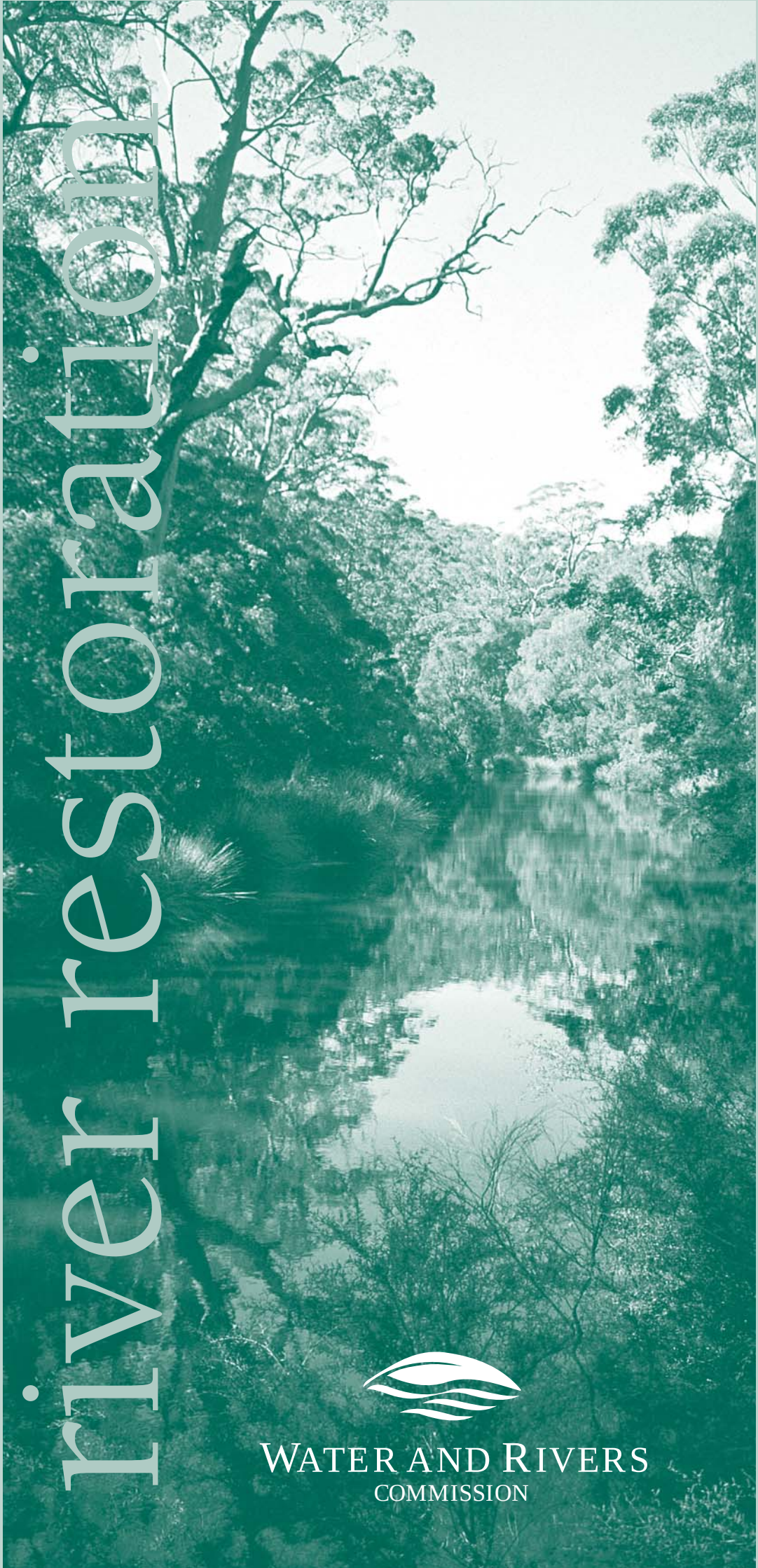

Planning and Management

Foreshore condition assessment in urban and semi-rural areas of south-west Western Australia

WATER AND RIVERS COMMISSION

September 1999
Report No. RR 2

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PLANNING & MANAGEMENT

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Ecosystem Management Services

jointly funded by

Natural Heritage Trust

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Foreword

Many Western Australian rivers are becoming degraded as a result of human activity within and along waterways and through the off-site effects of catchment land uses. The erosion of foreshores and invasion of weeds and feral animals are some of the more pressing problems. Water quality in our rivers is declining with many carrying excessive loads of nutrients and sediment and in some cases contaminated with synthetic chemicals and other pollutants. Many rivers in the south-west region are also becoming increasingly saline.

The Water and Rivers Commission is responsible for coordinating the management of the state's waterways. Given that Western Australia has some 208 major rivers with a combined length of over 25 000 km, management can only be achieved through the development of partnerships between business, landowners, community groups, local governments and the Western Australian and Commonwealth Governments.

The Water and Rivers Commission is the lead agency for the Waterways WA Program which is aimed at the protection and enhancement of Western Australia's waterways through support for on-ground action. One of these support functions is the development of river restoration literature that will assist Local Government, community groups and landholders to restore, protect and manage waterways.

This document is part of an ongoing series of river restoration literature aimed at providing a guide to the nature, rehabilitation and long-term management of waterways in Western Australia. It is intended that the series will undergo continuous development and review. As part of this process any feedback on the series is welcomed and may be directed to the Catchment and Waterways Management Branch of the Water and Rivers Commission.

Contents

1. Introduction

Rivers and streams are often a focus of settlement and recreation and as a consequence rivers and their foreshore (riparian) areas within the immediate surrounds of the Perth metropolitan area have been subject to continued disturbance. Many areas have been irreversibly affected and the physical and biological characteristics of the foreshore areas have been markedly altered (Pen and Majer 1993). Streamline degradation in the Swan-Canning Catchment in particular is widespread. Increasing community awareness of the importance of healthy riparian areas has led to the formation of community groups whose aim is to protect and rehabilitate the riparian zone. Many of these groups have insufficient information about the condition of foreshore areas to develop appropriate long-term management plans.

Limited resources determines the need for an inexpensive means of gathering information about the foreshore areas using methods that can be easily adopted by interest groups within the community. A method of foreshore assessment was developed in 1995 for streams in the southwest (Pen and Scott 1995), and has been used extensively by local landcare groups. The results of this survey technique have been used to identify and prioritise rehabilitation activities in farming areas including fencing for river protection and vegetation regeneration. The need to modify the Pen and Scott method for use in urban and semi-rural situations was identified in 1997 and resulted in the development of a funding application to the Natural Heritage Trust. The application was successful and resulted in the preparation of this report.

There are a number of benefits of using a standard methodology for assessing tributaries in urban and semi-rural areas. The information can be collected by state or local government authorities or the community, and then collated and distributed to all stakeholders to improve the level of understanding between groups. Many groups perceive differences between community and local government objectives for the management of foreshores and waterways. Developing a common understanding of the condition of the waterway through a process such as this will enable all groups to realise that they are working towards a common goal.

1.1 Objective

The objective of the following foreshore assessment survey is to provide a consistent method for groups and individuals involved in landcare to assess the condition of stream foreshores in urban/residential areas based on the methods developed by Scott and Pen (1995). It is important that the foreshore assessment survey is easy to use and reflects principles developed in similar studies to enable the comparison of results. This information can then be used to prepare management plans and identify priority areas for rehabilitation.

The environmental criteria included in this assessment process include condition and extent of foreshore vegetation, presence of dominant species (native plants and weed species), channel stability, areas suffering or prone to bank erosion and disturbance to the riparian zone as the result of surrounding landuse.

2. Approach

2.1 Background

The foreshore condition assessment methodology for urban/residential areas outlined in this document has evolved from existing survey methods. Each survey method used to determine foreshore condition assesses a number of factors seen as indicators of riparian health.

2.1.1 Rural foreshore systems

Pen and Scott (1995) developed a system that can be used to determine river foreshore condition and fencing status for rural based landcare groups in the southwest Western Australia. Fencing status is an important component of foreshore condition in rural areas. Uncontrolled stock access may reduce the health of the riparian zone through the grazing of foreshore vegetation and increasing erosion damage to foreshore banks. The erosion can be widespread as a result of stock movement across the foreshore or localised as a result of accessing a limited number of locations, for example watering points.

Within this survey there are three alternative methods. The first method is the Paddock Survey used to assess streams running though farm paddocks. Secondly, the Long Survey is used to obtain detailed information along large foreshore areas. The final component of this survey system is a Stream Health survey that summarises the ecological health of the riparian area using indicators of stream health such as bank and verge vegetation and stream cover. Each of the parameters assessed is ranked and given a score that is calculated at the end of the survey to give an overall summary of stream health.

2.1.2 Living stream assessment

The Ribbons of Blue method was developed as a teaching aid to educate primary school students. This method is based on field surveys assessing the following factors; bank vegetation (plants on the bank); verge vegetation (vegetation up to 20 m from the bank); in-stream cover; bank erosion and stability and pools and riffles (flowing water only). Ribbons of Blue uses a point system to determine the condition of each of the factors, eventually grading them as excellent, good, average or poor. The point system is weighted towards vegetation condition and the level of erosion along foreshore banks. The system compares flowing water to slow or non-flowing water and also encourages recording information about the presence of aquatic invertebrates, frogs and birds and common riparian trees. This recorded information is used to calculate a biodiversity index.

2.2 The assessment of foreshore condition

As with the Pen and Scott (1995) foreshore assessment system, this project works to develop an overall stream condition index which can be derived from the survey of foreshore areas and the assessment of certain principal parameters that are used as indicators of stream ecosystem health.

