while in other areas the reserve boundary is within the main river channel. The current reserve boundary alignments do not always correspond with the extent of the floodplain.

The boundaries need to be surveyed to enable fencing in some key locations, rationalisation of reserves to protect foreshore areas for flood mitigation and restoring river functions, and determining an appropriate agency for on-ground river management.

An additional issue requiring resolution is land ownership. Many of the foreshore reserves are unvested vacant Crown land. This means that private landholders are in the best position to contribute to managing the foreshore and river within their property.

It is understood that management is technically the responsibility of the Department of Land Administration where vacant Crown land exists, and there is funding available to support management activities by other bodies. This funding could be sought to contribute to management of the river environment.

Selective use is acceptable, as is weed control within the reserve, provided any activities meet the rules of the river and do not negatively impact on the waterway or its foreshores. For example, overstocking within reserves is contrary to the intention of the reserve, while crash grazing for a three – five week period for weed control is likely to be acceptable. Careful monitoring



of any stock within the river system is critical to protect a long-term agreement with any landholder. Abuse of the river system and its reserves may ultimately result in access being denied.

For example, anecdotal evidence collected during the survey also indicates that some landholders exceeded their involvement in river management by spraying for locusts in 1990. Comments were made that frogs have only been heard during the year 2000 in that river section for the first time since the spraying. While frogs provide an effective vocal reminder of their presence, many other animals within this river section would have been affected by the spraying. During the foreshore assessment survey, there was a distinct lack of large predators such as spiders and dragonflies and the diversity was limited. The lack of all levels of the food chain in a river system indicates that all is not well.

General suggestions

- Take advantage of any opportunity to review the current reserve alignment, amend to reflect the natural contours (floodplain margins) and ensure that the boundary is clearly identifiable.
- Remember that foreshore reserves belong to everybody, and that custodianship of the reserve is simply a reflection of proximity.
- Ensure management practices are appropriate for highly sensitive environments.

6.3 Bank stability

Blowouts occurring within the floodway are common along the lower reaches of the Chapman River. Blowouts occur where the river at peak levels locates weakness in the soil and causes erosion. The soil weakness often corresponds with areas lacking good vegetation cover.

Some of the Chapman River obtained a rating for bank stability of Very Good to Good. Sections 1, 12 and 16, show only minor isolated occurrences of bank destabilisation, slumping or sedimentation. These sections corresponded with areas that have been subject to minimal disturbance by stock, fire or other management activities. The extent of regions with these ratings is limited and of concern, as the pressure from accumulating drift sand and scouring will become greater with time.

These sections corresponded either with a granite bed, which is the most stable bed form, and granite rocks throughout the floodway, or low gradient saltmarsh areas. Both zones retain good levels of fringing vegetation, which helps to stabilise the sand moving through the river system, and there are no significant areas of disturbance within the riparian zone.

The remaining river sections are characterised by poor to moderate ratings with a canopy of trees over a chaotic weed assemblage or grassland below. These systems are not sustainable in the long-term.

Points on bank stability

- Feral pigs are one of the greatest threats to bank stability and the direct cause of many of the blowouts seen along both the Chapman and Greenough rivers.
- Feral deer along with farm stock also impact on the stability of sediment in areas, as do native animals.
- Erosion rills on the top of the river valley verge often start as a result of clearing of vegetation by ants or trampling by stock, often next to fencelines.
- Native animals, particularly kangaroos and emus, do less damage to waterholes than stock and feral animals because they have evolved to cope with these conditions.

Large woody debris

During the survey of the study area, a number of characteristics such as significant quantities of large woody debris and suspended woody debris were identified as impacting on the flow characteristics of the river. While this is a normal feature of river systems, the volume of material appears to be greater than in similar river sections throughout Western Australia. Frequent burning of the fringing vegetation encourages trees to drop more branches.

6.4 Salt

The upper reaches of the Chapman and Greenough rivers and many tributaries arise in salt pans. Salt is a natural part of these systems. There are many changes occurring that are increasing the rate at which salt enters the riparian zone, principally where the groundwater table is rising and farmers are constructing drains to remove the water from the property.



One of the predominant causes of the destabilisation of the banks along the 'Very Poor' rated sections was the presence of saline waters, creating salt scalds. These scalds kill off the fringing vegetation, leaving the banks of the waterway prone to the formation of erosion rills and gullies. Further anecdotal evidence and observations indicate that rising groundwater tables have increased the contribution of some springs.

There are some instances of landholders dredging the riverbed and tributaries to drain saline waters to both the Chapman and Greenough rivers. This not only impacts on the immediate discharge point often causing localised erosion, but also impacts on the river downstream. Continual drainage of saline waters can result in the loss of entire vegetation and fauna communities, where these communities are adapted to occasional exposure to hypersaline waters.

Rising groundwater is certainly an issue and is difficult to address. It is important to remember, however, that the rivers reflect the way in which the catchment is managed. There is a risk that as the river is expected to cope with unusual salt and water loads it will degrade and ultimately function as an unstable drain rather than a river.

Improving land management in the catchment is critical to prevent further impact on this issue.

There are many areas of healthy saltmarsh vegetation particularly in the upper reaches of the Chapman River and central sections of the Greenough River. The foreshore health of these sections is still high where the vegetation is intact. Loss of vegetation as a result of changes to hydrology, particularly damming the water up, is often the first step towards degradation of the river channel.

General suggestions

- Work with Agriculture WA, Water and Rivers Commission and catchment groups to develop catchment management plans that address groundwater and surface water issues.
- Obtain advice and approval from the Water and Rivers Commission before undertaking any works that impact on the bed or banks of a waterway.

