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Wimmera Catchment Management Authority

Waterways for Life.

Spring & Tuckers Creek Waterway Action Plan

- Final
- 4 August 2006

action Salinity & Water AUSTRALIA

Victoria The Place To Be

Spring & Tuckers Creek Waterway Action Plan

- Final
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Contents

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Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
Draft V1	05 May 2006	T. Dando	T. Dando	05 May 2006	Draft for WCMA Review
Draft V2	26 May 2006	T. Dando	T. Dando	26 May 2006	Draft for Comment
Draft V3	13 June 2006	D. Hunter	D. Hunter	13 June 2006	Final Draft
Final	4 August 2006	M. Hillemacher	T. Dando	4 August 2006	Final

Distribution of copies

Revision	Copy no	Quantity	Issued to
Draft	1	3	Rachel Smith (Wimmera CMA)
Draft V2	1	1	Rachel Smith (Wimmera CMA)
Final	1	1	Rachel Smith (WCMA)

Printed:	27 September 2006
Last saved:	4 August 2006 03:06 PM
File name:	D:\Projects\WC03502\Spring_Tuckers\Deliverables\STWAP_Final 040806.doc
Author:	Martin Hillemacher, Scott Seymour, Daniel Hunter
Project manager:	Trevor Dando
Name of organisation:	Wimmera CMA
Name of project:	Wimmera River Waterway Action Plan – Spring & Tuckers Creek
Name of document:	Wimmera River Waterway Action Plan – Spring & Tuckers Creek
Document version:	Final
Project number:	WC03502.200

Glossary

Term	Definition
Aggradation	The process of raising the bed level of a stream through deposition of sediment
Alluvial	Sediment deposited by flowing water, in a riverbed, flood plain, or delta
Bedrock	Exposed solid rock that underlies loose material, such as soil, sand, clay, or gravel
Bedload	Coarse solids transported by flows
Bench	A level elevation of deposited material attached to a stream bank that exists between the streambed and the floodplain
Degradation	A decline or lowering of the condition/quality, of the stream or floodplain
Erosion	Processes, such as weathering, dissolution, abrasion, and transportation, by which material is worn away from a surface
Geomorphology (morphology)	The branch of geology that studies the characteristics and configuration and evolution of rocks, land forms
Headcut	Vertical or near vertical drop in channel elevation greater than 300mm
Hyporheic	The interstitial spaces and voids (habitat) in the bed through which sub surface flows percolate
Incision	Lowering of a waterways bed level through water erosion
Reach	A stream management unit i.e. a segment of a waterway
Riparian	Of, on, or relating to the banks of a natural water course.
Turbidity	Muddiness created by stirring up sediment or having foreign particles suspended in water

Executive Summary

The Spring and Tuckers Creek Waterway Action Plan is one of many such plans being prepared by the Wimmera Catchment Management Authority (Wimmera CMA) as part of a program to identify works and activities across the Wimmera catchments that are needed to manage the stream systems with a view to improving the river health over time. This Plan covers the streams within the Spring and Tuckers Creek catchment. The catchment extends from the rocky hills that rise 8.5 km's north east of the Crowlands township and extends down to the Wimmera River at Crowlands.

The Plan focuses on addressing Wimmera CMA's key waterway management responsibilities and priorities as outlined in the Wimmera Waterway Health Strategy (2006). A key output of the plan is the identification and prioritisation of issues and actions that exist within the catchment boundary. Many of these actions will be progressively implemented over the next 5 to10 years.

The plan also provides an accessible form of information and analysis of the key waterway issues so that landholders and agencies can deliver a coordinated and well planed strategic response. It is hoped that this Plan will encourage landowners and community groups to work in partnership with Wimmera CMA to implement necessary works along the main creeks and tributary stream corridors.

Spring Creek and its tributaries contain both permanent and seasonal ephemeral streams. Tuckers Creek and its tributaries consist of ephemeral creeks only.

Following European settlement the Spring and Tuckers Creek catchment was subjected to widespread land clearance. This triggered a range of degradation processes including stream incision, tunnelling and gullying. As a result the streams have changed from minor well vegetated channels and or vegetated valleys to what are now highly unstable and deeply incised channels. The incision and gulley erosion process has occurred in most of the cleared areas with only those with some remnant forest cover not displaying the massive erosion responses. Most of the sediment that has eroded from these waterways has been either transported directly into the Wimmera River or deposited on the floodplain.

The resultant impact on water quality and instream values in the catchment and on the Wimmera River is significant. In particular the impacts of salinity, high sediment and suspended solids loads and very high turbidity levels are negatively impacting on the receiving waters of the Wimmera River.

Improved health of the Spring and Tuckers catchment will assist in limiting the sediment load on downstream waterways including high value segments of the Wimmera River.

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Whist a number of intervention efforts have been previously undertaken throughout the catchment, including the installation of wooden pile fields, many of these actions have only been partially successful and in some case have actually failed. Success is most evident where landowners have taken a strong long-term interest in the sustainability of the works and have followed through with coordinated and required maintenance works. Some of these areas and tributaries need follow up work to secure the good successes, but unfortunately many areas are still actively eroding and need further intervention. Without additional intervention many of these streams have the potential to degrade much further.

Very few remnant or high value environmental attributes were observed in the catchment that would occur in a healthy stream system. Many of the streams are highly saline and have unstable physical forms with large dynamic transportable sediment loads that preclude the establishment of an environment that would support any substantial stream ecosystem.

Whilst the ecosystem values and attributes have declined, sufficient values still remain to improve the health of the streams to a healthy state. A combination of key responses will be required to achieve this including:

- Stabilising stream erosion in the mainstem and tributaries through stabilisation and revegetation programs;
- The reconnection of key riparian linkages along the streams;
- The rehabilitation of past Wimmera CMA and former SCA works to secure the function and integrity of those works;
- Control stock access through cooperative fencing and revegetation programs with land owners;
- The establishment of innovative and improved stock watering arrangements with landowners to lessen the impacts of stock on the riverine environment;
- The study of, protection and enhancement of seasonal wetlands and sediment stores for the important water quality treatment role;
- The support and coordination of interagency programs tackling salinity management, soil management and sustainable land uses;
- The support of weed management programs along all streams; and
- Increased monitoring of water quality and instream fauna across the system to better inform management programs.

The investigation process undertaken for this study included a review of the relevant previous studies, aerial photography analysis, a information collection process with local landholders and agencies, followed by an on-ground inspection of the entire catchment.

Significant works have previously been implemented throughout the catchment by the former Soil Conservation Authority, landowners and Wimmera CMA in an attempt to achieve a state of stability. However, many of the waterways show marked indications of recent disturbances and a lot of additional work is still needed. This will require a coordinated effort on the part of landowners, Wimmera CMA and supporting agencies.

1. Introduction

1.1 What is a Waterway Action Plan

A Waterway Action Plan (WAP) is a document that details the condition of a catchment and individual reaches of waterways within that catchment and identifies site-specific actions to promote improved health and stability of these waterways.

The objective of Waterway Action Plans is to identify:

- the existing condition of the riparian zone;
- condition and extent of riparian vegetation (and fencing);
- location of weed infestations;
- bed and bank instabilities;
- the existing condition of instream habitat;
- guide appropriate management; and
- facilitate the implementation of waterway works where required.

The intent of this Waterway Action Plan is to provide the above information in an easily accessible form for users to understand. The Waterway Action Plan sets out both strategic directions and site-specific needs and outlines actions to address key issues associated with specific reaches of waterways. It also sets a framework from which Wimmera CMA is able to prioritise rehabilitation works over the next 5 to10 years. It is important to note that while the Waterway Action Plan defines the needs of specific projects it does not contain detailed project prescriptions or detailed costing estimates. These are additional tasks that will be undertaken at the implementation stage of respective projects.

1.2 Objectives of the Wimmera Waterway Action Plans

This plan focuses on key waterway issues for which the Wimmera Catchment Management Authority (Wimmera CMA) is responsible, namely:

- Progressive reduction in the amount of sediment, suspended solids and turbidity originating from the Spring and Tuckers Creeks and tributaries to the Wimmera River;
- Protection of the existing floodplains and wetlands for their water quality treatment role;
- Rehabilitation of unstable waterways and gullies through tackling bed and bank erosion and rehabilitation of old structures;
- Protection and enhancement of existing high value riparian areas to achieve an improvement in riparian vegetation condition with a key focus on regional biodiversity connection;
- Protection and rehabilitation of existing high value and critical instream habitat areas; and

- Supporting the attainment of the Regional Salinity Management Plan.

It sets out a framework by which Wimmera CMA is able to prioritise rehabilitation works over the next five to ten years.

Wimmera CMA will address the following aims through the development of this Waterway Action Plan:

1) establish a set of objectives for the management of the stream systems with a view to improving the river health over time;
2) produce a plan that focuses on key waterway management issues in Wimmera CMA's scope of responsibilities and priorities as outlined in the Wimmera Regional River Health Plan, such that an outline works program for the stream can be identified for the next 5 to 10 years;
3) provide an accessible form of information and analysis of key waterway issues so that other agencies organisations and community groups are aware of those issues and the plan's prioritisation of works; and
4) encourage landowners and community groups to be aware of the plan's contents, which provide a framework for undertaking additional planning or works along the stream corridors, and addressing their responsibilities in the areas of land management. Waterway Action Plans thus present an opportunity to assist coordination between management authorities and have the potential to promote a shared vision for the waterways between Councils, DPI, DSE, Wimmera CMA the community and other stakeholders.

1.3 Project Scope

The scope of this project is to develop a report and set of maps that documents appropriate management techniques for the Spring and Tuckers Creek system over the next 5 to 10 years.

1.4 Key Tasks

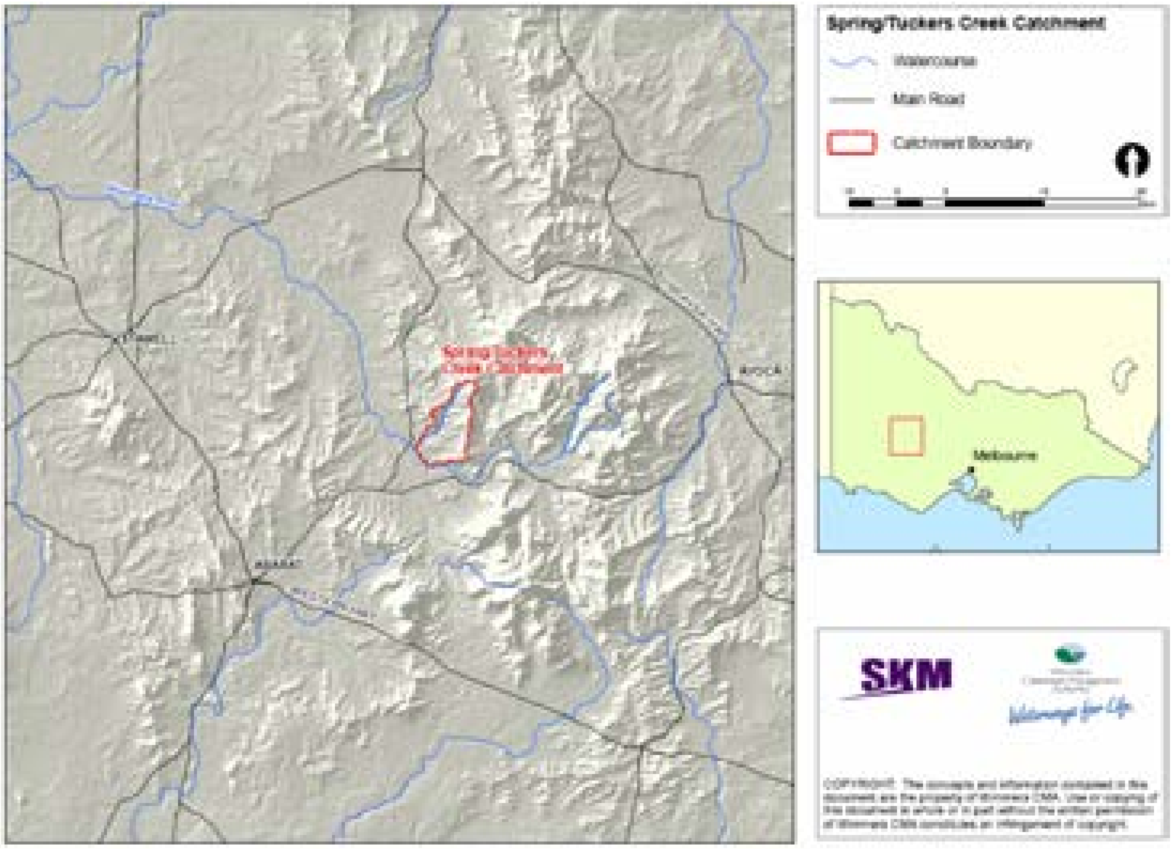
The following key tasks have been completed to achieve the above:

- Review of available information including relevant state and regional strategies, reports, aerial photography, longitudinal profiles, water quality information etc;
- Consultation with stakeholders, i.e. department organisations;
- Consultation with the community i.e. landholders;
- Aerial and on-ground inspection of the catchment;
- Division of the catchment into smaller 'sub-catchments' or 'reaches';
- Development of detailed sub-catchment management plans that detail the risks and opportunities within each sub-catchment;
- Identification of bed and bank instabilities;

- Identification of pest plant and animal species that may pose a threat to waterway health at a sub reach scale;
- Assessment of the extent and condition of riparian vegetation and fencing at a sub reach scale;
- Identification of high value assets and identification of opportunities to help secure these assets;
- Prioritisation of management actions;
- Development of detailed sub-catchment maps showing the location of proposed management actions;
- Provision of an indicative budget to undertake management actions; and
- Development of the WAP with a “Landscape” or whole of catchment approach to natural resource management (NRM), giving consideration for other natural resource management (NRM) programs and projects planned or underway within the catchment.