These parameters include:

- bank stability,
- foreshore vegetation,
- stream cover, and
- habitat diversity.

Each of these parameters is comprised of a number of components, which are assessed in the foreshore survey. In addition, the survey form provides opportunities to document other relevant factors that may further affect the riparian zone. Activities such as surrounding land use and types of disturbance, including the presence or absence of feral animals or livestock in the river, for example, can be documented.

Both the descriptions of the foreshore and the associated observations are collated and summarised. From this, the stream condition index can be determined using a colour coded system as outlined below. The colour codes are used as a means of providing an immediate and easily recognisable summary that represents a great deal of information on foreshore condition. Ultimately this

information will be used in the development of management plans for riparian zone rehabilitation and will provide a baseline for monitoring change in foreshore condition.

2.3 Stream condition index

A colour coded system has been developed to express the condition of each of the components of foreshore health. These colour results are summarised ultimately to determine the overall stream condition. The use of colours simplifies the recorded information into a recognisable form allowing immediate interpretation of the results.

A scoring system can be linked with the colour code summaries to enable a simple arithmetic calculation about how the stream rates. This is not weighted and is intended as a guide for those who prefer working with numbers instead of colours. Simply sum the value of each summary parameter colour, total these across the four components of foreshore condition, and cross reference with the overall stream condition index summary table to see how the stream rates.

The colour codes and the points value are defined as follows:

Colour rating	**Blue**	**Green**	**Yellow**	**Red**	**Black**
Condition	Excellent	Good	Moderate	Poor	Very Poor
Score	8	6	4	2	0

3. Survey method

3.1 Methodology

Aerial photographs, vegetation maps and satellite images provide broadscale information on the riparian zone, such as the presence of remnant vegetation, but they do not give an accurate picture of foreshore health on a local scale. It is essential to document more detailed information such as the composition of the vegetation (including the predominance of introduced weeds), points of severe erosion and the presence of human made features such as pipelines and fences. This information can only be obtained through a ground-based survey.

To enable community groups and individuals to conduct foreshore surveys to collect this type of information, a foreshore assessment form was developed (Appendix 1). This form will ensure that future assessments will record data in a consistent manner. Any number of people can conduct surveys over a period of time and the recorded information can be collated to provide a summary of the foreshore condition over the full length of a stream and across time.

Ideally, the foreshore areas should be traversed prior to the survey to gain familiarity with the area and to assess the range of condition and general accessibility. The site is then divided into relatively homogeneous sections delineated on the basis of vegetation structure or landuse. A survey form should be completed for each of these sections.

In areas with dense foreshore vegetation on both banks of the river, each side should be surveyed separately with survey forms completed for each side. On highly degraded rivers where the foreshore along both banks is easily observed from one side, and the vegetation and disturbance factors are similar, a single survey form may be used.

3.2 Foreshore parameters

The major components of foreshore condition are interrelated and each parameter should be considered in context when assessing stream health. As an example, the presence and condition of riparian vegetation will directly influence not only the structural stability of foreshore banks but also the extent of stream cover. Disturbance factors may impact on the foreshore and need to be noted. Where livestock have access to the riparian zone, for example, they not only cause grazing damage to the riparian vegetation but can also directly affect foreshore stability by accessing rivers for water and causing erosion.

4. Completing the foreshore condition assessment survey form

Detailed guidelines on how to complete the Foreshore Condition Assessment Survey Form are outlined below. The discussion provides details about the terminology in the methodology and information about how to complete the corresponding section of the foreshore assessment survey form. The specific instruction to complete the form is indicated in italics.

At the end of each section is the summary of condition for the foreshore parameters, including the corresponding colour code and score. The summary of condition should be completed at the end of the survey when all of the components of foreshore health have been assessed. Once the form is completed the Stream Condition Index (Section 4.8) can be determined by comparing the colour code and the total score of each of the four parameters.

A summary of the disturbance factors and the impact of the surrounding landuse should also be included. The summaries of foreshore condition enable easy comparison within stream sections of the same tributary and between streams.

4.1 Recorder information and survey details

Enter the name of the river or stream. The identity and contact details of the person conducting the survey should be recorded. Other details such as the date of the survey, nearest access roads, the particular bank surveyed (left, right or both) and the length of the section mapped is also important. Include the name and details of the landholder if possible.

Note: left and right banks are identified as looking upstream.

A Global Positioning System (GPS) instrument may be used to record the latitude and longitude of the survey site. Documenting this information will help to identify the exact location of the area surveyed. It is important to note that most hand-held GPS instruments have a distortion of between 10 m and 50 m.

It is essential to note the date the survey was undertaken as species composition may vary depending on the time of the year. For example, annual weeds are often obvious during the winter months when they are actively growing, rather than later in the year as they die off. Other species are conspicuous when they flower in the spring. Water flow rates also change throughout the year.

Recording the contact details of the person conducting the survey is also recommended, as follow up information may be needed in the future.

Documenting landholder details may also help to relocate the survey site in the future. If the landholder is aware that a survey is being conducted they may be encouraged to become involved with any rehabilitation work. They may also be in a position to provide information on the flooding or clearing history of the area. It is equally important to indicate if the landholder has not been contacted, to minimise possible conflict and misunderstandings in the future.

4.2 Summary codes

Complete the summary codes for each of the foreshore condition parameters and calculate the foreshore condition index at the end of the survey.

The criteria that determine the condition of each of the foreshore parameters and the corresponding colour code are outlined at the end of each of the parameter sections.

4.3 Bank stability

Recording the level of erosion, slumping and sedimentation will determine the condition of the foreshore and its vulnerability to further erosion. Erosion often occurs near disturbed areas where the soil is exposed. Steep graded banks are especially vulnerable, particularly after heavy rainfall events where the soil is sandy and lacks cohesive material such as clays. Increased water runoff near drainage points and discharge pipes may also cause erosion. Slumping or bank collapse often occur when the supporting vegetation has been removed or thinned. Sedimentation is indicated by large deposits of sand in the main channel or on the inside of channel meanders.

4.3.1 Section sketch

Draw a section sketch of the survey section.

A section sketch is a line drawing of the survey section from an aerial perspective. The sketch map should include information such as the width of the stream and the extent of the fringing vegetation. The presence of major weeds, and other important features such as discharge pipes, pump off-takes and fences should also be detailed.

4.3.2 Profile sketch

Draw a profile sketch of the survey section.

A profile sketch of the river floodway should be made, indicating stream depth and width, the height and grade of the foreshore banks and the structure and composition of fringing vegetation. The drawing should resemble the foreshore condition sketches included in Pen and Scott (1995) (Appendix 2).

4.3.3 Proportion of bank affected by erosion, slumping or sedimentation

The proportion of the bank affected by erosion, slumping and sedimentation is recorded as a percentage of the total length of each section of the foreshore bank surveyed. It is therefore necessary to walk and view the whole section prior to completing the form to determine the condition of the foreshore bank.

4.3.3.1 Erosion

Determine if the proportion of the bank affected by erosion is minimal; localised; significant or severe.

The level of foreshore erosion may be determined as follows;

- **Minimal 0 - 5%:**
  Little evidence of erosion. Erosion is a natural component of river systems and some erosion is likely to occur, particularly on the outside of river bends.
- **Localised 5 - 20%:**
  Localised areas of erosion only. Often observable as undercutting around the base of trees or near areas that have been disturbed and exposed. Localised erosion may also occur near outflow pipes where water flow increases.
- **Significant 20 - 50%:**
  Active erosion is obvious along many parts of the section.
- **Severe > 50%:**
  Significant erosion is more or less continuous along the length of the survey section.

4.3.3.2 Slumping

Determine if the proportion of the bank affected by slumping is minimal; localised; significant or severe.

The proportion of the foreshore bank affected by slumping or bank collapse may be recorded as follows;

- **Minimal 0 -5%:**
  Little evidence of slumping along the edges of the river bank.
- **Localised 5 - 20%:**
  Localised areas of slumping only. Occasional collapse of the river bank has occurred often due to disturbance and loss of supporting vegetation.
- **Significant 20 - 50%:**
  Slumping and large bank collapse is common along many areas of the survey section.
- **Severe > 50%:**
  Significant slumping more or less continuous along the length of the survey section. There is extensive degradation to the overall structural integrity of the river bank.

4.3.3.3 Sedimentation

Determine if the level of sedimentation within the survey section is minimal; localised; significant or severe.

The level of sedimentation within the stream channel is recorded as follows;

- **Minimal 0 - 50%:**
  Little evidence of sedimentation.
- **Localised 5 - 20%:**
  Localised deposition of sediment occurs infrequently along the river channel, mainly on the inside of meander bends.

- **Significant 20 - 50%:**
  Sediment has accumulated along many sections of the survey area.
- **Severe > 50%:**
  Sedimentation within the river channel is more or less continuous along the survey section. Large slugs (moving plumes of sediment) are common. Some large deposition areas may be stabilised by vegetation.

4.3.3.4 Comments

Include information on significant occurrences of erosion, slumping or sedimentation highlighting areas that need immediate attention.

4.3.3.5 Stabilisation Works

Note any artificial stabilisation structures utilised at the site. Include both constructed features and non-engineered structures.

River banks prone to erosion can be supported and protected from further damage using channel stabilisation structures. There are a variety of types including simple structures such as wooden boards used to shore up the river banks or the placement of concrete or gravel rubble around erosion points. Modern techniques include the use of geotextile matting fabrics and natural products like hemp matting to minimise soil surface runoff during rainfall events. The implementation of techniques such as the placement of limestone spalls (rocks) and gabion support structures near outflow pipes are relatively new methods used to minimise the erosive power of water entering rivers and streams.