6.5 Vegetation

The vegetation along both the Chapman and Greenough rivers is in variable condition, ranging from totally denuded with no vegetation cover, to occasional trees with an understorey dominated by annual grasses and occasional clumps of rushes including Spiny flatsedge (*Cyperus gymnocaulos*) or Shore rush (*Juncus kraussii*). This level of vegetation cover is poor.

An alternative similar community retains only trees with a groundcover of Couch (*Cynodon dactylon*) or the native Saltwater couch (*Sporobolus virginicus*). This type of vegetation provides better bank stability than areas with only annual cover because there is groundcover all year round. In summer, if there is little vegetation cover and a flood event comes through, the damage to the floodplain and channel banks tends to be significantly greater.

The vegetation communities then grade up into trees of all ages with dense perennial rush and sedge cover, with some annual grasses.

The loss of verge vegetation along almost all of the Chapman River and significant lengths of the Greenough River is of great concern, and threatens the long-term survival of many species within the foreshore area. The lack of linkages between the river environment and remnant bushland minimises the chances of recolonisation by many fauna species. Birds are able to fly away, but many ground or tree dwelling animals cannot get around without shelter from dense plants. This is particularly important when it is considered that there are additional predators such as foxes present.

6.5.1 Tax incentives for protecting vegetation

The public benefits of conserving areas of native vegetation that are of high conservation value are greater than the benefits of developing them for production because their biodiversity values are not replaceable through revegetation.

Managing land for conservation is much more expensive than managing land for production and nature conservation is rarely considered an income producing activity (Binning and Young 1997).



The current income tax system acts against nature conservation in two ways:

- (a) Failure of the tax system to recognise activities which are in the community's interest. This occurs because no financial transaction takes place as the goods do not have a market value.
- (b) Failure of the system to recognise negative externalities, such as increased risk of soil degradation, which are not directly related to production.

With the introduction of Section 387-55 of the *Income Tax Assessment Act 1997* there is a case for the public to invest via the tax system in the improvement of water quality, as land degradation is a prime source of water pollution.

Deductions Related to Clearing

Land clearing is a capital expense under current tax arrangements. Applications to clear land need to be approved by the Soil and Land Conservation Commissioner, to ensure that land degradation is not likely as a result of clearing. Generally, additional clearing of land is not approved. Development of farming land in this region has already resulted in the selection of the most arable land, with areas with high management costs generally left intact as bushland.

The clearing of woody weeds is allowable as a deduction under Section 387-55 of the *Income Tax Assessment Act 1997*.

Clarification should be sought from the Australian Taxation Office on the clearing of regrowth which has been re-established for a long period of time or when property has changed ownership.

Western Australia has broadscale controls in agricultural regions through a Memorandum of Understanding between the Commission for Soil and Land Conservation, Environmental Protection Authority, Department of Environmental Protection, Agriculture Western Australia, Department of Conservation and Land Management and the Water and Rivers Commission. As mentioned above, the relationship between State laws and tax laws needs to be understood.

Landcare related deductions:

Section 387-130 – allows a deduction for facilities to conserve or convey water.

Section 387-55 – allows expenditure to be deductible for the following;

- (a) the eradication or extermination of animal or vegetable pests from the land;
- (b) the destruction of weed or plant growth detrimental to the land;
- (c) preventing or combating land degradation, otherwise than by erection of fences on the land ('land degradation' includes not only soil erosion but also other effects detrimental to the land, such as decline of soil fertility or structure; degradation of natural vegetation; deposits of eroded material; or salinisation);
- (d) the erection of fences (including any alteration, extension or addition to fences) on the land to exclude livestock or vermin from areas affected by land degradation (see above) in order to prevent any aggravation of degradation in those areas and to assist in the reclamation of those areas;
- (e) the erection of fences (including any extension, alteration or addition to fences) to prevent land degradation where the fences separate different land classes and are erected in accordance with an approved land management plan in respect of the whole or part of the land;
- (f) the construction on the land of levee banks or similar improvements having like uses; and
- (g) the construction on the land of surface drainage works or sub-surface drainage works for the purpose of controlling salinity or assisting in drainage control (this would include, for example, the sinking of drainage bores and the laying of surface or sub-surface piping in the course of constructing floodwater drainage work (Taxation Ruling T/R 351) – however, the drainage of swamp or low-lying land is not included).

A land management plan must have been prepared or approved by the relevant government department or authority responsible for land conservation and show:

- the land classes;



- the location of fences necessary to separate land classes to prevent land degradation; and
- the kind of fencing and how it would prevent land degradation.

Rebates have been developed for low income earners.

6.6 Weeds

There are a number of serious environmental and agricultural weeds within the Chapman and Greenough river catchments.

Environmental weeds pose a threat to the integrity of remnant vegetation, often increase the fire risk and reduce the ability of the naturally occurring plant communities to survive. This lowered resilience impacts on native animals by removing habitat, reducing the appeal of bushland for these animals and encouraging them to feed in farmed land, and can result in the loss of animals from the system.

Agricultural weeds are often environmental weeds. The cost of weed control within cropped land is massive within Australia. Some landholders within the study area indicated that their herbicide purchases cost up to \$ 300 000 per annum. Weeds affect crop values, can poison stock and reduce the values of animal products such as wool and leather.

In these difficult times, managing weeds before they become a significant problem is critical although many landholders' resources are stretched to the limit. The cost of not controlling weeds when present in small numbers will be significantly greater in future years.