1.5 Catchment Location

The Spring and Tuckers Creek catchment is located near Crowlands in Western Victoria. The catchment boundary for this study covers an area of approximately 30 km^2 which discharges into the Wimmera River, as shown in Figure 1-1 below



▪ **Figure 1-1 Location of the Spring and Tuckers Creek Catchment**

1.6 Major waterways in the Catchment

Spring and Tuckers Creeks are the only formally named waterways in the catchment. A major subcatchment of Tuckers Creek is locally known as 'Tuckers Creek No 2' or 'Williams' Creek. For the purposes of this report it will be referred to as Tuckers Creek No 2 from this point on.

There are numerous unnamed tributaries throughout the system.

1.7 Relevant Reports and Background Information

Spring and Tuckers Creek are part of the upper Wimmera River catchment. Regional strategies and policies that are relevant to this WAP include:

- Victorian River Health Strategy (2002)
- Wimmera Regional Catchment Strategy (2004)
- Draft Wimmera Waterway Health Strategy (2006)
- Wimmera Water Quality Strategy (2002)

- Wimmera River Geomorphic Investigation (2001)
- Geomorphic Categorisation and Stream Condition Assessment of the Wimmera River Catchment (2003).

This Waterway Action Plan has been compiled in line with the key management actions, objectives, goals and recommendations set out in these documents.

1.8 Supporting Programs

Wimmera CMA, together with DSE and DPI are the principle authorities responsible for delivering the recommendations of these strategies and policies on a regional basis. Collaborative programs that play a vital role in supporting these objectives include:

- Wimmera Weed Action Plan (2000)
- Wimmera Water Quality Strategy (2002)
- Wimmera Salinity Management Plan (2005)
- Steep Hill Country Management Plan
- Whole Farm Planning
- Wimmera Rabbit Management Action Plan (2000)
- Victorian Pest Management Framework (DSE, 2002)
- Pyrenees Shire Planning Schemes
- Crowlands Landcare Group
- Project Platypus

1.9 Management Strategy and Rationale

The management objectives for the Wimmera River and its tributaries are derived from several levels. Firstly there is State level of policy and broad objectives as set out in the Victorian River Health Strategy (2002). The vision from this document is in the nature of ‘a beacon on the hill’ - a long term conceptual and aspirational goal that the States rivers of greatest value to the community will be protected as part of our natural heritage and that the States rivers will be ecologically healthy, managed within healthy catchments. This vision is the driver of the activities for the future. The goals include a series of clearly enunciated management approach including:

- Protecting the rivers that are of highest community value from any decline in condition;
- Maintaining the condition of ecologically healthy rivers;
- Achieving an ‘overall improvement’ in the environmental condition of the remainder of the State’s rivers; and
- Preventing damage from future management activities.

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The second level of management objectives are derived from the Draft Wimmera Waterway Health Strategy (2006). This document again contains a number of higher level objectives, but the most pertinent to this study are to:

- Improve the quality of water from the catchments entering the region's waterways;
- Improve in-stream habitat by measures such as fish passage, environmental flow and promotion of efficient water use;
- Rehabilitate waterways through on-ground works that target bed and bank erosion, sedimentation and gully erosion;
- Implement bed stabilisation in the upper Wimmera River and its tributaries;
- Repair and maintain priority structural assets in regional waterways;
- Protect and rehabilitate streamside frontage on the region's waterways while protecting cultural heritage and biodiversity values;
- Promote the adoption of the Healthy Waterways Incentive Scheme through out the region;
- Increase knowledge and awareness of waterway health issues.

The overarching environmental management objective is to maintain and where possible rehabilitate the environmental values of the waterways in the catchment. The rehabilitation of Spring and Tuckers Creeks, reducing sediment loads being transported to the Wimmera River and re-establishing the environmental connection along the streams are a key initiative in this process.

The management of stream erosion and degraded environmental values will require commitment and hard work over the long term and will only succeed through the establishment of a highly collaborative and long term partnership approach with landowners through whose land the streams flow. This approach will need to respect the mutual goals of waterway and farm management. The vexed issue of access for stock to the waterways will need to be addressed by innovative means to satisfy both the need for provision of access of stock to water, and the need to rehabilitate the waterways structurally and vegetatively.

The impact of the drought has had a marked effect on the health of both the land system and that of the streams and the decline of values is marked as a result.

This Waterway Action Plan for the Spring and Tuckers Creeks systems, considers both the high level State wide goals, but also critically takes account of the unique issues that affect the high value segments of the Wimmera River located downstream and recommends an array of actions to address those issues. Future implementation works will need to initially consider the most urgent actions, but also consider the matrix effect of many other issues.

Whilst some good work has been done in the Spring and Tuckers Creeks in the past few years, there is a significant need to revisit the success of those works and ensure that the whole package is addressed over the next 5 – 10 years to ensure that the streams are returned to a sustainable state. The observations in the field showed that the streams in the Spring and Tuckers Creek system are highly dynamic and could rapidly deteriorate in the return of normal wet winters or through an episodic rainfall event. To allow the streams to continue to decline will only see significant loss of both farm and waterway values.

2. Catchment Description

2.1 Whole of Catchment Overview

This section provides an overview of the catchment generally. A more detailed analysis on a reach by reach basis is provided in Sections 4 to 7.

The hills at the upstream end of the Spring and Tuckers Creek system have little woodland cover except a few patches to the north east on the catchment divide. The geology of these ranges is a mix of sedimentary materials such as sandstones, red shale and slates. The foothill slopes consist of weathered colluvium containing cobbles over deeper clays derived from sea transgression during the Miocen period. Streams that intersect these slopes are prone to incision and erosion and are often quite saline. The long term erosive processes over the catchment have produced a series of sediment stores in a range of foothill fans along the stream lines and in the associated floodplains and terraces down the valleys. These storage areas can be seen to have reducing particle sizes as the streams move downstream and gradients flatten. The streams have developed wider floodplain sediment stores in the less confined valleys. In the steeper upper catchments where the valleys have higher gradients and are more confined, the material is constantly being reworked. A large cobble load is being won from the colluvium of the banks in these areas. The lower segments of the streams do not have the cobbles but have silts, sands and gravels including quartz won from the many quartz beds. The bed load is relatively large and is being continually reworked in high intensity runoff events.

Other than a few remnant patches of Grey Box woodlands, the catchment is predominantly cleared. Clearance was undertaken after the establishment of the Tulkara Railway in 1910, with most of the woodland community removed and replaced with perennial pastures or annual crops.

The region has a semi arid climate, with a strong pattern of winter and spring rainfall of between 600mm on some of the higher slopes down to 400 mm on the lower plains. The porous nature of the geology results in springs occurring at the break of slope as well as a small salty base flow above the less porous clay materials. The porous nature of the soils means that substantial runoff only occurs after the infiltration rate is exceeded. The stream erosion in the catchments is driven by several factors. The small wicking flows that cause tunnelling and collapse in the weak and highly slaking subsoils as well as the rapid erosion under episodic rainfall; events where high intensities create rapid run off along the steep valley lines, and high stream powers that can not only move large cobbles in the bed but also see rapid incision of the already incised streams.

Except for the occasional summer convection storm event, runoff is predominantly generated in the winter and spring period. No flow monitoring data is available in the catchment. The lack of vegetation across the catchment and particularly along the stream corridors results in increased runoff coefficients. This impact of this is that surface runoff will be exported out of the catchment at a far higher rate than that which would occur from a wooded and well vegetated catchment. Major flows are likely to occur for a relatively short duration of a few hours to a day with near base flows being resumed relatively quickly.

As indicated earlier, base flows for the Spring and Tuckers stream system consist mainly of saline groundwater and spring fed flows derived from the porous geology of the catchment.

In longer drought sequences, flows in the creeks will cease to flow above ground, but will still occur in the sand and gravel substrates below the surface. At the time of this study, the base flow level was very low. Sub surface flows were observed in the coarser sediments of the stream bed at the lower end of the catchment. Pools only existed immediately upstream of Spring Flat Road.

The lower reach of Spring Creek has incised deeply into the former Pleistocene floodplain with significant amounts of material having being transported through to the Wimmera River. Much of Tuckers Creek has also incised, but is not carrying any substantial new bed loads due to stabilisation of the incision process. Both incisions are likely to have been instigated by stream channelisation and straightening and/or realignment works associated with the Tulkara Railway construction. Large historic loads of sediment have been transported into the Wimmera River and have been deposited onto the floodplain. A clear example of this is the gravel reserve that exists between the old railway embankment and the Wimmera River. The potential for reactivation of bed loads and transport is very high, particularly in the case of Spring Creek where there are readily erodible sediment stores that could be remobilised and transported under major flow conditions. Not withstanding this, the finer fractions and colloidal material will be transported down the stream system in relatively small events.

There is a need to address widespread erosion occurring across the catchment. Key tasks will be to prevent current process from continuing and also the protection and enhancement of sediment stores. This will primarily involve encouraging the streams to infill and store sediments and developing sustainable channel dimensions that reflect catchment size.

2.1.1 Water Quality

Water Quality is one of the key environmental and ecological factors that determine Stream Health. Water quality can be characterised by a range of parameters and include salinity, dissolved oxygen (DO), nutrients, pH and suspended solids and turbidity. With respect to the Spring and Tuckers Creek system no recorded data is available to assess the water quality The key factors that are likely to be of concern are those of salinity, suspended solids (both coarse and fine) and nutrients. At the time of field inspections, the streams were at very low flow levels, likely to be the result of a 7-8 year extended drought period. Large flow events were recorded in the area in February 2005 and June 2005, with the former being seen to have large impacts on erosion in the catchment.

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Salinity is often measured by Electro-conductivity (EC) or total dissolved solids (TDS). High TDS levels are usually caused by the presence of potassium, chlorides and sodium. Generally, a high salt content in a riverine environment will result in less fauna and flora species diversity and abundance. Similarly, a higher quality riverine environment is often typified by freshwater environments with low salt levels.

Suspended solids can vary in size from very fine colloidal material to coarse bedload material. The impacts of suspended solids can be severe. Fine suspended sediments can lead to the displacement of species that rely on gills for oxygen transfer and coarser materials can often smother or lead to gross sedimentation of physical habitats, resulting in a decline in habitat quality and abundance. Coarse material is often measured by weight per volume (mg/l) while finer particulates are measured according to turbidity or the clarity of water.

Turbidity is a measure of how cloudy the water is and is affected by suspended solids. High turbidity results in cloudiness, haze, or an absence of clarity in the water. The units of measurement for turbidity are ‘nephelometric turbidity units’ (NTU). ANZECC Guidelines suggest that turbidity levels of greater than 30 NTU reflect a state of degradation. For the purposes of this report, discussion on turbidity will limited, and reference will be made to fine, colloidal suspended solids and/or erosion products generally.

Nutrient levels are often measured by pH. While the pH scale ranges from 0 to 14 the pH of natural waterways tends to hovers between 6.5 and 8.5. Water with a pH of 7 is considered to be neutral, a pH of less that 7 is acidic; and a pH greater than 7 is basic. The major nutrients noted in the catchment were phosphorous and nitrogen. High nutrient levels can result in excessive algal production within waterways leading to deoxygenating and eutrophication which in turn reduces the ecosystem quality and species diversity

Unfortunately, the water quality of the study reaches was unable to be quantified as no data is available. Qualitative assessment of the streams was undertaken by the study team during field inspections. Most of the streams were determined to be afflicted by high salinity with some tributaries having salt concentration levels of almost marine strength. Salt encrustations were visible in many of the tributaries where salinity levels were highest. Of concern also was the high amount of fine suspended solids observed to be coating all instream vegetation and substrates. This indicates that finely divided erosion products of fine silts and colloidal materials are being readily produced from both the land surface and also within the eroding streams. Of great concern were observations of extensive sheet and rill erosion, gullying, and some tunnelling. Also of concern was the more recent advent of cropping on steeper slope areas of poorly structured soils where dispersive materials and topsoils were observed to have been lost. Some landowners are attempting to mitigate this loss with an integrated soil and crop cover management system, but this was not generally the case.

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The loss of productive soils, along with its associated nutrients, can only impact negatively on the water quality of the stream system. Whilst stabilisation of the stream system gradients is required, there is an apparent need for more guidance and assistance for farm based soils and cropping system management to protect the economic resource as well as the streams. It was of concern to observe tillage across areas of overland flow paths where high energy flows may run in episodic events with potentially large losses of soil and erosion products to the streams. It was observed that there is only a small area of attenuation of soil loss through the retention of floodplain wetlands or very wide vegetated buffers along streams in the Tuckers Creek system.