4.3.4 Summary of bank stability condition

Colour Code	Parameter Rating	Description
Blue (8 points)	**Excellent**	No erosion, slumping or sediment deposits; dense native vegetation cover on banks and verge; no evidence of disturbance or areas of exposed soil.
Green (6 points)	**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.
Yellow (4 points)	**Moderate**	Some localised erosion, slumping and sediment deposits; native vegetation cover on verges may be patchy and interspersed with patches of exposed soil.
Red (2 points)	**Poor**	Extensive active erosion slumping and sediment deposition particularly during peak flows; bare banks and verges common.
Black (0 points)	**Very Poor**	Almost continuous erosion; over 50% of banks slumping; sediment heaps line or fill much of the floodway; little or no vegetation cover.

4.4 Foreshore vegetation

4.4.1 Vegetation composition

4.4.1.1 Native vegetation

The species composition of foreshore vegetation is a major indicator of stream health. A list of selected native species common to the riparian zone within the Perth Regional area has been included in Table 1 in the Foreshore Assessment Survey Form (Appendix 1). For each species the following information will be recorded:

- abundance,
- condition, and
- regeneration status.

This species list may be easily modified to reflect local variation in species composition to allow the survey form to be used in other urban or semi-rural areas outside the Perth Metropolitan area.

The native plants have been divided into seven different life form categories as follows:

Life form	Description
Trees	large woody plants > 3 m, usually with a well defined trunk
Shrubs	woody plants less than 3 m tall
Creepers and ground covers	plants that twine around other plants or trail along the ground using tendrils or stems, ground cover plants < 1 m which are prostrate or clump near the base
Rushes and sedges	rush or sedge-like monocotyledons occurring in dense clumps or broad bands
Grasses	grasses and grass like plants
Annual herbs	small soft leafed plants < 1 m tall without woody stems
Emergent or floating river plants	attached or floating aquatic plants that are completely submerged or have leaves and flowering stems protruding above water

It is important that group members undertaking this part of the survey have some skill in identifying native and exotic plants.

Abundance of native species

Determine if each native species present is abundant; frequent; occasional or rare.

This section of the form records the presence of a species within the survey site. Abundance may be difficult to determine in some instances, as it is not always a reflection of species density (how many plants are present in an area). For example, the Flooded gum (*Eucalyptus rudis*) is often a dominant overstorey species which occurs consistently along foreshore areas. Due to the structure of the tree, *E. rudis* naturally occurs in low numbers. In this instance, even though the total number of *E. rudis* trees within any given area may be low, it may be recorded as abundant as it is always present.

The abundance of native species within the survey site is recorded as follows:

- **Abundant**:
  This species may predominate, occurring in high numbers or consistently within the site. It can almost always be seen from any section of the surveyed area.
- **Frequent:**
  This species is common, and may occur in patches or in low numbers over a large percentage of the section.
- **Occasional**:
  This species occurs sporadically, more than once or twice within an area. Not immediately observable at first glance.
- **Rare:**
  Occurs very infrequently, and may be observed only once or twice within the surveyed section.

Condition of native plant health

Determine if the particular species has some plants that are healthy; some sick; many sick or dying or majority dead.

The current status of plant health is an indicator of future species composition. For example if a number of trees at present are unhealthy it is possible that they may die in the near future.

The condition of native species within the survey site is recorded as follows;

- **Healthy:**
  There is no observable damage or injury to the plants.
- **Some sick:**
  Some species show signs of insect damage above normal levels or a general decline in health such as defoliation or the presence of dying branches.
- **Many sick or dying:**
  Many plants show signs of severe decline in health with a number of dead and dying plants present.
- **Majority dead:**
  Few of the native plants present are healthy and the majority are dead.

Regeneration of native species

Determine if each native species present has seedlings that are abundant; frequent; occasional or rare.

Record if any seedlings are present at the survey site. The presence of seedlings may indicate that the area has potential to regenerate if managed appropriately.

The regeneration of seedlings within the survey site is recorded as follows:

- **Abundant:**
  Seedlings occur in high numbers and are observable from any section in the area.
- **Frequent:**
  Seedlings are common. Regeneration may occur in small stands or sporadically over large areas of the section.
- **Occasional:**
  Seedlings are infrequent occurring no more than once or twice within the area. The seedlings are not immediately obvious at first glance but occur occasionally.
- **Rare:**
  Seedlings occur very infrequently and may be observed only once or twice within the surveyed section.

4.4.1.2 Weeds

Determine if each weed present is abundant; frequent; occasional or rare.

Foreshore condition is frequently reduced as a result of weed invasion and it is important to record how frequently each weed species occurs within the survey site. A weed can be defined as an introduced species with the capacity to invade native vegetation and displace native plant species. As the habitat diversity decreases with the loss of native plants there are fewer resources, such as food and shelter, for native animals. Consequently, weed invasion can significantly reduce the diversity of native plants and animals over time.

A healthy riparian zone will have a number of deep and shallow rooted perennial native plants, providing effective stabilisation of the foreshore banks throughout the year. Many annual weeds are short lived, shallow rooted and die off over summer and autumn. These annual species provide limited structural support to the soil and significant loss of topsoil can occur during major flow events.

It is essential to record the presence of exotic species, as weed control is a major component of foreshore rehabilitation. Species may currently occur infrequently but if they are not detected and subsequently controlled, numbers may increase in the future.

Abundance of weeds

Weeds common to the riparian zone within the Perth Regional area have been included in Table 2 in the Foreshore Assessment Survey Form (Appendix 1). The abundance of weeds present within the survey site is recorded as follows:

- **Abundant:**
  This weed may predominate, occurring in high numbers often in large stands. It can almost always be seen from any section of the surveyed area.
- **Frequent:**
  This weed is common, it may have a patchy distribution with large stands or occur in lower numbers over a large percentage of the site.
- **Occasional:**
  This weed occurs sporadically, more than once or twice within an area. Not immediately observable at first glance.
- **Rare:**
  This weed occurs very infrequently, may be observed only once or twice within the surveyed section.

The weeds have been divided into nine different categories as follows;

Life form/term	Description
Priority one weeds	weeds declared by Agriculture WA as representing a threat to productivity and the environment
Trees	large woody plants > 3 m, usually with a well defined trunk
Shrubs and perennial plants < 3 m tall	woody plants < 3 m tall or plants that live for more than two growing seasons
Annually renewed from bulbs and corms	soft leafed plants that reshoot from underground bulbs and corms, flower and die back each season
Annual herbs	small soft leafed plants < 1 m tall without woody stems that complete the lifecycle within a single year
Grasses	grasses or grass like plants
Climbers and creepers	plants that twine around other plants or trail along the ground using tendrils or stems
Rushes and sedges	rush or sedge-like monocotyledons occurring in dense clumps or broad bands
Emergent or floating river plants	attached or floating aquatic plants that are completely submerged or have leaves and flowering stems protruding above water

4.4.2 Vegetation structure

4.4.2.1 Proportion of cover

The proportion of cover is a measure of the continuity of the vegetation in an area, not the density of plants present. Healthy open woodland, for example, may have low numbers of trees but the overall canopy may be continuous and there may be few gaps in the vegetation. Continuous tree and shrub cover provides a corridor for birds and larger animals. Ground cover provides protection for small reptiles and other animals. Note that the absence of canopy is expected for some plant community types such as sedgeland or heathland areas.

It may be difficult to estimate the cover of a large area. Therefore focus on a small section, approximately 5x5 m (25 m2) and determine species cover within this area. Compare this area with the whole section to estimate the total cover.

Note that cover in this instance includes a measure of the continuity of both native and weed species present.

Overstorey

Record if the overstorey is continuous; patchy; sparse or absent.

The continuity of the overstorey trees within the survey site can be defined as follows:

- **Continuous > 80%:**
  The tree cover is continuous with very few open spaces present.
- **Patchy 20 - 80%:**
  The tree cover may have only a few open areas interspersed between continuous vegetation to large patches of open space.
- **Sparse < 20%:**
  Tree cover occurs very infrequently with only small stands of vegetation observed.
- **Absent 0%:**
  Trees are almost absent providing no cover over the site.

Middlestorey

Record if the middlestorey is continuous; patchy; sparse or absent.

The continuity of the middlestorey which is comprised of shrubs and taller perennial species can be recorded as follows:

- **Continuous > 80%:**
  The shrub layer is continuous with very few gaps in distribution.
- **Patchy 20 - 80%:**
  The shrub layer may have only a few open patches between continuous areas of vegetation to large areas of open middlestorey.

- **Sparse < 20%:**
  Shrubs occur very infrequently with only small stands occurring along the survey site.
- **Absent 0%:**
  There is no shrub layer present.

Understorey

Record if the middlestorey is continuous; patchy; sparse or absent.

The continuity of the ground cover within the survey site can be recorded as follows:

- **Continuous > 80%:**
  Ground cover is continuous with very few open spaces within the area.
- **Patchy 20 - 80%:**
  Ground cover may have only scattered exposed areas to large areas of open ground within the sites.
- **Sparse < 20%**:
  Ground cover species occur very infrequently with only small patches of vegetation present.
- **Absent 0%:**
  There is little to no ground cover present.

4.4.2.2 Proportion of native species

Indicate the percentage of the native species present in the overstorey, middlestorey and understorey.

It is important to record the percentage of the vegetative cover that is comprised of native plants as it provides further information about the composition of the foreshore vegetation. An area may have continuous (> 80%) ground covers but a very low percentage of the total is comprised of native species. This indicates that ground cover weeds dominate the area.