Many of the weeds present in the catchment are 'Declared' under the Agriculture Protection Act. This means that all landholders, no matter what size or zoning, are responsible for the control of these plants on their land. The intention of declaring particular weed species is to ensure the protection of horticultural and agricultural industries. Making weed control the responsibility of every landholder minimises the risk that weeds and pest fauna are building up on one property and spreading to neighbouring land. Even if weeds are considered to be endemic, the legal requirement is to control these plants in an ongoing reduction program. Agriculture protection is everyone's business.

It may be beneficial for the LCDCs, Agriculture WA and Water and Rivers Commission to collate knowledge from landholders about different weed control techniques. This information could possibly be collected between cropping and harvesting, once machinery has been overhauled and there is a lag in on-ground activity.

A number of weeds within the catchment are considered to be management priorities. There is a brief overview of each of these weeds below.

Castor oil plant (*Ricinus communis*) (Priority 3)

This plant is considered to be a substantial problem because of the longevity of the seed, and its toxicity to both native animals and stock. Seed of this plant was removed from an Egyptian tomb after approximately 1200 years, and germinated within days. Minimising seed production is critical to prevent this species from becoming prevalent.

Suggested control: To minimise the risk to bank stability the recommended action is to cut the trunk about 10 cm above the ground and immediately poison the stump by painting a systemic herbicide such as Glyphosate on the cut edge. This needs to be done within about 60 seconds of cutting, otherwise the plant will form a protective skin and not absorb the herbicide. The remainder of the plant should be dragged out of the river environment. If the plant is seeding, it is worthwhile to bag and remove the seed heads to reduce the need for future weed control. For large populations of seedlings, spot spray with Glyphosate 1 in 80.

Fountain grass (*Pennisetum setaceum*) (Priority 3)

This species of plant is becoming an increasing problem within both river catchments, but particularly in the upper reaches of the Chapman River. It is a common roadside weed and causes difficulty for many landholders.

It is considered to be an important weed because it is highly flammable, invasive and not particularly palatable to stock. These features make it able to spread very rapidly. A paddock fire escaped into a foreshore reserve during the survey. The fire crossed the river and the African spear grass on the roadside supported the rapid spread across roads and into neighbouring properties. In another incident, one landholder had a shearing shed burnt down when a paddock with a severe infestation caught fire.



Unpublished data have indicated that the maximum core temperature of this grass can approach that achieved by burning a piece of wood.

Suggested control: Stock can control this species when the plants are small, however are generally unwilling to graze on mature plants. Repeated slashing to prevent seeding can control the extent of populations and eradicate this weed over time. In areas where it occurs on steep banks or access is difficult, manual brushcutting can work but is only feasible in small areas. Alternatively spraying with Fusillade at 4 L / ha before flowering when actively growing is effective but costly, and using broad-spectrum herbicides has varying success levels.

Paterson's curse (*Echium plantagineum*) (Priority 3)

This plant has been established in this region for decades, and has been able to persist due to different levels of control exercised by landholders. This species is Declared, meaning that landholders are required by law to control this species and work to eradication.

Suggested control: It is possible to remove small populations by hand or use a wick application of Glyphosate or Glyphosate / Roundup 75-100 mL in 15 L water by knapsack. Preventing seed production is again an important technique to control the rate of spread of this species –slashing paddocks during flowering can help to limit seed production and therefore the spread of this plant. Information on the most effective way to control this species should be obtained from landholders who do not currently have it on their properties while their neighbours do. Local knowledge is of enormous benefit with this species.

Doublegee (*Emex australis*) (Priority 3)

This plant has been established in this region for decades, and has been able to persist due to different levels of control exercised by landholders. This species is now a part of the preferred diet of Red-tailed black cockatoos, however it is unknown whether or not the seed is still viable once it has passed through the digestive process of these animals. It is difficult to control as it easily spread on machinery. Undertaking Doublegee counts can be achieved relatively quickly and easily by driving through a paddock, then drawing a 10 cm by 10 cm chalk line on a tyre and counting the number.

Suggested control: Again, removing small populations by hand and destroying plants with seeds is only feasible in small lots. Spraying with Glyphosate / Roundup 75mL in 15 L water in winter and spring has been demonstrated to work. Again, some landholders have had considerable success in controlling this weed and would be in the best position to advise on control techniques.

Saffron thistle (*Carthamus lanatus*)

This plant is widespread throughout both catchments. This species should become a focus for control by all landholders, as it has implications for wool quality if the market picks up and fine grade wool becomes a viable farming option. High grade wool production will be difficult if this species is allowed to spread further.

Suggested control: Preventing flowering is a key to achieving long-term control of this species. Where large populations of this plant occur they are difficult to control as there is poor access to many of the sites. Other populations occur within the adjoining cropped paddocks. Some landholders have achieved high levels of success in controlling this species, and would be in the best position to advise on control.

Datura (*Datura*)

This plant was located in a few sections along the Greenough River. It is a hallucinogen and toxic to stock and humans.

Suggested control: Hand weed the plants as soon as they are identified. It is the quickest and most time-efficient way to control this plant while the populations are limited to single plants.

Arum lily (*Zantedeschia aethiopica*) (Priority 1)

Arum lilies occur in sections of the Chapman Valley catchment and were identified in the river in two areas. It is important that this species be controlled now before they become more widespread. The current distribution could be reduced and eradicated within five years if action is taken now.

Arum lily control costs the southwest region considerable resources. This species can be toxic to stock and native animals.



Suggested control: Manual removal is feasible, as the populations are currently limited to a few plants. Care should be taken to remove all underground stems, and debris deposited in the resulting hole to minimise the potential for scouring in the next flow event. On dry sites use a Peter lever and Glyphosate 1 in 100 with several applications used between June and October. Glean Ally/Brushoff can also be used 1g in 50 L water plus wetter, using 20 g per ha.