The observation of large standing blooms of filamentous algae in Spring Creek at Spring Flat Road indicates that nutrients are being transported out of the catchment. The transport of applied phosphorus will impact readily on stream health and lead to eutrophication impacts on the receiving waters of the Wimmera River.

Hence the water quality of the Spring and Tuckers Creeks is a reflection of the disturbed state of the catchment, which is poor, given the extended drought period and low cover of vegetation. The programs recommended to mitigate this will involve a partnership approach between Wimmera CMA, DPI, DSE and landowners to improve the management of the streams and wider catchment to attain mitigation of transported erosion products and nutrients from the land.

2.1.2 Vegetation

Prior to European settlement, vegetation of the Wimmera catchment was a mixture of forests, woodlands, grasslands and seasonal wetlands. Since that time large areas have been cleared and converted to agriculture with only fragmented and degraded examples of the woodlands and grasslands of the fertile plains remaining. These are often confined to roadsides and other small areas of public and private land (the former DNRE, 1997).

The Spring and Tuckers Catchment has been previously disturbed by agricultural practices, with a mosaic of cleared paddocks and small parcels of remnant vegetation remaining. Large scale land clearance associated with agriculture has removed a large majority of the original vegetation cover while introducing many exotic species, some of which have spread to become significant weed issues for the region. Unrestricted livestock access within the fragile riparian environment has resulted in significant erosion and poor recruitment of native vegetation which has reduced the capacity to cope with natural environmental issues faced by the area such as drought and flooding. The majority of the catchment consists of cleared paddocks which were generally represented by a cover of exotic pasture species, low native species diversity and all structural vegetative layers either modified or absent (refer to Figure 2-1)

Figure 2-1 The majority of the Spring and Tuckers catchment is characterised by cleared paddocks and scattered trees.

Except for the northern areas and eastern fringes of the catchment, little remnant vegetation remains intact within the catchment. The areas of high relief in the northern section of the catchment, unsuitable for agricultural production, have retained a healthy cover of vegetation, while the lower hills and valley floor have little to no remnant vegetation remaining. Remaining remnant vegetation of the lower slopes and valley floor occurs mainly as small isolated pockets or scattered trees which are exposed to degrading pressures of stock damage and weed invasion.

The riparian vegetation assemblages generally consist of discontinuous coverage of native vegetation, often lacking in understorey shrubs, with a mixture of exotic and scattered native grass species. A healthy coverage of native tree species exist at the top end of the catchment, however they are only found as scattered individuals throughout the lower hills and valley floor. The remaining vegetation tends to be very narrow and discontinuous across the landscape. The regeneration of native vegetation is nominal within the riparian zone, largely the result of unrestricted livestock assess to the riparian environment and the ongoing encroachment of weed species such as Spiny Rush that has restricted natural recruitment. Table 2-1 below lists the remnant vegetation remaining within the catchment and the reaches in which they occur.

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Table 2-1 Remaining EVCs in the Spring and Tuckers Catchment (DSE, 2005a,b&c)

Current EVC Remaining in Catchment (DSE, 2005)	Reach	Remaining Character	Location
22 – Grassy Dry Forest	1, 4	Mid to upper slopes of the eastern part of the catchment.	Range of slopes and altitudes outside of the riparian zone.
23 – Herb-rich Foothill Forest	1, 2	Occurs only on the upper slopes of Tuckers Creek.	Relatively fertile, moderately well drained soils. Easterly and southerly aspects of lower slopes and gullies.
67 - Alluvial Terraces Herb-rich woodland	1,2	Mid to upper slopes of the northern sections of catchment, predominately along the higher tributaries of Spring Creek.	Range of slopes and altitudes outside of the riparian zone.
68 – Creekline Grassy Woodland	4	Small, discontinuous remnants along the main stems of Spring and Tuckers Creeks, predominately in the lower sections.	Drainage lines and adjoining flats
76- Grassy Woodland/ Alluvial Terraces Herb-rich Woodland Mosaic	1	Occurs in the lower to intermediate tributaries of Spring and Tuckers Creeks.	Intermediate slopes between the plains and more infertile upper slopes.
175 – Grassy Woodland	5	Small isolated remnant on lower to intermediate slopes of Tuckers Creek.	Intermediate slopes between the plains and more infertile upper slopes.

In-stream vegetation occupies the channel and lower banks of waterways and plays an important role in riparian ecosystems. Native plant species such as Cumbungi and Phragmites help stabilise streams, improve water quality and reduce erosion. In-stream vegetation also helps reduce water velocity and provides important habitat for many terrestrial and aquatic fauna species.

The riparian vegetation on the valley floor is mainly dominated by exotic pastures with a sparse canopy cover of River Red Gum (*Eucalyptus camaldulensis*) and Swamp Gum (*Eucalyptus ovata*), while Red Box (*Eucalyptus polyanthemos*), Grey Box (*Eucalyptus microcarpa*), Yellow Box (*Eucalyptus melliodora*) and Yellow Gum (*Eucalyptus leucoxylon*) were found scattered in the higher reaches amongst the sedimentary valleys and metamorphic ridges. Occasional pockets of remnant herbs and grasses were identified where stock access is limited. There is limited natural recruitment observed throughout the catchment. Generally, the abundance and quality of remnant vegetation improves in the higher reaches of the catchment, where agricultural activity is restricted.

Available fauna habitat within the catchment closely corresponds to the coverage of vegetation in either cleared paddock environments and/or woodland/forest communities. The suitability, size

SKM

and configuration of vertebrate fauna habitats generally correlate with the structure, connectivity and quality of vegetation communities.

2-2 – Aerial view of Spring Creek

Vegetation management approaches need to focus upon the protection and enhancement of existing remnant vegetation and the stabilisation of the riparian landscape to capitalise on natural revegetation/rehabilitation. This process will help provide connectivity between remnant stands by establishing wildlife corridors. The best form of riparian protection in the capacity of the Spring and Tuckers catchment should take the form of riparian fencing to control stock access, with the inclusion of simple revegetation works to encourage the natural regeneration of remnant vegetation. Within the scope of such revegetation works, the establishment of revegetation nodes within the riparian zone would help return a diverse species assemblage to the area, allowing species to disperse into adjoining areas with time. Once the riparian systems have been stabilised, natural regeneration should facilitate the return of the species diversity of the surrounding remnant vegetation cover. The establishment of indigenous vegetation seed banks which specialise in local species (i.e. local nurseries) would be a valuable approach in undertaking these revegetation activities. Additionally, the identification and establishment of seed production areas to efficiently collect seed from local species would aid this process.

2.1.3 Stream Ecology

No prior investigation or specialist studies of stream ecology have been undertaken for the Spring and Tuckers Creek catchment. No records of any fish, mammals or invertebrates are available.

The only surface flow observed in the catchment at the time of inspection was a small saline base flow that occurred in Spring Creek downstream of Spring Flat Road. Subsurface flows occur beneath the surface within the porous bed materials of the streams. It should be noted however that the field inspections were conducted at the end of an extended dry period. In the few areas where water was present, a limited suite of invertebrates were observed and a species of snail. This indicated that the water was highly saline. The quality of ecosystem is likely to also be limited by the lack of a strong flow regime, lack of suitable habitats and also the elevated levels of salt and nutrients.

Filamentous algal blooms were evident in the lower Spring Creek at Spring Flat Road these being a mixture of *Cladophora* and *Spirogyra* species. Some *Oscillatoria* was also observed on the bed of the pools indicating the presence of organic pollution form stock defecation.

Not withstanding the condition at the time of inspection, it is likely that a range of ephemeral invertebrate species are likely to inhabit the stream environments in the winter and late spring periods. No amphibious or crustacean species such as yabbies were observed in the field adding to the picture of a depauperate community.

In a fresh water environment, contrary to what was observed, the present of short life cycle species such as mayflies and fly species would be expected to occur. This is a further indication that the water was of a low quality. In addition, the upper tributaries of the stream system rise in patches of remnant bushland there may be some colonisation or allochthonous input of insect larvae from those sources.

Based on water quality observations and the condition of the catchment, it is reasonable to say that the instream fauna will remain limited and the ecosystem will continue to struggle in the fragile and depauperate conditions that prevail.

2.1.4 A model of catchment change

During the period of initial settlement of the upper Wimmera region, many of the waterways contained chains of ponds. However, with the onset of European-style agriculture, channel entrenchment, land clearing and grazing, many of the natural stream features were lost. Effects of

SKM

these wholesale catchment changes include the loss of the once present chain of ponds, discontinuous gullying, incised channels and general stream instability. Since the middle of last century, though, general improvements in farm practices and the application of soil conservation works in some valleys have further increased the diversity of fluvial forms.

The gullies and broader-scale hillslope erosion that are now apparent in the Spring and Tuckers Creek catchment are likely to have been initiated in the middle of the Nineteenth Century when valley floor vegetation was cleared for agriculture for fuel to power gold mining operations along with the introduction of hoofed stock. These changes in landuse have resulted in increased runoff and decreased erosion resistance (Prosser and Slade, 1994). When runoff is concentrated in hillslope hollows, the ability of flows to erode waterways increases, sometimes incising gullies into the valley floor. Once initiated, gullies spread at an exponentially declining rate with much of the networks being formed within the first few decades (Graf, 1977). This model of landscape change has been widely used to explain the occurrence of gully erosion (Prosser and Slade, 1994).

Channel initiation due to by overland flow runoff that has occurred in cleared catchments such as in the Spring and Tuckers case, may be viewed as a threshold phenomenon related to the size of the contributing area and its slope (Horton, 1945). The relationships between source area and slope have been explored in a number of environments to predict the onset and the stable extent of gully networks (e.g. Dietrich *et al.*, 1992; Prosser and Abernethy, 1996; Morgan and Mngomezulu, 2003). These studies show that once incision occurs, gully heads migrate upslope until some threshold of contributing area and/or slope is met. In these instances, ongoing runoff is likely to cause further incision until the gully stabilises in its headward extent. This topographic threshold is also influenced by vegetation. The loss of groundcover results in enhanced runoff which leads to an increase in the erosivity of flows on the valley floor. The effect of this is to reduce the critical area/slope required for gully initiation and stabilisation.

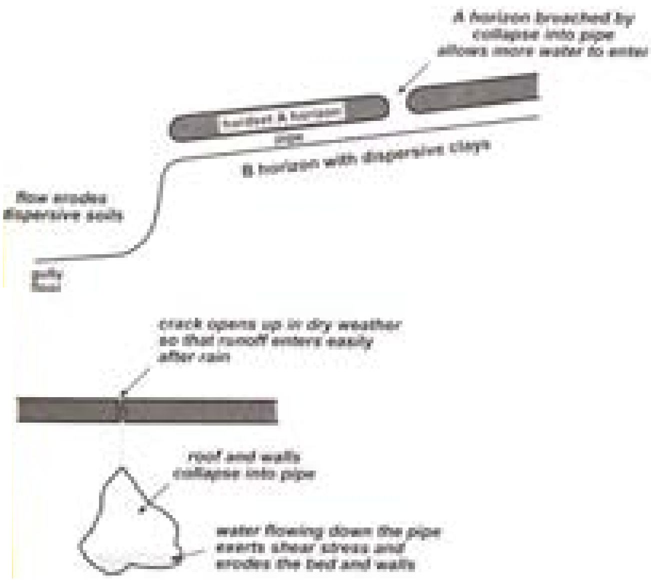
The other dimensions of the Spring and Tuckers gully networks to be considered are gully width and depth. The gullies will either continue to incise down to bedrock or until some stable gradient is achieved from the baselevel of the downstream drainage network, which in this instance relates to the base level at the Wimmera River (see Schumm *et al.*, 1984). After the gully floor has stabilised the gully walls will tend to lay back under the influence of water and gravity until they are reduced to relatively stable slopes (Crouch, 1987). As gully floor elevation and sidewall slopes stabilise, and the impacts of stock are controlled, vegetation is able to colonise the surfaces, further damping the effects of erosion processes.

Relating gully morphology to erosion process provides a useful field technique to assess gully stability. The further a gully head is from its upstream drainage divide the more potential there is for continued headward extension. The secondary nickpoints that have been observed in many of the gully floors indicate that a change in baselevel has renewed the incision process and that the

SKM

gullies will continue to deepen until a stable grade is achieved or bedrock is intersected. Deepening gullies will promote sidewall instability and maintain the walls at steep angles. Lower angles on the sidewalls indicate general gully stability. Overtime, with the establishment of vegetation, the gully will begin to infill and begin the process of landscape recovery.

Much of the gully erosion in southeast Australia, and particularly western Victoria occurred after large scale vegetation clearance of the valley occured (Prosser and Slade, 1994). However, other factors, such as the strength and hydraulic properties of valley-floor soils, also influence erosion processes. Many Australian soils have hard-setting A-horizons, and more clayey sodic B-horizons (Young and Young, 2001). The B-horizon often has a lower permeability.. If the clays in the B-horizon are dispersive, as is the case with in the Spring and Tuckers Creek catchment, the fine soil particles will be eroded and carried in suspension to downstream waterways (Figure 2-3). There are also many examples of subsurface flows leading to piping, tunnelling and seepage erosion (Young and Young, 2001). While the removal of vegetation has increased runoff rates, the characteristics of the underlying soils have also had been a major factor in the gully erosion that has occurred.