Colour Code	Parameter Rating	Description
Blue (8 points)	**Excellent**	Healthy, undisturbed native vegetation with structure intact and verges more than 20 m wide; no weeds or signs of disturbance evident.
Green (6 points)	**Good**	Vegetation structure dominated by native plants that comprise 80 - 100% of the total number of species; only scattered weeds or rarely evident in small clusters; nil or minor signs of disturbance (i.e: tracks, rubbish dumping).
Yellow (4 points)	**Moderate**	Some changes in vegetation structure, native plants comprising 50 - 80% of the total species composition; little regeneration of trees and shrubs; weeds occurring occasionally; moderate levels of disturbance.
Red (2 points)	**Poor**	Modified vegetation structure with native plants comprising only 20 - 50% of the total species composition. Trees remain with only scattered shrubs and an understorey dominated by weeds; prevalent disturbance.
Black (0 points)	**Very Poor**	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.

4.4.3 Summary of foreshore vegetation condition

4.4.2.3 Leaf Litter

Determine if the level of leaf litter cover within the survey section is absent; minimal; good or deep.

Leaf litter is comprised of fallen leaves, barks and branches and provides food and shelter for invertebrates and other biota along the riparian area. A healthy system with long standing vegetation tends to have deeper leaf litter.

There is evidence that the rare and endangered Western swamp turtle (*Pseudemydura umbrina*) may bury itself under leaf litter and logs (Bush B. *et al.* 1995).

The amount of leaf litter present is recorded as follows:

- **Absent:**
  There is no leaf material present at the survey site.
- **Minimal cover:**
  Scattered areas of leaf material may occur in patches usually near stands of vegetation.
- **Good cover:**
  Leaf material may occur over a large area but it is only a 3 - 4 cm deep.
- **Deep cover:**
  Large amounts of leaf material is present to a depth of 5 cm or more.

4.5 Stream cover

Fringing vegetation along the stream banks is an important component of riparian ecosystems. Overhanging vegetation provides shade, which reduces water temperatures. Shade is essential for some cold-blooded animals such as fish, which cannot regulate their body temperature. The reduced levels of light help to minimise excessive growth of algae and dappled sunlight helps to protect animals such as fish and crustaceans from exposure to predators.

The overhanging vegetation also provides resources for aquatic organisms. Leaves, flowers, fruits, even insects falling from above, all provide food. Larger debris such as branches and whole trees are also important. Fallen logs may slow water flow, allowing deeper water to pool. These pools provide a refuge for aquatic plants and animals particularly as water levels drop over the dry season. Debris also provides shelter and breeding sites for larger organisms and a substrate for establishment for small invertebrates and aquatic plants. As stream flow slows, smaller debris such as leaf litter is retained and breaks down, providing further nutrients.

It is important to record the abundance of exotic species providing stream cover. The presence of introduced plant species can upset nutrient availability within the aquatic food chain. Exotic species are often deciduous and may drop all their leaves in a relatively short period of time. The introduction and subsequent rapid breakdown of large amounts of soft leaves into the water column can cause a sharp depletion of dissolved oxygen affecting aquatic organisms. The sudden change of the foreshore microclimate from a shaded stream to an area that is directly exposed to sunlight may also affect instream biota.

4.5.1 Abundance of stream cover

Indicate if overhanging native vegetation is abundant; frequent; occasional, rare or absent.

Indicate if overhanging exotic (weed) vegetation is abundant; frequent; occasional, rare or absent.

The amount of stream cover present can be recorded as follows:

- **Abundant:**
  Stream side vegetation is abundant and continuous along the length of the survey site.
- **Frequent:**
  Overhanging vegetation is common along the stream banks with a few areas open and exposed.
- **Occasional:**
  Stream cover is less frequent with occasional stands of vegetation overhanging the banks of the stream providing infrequent patches of shade.
- **Rare:**
  Overhanging stream side vegetation is very infrequent occurring only once or twice along the survey site.
- **Absent:**
  Stream cover is absent.

4.5.2 Deciduous trees

Indicate the presence or absence of deciduous trees.

Deciduous trees defoliate during the autumn months when the temperature begins to fall. These plants do not provide year round food and shelter for birds, animals and aquatic species as the trees are bare in winter.

4.5.3 Instream cover

Record the presence of any:

- *Leaf litter/detritus*
- *Rocks*
- *Branches*
- *Vegetation*

Provide more information such as the size of the branches or the kind of vegetation present if these features are of particular importance.

Vegetation, rocks and branches present in the stream channel provide habitats and refuges for aquatic organisms. This material may also provide protected breeding sites. Emergent branches and rocks at shallow angles are ideal basking sites for turtles and roosting and perching sites for birds. Stream movement over rocks and logs also helps to oxygenate the water.

4.5.4 Summary of stream cover condition

Colour Code	Parameter Rating	Description
Blue (8 points)	**Excellent**	Abundant stream cover from dense overhanging vegetation providing almost continuous shade; frequent instream cover from aquatic vegetation and/or leaf litter, rocks or logs.
Green (6 points)	**Good**	Abundant shade from overhanging vegetation; occasional instream cover from patches of aquatic vegetation and isolated heaps of leaf litter or rocks and logs.
Yellow (4 points)	**Moderate**	Scattered fringing vegetation with occasional patches of shade; infrequent instream cover with little aquatic vegetation, very infrequent rocks and logs.
Red (2 points)	**Poor**	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.
Black (0 points)	**Very Poor**	Zero or minimal stream cover with no permanently shaded areas and no instream cover.

4.6 Habitat diversity

Water permanency, depth and quality will affect both plants and animals within the stream and the fringing riparian zone. Streams that flow throughout the year provide a vital refuge for both terrestrial and aquatic animals during the dry summer months. As water slows in the shallower rivers, water temperature increases and the level of dissolved oxygen generally decreases. As streamflow becomes sluggish, sediments accumulate and plants begin to decompose.

Many streams around Perth are seasonal, however, there are some which are fed by groundwater and others which are artificially maintained by the Water and Rivers Commission and Water Corporation.

4.6.1 Permanent water

Note the flow of water throughout the year.

If there is no recorded data available on stream flow, the site should be visited during the summer months to determine if there are any pools or water flow during the dry season.

4.6.2 Water depth

Note the range and average water depth along the section.

It is often difficult to determine variations in water depth without physically measuring the depth along the length of the stream, particularly if turbidity is high and the water colour is dark. In some systems it is obvious that there is a great deal of variation particularly if there are large sediment slugs decreasing water depth in places.

High levels of tannin in the water limit light penetration upon which submerged plants depend, so generally there is less instream plant growth in these areas.

Variable water depths provide a wider range of habitat for aquatic flora and fauna and can provide an indication of habitat diversity.

4.6.3 Water quality

Record the quality of water and any variations along the surveyed section. Document the presence of any microscopic or filamentous algae, particularly as water flow slows during the summer months. Note the presence of any dead animals.

Water quality can be affected in a number of ways, surface runoff from surrounding land particularly near agricultural areas may introduce sediments, nutrients (such as nitrogen and phosphorus) and salt into the waterway. Chemicals, including oil, petrol and heavy metals may also contaminate waterways, particularly near residential and industrial areas.

The presence of pollutants can often be detected as an oily sheen on the surface of the water or an unpleasant odour, particularly near slow moving pools.

Excess nutrients often encourage the growth of algal blooms, particularly during the summer as water flow begins to slow, water temperatures rise and nutrients are not flushed downstream. Blue-green algal blooms may be a problem due to the toxicity of the algae and the formation of dense scum layer on the water surface.

As leaf material from fringing vegetation enters the water column and breaks down, tannins are released. The presence of tannins in streams, indicated by dark brown or tea-coloured water should also be recorded. Tannins may also come from peaty soils and swamp systems. As mentioned above, high tannin levels reduce light penetration and subsequently submerged and emergent vegetation.

4.6.4 Wildlife habitat diversity

Note any animals observed during the survey.

Healthy vegetation in the riparian zone provides a range of habitats for a variety of wildlife. Along the foreshore, animals such as birds, reptiles, spiders and insects, and even larger mammals such as bandicoots, can be observed. Frogs, fish, turtles, crustaceans and macro-invertebrates are often recorded in healthy streams. In turn the fringing vegetation is sustained by the presence of these animals. Insects and birds pollinate flowers, disperse seeds and prey upon damaging herbivorous insects.

4.6.4.1 Aquatic organisms

Invertebrates, amphibians, reptiles and fish

Record the presence of habitats suitable for aquatic organisms.

Fast moving water that free falls over large rocks, forming cascades and rapids, or that moves over stones, rocks and tree roots along riffle zones are important habitats for macro-invertebrates such as stoneflies and fish such as minnows. The movement of water over branches and litter aerates the water, increasing the levels of dissolved oxygen.

Slow moving water, where the stream meanders, and pools provide deeper water for turtles and fish. Emergent, submerged and bank vegetation in conjunction with large stones and rocks provides a range of habitat requirements including food resources, substrates for attachment, breeding sites and protection from predators for many aquatic animals. Turtles require large logs at a low angle for basking and sandy patches or logs covered with deep leaf litter for nesting. They also utilise dense leaf litter and logs along the foreshore area particularly during the summer months.

4.6.4.2 Terrestrial animals

Invertebrates

Record the presence of habitats suitable for terrestrial invertebrates.

A variety of vegetation types adjacent to streams will create many suitable habitats and food resources for terrestrial invertebrates. Tree bark and leaf litter also provide protection from predators.

Amphibians

Record the presence of suitable habitats for frogs. Check pools for the presence of tadpoles. Listen during the day and at night for calling frogs.

Frogs require dense streamside vegetation to protect them from direct sunlight and high temperatures, and also from predators. The emergent plants or the soft muddy substrate near stream banks are suitable breeding grounds for frogs.