Spot spray when plants are 8 – 12 cm high between April and November. Two months later spray any missed plants. Try to spray before flowering to stop seed set. To avoid problems with frogs and tadpoles in wetland areas use Glyphosate without a surfactant. The herbicide will form a pool at the leaf base and be absorbed into the plant.

Red Natal grass (*Melinis repens*) (Priority 1)

This introduced grass is common along roadsides and railway lines, and is in the early stages of spreading through the Chapman River catchment. It is an effective competitor against native plants, reduces habitat diversity, increases fire risk and can become a crop weed.

Suggested control: This plant is considered to be relatively easy to control. At 3 to 5 leaf stage, use 1 L / ha of Fusilade, while for mature plants a stronger dose is necessary at 4 L / ha of Fusilade or Targa. The best time to spray is between June and August.

Pie melon (*Citrullus lanatus*) (Priority 3)

This melon is widespread throughout both the Chapman and Greenough Rivers. Some landholders have achieved high levels of success in controlling this plant.

Suggested control: The Kings Park and Botanic Gardens have successfully used 2,4-D amine (500 g/L) at a rate of 20 mL in 10 L of water plus 0.25% wetting agent to control this plant. Spraying while the plant is actively growing is important to maximise the success. Again, discussing management of this weed with landholders who have been successful in eradicating it from their properties is likely to identify the most effective techniques.

6.7 Pest fauna

There are a number of legal requirements associated with owning rural or special rural lands and pest fauna. The owner is responsible for the control of all Declared Animals on their land. Appropriate action must be taken to prevent the build up of rabbit numbers.

Many landholders indicate that it seems pointless to control the animals when there is no active management of the reserves that adjoin their properties. This is a very real and valid concern because there is limited active management of the foreshore reserves. Many landholders are willing to extend their management activities into the reserve, which is the most effective way to link some resources with this land.

The crux of the issue is that most of the reserves are invested vacant Crown land. It is understood that management is technically the responsibility of the Department of Land Administration where vacant Crown land exists, and there is funding available to support management activities by other bodies.

6.8 Farm plans

Farms, as with any other business, should have a plan. Farm management plans are important to ensure that the land is managed in a way that protects the sustainability of the environmental, financial and social values.

Managing water movement across, through and beneath the surface is one critical component of such plans. Land that is unproductive or difficult to farm, often in the floodplain, could be written off to help restore river function. By restoring vegetation to the floodplain, peak flows can be slowed more consistently and may reduce some of the flood damage. Cropping within the floodplain is a gamble but is very risky. Ultimately, occasionally productive land could be lost and the damage downstream would be considerable. The off-site impacts of rivers are rarely recognised as many landholders have never seen any other properties on the same river.



6.9 Fire

As mentioned above, many tree deaths cannot be attributed to natural attrition. Frequent fires in the floodway result in more branches falling from the River gums, sheoaks and paperbarks, further blocking the river. Usually this blockage occurs downstream from landholders using fire as a management tool, and they do not have an opportunity to see the impact of this work on the river as a continuum.

Fires occur in the riparian zone following paddock fire escapes, deliberate lighting or uncommonly as the result of lightning strikes. There is a strong belief within the local community that clearing the vegetation will make the river flow faster and reduce sedimentation within their immediate area. It is critical to remember that as water flows faster, it has more power and can pick up more sediment. It is also able to spread more widely. As the river collects more sediment, it broadens its river channel and more land is lost. Also, when the water reaches a well-vegetated section, it will bank up upstream and can cause blowouts.

Manual removal of large and fine woody debris is by far the most effective management technique. Often there are only small numbers of blockages that are causing problems, and often burning does not target the sections that require treatment. Woody debris that is suspended between 1 m and 2.5 m above the main channel is commonly the material that contributes to damage during peak flow events. The material on the ground helps to slow water movement on the margins of the floodway and focus the flow into the main channel, which helps the river to clean itself out. Fires usually result in loss of vegetation and debris to slow the big flows, resulting in blowouts downstream and loss of arable land within the floodway. This allows the river to spread itself out and create what are known as braided sections – or several main channels.

Weeds also impact on the stability of the floodway. Native rushes and sedges tend to be tall cylindrical plants with dense underground stems that help to hold the soil down. These plants also trap leaf litter and other material that provide habitat for native animals. In comparison, plants like the introduced couch (Saltene, standard Couch and others) have limited habitat value

but provide cover more than 250 mm deep. During peak flow events, the height and shape of the rushes and sedges enables them to lie down in the stream and allow the water, fully loaded with sand, to pass through. In sections where the dominant plant in the floodway is couch, there is considerable sediment accumulation and the floodway is building up in height.

Comments are often made about vegetation instream causing the water to bank up, which allows it to spread out and drop more sediment. Along a lot of the length of the Chapman River the riverbed is actually incising, digging itself out because there is nothing left to slow the water flow. Instead of digging out and maintaining pools, the riverbed is dropping on long sections.

6.10 Cropping

Farming can be a difficult business from which to make a livelihood. In many situations, gaining as much land as possible for production is a priority. The nature of cropping processes affects on sediment stability, however changing land management practices such as minimal tillage is reducing some of that impact.

Along both the Chapman and Greenough Rivers there are sections where cropping is occurring within 3 m of the low flow channel. This land occurs within the bank full channel and the floodway. Much of the damage to farming land is the direct result of a high rainfall event immediately following furrowing, ploughing or some site preparation. In many instances, luck may be on the side of the landholder and they may gain extra crops, however at other times the river will flow and damage the cropped land.