- **Figure 2-3 - Gullies and seepage flow (from Young and Young, 2001).**

These principles and geomorphic processes, provide an appreciation of the setting in which the processes of erosion and deposition operate within the catchment. The potential to misinterpret the natural instability which can exist in a catchment, as simply being a result of human impact, or to exaggerate the human impact, has been recognised as a consistent problem in geomorphic studies (Dollar, 2000). Recognition of the different factors that have contributed to the development of the erosion problem, and the role that subsurface and overland flow paths have in driving the erosion processes is important as a precursor to recommending appropriate rehabilitation options.

In assessing the stability of the waterways within the catchment, it is important to consider the natural characteristics of the area such as the geology, soil types, topography, and type and extent of vegetation cover.

2.1.5 Flooding

Flooding within the Spring and Tuckers Creek system is characterised by two types of rainfall event. The short duration- high intensity event is the most problematic with high coefficients of runoff likely as the semi porous and rocky geology is unable to sustain rapid infiltration. Flows are likely to be flashy and as the catchments are steep and there is a high branching and nesting of the catchments, flood flows at the Spring Flat Road are likely to be fairly high. The bridge at this point is of limited capacity and overland flows will flood the road readily at this point.

As most of the valley morphology of the catchment is one where there is only small confined flood plains in the mid and lower reaches flood are rapidly conveyed through the system

The increased capacity of the incised channel of Spring Creek downstream of Spring Flat Road results the containment of most flood flows. This has the unfortunate impact of increasing stream powers through this reach and this further exacerbates the erosion activity in that area.

With respect to Tuckers Creek and Tuckers Creek No.2, a larger and flatter floodplain exists in the mid stream sections allowing for a dissipation of energy and some retarding affect. This enables some mitigation of erosion product transfer, but also is likely to cause local short term flooding of land and some access tracks.

Downstream of the Eversley-Crowlands Road, flood flows are likely to be contained in channel for most of the Spring Creeks length – only spilling overbank at the lower part of the Wimmera River floodplain. There appears to be excess channel capacity in Spring Creek allowing opportunity to undertake some grade control work without impacting on the surrounding lands. Similarly Tuckers Creek will again be predominantly contained in channel, but will spill earlier due to the smaller cross sectional area. There are signs of overbank activity with silt levees being established.

Long duration low intensity events may cause local flooding but this is unlikely to be too disruptive as flows generally are less under this scenario. If an extended period of rain is experienced on a saturated catchment, flows may get larger as interception losses and infiltration rates are exceeded. This may disrupt local activity for several days.

No public or private infrastructure appears threatened by flooding although some roads may be inundated for a period of time.

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2.2 Management Reaches

To describe the condition, issues and recommended actions along the various segments of the Spring and Tuckers Creek system, the streams have been divided into four primary reaches. Spring Creek, the largest of the streams has been divided into two reaches, S1 (the lower part) and S2 (the upper part). Tuckers Creek has been classed as an individual reach, T1 and Tuckers Creek No. 2 has been treated as a separate reach (T2).

This delineation of the catchment into reaches has been based on geomorphic characteristics. Tributaries connected to these four main stem reaches have been described as 'sub reaches'.

2.2.1 Reach, sub reach and tributary labelling convention

For the purposes of this report, a numbered labelling convention has been applied that identifies individual reaches, sub-reaches and tributaries throughout the catchment. This convention enables each waterway to have a unique number to help identify waterways within the catchment for the purposes of discussion in this report.

An example of the convention that has been applied is S1. This example refers to Reach 1 of Spring Creek. Similarly S1/2/1 refers to Spring Creek Reach 1, sub-reach 2, tributary 1. Maps of each of the four reaches of the Spring and Tuckers Creek catchment covered in this study (Reaches S1, S2, T1 and T2) are provided at the start of Sections 4 to 7. These maps show all waterways within each of the reaches together with specific numbers allocated.

The location and extent of the four reaches are detailed in Table 2-2 below and shown in Figure 2-4overleaf.

- **Table 2-2 – Reach delineation of the Spring and Tuckers Creek catchment**

Reach #	Reach and Location description	Easting and Northing (GDA 94)
S1	Reach S1 – Spring Creek (Wimmera River to break of slope).	U/S - 690653 5889150 D/S – 687687 5885554
S2	Reach S2 – Spring Creek (Break of slope to top of catchment).	U/S - 692799 5891863 D/S - 690653 5889150
T1	Reach T1 – Tuckers Creek (Wimmera River to top of catchment).	U/S - 692270 5885079 D/S - 687770 5885554
T2	Reach T2 – Tuckers Creek # 2 (Eversley –Crowlands Road to top of catchment).	U/S - 691564 5886481 D/S - 688054 5885829

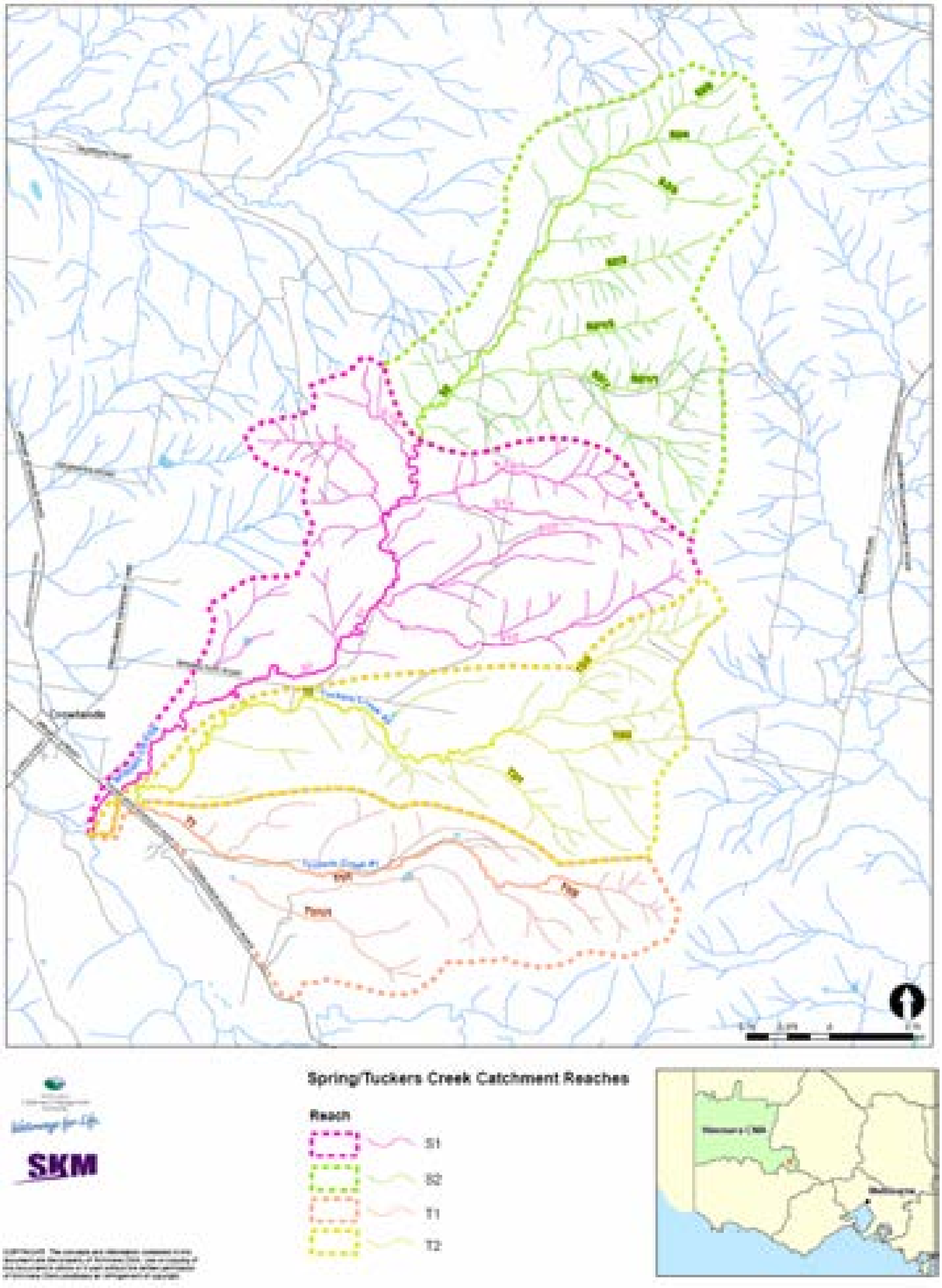

Figure 2-4 Delineation of the four catchment reaches

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3. Method for assessing the Catchment

3.1 Information Collection

The following information sources were used to compile the information, which forms the basis of this plan:

- A desktop review of available information and documents;
- A meeting with respective stakeholders was held on 6th February 2006. Stakeholders include (but is not limited to) DSE, DPI, Project Platypus and the Pyrenees Shire Council;
- Community consultation meetings held on the 6th & 7th of April 2006. Advertising means included the distribution of an information sheet via a letterbox drop, advertising in the local paper, and the placement of information sheets at various community centres/locations in the catchment;
- The study team also undertook an aerial inspection of the catchment on the 9th of April 2006; and
- The study team undertook an inspection of the catchment over the period 6th to 17th of April 2006.

3.2 Risk Assessment and Priority Setting

To help prioritise the recommendations made in this project, a risk assessment approach has been used to help rank the relative importance of actions within the catchment of the Activity Plan.

Priority has been established through an assessment of the condition (based on ISC scoring 1-5), then an assessment as to its Consequence (via a Risk/Threat matrix with a score of 1-5) and then an assessment of the urgency or need to intervene quickly or over time with the action (score 1-10). These were multiplied together to get an overall numeric ranking score to determine the priority. This has then been translated into one of five descriptors ranging from Urgent, Very High, High, Moderate through to Low according to the following bands:

Table 3.2-1 Priority ranking scores

Priority	Ranking Score
Urgent	201-250
Very High	151-200
High	101-150
Moderate	51-100
Low	0-50

The priority actions identified in the catchment are shown in Appendix A to Appendix I at the rear of this report.

3.3 Reach Activity Spreadsheets (Summary of Issues and Actions)

Activity spreadsheets have been compiled to document important site specific issues identified in each of the four reaches, refer to Appendix A to Appendix D. The spreadsheets offer an overview of the extent of expenditure required to achieve the vision of this Plan in the next five to ten years. The spreadsheets detail the issues, location, recommended actions, cost estimate to and assign a priority to each respective issue. The issues for each reach have been grouped into the following activity headings:

- Habitat (H);
- Stream Stability (S);
- Water Quality (WQ);
- Vegetation (V); and
- Flooding (F).

3.3.1 Issue – Naming convention

Issues have been identified using a naming convention that refers to 1) the Activity Heading, 2) the Issue Number, and 3) the respective Reach/Tributary. For example H/R3/1, refers to a Habitat issue identified in Reach #3, Tributary #1. Similarly, S/R4 refers to a Stability issue identified in Reach 4. The issue number is used to identify specific issues only and is not related to a priority. Priorities are set in the spreadsheets that are attached as Appendices to the report (refer to Section 3.2 above).