Reptiles

Record the presence of suitable habitats for reptiles.

The presence of a variety of vegetation types often indicates that reptiles such as skinks, lizards and snakes may also be present. Dense vegetation supports other organisms that will, in turn, be prey for larger reptiles. Vegetation also provides shelter. Reptiles are cold-blooded and need to bask in sunny, protected areas.

Birds

Record the presence of suitable roosting and nesting sites for birds or any birds noted during the survey.

Older trees with hollow branches are important nesting and roosting sites for many birds commonly found along bushland corridors adjacent to streams. Smaller birds rely on these trees and medium to large shrubs for perching and nesting sites. Flowers provide nectar and attract insects, which in turn provide important food resources for birds.
Dense stands of rushes and sedges provide roosting, feeding and breeding habitats for waterbirds.

Mammels

Record the presence of suitable habitat for mammals.

Small animals require protection from predators, especially feral animals such as cats, foxes and dogs.

Dense vegetation provides protection and nesting sites.

4.6.5 Summary of habitat diversity

Colour Code	Parameter Rating	Description
Blue (8 points)	**Excellent**	Excellent water quality with areas of permanent water (i.e: pools and creeks); three or more aquatic and terrestrial habitats including diverse vegetation types, edgewaters, instream cascades, riffles, pools and woody debris.
Green (6 points	**Good**	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, mammals and birds).
Yellow (4 points)	**Moderate**	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.
Red (2 points)	**Poor**	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.
Black (0 points)	**Very Poor**	Poor water quality; almost no healthy habitats available for aquatic and terrestrial organisms.

4.7 Additional information

4.7.1 Disturbance factors

Record the types of disturbance observed.

Types of disturbance along the river foreshore and in adjacent areas are good indicators of riparian condition. Rubbish, garden refuse and service corridors indicate high human use of an area which frequently results in a detrimental impact on the riparian environment.

Stock access will often cause damage to stream foreshores. Overgrazing, stock tracks and pad areas where the stock camp, cause a deterioration in soil structure where the soil either breaks up or is compacted. Exposed soil increases foreshore erosion and the amount of sediment entering the waterway. In addition stock manure and urine entering the stream increase nutrient loads and may introduce diseases.

Plant community diversity often decreases with increasing grazing pressure and fire frequency. As plants become stressed they become more susceptible to disease causing further decline in plant numbers. As disturbance increases, so does weed invasion, causing further degradation of the riparian zone.

Instream disturbance caused by the presence of pumps, bores and discharge pipes, may cause increasing erosion and slumping along foreshore banks. Dams and crossovers may also cause hydrological disturbance.

4.7.2 Surrounding land use

Record the surrounding landuse adjacent to the foreshore area.

The surrounding landuse can have an impact on the health of the riparian system although the consequences may not be immediately evident, particularly during the foreshore survey. Potential problems associated with various landuses are:

- human impact from increased recreation in reserves,
- pollutant runoff from industrial and commercial sites,
- storm water runoff from residential areas,
- nutrients from rural and agricultural areas,
- erosion and weed invasion caused by livestock grazing,
- pesticides from orchards and crops, and
- weeds/exotic plants invading from residential, landscape gardens and agricultural trials.

4.7.3 Evidence of management

Record any evidence of management.

It is important to record any management practices currently underway in the riparian zone either by landholders, community organisations, landcare groups, local government agencies or any other associated groups. An awareness of current practice enables appropriate decisions to be made about future management of the area and avoids potential conflict between groups and landowners in the area.

4.7.4 Cultural value

Record any available information sources relating to sites within the area of Aboriginal or European interest.

It is important to determine the cultural importance of the surveyed area to gain an understanding of the community's requirements and to ensure appropriate decisions are made in regard to long term management of the riparian zone.

4.7.5 Additional comments

- Weather conditions.

Record the weather conditions during the survey.

The number of animals observed during the survey may be affected by the weather. If it is cold, overcast or wet, insects and reptiles may be less active and not as easily observed.

• Other data

Detail any relevant information, photographs, knowledgeable persons and any useful documents that pertain to this site.

Record any other relevant information about the site. This may include comments from local landholders or people using the site for recreation. Old photographs and information from long term residents provide information about the history of the area and changes in condition.

It is important to note if other information is available about the survey site to ensure a complete assessment of the area has been conducted, and all information can be collated to provide an accurate picture of the overall foreshore condition.

- Safety/health hazards

Note any safety/health hazards at the site.

It is important to document any hazards in the area particularly if future rehabilitation projects are to be undertaken.

4.8 Overall stream condition index

Complete the summary codes for each of the foreshore condition parameters and the foreshore condition index at the end of the survey.

The criteria that determine the condition of each of the foreshore parameters and the corresponding colour code are outlined at the end of each of the parameter sections.

The overall stream condition index can be determined after the foreshore parameters have been assessed. The stream condition index can be used to give an immediate summary of foreshore health collating diverse information into a simplified form. This information may be used to produce maps of the surveyed riparian foreshore, highlighting focus areas that may require rehabilitation work.

It is essential to recognise that any weed control activities or physical works in the areas assessed will automatically reduce parameters such as bank stability and habitat diversity, and therefore affect the stream's overall rating.

Having determined condition values for bank stability, foreshore vegetation, stream cover and habitat diversity you can now calculate the overall stream condition index using the table below.

Colour Code	Parameter Rating	Description
Blue (32 points)	**Excellent**	All parameters blue.
Green (22-30 points)	**Good**	Three to four parameters rated green or better with only one parameter rated yellow; no red or black ratings.
Yellow (14-20 points)	**Moderate**	Three parameters rated yellow or better with no more than one red; no black ratings.
Red (6-12 points)	**Poor**	Two or three parameters rated red with no more than one black.
Black (0-4 points)	**Very Poor**	Two or more parameters rated black.

5. Making use of foreshore reports

The foreshore assessment process is designed to assess the condition of foreshore areas and to enable ready comparison between survey sites along a specific stream and between waterways. This tool assists individuals and groups involved in hands on activities, as well as those responsible for planning within local government areas and within urban areas.

It is essential that groups, who have a specific area of interest within a waterway, also assess the environment upstream as well as tributaries feeding into the focus area; that is, an entire catchment approach is needed. This process will highlight areas of greatest vulnerability and enables managers to focus or direct activities to areas requiring the greatest support.

The needs of the entire catchment must be considered when planning alterations or rehabilitating parts of the streamline. By working with the waterway and recognising all aspects of the catchment system (including physical, biological and social), it is possible to restore a near self-managing waterway that meets several objectives.

Stream management in developed sub-catchments and catchments can generally be more readily managed than areas where final landuses have not yet been determined. This is due to limited information relating to the predicted impact on stream flow and load. Pre-emptying physical factors is extremely difficult and rarely achievable, making it more difficult to develop strategies to manage and improve stream health. In fully developed areas, management can be more difficult due to limitations associated with meeting drainage requirements, limited land availability and recreational and other human uses within the riparian zone.

To develop rehabilitation strategies based on the results of this survey it is recommended that following process be used.

5.1 Background data

Identify the cadastral data relating to the area, and from this information identify the landholder and land manager and ensure that the responsible person/agency is aware of the interest and approves of the proposed process.

5.2 Summarising results

Collate the survey results into maps for the entire waterway system of interest, assessing the physical and ecological condition of the stream and pinpoint areas of degradation and consider possible actions and priorities to reverse the deterioration. The results should be passed on to the Water and Rivers Commission to improve their baseline data on the State's waterways. Your local government authority may also be interested in this data.

It is important to note that there are a number of different ways in which actions are identified and priorities drawn. For weed control for example, the preferred system for focussing action includes developing activities which:

- *enable natural regeneration by controlling weeds around persistent native plants,*
- *target weeds which are present in low numbers; and/or*
- *maintain the level of cover and control the spread of weed species by managing the seed of weed species.*

Prioritising works needs to take into consideration the effectiveness of the action in improving the environment, cost-effectiveness and implications for long term management.

5.3 Objectives

For each priority action, determine the objectives and ultimate goal of the works, which will guide the way in which the rehabilitation design is directed. It is also important at this stage to identify sources of technical support within government agencies and other conservation organisations that may be in a position to assist in the rehabilitation design.

5.4 Develop rehabilitation design

Develop the rehabilitation design program which meets the objectives and goals determined in the previous stage. The objectives determine which method of management is feasible for each particular situation and minimises the impact on other aspects of the environment. For example, if fauna protection is a goal then weed management will need to be designed to provide sufficient corridors for animals to move along and live within - taking into account their requirement for territory and other aspects of their biology.

General considerations in rehabilitation design include: natural stream morphology, ratio of pools to riffles, sediment types, the presence of bank and instream structures, substrate, stream velocities, revegetation requirements and maintenance and monitoring systems. All works need to take into consideration the impact of any activities on the upstream and downstream environments.

A number of activities can occur concurrently with the development of the rehabilitation plan, including preparing a herbarium and gaining training in plant identification and weed control techniques, researching best management practice, identifying key agency staff who are able to provide support and advice and documenting the process. Ensuring that the local community is kept informed of the activities is also useful.

Generally it is recommended that the works occur over a period of time to ensure that people involved in the project are not overworked and can achieve maximum effect with minimum effort. This also helps to assess the effectiveness of different components of the works and enables modification of the design as required.

5.5 On-site meeting with all stakeholders

On-site plan adjustments may be required to ensure that the rehabilitation plan does not impact on existing physical and biological features of the environment. For example, if there is an existing natural riffle system which is functioning, it should not be disturbed whilst implementing additional sediment management techniques. Further, previously unidentified issues may become apparent on-site which impact on the design. Square gabions for example might prevent wildlife from readily accessing the banks of the river and require modification to provide a ramp and/or small steps to facilitate faunal movement.