The bank full channel and floodway are designed to take peak flows for the river, and trying to force the river into one channel is not possible.

Poor riverbank and floodplain stability occurs in all areas where annual grasses and herbs dominate. This is because there are limited deep-rooted plants, little living plant material and insufficient groundcovers to protect the soil from water movement. In the event of summer rain, these plants have often broken down and there is little cover.



Ensuring perennial vegetation cover occurs evenly across and along the rivers is an important part of managing flows. Respecting the natural landform and working beyond the floodway will ultimately protect infrastructure and assets for all landholders along the entire river length. In the long-term, the river may evolve into a braided channel that occupies the entire floodway, and reduce the area of land available for cropping.

General suggestions

- Aim to restore native vegetation to the floodway boundary to protect the bed and banks from erosion, provide improved flood attenuation and control the rate of sediment movement through the river system.
- Consider the risks when cropping within 3 m of the low flow channel, extending beyond each individual property to think about the potential impacts on landholders downstream.
- Obtain information packs from the Water and Rivers Commission and Agriculture WA to learn more about river processes, management and techniques to minimise risk to the land.

6.11 Fence alignment

There are many examples of washed out fences along the length of the rivers. Where property boundaries cross the river it is difficult to manage the fence during the flow events. It may be useful to consider using temporary fences, either electric or ringlock, which are reasonably quick to install and remove in case of a flow event. Monitoring the weather and radio are often sufficient to provide one day's notice of a flow event. Further, the Water and Rivers Commission has developed a flood warning system for the Chapman and Greenough Rivers to provide information to local ABC radio stations about flow events.

This may seem labour intensive however, as it is unusual for peak flows to occur for any significant duration. In the long-term it is likely to be cheaper and more effective as it will save on the cost of replacing fences annually.

Under the *Rights in Water and Irrigation Act 1914* it is illegal to disrupt the flow of any water body, declared

or not. This means that if fencing is used across the river and traps debris, which impacts on water flow, then that contravenes the Act. Common sense needs to apply, however fencing across waterways is not generally recommended.

Fence alignments parallel with the water flow are also often at bank full height, within the floodway and in some situations constructed very close to the low water level. This greatly increases the risk of losing the fence to the river, while possibly only gaining an extra hectare of land. If the fence is at risk of being washed away, so too is the top soil because it means that should the water level reach the areas prepared for cropping, it will have limited resistance to water erosion.

It is important to weigh up the value of locating a fence above peak events and loss of potentially productive land.

Use of trees as strainers can impact on plant health. Further, should a large tree with fences attached be undermined and fall in during a peak flow event, there may be sufficient force in the water to remove long sections of fence during one event. While some landholders try to protect the trees by placing rubber around the wire, when the tree is not mature and is still actively growing the wire still cuts into the bark. This effectively ringbarks the tree and results in tree death.

As the tree is dying and is stressed it may also drop branches. This contributes to the woody debris load of the river. This woody debris, along with that caused by natural attrition and loss of branches following fire damage, is washed downstream; during peak flows or flood events it crashes into trees along the riverbank. This in turn can knock more branches from living trees, producing more debris. As the amount of debris in the water increases, the impact becomes greater and the river flow can be blocked. This can cause erosion of the riverbanks.

6.12 Stock access

The riparian zone is often used as a summer paddock for stock as it often retains the only shade trees on the property, and may have permanent water and sufficient fodder during the harsh summer months.



Stock camps within the floodway are characterised by denuded unstable sands, loam or clay, large quantities of sheep, cattle or goat droppings and an overall lack of vegetation both instream and on the floodway. The water that will pass through these sections is able to wash away not only the nutrients and bacteria in the livestock droppings, but also the sand and clay that have been loosened by long-term trampling and grazing. This sediment continues to move to the river mouth.

The way in which sediment moves, varies in accordance with the flow characteristics. The Water and Rivers Commission has a publication describing sediment movement in river systems that is easy to read. Many river pools are being filled up, and appear to be unable to self-clean due to the sediment load. To protect summer watering points, it is important to ensure that perennial vegetation cover within the river system is maintained at about 70% cover to minimise the potential for blowouts, erosion and mobilisation of significant quantities of drift sand.

Ultimately, if the processes continue at the current rate, it will become very difficult to water stock in the river. Large amounts of mobile sand are often unstable – with animals sinking in to the substrate and unable to get out, and pools unavailable for drinking water. While pool in-filling is a natural process, the rate is accelerated by increasing sediment loss from all river sections, not the localised erosion problems experienced in well-vegetated systems.

Anecdotal evidence from many private landholders suggests that water quality has deteriorated in terms of the extent and types of algal blooms within river pools. There is a wide range of algal species in both rivers. Some species are indicative of salinity levels and dominance of freely available nutrients (plants preferring higher nitrogen or phosphorus conditions), and others show changes to water quality in recent times.

The river mouth is a popular holiday location and many people surf and swim in the sheltered waters. While the volume of water may dilute the nutrient levels it may do little to impact on the bacteria. Further, the remains of animals trapped in the loose sediment will be washed downstream. Purely from the point of view of good taste, swimming with decaying animal material is undesirable. Discovering decaying animal material

is probably not considered an enjoyable component of any recreational activity.

Because the river is seasonal and does not necessarily conform to a winter flow pattern, it is not realistic to think that any contamination will have broken down significantly prior to any flows. The nature of the river is that any significant rainfall event inland of Talling Peak may result in a flood event. This was seen in both March and May of 1999.