3.3.2 Location of issues

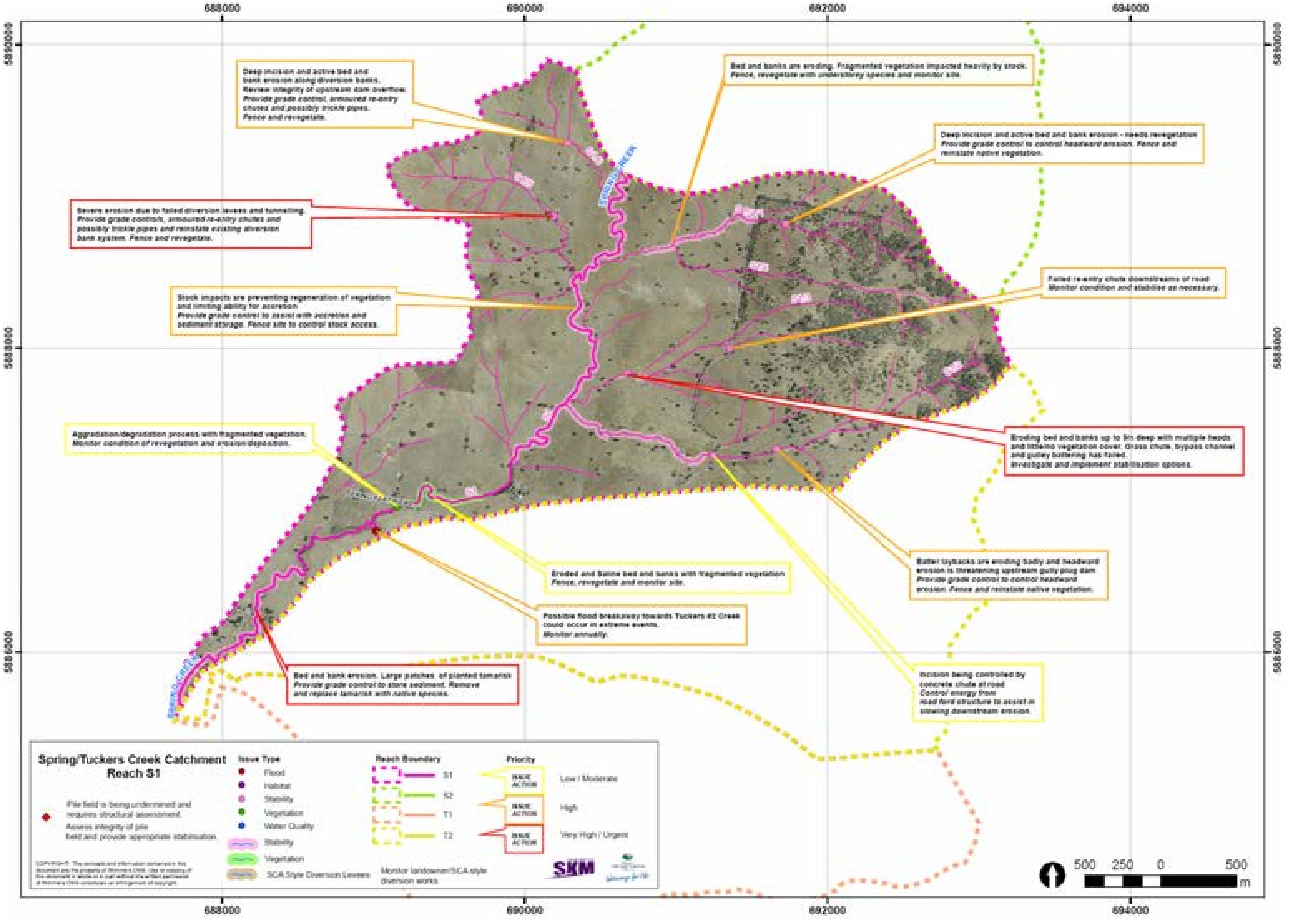
GPS locations have been provided (Easting and Northing) in the MGA datum (GDA94) to help identify site specific locations. Reach maps have also been compiled with an overlying grid to help identify where the respective issues are located. Further, each activity is distinguishable by colour i.e. ‘Stability’ issues are represented by a different colour to ‘Vegetation’ issues. Site numbers have also been provided that relate to specific locations where areas of significance have been identified.

3.4 Catchment Analysis by Reach

The next four Sections (Sections 4 to 7) analyse the following four reaches in detail:

- Reach S1 – Spring Creek (Wimmera River to break of slope)
- Reach S2 – Spring Creek (Break of slope to top of catchment)Reach
- Reach T1 – Tuckers Creek (Wimmera River to top of catchment)
- Reach T2 – Tuckers Creek # 2 (Eversley –Crowlands Road to top of catchment).

4. Reach S1 – Spring Creek (Wimmera River to break of slope)



4 Reach S1 – Spring Creek (Wimmera River to break of slope)

4.1 Reach Location

This reach extends from the lower portion of Spring Creek, where it flows across the Wimmera River's contemporary floodplain, upstream to the break in grade at the toe of the foothills some 1.5 km's north of Spring Flat Road. It includes six tributaries streams.

4.2 Morphological description

The lower portion of the waterway downstream of the Eversley-Crowlands Road has been highly modified and is now characterised by a straightened channelised form. There are at least two former courses to the west of the current alignment, one of which is known to contain a significant gravel deposit. The stream straightening was probably undertaken to achieve two goals: define the watercourse under the Tulkara Railway (circa 1910) where a former sediment fan of layered gravel and alluvium is located; and to prevent the inundation of valued floodplain lands to the west. This straightening process triggered incision through the former sediment fan and well upstream. The channel straightening and repositioning dramatically altered the local gradient and increased stream power. This has resulted in large amounts of eroded gravels sand and finer material to be washed into the Wimmera River actually causing a complete infill of that portion of the river channel and pools. This was subject to a desilting program in the late 1970's by SR&WSC after landowner approaches. The impact of the current sediment load can be seen to infilling the recreated pools and also channel closure downstream of the Dunneworthy Road.

The stratigraphy of the current bed and banks is interesting in that the incised stream has cut 4-5 m below the former bed and is carrying large loads of mobile gravels and sands from upstream erosion. The channel is some 10 m wide and up to 5 m deep and would convey all but extreme floods. The bed load consists of a series of dynamic wave deposits interspersed with scour holes. The bank profile shows a former streambed intersect with a channel of about 1.5 m wide by 0.5 m deep filled with gravels, with the current bed some 3 m below that. There is no appreciable vegetation along the streambed through the section downstream of the Eversley Road. Some older River Red Gums occur along the old courses.

The current deep profile clearly shows the former sediment fan deposit at the intersect with the former floodplain step. This material is highly erodible and not resistant to the increased stream power of the current channel system. Indeed, the downstream incision process has raced away up the catchment to the Spring Flat Road, with a 6-8 m wide channel developing to a depth of 3-4 m. The landowner of this segment has intervened with a series of stabilisation attempts using a range of rock treatments, some of which some have slowed the rate of erosion. The use of Tamarisk (*Tamarisk aphylla*) as a species to assist stabilisation is of concern due to its long-term impacts. It

SKM

is strongly recommended that native sedges and rushes or fine rooted shrubs, which formerly existed in the area, be incorporated into stream works to achieve a comprehensive vegetative cover able to withstand high stream powers.

- **Figure 4-1 Soil cross sectional profile downstream of Eversley-Crowlands Rd.**

- **Figure 4-2 Previous rock treatment to try and prevent bank erosion**

Erosion and deposition are still occurring in the upper portion of the section towards Spring Flat Road and this will require intervention as the scale of adjustment is beyond the capability of the landholder to manage. It is clear that this area is still subject to episodic changes and will readily reactivate. A series of bed grade controls and some groyne and bank works are needed to secure the hard won position the landowners have established. On top of the basically unstable bed conditions within this section there is a large supply of bedload from upstream. This mainly consists of silts, sands and gravels that are pushed into the area with each storm event. Again the efforts of the landowner in fencing and revegetation in this area needs to be encouraged and supported.

Upstream of Spring Flat Road the stream lies within a confined valley with a small floodplain. The channel is incised and relatively steep with some isolated examples of bank instability. A few old courses are noted as the stream continues to rework old sediment deposits as well as the colluvial slopes of the valley form. The uncontrolled access of stock along this stretch is a major impact on the instability with cattle disturbing both bed and banks; the few pools are particularly disturbed. Some minor head erosion is still evident but this is masked by gravels and sands that comprise the bed. Interestingly the upper part of this reach displays a cobble deposition zone. A series of small bed control structures along this reach, plus revegetation, is needed to assist the infill and retention

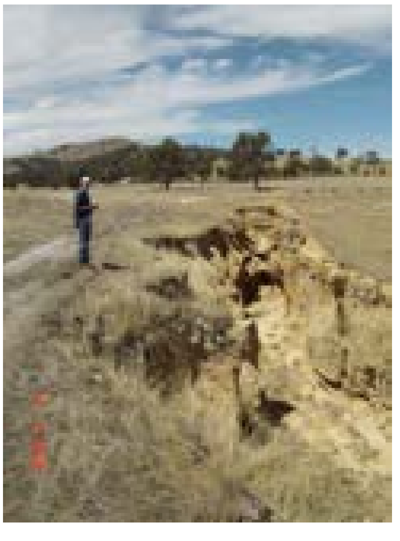
SKM

of the sediment. Obviously this cannot be achieved without a high degree of landowner cooperation as the process of rehabilitation will be long term and require vigilance over fencing and stock access.

There are a number of small tributaries in this part of the reach that do not require active management at this stage but should be watched for any change. However, six tributaries have been identified that need a range of interventions. Most of these streams are fairly steep and run up the dissected valleys of the sedimentary hills, intersecting highly dispersive and slaking colluvium. Incision has invariable occurred due clearing, channelisation, incision and reduced base level in the mainstem and the constant grazing pressure through rabbits and stock.

Tributaries S1/2, S1/3, S1/4, S1/5 and S1/6 all exhibit a mix of stability and degradation. With respect to S1/2 downstream of Spring Flat Road the stream is deeply incised with extensive bank erosion. There are a number of bedrock intersects that prevent the stream getting deeper, but stock pressure is maintaining the bare erodible banks. Controlling flow energy at the road ford and drop structure would assist in slowing the current erosion for some 200 m downstream of the road. Upstream of the road some past bank batters are eroding badly and the headward erosion towards a gully plug dam is still very active.

The past severe erosion of tributary S1/3 has been treated with batter laybacks, a gully plug dam and new overflow. Unfortunately, these assets are in a serious state of failure with a new 4 m deep gully formed along the new overflow line and the past battered gully is totally bare and seriously eroding. Upstream and east of Spring Flat Road, a number of hillslope gullies need to be watched for further deterioration.



- **Figure 4-3 Deep gully on S1/3**

- **Figure 4-4 Failed batter laybacks on S1/3**

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Tributary S1/4 is seriously eroding and is deeply incised over a distance of 400 m up the slope from Spring Creek. Whilst some bed rock intersects are apparent, the bed and banks are all actively adjusting in this area. Uncontrolled stock access is a major contribution to the erosion of the banks. Upstream and east of Spring Flat Road, an active gully is forming in the paddock and may need rapid intervention if it starts to erode rapidly. Similarly the upper part of this reach is eroding at the break of slope of the steeper and rocky hills.

Tributary S1/4/1 is an extension of the above tributary and the deep incision and active bed and bank erosion very evident. Again the causes are bed incision and bank erosion with stock access contributing heavily to this. The erosion heads have extended about 100 m upstream of Spring Flat Road and will continue to get worse unless arrested.

Tributary S1/5 is in a very seriously eroded state with not only the deep incision of the main valley line, but also the spectacular failure of old SCA style works. A diversion bank system that was installed to divert the flows around the eroding stream has been breeched and a massive 5 m deep erosion head developed. This will require very detailed analysis to resolve but a significant and comprehensive structural solution will be required involving bed controls re-entry chutes and possibly trickle pipes, plus rehabilitation of the diversion bank system.

- **Figure 4-5 Failed diversion levee on S1/5 has resulted in major erosion**

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Tributary S1/6 is also in a worrying condition with the failure of another old SCA style diversion bank which is causing significant gully erosion downslope and also the initiation of a new gully and headward erosion off the mainstem that discharges into the Reach S2 upstream of the natural junction with S1. The concentration of large flows off the valley axis in areas of poor soils has triggered this incision. Again the response to this will be complex and involve a number of structures. A stock dam in the upper catchment is also in need of attention with the overflow eroding into the slope.

Vegetation along most of the tributaries is poor with only remnant patches of River Red Gum and Yellow Box evident. The very upper slopes have generally limited ground cover and are prone to sheet erosion.

4.3 Vegetation

Current EVC mapping indicates that vegetation in this reach includes four vegetation communities. Table 4-1 details the specific EVCs that have been previously recorded within the study reach and the general vicinity of occurrence.

The remnant vegetation along the main stem of Reach 1 is restricted to a very narrow and discontinuous band that is, without significant overstorey in many sections. Scattered River Red Gum (*Eucalyptus camaldulensis*), Grey Box (*E. microcarpa*) and Yellow Box (*E. melliodora*) can be observed throughout the reach. Ground cover mainly consisted of a few salt tolerant species including Rye Grass (*Lolium spp*) and a suite of exotic weed species including Spiny Rush, Tamarisk, Willows and Phalaris.

In-stream vegetation is limited to a few stands of Phragmites (*Phragmites australis*) and Cumbungi (*Typha domingensis*) in the lower reaches at the intersection of Spring Flat Road. However, small populations of emergent macrophytes such as Rushes (*Juncus spp*) and Sedges (*Carex spp*) can be observed scattered throughout the reach.

Many factors have contributed to the decline in health and extent of riparian vegetation within the reach. The pressures of drought conditions in combination with uncontrolled stock access are having a significant impact on the existing riparian vegetation and habitat values within the reach. Scattered trees along the riparian zone represent the only remaining native vegetation in many paddocks. These trees provide shelter for stock which, in tern, impact the stream zone (refer to Figure 4-6).

▪ **Figure 4-6 Unrestricted stock access has degraded many sections of Spring Creek and its tributaries.**

Creekline Grassy Woodland is the most relevant EVC to the riparian environment within Reach S1. Due to current and past disturbance, the re-establishment of a native understorey would be an important step in the improvement of the waterway and initiation of a long term environmental improvement program.

The remaining remnant vegetation within the reach is generally restricted to the upper eastern sections of the reach. The riparian associations of the reach have been largely removed or are highly degraded. Some revegetation works are evident within the reach, which need to be further protected and require increase in species diversity in areas.