An on-site meeting should be held with all interested parties walking through the site and discussing the rehabilitation plans to ensure that the proposal will meet the objectives and the requirements of all state and local government authorities with interest in the riparian zones. At this stage it is essential that the appropriate technical people have assessed and approved the proposed works and worked with the community groups and other stakeholders to schedule implementation.

5.6 Implementation

Implementation of the plan is the next stage of the process. The timing of works will be determined by the availability of resources such as labour, financial support, materials and the level of construction, weed control, planting and maintenance required. Where instream erosion management works are necessary, it is preferred that the materials used are common in the environment and are as natural as possible. This will encourage use by native fauna and minimise aesthetic disruption.

Developing a timeline for all project activities is useful. The schedule should include activities such as seed collection, organising training days, ordering plants for revegetation works, preparing a herbarium, implementing scheduled weed control works and ordering materials for structural works to ensure availability when required. The schedule should take into consideration the optimum time for each activity, for example, implementing instream works during low flow periods and ensuring sufficient time for instream revegetation works to establish before peak flows i.e: planting between September and April in permanently damp waterways.

5.7 Monitoring

The foreshore assessment process provides a baseline record against which to determine effectiveness of the stream rehabilitation works. It is important to regularly monitor the changes to the environment as a result of the works undertaken.

Unexpected changes to the environment may arise through fire, seasonal storm events and vandalism. Such occurrences may provide opportunities to implement broader works in a shorter time frame, and the proposed timelines should provide sufficient flexibility to cater for such events. Fires in severely weed infested areas, as an example, may increase access to sites that were previously impossible to move through. Broadscale herbicide applications on the re-sprouting weed species may be an appropriate management technique to prevent the site returning to the same level of degradation. Use of fire as a management tool in riparian areas is not recommended and can cause permanent damage to the plants within the riparian zone.

Monitoring changes to the stream over time using the foreshore assessment method will enable groups to assess the effectiveness of the work and the impact of the activities on the foreshore environment. It is important that monitoring is not restricted to changes in the physical and biological environment, but also includes social and behavioural changes and assessing the effectiveness of money spent.

5.8 Maintenance

All works need long term maintenance and will require significant resources. A considerable amount of time and money is likely to have been spent in developing and implementing the foreshore rehabilitation strategy. Ongoing weed control and maintenance can not be avoided and will be required every year ad infinitum. The effort put into weed control should diminish over time, but sustaining interest in managing weeds is very difficult. It is possible to create self-sustaining natural environments provided that the local community becomes aware of their role in tending to the natural environment.

The importance of sustaining maintenance and management of areas rehabilitated in previous years is vital to the success of the project in the medium to long term. Maintenance of previous works is likely to take up one third of to half of the annual effort in rehabilitation - and must be included as a vital component of the rehabilitation schedule.

Continued weed management and supported regeneration through direct seeding and replanting are unavoidable.

5.9 Community awareness and education

Increasing community awareness is a vital component of rehabilitation and revegetation projects. Decisions about management of riparian zones and waterways on privately owned land are frequently determined by the landholder. While many landholders and managers are interested in improving their foreshores, they may lack the skills to effectively develop and implement a foreshore management strategy. Other individuals may not recognise the value of the waterways and foreshore environments, and therefore require a different form of encouragement. For example, individuals involved in the activities listed below may need to be made aware of the implications of their actions.

Inappropriate activities include;

- dumping garden waste along foreshores,
- discharging water from swimming pools into local waterways,
- failing to keep dogs on leashes in reserves,
- not following established access points, and
- cutting branches from trees to enhance views.

The importance of awareness raising activities and provision of information about the different roles which residents and interest groups can take to improve and enhance the riparian zone of their local waterway can not be sufficiently emphasised.

Frequently contacting local media with news articles covering all aspects of developing and implementing rehabilitation projects, as well as holding field/information days, are effective components of any rehabilitation effort being undertaken on public land. Private landholders effectively managing their riparian zone may be able to invite members of community groups to visit their property as a demonstration of best management practice - where weed control, maintaining native vegetation within their floodway and managing erosion has improved the health of their property.

Education is an essential component of the rehabilitation process. Outlining the benefits of protecting native vegetation, improving nutrient and water management and appropriate methods to minimise erosion and management of other potential impacts along waterways should be distributed to landholders adjacent to riparian areas.

Establishing signage within foreshore reserves indicating unacceptable practices such as dumping garden waste or pruning native vegetation should also be a priority.

Advertising the activities and focussing on increasing awareness of the issues occurring within riparian zones and waterways will hopefully in the long term, improve foreshore condition. Signage can also be helpful in advising people of revegetation works occurring in the area and providing them with information about how they can get involved in supporting their waterway.

KEEPING GREEN AREAS IN URBAN ENVIRONMENTS IS BECOMING A HIGHER PRIORITY IN LAND MANAGEMENT AS GREEN SPACE IMPROVES LAND VALUES

Other points

Sustaining community interest is difficult in the implementation of long term projects, as is identifying sources of support within local and state government agencies. Funding is available through a range of programs including the Natural Heritage Trust, Gordon Reid Foundation, Lotteries Commission, some government agencies and groups such as Lions and Rotary Clubs.

Continuity of funding from these sources can not be guaranteed which makes it difficult to schedule works realistically. It is important that rehabilitation projects are inherently flexible and are broken into manageable sections, with recognition of the need for maintenance of any works undertaken previously.

Encouraging members of the community to join interest groups and to sustain interest and activity is also extremely difficult. It is essential to harness any sources of interest to become involved in the different stages of developing and implementing a rehabilitation program. Holding working bees at which the local group provides food, drinks and a friendly environment can be effective. Establishing links with school groups, retirement homes and other clubs can increase the level of involvement in such projects.

Advertising the activities and focusing on increasing awareness of the issues occurring in waterways and along foreshores will hopefully in the long term encourage residents, landholders and managers to endeavour to improve foreshore condition and keep our cities and towns green.

In conclusion, implementing a systematic approach to collecting information about waterways in conjunction with increasing environmental awareness will benefit both the environment and the community.

While this standard format may initially seem comprehensive and complicated, it is not difficult to undertake. As experience in using this system grows, using the method and developing rehabilitation strategies will become progressively easier.

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Appendix 1

Foreshore Condition Assessment Form for urban and semi-rural surveys

Foreshore Condition Assessment Form:

for urban and semi-rural surveys

General details

Recorder's Name: Contact Number: Date:

River Section Number: Length of Section:

Catchment : Stream Name:

Lot Number/Address:

Nearest Road Intersection:

Aerial Photo Reference:

Landholder contacted: Yes ☐ No ☐

Landholder consent obtained: Yes ☐ No ☐

Landholder present during survey: Yes ☐ No ☐

Bank(s) surveyed: (facing upstream)

left ☐ right ☐ both ☐

Landholder: Contact Number:

Section Sketch

Bank Stability

Profile Sketch - typical cross section

Bank Steepness/Slope	✓
 > 60˚ Very Steep	☐
 > 45-60˚ Steep	☐
 > 10-45˚ Moderate	☐
 > 0-10˚ Slight	☐

Erosion, slumping or sedimentation

Proportion of bank affected (% of survey area)	Erosion	Slumping	Sedimentation
0-5% Minimal			
5-20% Localised			
20-50% Significant			
> 50% Severe			

Stabilisation Works

Are the banks subject to any artificial stabilisation? Yes ☐ No ☐

Give details:

Other comments

Foreshore Vegetation

Native and weed species surveys should be completed on Tables 1 & 2 (attached)

Proportion cover	Overstorey	Middlestorey	Understorey
> 80% Continuous			
20-80% Patchy			
< 20% Sparse			
0% Absent			

	Proportion (%) native species
Overstorey	
Middlestorey	
Understorey	

Leaf Litter

absent ☐ minimal cover ☐ good cover ☐ deep cover ☐

Table 1: Abundance, condition and regeneration of native species

This table is an example only and species lists should be compiled relevant to the area being surveyed.

Key : Abundance:	**1** abundant	**2** frequent	**3** occasional	**4** rare
Condition:	**1** healthy	**2** some sick	**3** many sick or dying	**4** majority dead
Regeneration (seedlings/suckers):	**1** abundant	**2** frequent	**3** occasional	**4** rare