6.13 Grazing

Another key contributor to erosion occurs in sections where there are significant numbers of stock within the river system. Grazing pressure and trampling of the soils is increasing the rate of erosion of some sections of the riverbanks. While low level grazing is an effective weed management tool, long-term stocking with large numbers of animals can result in clearly defined tracks across the floodway and the loss of perennial vegetation across large areas.

Depending on whether the bank is sand or clay, these tracks are compacted or loosened. Both pressures reduce soil cohesion, making them more susceptible to erosion. As these tracks are typically aligned parallel with the riverbanks, the peak flows (which are the flows that cause the damage) move preferentially along these tracks because there is no vegetation to slow water flow.

This can either result in large sections of the banks collapsing into the river in steep areas, or large plumes of sediments being scoured out of the floodway and deposited either further down the floodway or in the river. This sediment is then washed downstream, giving the river more power to erode other weakened sections of the bank further downstream. And so the process moves on.

As the riverbanks are eroded, large trees can be washed in. While it is natural for some plants to be washed into the river, changes to the river system can result in large numbers of plants falling into the river. More frequent tree deaths occur from ringbarking where trees are used as fenceposts, trampling by stock causing soil loss from around the roots of the trees, use of fire to clear debris and slumping of large areas with trees, all as a result of management practices.



These trees may impact on the river flow depending on the way they fall across the river. As trees fall into the river, they also impact on river health by causing blockages (natural dams). The water is deflected either below or around the dam, causing new erosion in areas lacking vegetation cover.

Loss of perennial vegetation cover is a significant step towards facilitating erosion during any flow event. As both the Chapman and the Greenough rivers respond to substantial rainfall events in any season, summer, autumn, winter and less frequently spring, it is critical that there is vegetation cover along the foreshore all year round. Significant lengths of the foreshores of the Chapman and Greenough rivers had only annual grass species present or were totally denuded at the time of survey between April and October.

River paddocks are important components of many farms. The presence of foreshore reserves, however, puts the onus on private landholders to ensure that management of the foreshore is consistent with the objectives of the reserve. Stock exclusion is occasionally necessary where stock management practices are inconsistent with the protection of the riverbed, banks and floodplain.

Treating the river foreshore as a sensitive river paddock and monitoring stock impacts are essential components towards protecting the river's form and function. Some inappropriate stock management practices observed during the foreshore assessment survey include:

- overgrazing,
- allowing stock to die in the river and making no effort to save them,
- not providing shade or shelter for stock elsewhere on the property,

- not monitoring stock for long periods,
- retaining only instream watering points, and
- poor animal husbandry.

These do have a significant impact on foreshore health and reflect poor farm management practices. The farming industry is going through difficult times, and losing sight of managing assets in the best possible manner does not help. The vast majority of landholders in the study area want to protect their future in farming. These people are adapting to changing conditions and are taking an interest in the environment as a whole. Others have an interest, but have been slower to adapt to the dynamic nature of the physical, biological, social and economic environments, and their inability to adapt is reflected in an increasing rate of degradation of the foreshore.

General suggestions

- Develop river paddocks and manage them as 'sensitive areas' when determining stock rotation.
- Design river paddocks to minimise the chance of stock walking parallel with the riverbanks.
- Monitor the impact of stock on the vegetation and aim to restore or maintain at least 70% perennial vegetation cover at all times of the year.
- Ensure that farm management plans include grazing schedules, recognise surface and groundwater issues and the need to manage these within statutory requirements, and aim to reinvest in improving the land when times are good.
- Develop guidelines for landholders with your local LCDC and the support of Agriculture WA, Water and Rivers Commission and Department of Conservation and Land Management and the local government authority.



7. General recommendations

A number of general recommendations apply to all of the sites. They are listed under the core activities, which will be required for groups to successfully develop and implement rehabilitation strategies.

7.1 Planning

- Determine cadastral boundaries and landowner/manager and ensure that the landholders support the foreshore assessment process, and are involved in the development and implementation of any remedial strategies.
- Collate as much existing information about the focus waterway and catchment as possible.
- Focus initial foreshore assessment survey work in areas where future rehabilitation projects may be undertaken.
- Extend future foreshore assessment work from previously surveyed areas along the foreshore, eventually mapping all sites. Future surveys may also include re-assessment of earlier surveys to assess changes to the environment.
- Create herbariums of native and weed species to teach group members and other interested parties to distinguish between native and introduced plants present in the riparian zone. This could include seedlings.
- Ensure that all works are planned well in advance and that a long-term strategy has been developed and is amended as new information becomes available.
- Ensure that all agencies with statutory responsibilities such as the relevant local government authority, Water Corporation, Water and Rivers Commission and Department of Conservation and Land Management are advised of any works within their management areas, to ensure that the works meet legislative requirements.
- Develop information brochures to increase community awareness of the importance of foreshore areas and to encourage community involvement in managing their own foreshores and surrounding reserves.

- Develop an information brochure for the landholder to suggest methods of improved land management and encourage rehabilitation of the foreshore area.
- Endeavour to obtain funds from outside sources to assist both the group and any private landholders who are willing to implement rehabilitation activities.

7.2 Site preparation

7.2.1 Weed control

- Ensure weed control activities are undertaken in manageable-sized nodes, reinforcing overstorey species and restoring the middlestorey and understorey species once weeds have been eradicated.
- Tag any native plants present to protect them from weed control activities.
- Use a qualified herbicide operator if chemical control is undertaken near waterways.
- Always consider the impacts that weed control will have on habitat, particularly for reptiles and small mammals such as bandicoots. Maintain vegetated corridors within which animals can move until sufficient native plants have re-established.
- Ensure that all weeds are removed from the site to limit re-infestation.
- Create buffers around existing clumps of native vegetation to encourage natural regeneration of existing plants, e.g. spray Fusilade around native rushes to control introduced grasses and enable the clumps of rushes to spread naturally.
- Ensure the impact on bank stability is considered before weed control works are undertaken. Consider potential for use of erosion control matting as an option to reduce weed re-emergence, support plants installed and improve bank stability on steeper gradient banks.