▪ **Table 4-1 Current Vegetation Attributes (EVC) Reach S1**

Current EVC Remaining in Reach (DSE, 2005)	Remaining Character	Location
22 - Grassy Dry Forest	Located along S1/3, S2/1/2, S2/2, S2/4 and S2/5	Range of slopes and altitudes outside of the riparian zone
68 - Creekline Grassy Woodland	Located on the lower slopes of the main stem	Drainage lines and adjoining flats.
67 - Alluvial Terraces Herb-rich Woodland	Found as small clumps along S1/4, S1/4/1, S2, S2/1, S2/1/1, S2/1/2 and S2/2	Range of slopes and altitudes outside of the riparian zone.
76 – Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	Found scattered along the main stem, S1/5, S1/6, S1/4 and S1/3	Intermediate slopes between the plains and more infertile upper slopes.

Vegetation management for Reach S1 should mainly associate with the protection of the riparian zone from the adverse impacts of domestic stock and the establishment of a suitable canopy and ground storey cover. As the majority of the reach is largely unfenced, it would be recommended that a targeted fencing program be initiated to help protect the existing remnant vegetation cover. With suitable stock control in place, native vegetation is more likely to establish naturally over time. After securing existing native vegetation cover and in addition to fencing works, a targeted revegetation program should also be encouraged in areas that have unsuccessfully regenerated. Due to the limited extent of vegetation within the riparian zone, it is expected that any revegetation efforts in the early stages of development would focus on the re-establishment of species such as River Red Gum (*E. camaldulensis*) and Black Wattle (*Acacia mearnsii*) in the lower sections, and Grey Box (*E. microcarpa*) Yellow Box (*E. melliodora*), Yellow Gum (*E. leucoxylon*) and a variety of Acacia species such as Golden Wattle (*A. pycnantha*) and Hedge Wattle (*A. paradoxa*) in the higher sections of the reach. In-stream and batter re-vegetation is also highly encouraged. Species such as native Rushes (*Juncus spp*), Sedges (*Carex spp*) and Tussock Grasses (*Poa spp*) should be used for this purpose. The provision of overstorey trees on the verge of the riparian zone should be complimented by a cover of native grasses and sedges.

The success of this program should be monitored regularly and subsequent assessment could be carried out to determine the success of native vegetation recruitment, survival rate of revegetation efforts and the need for additional weed control.

4.4 Habitat

The habitat complexity of the reach was generally very poor. The majority of the waterway generally lacked key habitat attributes such as in-stream and riparian vegetation. Canopy coverage is generally restricted to higher topography settings where grazing and cropping activities have been limited. The overstorey component tended to be depleted in the lower slopes of the western flank (right bank) of the reach, where grazing and cropping activities have encroached right to the top of the bank and into the stream zone.

The permanent pools within the reach are likely to provide important refuges for a variety of ephemeral fauna species such as amphibians and invertebrates. While there is not sufficient detailed data available to make a full judgement, the pools may provide habitat for species such as the Water Rat, that would readily feed on any Yabbies and Shrimps depending on water quality and availability. There were only a few sites which contained large woody debris. Unfortunately, the habitat condition for most of the ephemeral tributaries is extremely poor with limited appreciable significance.

Scattered individuals of Athel Pine or Tamarisk (*Tamarisk aphylla*) were identified downstream of Spring Flat Road. Although this species has been used locally to assist the stabilisation of streams throughout the catchment, its use is of great concern. Tamarisk is a weed of national significance and it is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economical and environmental impacts. It consumes water more quickly than native plants, thereby reducing the number of watering holes. Tamarisk also concentrates salt, which is excreted by its leaves. This causes the ground beneath the plant to become more salty which excludes native grasses and other salt sensitive plants (DEH, 2003)

The prevention of further spread of Tamarisk should be high in priority and that further use of this species for erosion control is discontinued and native substitute species should be encouraged.

4.5 Water Quality

Water quality in this reach is of real concern. Under low flow conditions as observed during the field inspections, a small saline flow (estimated to be in the order of 5,000 µS) was observed in the mainstem. Growths of filamentous algae were evident in the mid segment pools near Spring Flat Road. After this the flows were mostly subsurface.

- **Figure 4-7 Algal bloom in pools on S1**

In rainfall events, flows are likely to have a high content of suspended solids, turbidity, nutrients and salt. The widespread sheet, rill, tunnel gully and stream erosion is contributing significant loads downstream. The quality of waters in the dams was poor with very high suspended solids and turbidity, indicating that the geochemistry was playing a part in not allowing the finer colloidal and particulate materials to settle.

The answer to reduction in the erosion product loads is to undertake both stream and land management actions to both stop the production but also mitigate the transport through the use of small wetlands and introduction of fans and sedged swale systems.

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4.6 Flooding

Flooding is not a major issue from the point of view of impacts on private and public assets. Fencing can be seen to be damaged by the peak flows generated under episodic condition and there needs to be a detailed provision of flood fence design throughout the catchment.

Flooding of Spring Flat Road at the mainstem crossing mid reach and also on three of the tributaries will occur but is unlikely to interfere greatly with normal social activities. There are no flood markers on any of the crossings and these need to be installed.

A flood breakaway on the left bank towards Tuckers Creek No 2 (T2) could occur in extreme events downstream of Spring Flat Road. This possibility needs to be monitored and watched, as if it occurred it could trigger a major activation of erosion in that creek.

4.7 Threats and Priorities

THREAT	RISK
Old SCA style works in S1/4, S1/5 and S1/6 have failed and causing very significant impacts on erosion	Urgent
Significant reactivation of erosion in the mainstem leading to transport of erosion products to the Wimmera River	Very High
Large bed loads along the whole reach require the introduction of bed and bank controls to arrest further incision and erosion and encourage infill	Very High
Uncontrolled stock access to most areas of the mainstem and tributaries	Very High
Loss of Riparian, bank and in channel vegetation adding to erosion and decline in stream values	Very High
Tributaries S1/2 – S1/6 all have active bed and bank erosion	Very High
Salinity and nutrient export is high from the eroding lands	High
Loss of mature trees in the catchment impacts on the long term health of the stream and landscape	High
Further spread of *Tamarisk aphylla*	High
Road crossings at Spring Flat Road on mainstem and tributaries are potentially unsafe under flood conditions	Moderate
Stream habitats have declined significantly across the catchment	Moderate

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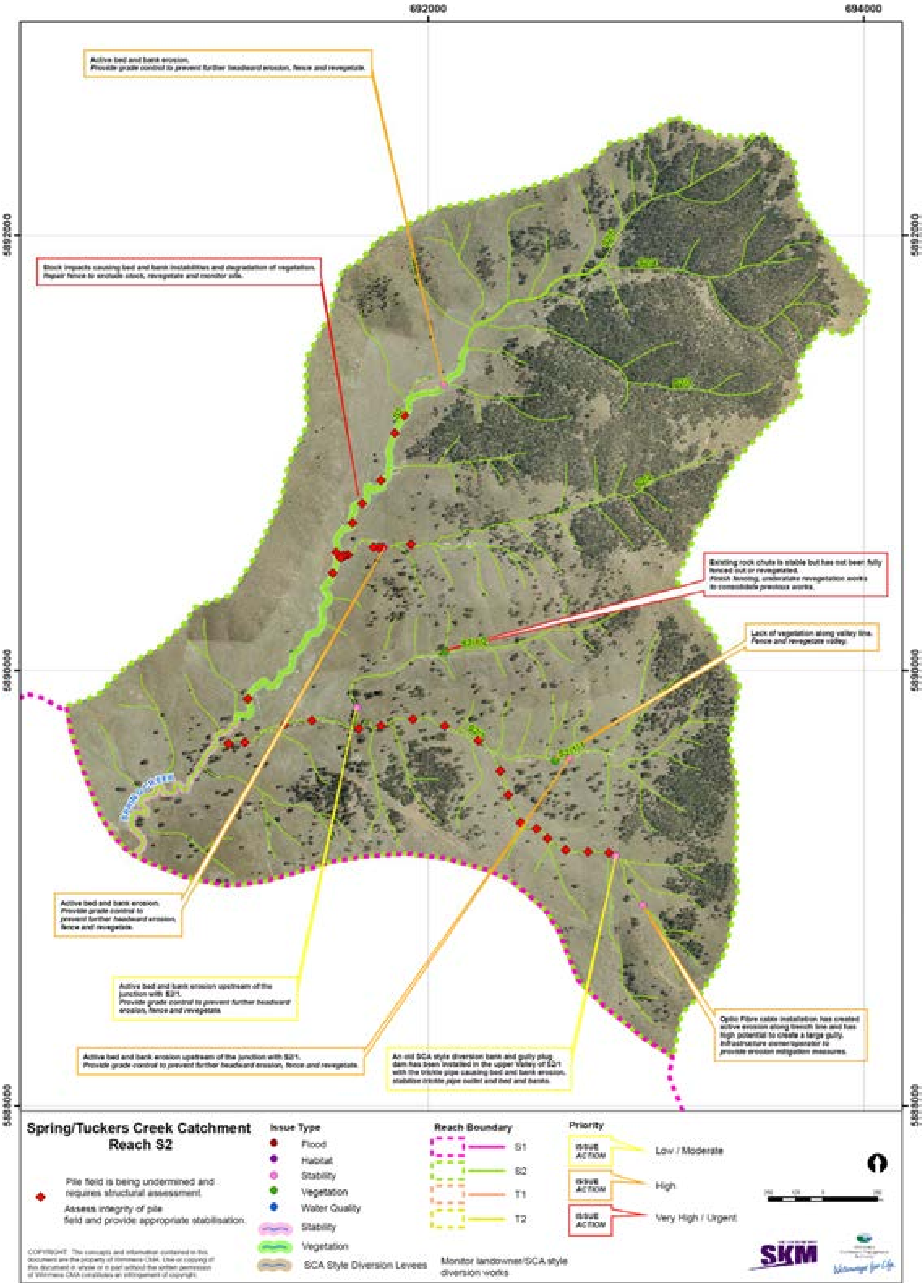
5. Reach S2 – Spring Creek (Break of slope to top of catchment)



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5 Reach S2 – Spring Creek (Break of slope to top of catchment)

5.1 Reach Location

This reach starts at the break of grade and runs to the top of the catchment and includes the tributaries on left bank (east) that lead into the steep and partially forested hills.

5.2 Morphological description

The streams in this reach are very steep as they flow out of the rocky upper catchment. There is generally limited or no associated floodplain with the streams being incised in the confined valley floor. The incision has intersected cobble layers in the bank side colluvium and a bed load of cobbles and gravels is very prominent in most of these upper streams. The streams are very well coupled with the adjacent slopes and over bank flow is prevalent along the mainstem and the lateral tributaries. Some of these minor valley lines show distinct break of slope sediment fans and tunnel erosion is occurring in some of these.

The incision and headward erosion process is still fairly active throughout this reach, driven by high streampower and the saltation of the gravel bedload. The upper end of the mainstem has intersected some bed rock and this has arrested the main headward erosion. Notwithstanding this, a series of tunnels can be observed running up the valley to the north. Deep erosion in the steep rocky valleys on right banks and to the north was noted. Interestingly, the small base flow over the rock bars was relatively fresh.

A program of works was initiated along Spring Creek a few years ago, with the provision of a series of pile-field sediment control measures across the stream. The rationale of these placements was “to reduce the cross-sectional area of flow thereby reducing flow velocity, reducing erosion, and depositing sediment” (Earthtech, 2002). Both single row and double row pile fields were installed with rock riprap placed on the downstream side to reduce erosion. A large flow event in the catchment tested these structures soon after installation. Some four years later the pile fields are showing signs of failure and also signs of creating their own set of new erosion problems with the timbers splitting and breaking, outflanking in the banks occurring and large scour holes being cut into the bed due to a large increase in streampower over the structures. Large rocks with an estimated average diameter of 400 mm placed downstream of the structures to alleviate scouring and try and transition energy have also failed with them being distributed downstream. Concern is held that as these structures fail a significant wave of new incision will start.

Fencing along Spring Creek was also undertaken at various locations to preclude stock access and allow the area to revegetate. Unfortunately the fences are now in disrepair and/or gates left open, allowing stock full uncontrolled access to the stream, defeating the purpose of the fencing with all bar a few hardy and unpalatable macrophytes now remaining (including *Juncus acutus*). Other works including a dam re-entry channel were installed on one of the left bank tributaries. This appears to be stable. The loss of program continuity, plus design and construction issues, an apparent lack of follow-up and the loss of landowner confidence has all contributed to the loss of investment in this area. This needs to be addressed and a co-operative relationship re-established with the land owner and rehabilitation works undertaken to recover the situation. The works are likely to be extensive and involve replacement of the deteriorating pile fields with a series of structures, plus revegetation (bed, bank and riparian zone) and fence repair.

- **Figure 5-1 Failing pile field on S1**

- **Figure 5-2 Wooden Pile field**

Towards the lower end of the reach at the break of slope, sediment coarser than gravels are deposited with only smaller gravels and finer material carried on. The cobbles are imbricated in the upper reach thus serving to semi-stabilise these areas where they occur. The pile fields have broken the natural process of cobble movement and hence there are areas of scouring. The stream-form takes on a more meandering pattern as it progresses to the lower parts of the reach with the sediment store increasing as the grade changes. These stores are dynamic as the more meandering pattern within the confined valley floor constantly rework the stored material and the adjacent hillslopes. Some stabilisation of this very active area could be achieved through installation of some minor bed grade controls and bank groynes.