	Abundance	Condition	Regeneration		Abundance	Condition	Regeneration
TREES				**CREEPERS and GROUNDCOVERS**			
Christmas tree (*Nuytsia floribunda*)				*Cassytha flava*			
Coastal blackbutt (*Eucalyptus todtiana*)				Common clematis (*Clematis pubescens*)			
Flooded gum (*Eucalyptus rudis*)				Cottonheads (*Conostylis* spp.)			
Jarrah (*Eucalyptus marginata*)				Coral vine (*Kennedia coccinea*)			
Marri (*Corymbia calophylla*)				Native wisteria (*Hardenbergia comptoniana*)			
Modong (*Melaleuca preissiana*)				Purple flag (*Patersonia occidentalis*)			
Saltwater paperbark (*Melaleuca cuticularis*)				Running postman (*Kennedia prostrata*)			
Swamp paperbark (*Melaleuca rhaphiophylla*)							
Wandoo (*Eucalyptus wandoo*)				**RUSHES and SEDGES**			
Woody pear (*Xylomelum occidentale*)				Angle sword sedge (*Lepidosperma tetraquetrum*)			
				Centrolepis (*Centrolepis* spp.)			
SHRUBS				Finger rush (*Juncus subsecundus*)			
Blackboy (*Xanthorrhoea preissii*)				Joint leaf rush (*Juncus holoschoenus*)			
Bossiaea spp.				Jointed twig sedge (*Baumea articulata*)			
Bracken fern (*Pteridium esculentum*)				Knotted club rush (*Isolepis nodosa*)			
Common astartea (*Astartea fascicularis*)				Lake club rush (*Schoenoplectus validus*)			
Coojong (*Acacia saligna*)				Marsh club rush (*Bolboschoenus caldwellii*)			
Green stinkwood (*Jacksonia sternbergiana*)				Pale rush (*Juncus pallidus*)			
Grey stinkwood (*Jacksonia furcellata*)				Pithy sword sedge (*Lepidosperma longitudinale*)			
Harsh hakea (*Hakea prostrata*)				*Restio* spp.			
Kunzea spp.				Sedges (*Carex* spp.)			
Leucopogon spp.				Shore rush (*Juncus kraussii*)			
Narrow leaved oxylobium (*Oxylobium lineare*)				Spreading sword sedge (*Lepidosperma effusum*)			
Native albizia (*Paraserianthes lophantha*)				Tufted sedge (*Isolepis setiformis*)			
Native buttercups (*Hibbertia spp.*)							
Prickly moses (*Acacia pulchella*)				**GRASSES**			
Regelia ciliata				Kangaroo grass (*Themeda australis*)			
Robin redbreast bush (*Melaleuca viminea*)				Mat grass (*Hemarthria uncinata*)			
Swamp peppermint (*Agonis linearifolia*)				*Notodanthonia* spp.			
Swamp teatree (*Pericalymma ellipticum*)				Saltwater couch (*Sporobolus virginicus*)			
Swan River myrtle (*Hypocalymma robustum*)							
Swishbush (*Viminaria juncea*)				**HERBS**			
Thomasia spp.				Button weed (*Cotula coronopifolia*)			
Trymalium ledifolium				Centella (*Centella cordifolia*)			
Two leaved hakea (*Hakea trifurcata*)							
Variable leaved grevillea (*Grevillea diversifolia*)				**EMERGENT and FLOATING**			
White myrtle (*Hypocalymma angustifolium*)				Azolla (*Azolla* spp.)			
Winged wattle (*Acacia alata*)				Duckweed (*Lemna* spp.)			
Zamia (*Macrozamia reidlei*)				Ribbon weed (*Vallisneria gigantea*)			
				Water ribbons (*Triglochin procera*)			
OTHER							

Table 2: Abundance of weeds species

This table is an example only and species lists should be compiled relevant to the area being surveyed.

Key : Abundance:	**1** abundant	**2** frequent	**3** occasional	**4** rare

PRIORITYONE WEEDS		**Grasses**	
Blackberry (*Rubus fruticosus*)		African lovegrass (*Eragrostis curvula*)	
Bridal creeper (*Myrsiphyllum asparagoides*)		Blowfly grass, shivery grass (*Briza* spp.)	
Hydrocotyle (*Hydrocotyle ranunculoides*)		Couch grass (*Cynodon dactylon*)	
Perennial veldt grass (*Ehrharta calycina*)		Fountain Grass (*Pennisetum setaceum*)	
Watsonia (*Watsonia bulbillifera*)		Guildford grass (*Romulea rosea*)	
		Kikuyu (*Pennisetum clandestinum*)	
OTHER ENVIRONMENTALWEEDS		Pampas grass (*Cortaderia selloana*)	
Trees and shrubs		Paspalum (*Paspalum* spp.)	
Castor oil (*Ricinus communis*)		Phalaris (*Phalaris* spp.)	
Coral tree (*Erythrina x sykesii*)		Red natal grass (*Rhynchelytrum repens*)	
Japanese pepper (*Schinus terebinthifolia*)		Ryegrass (*Lolium* spp.)	
Poplars (*Populus* spp.)		Wild oats (*Avena fatua*)	
Radiata pine (*Pinus radiata*)			
Tagasaste (*Chamaecytisus palmensis*)		**Climbers and Creepers**	
Victorian tea-tree (*Leptospermum laevigatum*)		Black-eyed susan (*Tetratheca hirsuta*)	
Weed wattles (*Acacia* spp.)		Dolichos pea (*Dipogon lignosus*)	
Willows (*Salix* spp.)		Lantana (*Lantana camara*)	
Edible Fig Tree (*Ficus* spp.)		Morning glory (*Ipomoea* spp.)	
Olive Tree (*Olea europaea*)		Nasturtium (*Tropeolum* spp.)	
		Periwinkle (*Vinca major*)	
Perennials			
Arum lily (*Zantedeschia aethiopica*)		**Rushes, Sedges and Reeds**	
Cotton bush (*Gomphocarpus fruticosus*)		Bulrush (*Typha orientalis*)	
Deadly nightshade (*Solanum nigrum*)		*Cyperus* spp.	
Dock (*Rumex* spp.)		Giant reed (*Arundo donax*)	
Fennel (*Foeniculum vulgare*)		*Juncus articulatus*	
Rose pelargonium (*Pelargonium capitatum*))			
Ribwort plantain (*Plantago lanceolata*)		**Aquatic**	
		Aponogeton elongatus	
Annually Renewed from Bulbs and Corms		Elephant ear (*Alocasia brisbanensis*)	
Freesia (*Freesia aff. leichtlinii*)		Watercress (*Rorippa nasturtium-aquaticum*)	
Gladiolus (*Gladiolus* spp.)		Water lilies (*Nymphaea* spp.)	
One leaf cape tulip (*Homeria flaccida*)			
One leaf cape tulip (*Homeria flaccida*)			
Three-cornered garlic (*Allium triquetrum*)		**OTHER**	
Annuals			
Bushy starwort (*Aster subulatus*)			
Capeweed (*Arctotheca calendula*)			
Fat hen (*Chenopodium album*)			
Fleabane (*Conyza* spp.)			
Soursob (*Oxalis pes-caprae*)			
Thistles (*Centaurea* spp.)			
Vetch (*Vicia sativa*)			
Wild radish (*Raphanus raphanistrum*)			
Whiteflower fumitory (*Fumaria capreolata*)			

Stream Cover

Abundance of stream cover

Native vegetation: abundant ☐ frequent ☐ occasional ☐ rare ☐ absent ☐

Exotic vegetation: abundant ☐ frequent ☐ occasional ☐ rare ☐ absent ☐

Deciduous Trees

Are deciduous trees present? Yes ☐ No ☐

Instream cover

leaf litter/detritus ☐ rocks ☐ branches ☐ vegetation ☐

Comments

Habitat Diversity

Is there **permanent water**? Yes ☐ No ☐ Uncertain ☐

Any data or observations on variation in **water depth**?

Any data or observations on **water quality?** (discoloured water, debris, algal blooms)

Any wildlife (or evidence of presence) observed?

Habitats

Aquatic organisms

Invertebrates, reptiles and fish

- ☐ cascades, rapids, riffles
- ☐ meanders, pools
- ☐ instream cobbles, rocks
- ☐ instream logs
- ☐ variety of instream and bank vegetation types

Terrestrial animals

Invertebrates

- ☐ variety of vegetation types
- ☐ protected basking sites (tree bark, leaf litter)

Birds (roosting/nesting sites)

- ☐ trees
- ☐ shrubs
- ☐ rushes

Frogs

- ☐ dense streamside vegetation
- ☐ emergent plants/soft substrate for eggs

Reptiles

- ☐ variety of vegetation types
- ☐ protected basking nesting sites (leaf litter, logs)

Mammals

- ☐ dense protective vegetation

Additional Information

Disturbance Factors

- ☐ Rubbish
- ☐ Garden refuse
- ☐ Service corridors
- ☐ Stock in river
- ☐ Grazing
- ☐ Crossing point
- ☐ Fire (e.g. blackened plants/bark)
- ☐ Disease (e.g. defoliated trees and shrubs)
- ☐ Point source discharge
- ☐ Pumps or off take pipes
- ☐ Dam/Weir
- ☐ Hydrological disturbance
- ☐ Feral animals (e.g. rabbit droppings)
- ☐ Vandalism
- ☐ Antisocial behaviour (e.g. syringes)

Other (please describe):

Surrounding Land Use

- ☐ Reserve (give details - e.g. bush/parkland) .....
- ☐ Vehicle infrastructure (e.g. road, car park)
- ☐ Industrial
- ☐ Commercial
- ☐ Residential
- ☐ Residential bushland
- ☐ Rural
- ☐ Semi rural
- ☐ Irrigated area
- ☐ Orchards
- ☐ Crops/Market Garden
- ☐ Sown pasture
- ☐ Livestock (specify).....
- ☐ Agriculture WA trials (describe) .....
- ☐ Landscape/exotics

Other (please describe):

Evidence of Management

- ☐ Prescribed burning
- ☐ Firebreak control
- ☐ Fencing
- ☐ Nest boxes
- ☐ Recreational facilities (e.g. rubbish bins BBQ's, benches
- ☐ Signs
- ☐ Planting
- ☐ Weed control
- ☐ Erosion control
- ☐ Earthworks
- ☐ Dredging

Other (please describe):

Cultural Value

Are there any known sites of Aboriginal significance? (Give details)

Other cultural, scenic or recreational values?

Additional Comments

Weather conditions

Safety/health hazards

Other data

Summary Codes

Indicate colour when survey is complete.

Parameters	Bank Stability	Foreshore Vegetation	Stream Cover	Habitat Diversity	Stream Condition Index
					
Colour					
Condition					
Score					

Refer to Appendix 2 for Stream Condition Index .