7.2.2 General site preparation

- Encourage landholders throughout the rural and semi-rural catchments to fence off or delineate



waterways and tributaries and implement a broadscale revegetation program.

- Provide financial support or material assistance to landholders willing to implement rehabilitation activities.
- Define access tracks to weed management areas or where there are planting programs, to minimise disturbance and limit damage to existing vegetation and soil.
- Implement intensive weed control activities in manageable-sized nodes where planting will be undertaken.
- Slash flower heads prior to seed ripening to limit reinforcement of the weed seed bank.
- In broadscale areas proposed for future works or in high-risk areas of dense weeds with few native plants where complete removal is inappropriate, ensure either flower removal or repeated slashing occurs prior to seeding.

7.3 Planting out

- Ensure planted areas within streamlines are artificially stabilised and planted in low-flow conditions to enable sufficient time for establishment, to reduce the chance of plants being washed out during peak flows.
- Plant native species only in areas where weeds have been effectively controlled and managed for a preferred minimum of two seasons.
- Encourage landholders to ensure all strata of vegetation, including understorey, middlestorey and overstorey species, are over time included in revegetation works to reinforce bank stability.
- Plant overstorey species initially in highly exposed regions lacking vegetation, to create a level of cover and protection for future plantings.
- Plant emergent and wetland plants in permanent water between September and March, securing those planted in flowing water with 600 mm steel U-shaped pegs.

- Plant in dryland areas in May to July and in seasonally inundated areas in August to September.
- Plant in higher densities than ultimately required to create instant habitat and improve weed exclusion, particularly in the inner urban environments.
- Obtain professional advice about planting densities for each recommended species, to optimise chances of success and re-create a more natural ecosystem.

7.4 Maintenance

- Ensure the works program includes ongoing intensive maintenance of areas where weed control and planting works have previously been undertaken.
- Implement ongoing weed management, before site preparation and planting works in new areas.
- Monitor for any natural regeneration on a regular basis, and undertake weed control around any emerging native plant seedlings.
- Assess the effectiveness of any river restoration works or installation of any products such as hemp matting, and modify as required.

7.5 Monitoring

- Continue to use the proforma to assess changes and improvement to foreshore health over time.
- Assess the effectiveness and relative benefits of different management techniques utilised and update the works program accordingly.
- Document the results and learn from experience.
- Monitor the effectiveness of sustaining interest within the project at both the management and implementation level. Develop techniques to support community groups and individuals in undertaking this work.
- Minimise the potential for burnout by not over-extending limited resources, particularly labour.



7.6 General management suggestions for each foreshore rating

A – Near pristine (Very good)	<p>River sections achieving this rating require minimal maintenance effort including:</p> <ul style="list-style-type: none"> • Removal or realignment of large and suspended woody debris where it is causing localised erosion. • Eradication of isolated occurrences of weeds. • Maintenance of fencing to exclude livestock and feral animals. • Establishment and maintenance of fire access tracks.
<hr/>	
B – Moderate	<p>Management effort required is greater than in A grade foreshore sections and generally relates to:</p> <ul style="list-style-type: none"> • Eradication of minor weed infestations and ongoing maintenance control of more widespread weeds. The weed control effort should be focussed on establishing buffers around native plants to encourage regeneration. • Monitoring and realignment of woody debris to ensure that natural dams that are exacerbating erosion are realigned to improve flow. Any debris that is not resulting in erosion needs to be left as habitat. • Close stock management is necessary to achieve effective weed control without reducing the values of the persisting native vegetation or the creation of clearly defined tracks.
<hr/>	
C – Poor	<p>Management activities are becoming more difficult as the degradation has stepped up an order of magnitude. Potential management activities include:</p> <ul style="list-style-type: none"> • Using woody debris to direct peak flows back to the main river channel and working to slow flows across the floodway • Revegetating using a combination of direct seeding and tubestock planting on the floodway margins. Planting close to the main channel is unlikely to be successful due to the volumes of mobile sediment and instability of the channel. • Controlling stock access until there is sufficient groundcover to improve bank and floodway stability.
<hr/>	
D – Very poor	<p>It is very costly to restore river systems once they degrade to this level. Priorities include:</p> <ul style="list-style-type: none"> • Re-establishing nodes of vegetation using fast growing species initially then infilling with slower growing plants. All plants need to be protected from peak flow events. • Developing and implementing strategies to slow water flow – possibly using instream large woody debris or riffles/causeways. • Undertaking localised weed control around revegetation works only. • Excluding stock until there is sufficient vegetation cover to protect the channel banks and floodway.



8. Working with government

8.1 Liaison with government agencies

A number of recommendations cited throughout this report require substantial technical assistance or additional funds to implement. Consequently, it may be beyond the scope of many community groups to undertake these projects due to a lack of available resources. Further, in many instances approval from the appropriate authority is required before any works can progress. Liaison with government agencies at the local and State level is an important step in determining if these remedial strategies can be implemented. Therefore, even though these recommendations can often not be addressed immediately, they can become a focus for future works when funds and assistance become available.