With respect to the tributaries there are no significant right bank tributaries except for a couple of areas where over bank entry of valley lines may be active under intense rainfall events. These areas of re-entry to the main stem need to be managed through re-entry chutes.

There are five large unnamed left bank tributaries, with these being given the notional reach descriptors of S2/1, S2/2, S2/3, S2/4 and S2/5. S2/3, S2/4 and S2/5 arise in the rocky and reasonably wooded slopes of the steep rocky hill land and are not showing any significant signs of

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erosion or disturbance. The retention of the woodland on the slopes is very important and gives an opportunity for future environmental processes to be introduced to the mainstem if that can be stabilised.

Tributary S2/1 has two main branches (S2/1/1 and S2/1/2) both of which rise on the cleared slopes of the steep rocky red shale hills. There are number of very steep valley lines and only a little woodland cover on the northern parts of the hills. The channels downstream of the break of slope are incised and actively eroding. The incision process has intersected colluvial cobble layers and a sizable bed load of small and large cobbles is evident all along the stream. The incision process has intersected some weathered rock in some locations but is also active within the clay layers lower down the valley.

The upper reaches of S2/1 have had some past and more recent works undertaken to try and arrest the stream incision in the confined valley floor. An SCA style diversion bank and gully plug dam has been installed in the upper valley of S2/1 with the trickle pipe currently causing bed and bank erosion. More recent installations of pile fields have not been helpful to stream stability with re-initiation of bed and bank scour at each structure evident. Debris loads on the piles and splitting of the timber piles is contributing to the failure of the pile fields, with the likely result being a significant failure of structures and reactivation of bed erosion. These pile fields and the current stream erosion will need to be reviewed and tackled with a new method and works program. It is likely that multiple structures will be required to slow down the erosion.

A major problem at the head of the S2/1 valley is occurring following the installation of the fibre optic cable up the very steep slope without any significant erosion control measures put in place (Figure 5-3). The trench line is gullying out significantly and erosion products being transported into the stream. This issue needs to be followed up with the constructor or asset owner as a matter of urgency.

Figure 5-3 Fibre optic cable trenchline adjacent to S2/1

5.3 Vegetation

Current EVC mapping indicates that vegetation in this reach includes two vegetation communities. Table 5-1 details the EVCs that have been previously recorded within the study reach and the general vicinity of occurrence.

Dominant canopy species associated with these vegetation communities include, Red Stringybark (*Eucalyptus macrorhyncha*), Red Box (*E. polyanthemos*), Grey Box (*E. microcarpa*), Yellow Gum (*E. leucoxylon*) and Yellow Box (*E. melliodora*). However, scattered individuals of River Red Gum (*E. camaldulensis*) and Swamp Gum (*E. ovata*) were observed on the main stem in the upper regions of the reach (refer to **Error! Reference source not found.**). Generally the health of these trees varied from moderate to unhealthy.

Figure 5-4 Scattered Swamp Gum (*E. ovata*) and Black Wattle (*A. melanoxylon*) are found scattered along the upper reaches of Spring Creek (Reach S2).

The vegetation along the main stem of the reach is generally restricted to scattered trees, which are mostly mature and senescing. This is particularly evident in the lower hills and valley floor where there has been extensive broad-acre grazing. The majority of the native vegetation cover within the reach is located on the higher slopes, particularly in the upper ephemeral tributaries on the north-eastern hill slopes. Although these areas have an extensive canopy cover, they lack any substantial understorey component.

Generally, ground cover is minimal, particularly in the lower hills and valley floor and is largely restricted to a thin and sparse cover of exotic pasture species, a few salt tolerant species and a suite of weeds including Spiny Rush.

- **Table 5-1 Current Vegetation Attributes (EVC) Reach S2**

Current EVC Remaining in Reach (DSE, 2005)	Remaining Character	Location
22 - Grassy Dry Forest	Found in isolated patches along the upper reaches of the main stem, S2/1/1, S2/1/2, S2/2, S2/3, S2/4 and S2/5	Range of slopes and altitudes outside of the riparian zone.
67 - Alluvial Terraces Herb-rich Woodland	Found in small patches along the lower reaches of the main stem, S2/1/2 and S2/2.	Range of slopes and altitudes outside of the riparian zone.

In-stream vegetation is limited to scattered individuals and pockets of rushes, sedges and exotic weed species such as Phalaris. Small scattered pockets of Cumbungi are located along the main stem, which are mostly senescing as a result of increasing salinity. Spiny Rush is also found scattered and in small patches throughout the main stem and ephemeral tributaries on the eastern hill slopes which suggests the presence of saline base flows. Whilst the Spiny Rush could be regarded as a pest it has value in arresting bed erosion in these saline impacted streams, Spiny Rush also has good habitat qualities, particularly for amphibian species.

As a replacement for Spiny Rush, a trial of various macrophyte species would be a valuable exercise in an effort to remove Spiny Rush. Spiny Rush removal and control should be undertaken in an ecologically sensitive fashion. It is recommended that entire patches of Spiny Rush not be removed (physically or chemically) in a single episode, but rather to maintain some habitat (and erosion control) facilities and treat remaining areas at a future date, once replacement habitat has established.

The rehabilitation of the riparian zone of the ephemeral tributaries and mainstem back towards the forest edge on the north-eastern hill slopes should be a long-term goal. Due to the current depleted state of the vegetation within this reach, particularly in the tributaries and main stem in the lower hills and valley floor, revegetation works will require a great deal of work. The immediate and ongoing removal of stock from the riparian zone and the establishment of canopy species within the area are recommended. Species augmentation along the main stem should also be undertaken to improve the ecological condition of the reach. Some fencing has occurred along the upper reaches of the mainstem, however stock access in this area continues uncontrolled. Large sections of the main stem have been fenced creating a great opportunity to revegetate these areas, providing that stock is controlled.

5.4 Habitat

Apart from a few minor ephemeral pools, which are currently saline, very limited habitat for aquatic fauna species exists along the reach. This is mainly due to the ephemeral nature of the waterway, the highly mobile bed materials and the lack of any substantial instream and bank vegetation due to salinity and heavy grazing which has occurred, particularly on the lower hill slopes and valley floor. Overall, the habitat of all of these tributaries is severely depleted by the lack of vegetation and permanent flows.

5.5 Water Quality

Water quality in this reach is poor with the small base flows being high in salinity. Similarly it is expected that the event flow quality will be similarly poor with very high salinities and high levels of suspended solids and turbidity arising from both stream and catchment erosion.

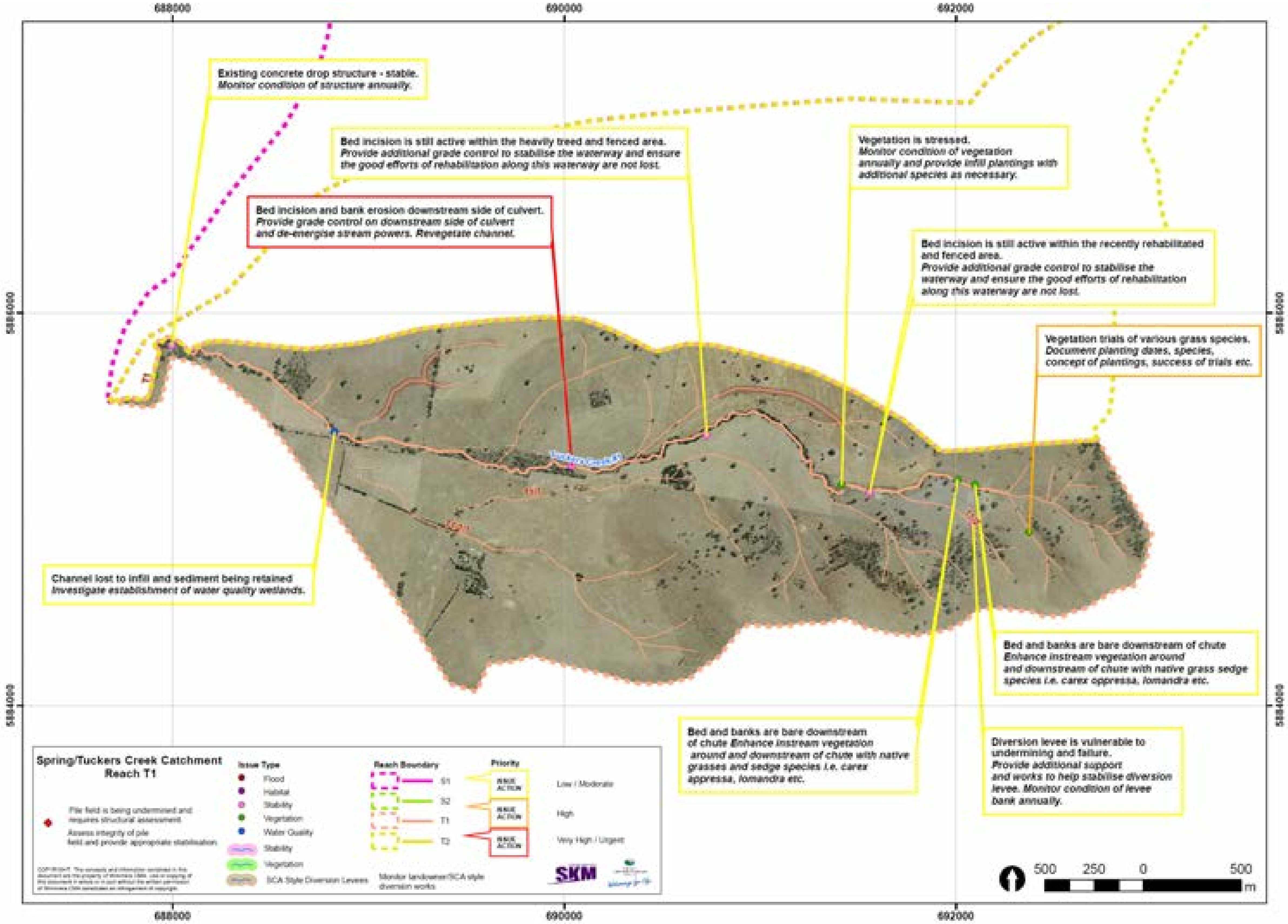
5.6 Flooding

There are no substantial flooding issues in this reach, with no assets under threat and flows generally contained in the confined valley floor. Care will need to be taken with the establishment of suitable flood fences to ensure the integrity of the fenced areas.

5.7 Threats and Priorities

THREAT	RISK
Optic Fibre cable installation has created very serious active erosion of trench line with the potential to create a large gully	Urgent
Significant activation of erosion in the mainstem leading to transport of erosion products to downstream reaches the Wimmera River	Very High
Large bed loads along the whole reach require the introduction of bed and bank controls to arrest further incision and erosion and encourage infill	Very High
Uncontrolled stock access to most areas of the mainstem and tributaries	Very High
Loss of riparian, bank and in channel vegetation adding to erosion and decline in stream values.	Very High
Mainstem S2 and tributaries S2/2 and S2/2 have active bed and bank erosion reactivated by the installation of pile fields which are declining	Very High
Salinity and suspended solids export is high from the eroding lands and stream channels	High
Loss of mature trees in the catchment impacts on the long term health of the stream and landscape	High
Old SCA style works in S2/1 have failed and causing very significant impacts on erosion	High
Stream habitat values are depauperate across the catchment	Moderate

6. Reach T1 – Tuckers Creek (Wimmera River to top of catchment)



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6 Reach T1 – Tuckers Creek (Wimmera River to top of catchment)

6.1 Reach Location

Tuckers Creek runs from its junction with Spring Creek immediately upstream of the Wimmera River through to the eastern hillslopes. The catchment is drained by two main streams: Tuckers Creek (T1) locally passing through the former Tucker family lands; and another creek sometimes referred to as ‘Tuckers Creek No 2’ or ‘Williams Creek’.

6.2 Morphological description

Tuckers Creek rises in the rocky and relatively steep red shale and slate hills in the east of the catchment. There is little forest or woodland cover and many of the foothills consist of weathered shale colluvium with thin and highly erodible soils.

Recently, probably following post settlement clearance and channelisation, channel incision has taken place through the stream system. It is likely that this incision was started by landowners wishing to drain the natural flat swampy areas in the mid-catchment to allow for cropping of these higher fertility areas. Similarly channelisation has been undertaken on the lower end of the waterway from the Wimmera junction through to the Eversley-Crowlands Road, probably as part of the Tulkara Railway construction. This position is supported by evidence of old courses to the east of the existing channel.

Erosion in this lower segment is far less active probably due to the intervention and construction of a number of concrete drop structures near the road in about the early to mid 1960’s. The straightened and channelised stream downstream of the Eversley-Crowlands Road is basically stable and is slowly aggrading with signs of overbank deposition.

Immediately upstream of Eversley-Crowlands Road a large concrete drop structure has arrested the incision process at the upper end of the grade break of the end of old floodplain sediment fan. This has prevented substantial head cutting advancing upstream into the old plain.