Colour	Condition	Score
Blue	Excellent	8
Green	Good	6
Yellow	Moderate	4
Red	Poor	2
Black	Very Poor	0

Appendix 2

Summary of the foreshore condition parameters and overall stream condition index

Appendix 2: Determining summary foreshore health

	Blue - Excellent 8 points	Green - Good 6 points	Yellow - Moderate 4 points	Red - Poor 2 points	Black - Very poor 0 points
Bank Stability	No erosion, slumping or sediment deposits; dense native vegetation cover on banks and verge; no evidence of disturbance or areas of exposed soil.	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.	Some localised erosion, slumping and sediment deposits; native vegetation cover on verges may be patchy and interspersed with patches of exposed soil.	Extensive active erosion slumping and sediment desposition particularly during peak flows; bare banks and verges common.	Almost continuous erosion; over 50% of banks slumping; sediment heaps line or fill much of the floodway; little or no vegetation cover.
Foreshore vegetation	Healthy, undisturbed native vegetation with structure intact and verges more than 20 m wide; no weed or signs of disturbance evident.	Vegetation structure dominated by native plants that comprise 80 - 100% of the total number of species; only scattered weeds or rarely evident in small clusters; nil or minor signs of disturbance (i.e: tracks, rubbish dumping).	Some changes in vegetation structure, native plants comprising of 50 - 80% of the total species composition; little regeneration of trees and shrubs; weeds occurring occasionally; moderate levels of disturbance.	Modified vegetation structure with native plants comprising only 20 - 50% of the total species composition. Trees remain with only scattered shrubs and an understorey dominated by weeds; high prevalence of disturbance.	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.
Stream Cover	Abundant stream cover from dense overhanging vegetation providing almost continuous shade; frequent instream cover from aquatic vegetation and/or leaf litter, rocks or logs.	Abundant shade from overhanging vegetation; occasional instream cover from patches of aquatic vegetation and isolated heaps of leaf litter or rocks and logs.	Scattered fringing vegetation with occasional patches of shade; infrequent instream cover with little aquatic vegetation, very infrequent rocks and logs.	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.	Zero or minimal stream cover with no permanently shaded areas and no instream cover.

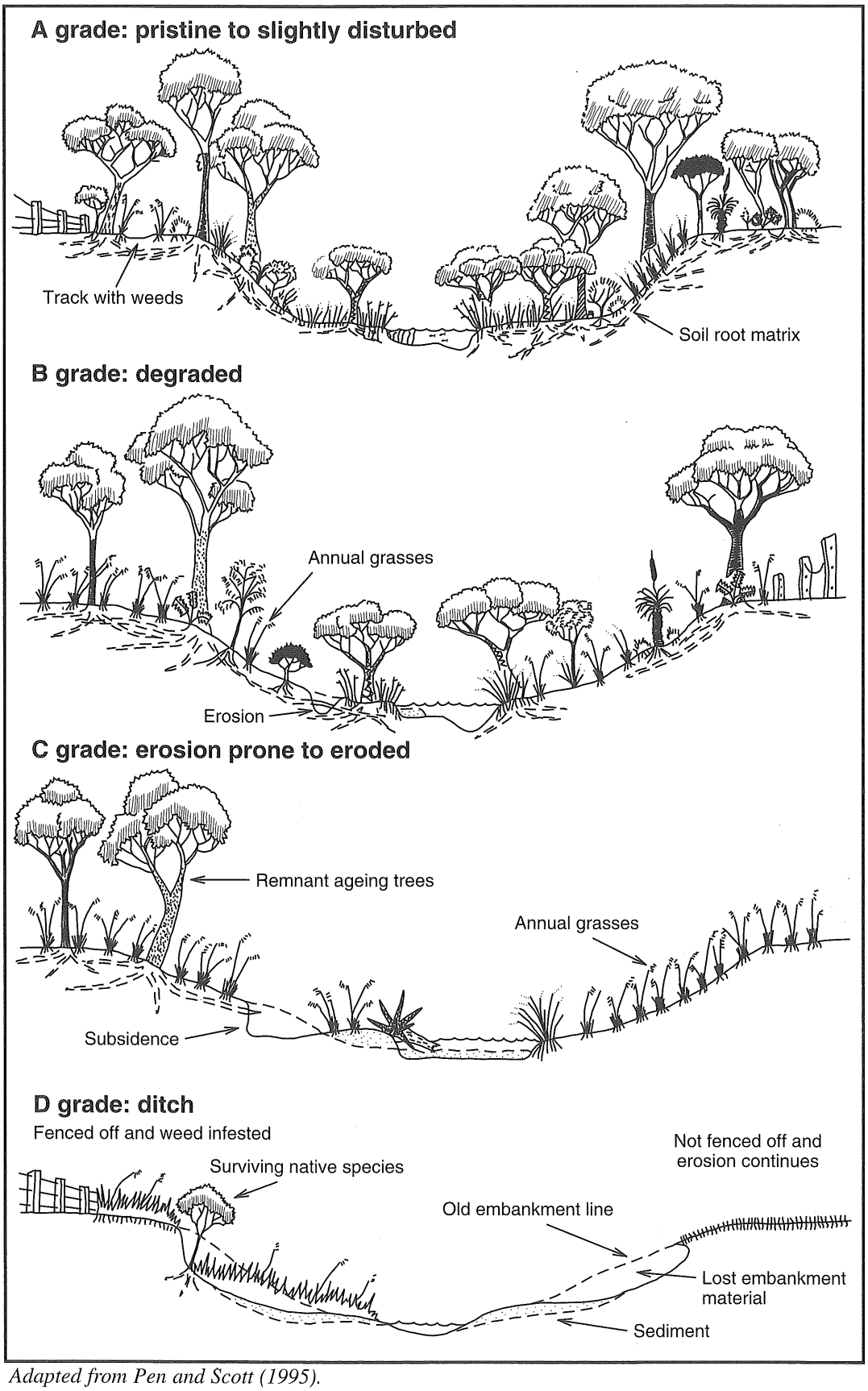
	Blue - Excellent 8 points	Green - Good 6 points	Yellow - Moderate 4 points	Red - Poor 2 points	Black - Very poor 0 points
Habitat Diversity	Excellent water quality with permanent water (i.e: pools and creeks); three or more aquatic and terrestrial habitats including diverse vegetation types, edge waters, instream cascades, riffles, pools and woody debris.	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).	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.	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.	Poor water quality; almost no healthy habitats available for aquatic and terrestrial organisms.

Colour Code	Parameter Rating	Description
Blue (32 points)	**Excellent**	All parameters blue.
Green (22-30 points)	**Good**	Three to four parameters rated green or better with only one parameter rated yellow; no red or black ratings.
Yellow (14-20 points)	**Moderate**	Three parameters rated yellow or better with no more than one red; no black ratings.
Red (6-12 points)	**Poor**	Two or three parameters rated red with no more than one black.
Black (0-4 points)	**Very Poor**	Two or more parameters rated black.

Appendix 3

River foreshore condition assessment in farming areas

Appendix 3: River Foreshore Condition Assessment in Farming Areas.



Adapted from Pen and Scott (1995).

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Appendix 4

Condition mapping symbols

Weeds

Symbol	Common name	Scientific name
⋈	Weed wattles	*Acacia spp.*
|||||||	Giant reed	*Arundo donax*
❀	Canna lily	*Canna spp.*
*	Pampas grass	*Cortaderia selloana*
◑	Perennial veldtgrass	*Ehrharta calycina*
⊕	African lovegrass	*Eragrostis curvula*
C	Coral tree	*Erythrina x sykesii*
⊤	Edible fig tree	*Ficus spp.*
Z	Cotton bush	*Gomphocarpus fruticosus*
△	One leaf cape tulip	*Homeria flaccida*
⌒	Morning glory	*Ipomoea spp.*
⊞		*Juncus microcephalus*
ⓗ	Lantana	*Lantana camara*
◹	Bridal creeper	*Myrsiphyllum asparagoides*
∩	Paspalum	*Paspalum spp.*
♦	Castor oil bush	*Ricinus communis*
#	Blackberry	*Rubus fruticosus*
⌐	Willow	*Salix spp.*
●	Japanese pepper	*Schinus terebinthifolia*
S	Deadly nightshade	*Solanum nigrum*
∞	Nasturtium	*Tropeolum spp.*
★	Bulrush	*Typha orientalis*
⊷	Vetch	*Vicia sativa*
≤	Watsonia	*Watsonia bulbillifera*
⊗	Arum lily	*Zantedeschia aethiopica*

Native Species

Symbol	Common name	Scientific name
Al	Swamp peppermint	*Agonis linearifolia*
As	Coojong	*Acacia saligna*
Ba	Slender banksia	*Banksia attenuata*
Bj	Bare twigrush	*Baumea juncea*
Ca	Tall sedge	*Carex appressa*
Cc	Marri	*Corymbia calophylla*
Er	Flooded gum	*Eucalyptus rudis*
Hc	Native wisteria	*Hardenbergia comptoniana*
Jp	Pale rush	*Juncus pallidus*
Js	Green stinkwood	*Jacksonia sternbergiana*
Kp	Running postman	*Kennedia prostrata*
Ll	Pithy sword-sedge	*Lepidosperma longitudinale*
Lt	Angle sword-sedge	*Lepidosperma tetraquetrum*
Mr	Swamp paperbark	*Melaleuca rhaphiophylla*
Ol	Narrow-leaved Oxylobium	*Oxylobium lineare*
Pe	Bracken fern	*Pteridium esculentum*
Vj	Swishbush	*Viminaria juncea*

Cadastral and Streetsmart data supplied by the Dept. of Land Administration (1998)

Map Legend