8.1.1 Water and Rivers Commission

The Water and Rivers Commission plays an integral role in the management and protection of our waterways. Many of the recommendations suggest that community groups liaise with these agencies to determine opportunities to investigate the following:

- Monitor stream health at a catchment level to assess erosion events, sediment loads, peak flow rates and pollution levels.
- Determine opportunities to retain water upslope when flow rates are high by increasing groundwater use through planting trees or to investigate the feasibility of diverting water flow into holding ponds.
- Assess the potential to minimise the amount of saline water entering waterways by installing upslope interception banks.
- Determine the legality of all off-take pipes, pumps and water containment structures (ponds and dams) located along waterways to investigate the level of water extraction.
- Assess the impact of dams and ponds on stream flow and sedimentation ensuring that these structures meet with stipulated conditions of construction and design and do not impact on stream hydrology or foreshore stability.

8.1.2 Local government authority

Community groups need to establish close links with the local government authorities when aiming to undertake any rehabilitation works on foreshore areas as approval and support is required. It is important to understand the current policies and requirements of these authorities and to undertake works within a framework that complements their own aims for the management of these riparian areas.

Work with the local government authorities to:

- Review current structures that may be exacerbating erosion and address these problems using appropriate water sensitive urban design principles.
- Determine the possibility of constructing where required, crossover points, drainage outfalls, rock spillways and riffle zones that promote the stabilisation of foreshore areas.
- Assess the provision of recreational facilities such as bins to limit rubbish entering the waterway.
- Provide guideways using bollards and woodchip pathways to minimise the trampling of vegetation particularly near revegetation works or valuable remnant vegetation.
- Promote careful management of recreational parks ensuring mowing and other maintenance work does not threaten native plants.
- Encourage the use of appropriate native species in any planting works associated with foreshore areas.
- Assess and limit access to areas if required.
- Implement signage to inform the local community and promote care of the foreshore environment.
- Ensure that any prescribed burns are undertaken in a mosaic pattern to provide sufficient cover and habitat for fauna while the vegetation is regenerating.

8.1.3 Department of Environmental Protection

The primary responsibility of the Department of Environmental Protection is to monitor and protect the



environment. This department will provide information to the community about numerous issues such as stating appropriate guidelines for development proposals, environmental protection and management rules and policy directions, and undertaking assessment of reports of pollution or environmental damage.

Contact the Department of Environmental Protection to assess:

- Potential source points of nutrient or chemical pollutants entering the waterway from surrounding residential, business (such as petrol stations) or rural developments.

8.1.4 Ministry for Planning

The Ministry for Planning is the government agency responsible for landuse planning and therefore the community should liaise with this department (and the Department of Environmental Protection) to ensure:

- Any future subdivisions and residential developments close to foreshore areas have suitable management systems and infrastructure in place, to prevent degradation of the foreshore and stream environments.
- The use of water sensitive urban design principles, to aid in decreasing potential water and sediment loads to waterways when developing drainage infrastructure close to waterways.

8.1.5 Main Roads WA

Main Roads Western Australia manages the road and transport network and associated road reserves. Encourage the Main Roads WA to:

- Install gross pollutant or sand/silt traps on stormwater system outfalls into waterways to collect rubbish and sediment,
- Maintain weed management in road reserves adjacent to riparian areas.

8.1.6 Department of Conservation and Land Management

The Department of Conservation and Land Management is the State government agency that manages our national parks and reserves. Foreshore

areas on reserve land are protected by legislation and managed by the department and therefore approval is required if community groups wish to undertake any works in these areas. CALM also provides a wide range of information and support to community groups. Contact the department to find out information about:

- Western Shield Program to control feral animals;
- Declared and protect fauna and flora;
- Joining the land for Wildlife Scheme; and
- Detection and management of plant diseases.

8.1.7 Agriculture Western Australia (AgWA)

Agriculture Western Australia has a great deal of information that is available to the community including pamphlets and publications on a range of landcare subjects. They also provide a number of services. Liaise with AgWA to:

- Gain advice on the identification and control of pest insects.
- Assess salinity levels in salt affected areas and investigate mechanisms to contain saline runoff upslope away from waterways to protect vegetation from the hypersaline waters.
- Determine if it is appropriate to establish perennial pastures associated with foreshore areas to provide an alternative to landholders that currently allow stock to freely graze these areas. Ensure that the management of such a cropping system prevents the plants from seeding, and that plant fragments are trapped to prevent these species from invading the riparian foreshore.

8.1.8 Fire & Emergency Services Authority of WA

It is essential that community groups ensure that appropriate fire management plans are developed for foreshore areas as these sites are often in close proximity to high-density residential areas and may pose a threat to public safety. Community groups should liaise with the Fire & Emergency Services Authority of WA to ensure a comprehensive plan is maintained. It is important that all associated agencies such as the Department of Conservation and Land Management, the local volunteer fire brigade and the



State Emergency Service are informed of any changes to access to sites. It is also important to ensure that firebreaks are maintained.

8.2 Further Information

The world wide web can provide a wealth of information and useful contacts, following are some URL addresses that may be of use:

The Government of Western Australia:

<http://www.wa.gov.au/>

Water and Rivers Commission:

<http://www.wrc.wa.gov.au/>

Water Corporation:

<http://www.watercorporation.com.au/>

Department of Environmental Protection:

<http://www.environ.wa.gov.au/>

Main Roads WA:

<http://website.mrwa.wa.gov.au/>

Ministry for Planning:

<http://www.planning.wa.gov.au/index.html>

Department of Conservation and Land Management:

<http://www.calm.wa.gov.au/>

Agriculture Western Australia:

<http://www.agric.wa.gov.au/agency/index.htm>

Fire and Emergency Services Western Australia:

<http://www.fire.wa.gov.au/>

WA online:

<http://www.onlinewa.com.au/enhanced/>



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