The section upstream of the road and for about 0.85 km eastwards flows across a very flat plain where the channel is very shallow and in places almost discontinuous where sediments from erosion over the last 100 years has filled the channel and created an anastomosing channel pattern through the various deposits. Most of these deposits of sediment are fine silts through to small gravels. The channel alignment has a line of mature River Red Gums along it. Upstream of this and adjacent to a current farm track it is obvious that the stream has been historically channelised and straightened. Indications of old course are evident to the south particularly. This channel has incised and is larger than downstream. Bed cutting is still occurring at a slow rate whilst bank

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erosion is more dominant and producing the bedload observed downstream. This section has been subjected to a substantial revegetation program but unfortunately no bed or bank erosion control. A ford and a 1.5 m high drop structure 1.6 km's upstream of the Eversley Road is causing bed and bank erosion and needs work to improve the transition of flows. Upstream of this ford another substantial revegetation program has been undertaken but again without any substantial bed controls. Again some bed incision is still active within the heavily treed and fenced area and this is likely to need some intervention works to ensure the good efforts of rehabilitation along this waterway are not lost. Repair works on minor tributary erosion through use of a diversion bank, dam and trickle pipe appears to have been successful. Landholder vigilance and follow up appears to have been an important part of ensuring success in this area with these activities.

- **Figure 6-1 Ford crossing that is providing grade control but is in danger of being undermined**

Upstream, a series of works have been conducted to limit the erosion heads with a grade control structure and a valley re-entry channel and associated check bank system being constructed. These works are showing signs of needing some minor repair works. Another valley diversion bank installation (upstream from the previous one) is showing signs of failing. Failure will activate scouring through the relatively steep downstream valley which is now under cropping. Works on this asset are required.

The scale and degree of erosion within this reach is far less than that in the adjoining reaches. This can be attributed to the careful long-term management by the landowners and the degree of understanding they have developed of the land system and the appropriate rehabilitation techniques. The newer works need monitoring and adjustment to continue this success story. The lack of transported sediment downstream can be attributed to both the interventions and the presence of the floodplain downstream that stores any erosion products exported out of the catchment.

6.3 Vegetation

Current EVC mapping indicates that vegetation in this reach includes three vegetation communities. Table 6-1 indicates the specific EVCs that have been previously recorded within the study reach and the general vicinity of occurrence.

The revegetation along the mainstem of the reach was abundant in some areas, but generally the remnant vegetation consisted of a narrow and discontinuous strip of aged River Red Gums (approximately 900m) is located midway along the mainstem. The riparian vegetation consisted mainly of River Red Gums, Grey Box, Black Wattles and pasture grasses with some weed species such as Phalaris. Ground cover mainly consists of a few salt tolerant species, exotic pasture species and a suite of weed species including Spiny Rush and Phalaris. The majority of the reach has been fenced and has restricted cattle access and as a consequence vegetation cover is beginning to re-establish. There are also indications of the recruitment of native canopy species, particularly River Red Gum throughout the reach.

The lower segment of the Tuckers Creek downstream of Eversley-Crowlands Road is virtually devoid of any riparian vegetation. It is recommended that revegetation in combination with protective fencing should occur at this site to help stabilise the streamzone.

- **Table 6-1 Current Vegetation Attributes (EVC) Reach T1**

Current EVC Remaining in Reach (DSE, 2005)	Remaining Character	Location
22 - Grassy Dry Forest	Located along the upper reaches of the main stem	Range of slopes and altitudes outside of the riparian zone.
68 – Creekline Grassy Woodland	Located along the lower reaches of the main stem	Drainage lines and adjoining flats.
76 – Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	Located along the main stem.	Intermediate slopes between the plains and more infertile upper slopes.

Creekline Grassy Woodland and Alluvial Terraces Herb-rich Woodland provides the most relevant EVCs to the riparian environment and the re-establishment of the River Red Gum, Woolly Tea-tree (*Leptospermum lanigerum*) and Grey Box canopy would be an important step in the improvement of the waterway and initiation of a long-term environmental improvement program. The bed

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vegetation is mainly dominated by salt tolerant species such as Spiny Rush indicative of saline base flows.

Vegetation management requirements for this reach centre on the need to secure and consolidate the revegetation efforts by landholders completed along the riparian zone by extending, enhancing and revegetating areas that are yet to be planted. The considerable riparian zone revegetation efforts driven by landowners along the middle portions of this reach are commendable and apparently spans nearly 25 years of effort (V. Start *pers comm*). However, the re-establishment of in-stream vegetation is still crucial for the health of the waterway. A vegetation trial located on the upper reaches of the mainstem was initiated approximately three years ago. The purpose of the trial was to experiment with various grass species such as Vetiva (*Vetiveria zizanioides*) (a grass species that originates from India) and other grasses including Tussock Grass (*Poa spp*) to determine a appropriate species for use in harsh environments and to consolidate the soil for improved cohesion (refer to Figure 6-3). Introduced species are not recommended for erosion control and a variety of locally indigenous species are available as substitutes to these species. To date, the success of these trials has not been documented. Further trials of various macrophyte species as a replacement for Spiny Rush (habitat value and erosion control value) should be encouraged. Spiny Rush removal and control should also be undertaken in an ecologically sensitive fashion. In that entire patches of Spiny Rush should not be removed (physically or chemically) in a single episode, but rather to maintain some habitat (and soil stability) attributes and treat remaining areas at a future date, once replacement habitat has established.

Although revegetation efforts have helped stream stability in some sections, there are extensive opportunities to expand these plantings and utilise specially selected indigenous species as substitutes to exotic species (i.e. Vitiva) (refer to Figure 6-2). Existing revegetation sites should be protected from stock and further planting should be encouraged in the voids where plants have died. A revegetation program for in-stream areas could include species such as sedges, (*Carex spp*), rushes (*Juncus spp*) and Lomandra (*Lomandra multifolia*). All of these species are found to be highly effective in soils with poor moisture and high salt content. They all have robust fine hair root systems that aids erosion control and are very drought tolerant.

Figure 6-2 Revegetation along the upper reaches of T1

- **Figure 6-3 Vegetation trials of Vetiver (Vetiveria zizanioides) along the upper valley of reach T1.**

6.4 Habitat

Fencing and revegetation works has restored some habitat continuity along the mainstem, particularly in sections midway along the reach. Generally, the habitat complexity of the reach is better in areas where there has been restricted stock access and revegetation works. This is evident in areas midway along the reach.

The canopy cover tended to be discontinuous on the downstream end of the reach, while the coverage improved further upstream.

Ephemeral pools of the reach could provide for important habitat and refuge for several water dependant fauna species including short lived invertebrate species, amphibians and potentially mammals such as the Water Rat if the salinity is not too much of an impediment. Clearly their presence would be dependent on the quality and availability of water.

As with previous reaches, the habitat condition of most of the cleared and grazed ephemeral tributaries is extremely poor with no appreciable significance.

6.5 Water Quality

The water quality of the small trickle flow observed in places along this reach was poor with elevated salinity. Event flow quality can be expected to have higher suspended solids and turbidity sourced from both sheet erosion of the fairly bare and erodible soils and from within the eroding stream. The retention of the mitigating swampy areas in the kilometre upstream of Eversley-Crowlands Road needs to be retained and not drained.

6.6 Flooding

Flooding is only an issue for the property in mid reach, on the very flat low gradient plain. Improvements can only be achieved in this area through the use of wetland systems to win gradient.

The main track within the Start property is subject to inundation at the mainstem crossing, but the inconvenience of this is liable to be short-lived as most events will only have a duration of hours or a day.

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6.7 Threats and Priorities

THREAT	RISK
Upper catchment valley diversion swale in process of failure and could cause significant valley erosion	Urgent
Loss of swamp sections in mid section would result in increased export of erosion products to the Wimmera	Very High
Reactivation of bed and erosion in the mainstem upstream and downstream of ford leading to transport of erosion products to downstream reaches	Very High
Uncontrolled stock access to the lower and mid section of the mainstem	Very High
Lack of bank and in channel vegetation adding to erosion and decline in stream values	High
Loss of riparian vegetation and uncontrolled stock access to segment upstream of Wimmera may trigger incision	High
Monitor recent stabilisation works for minor adjustment needs	High
Salinity and suspended solids export is high from the eroding lands and stream channels	High
Loss of mature trees in the catchment impacts on the long term health of the stream and landscape	High
Stream habitat values are depauperate across the catchment	Moderate

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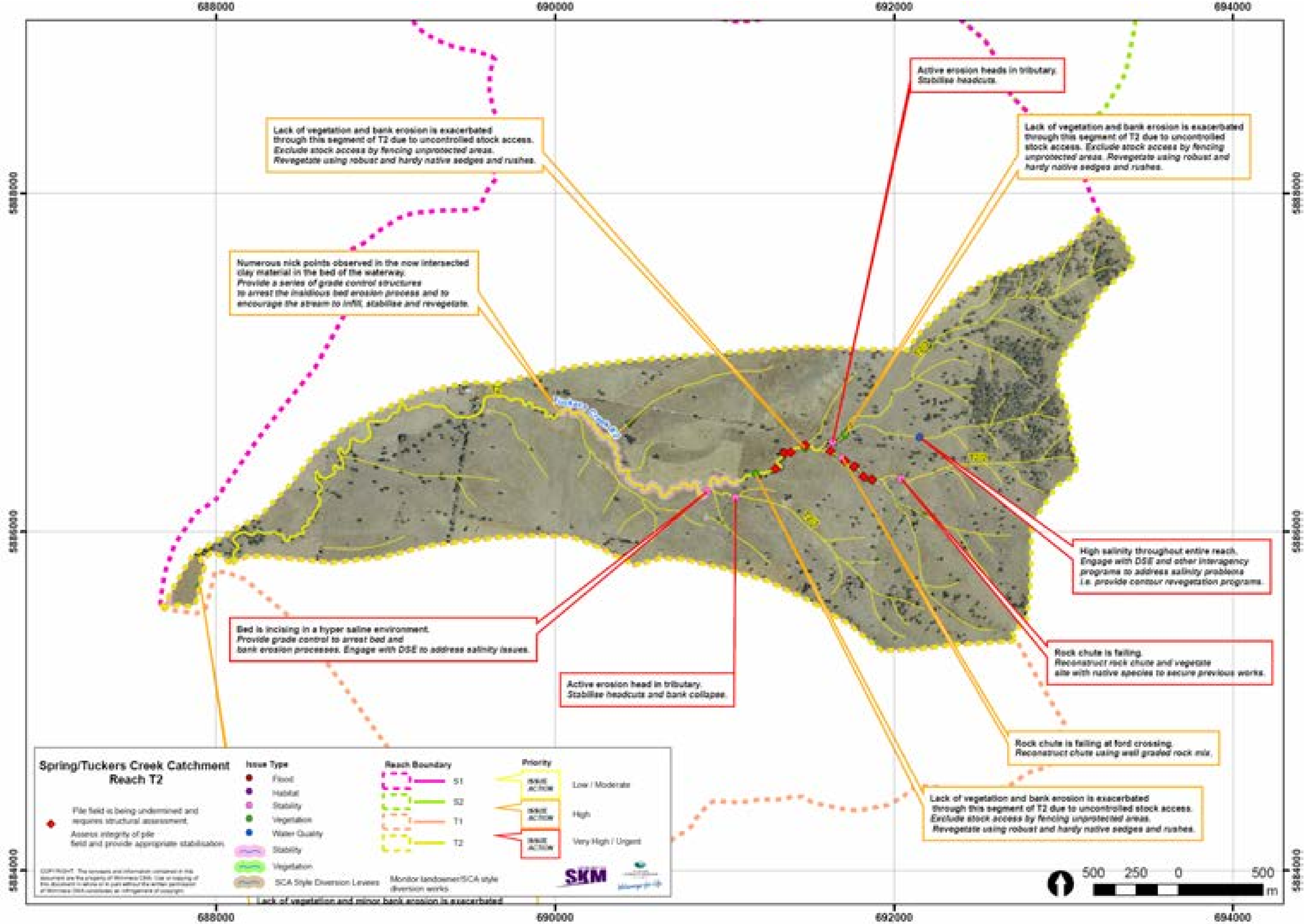
7. Reach T2 – Tuckers Creek # 2 (Eversley –Crowlands Road to top of catchment)



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7 Reach T2 – Tuckers Creek # 2 (Eversley – Crowlands Road to top of catchment)

7.1 Reach Location

This reach starts at a junction point with Tuckers Creek immediately upstream of the Eversley-Crowlands Road and runs to the top of the catchment in the steeper rocky hills to the east some 5.5 km away. This Reach has no official name but is sometimes referred to locally as 'Tuckers Creek No 2' or 'William's Creek'.

7.2 Morphological description

For descriptive purposes, the mainstem of this reach has been discussed in three sections. The most downstream sub-reach runs from the edge of the former floodplain and meanders its way through to near Spring Flat Road. This reach has previously been incised but the installation of an SCA drop structure appears to have arrested the process. This has allowed the channel upstream to aggrade to the point that the channel is now infilled and quite stable compared to the nearby Spring Creek. Upstream of this the channel grade steepens and incision and active bed and bank erosion is evident.

- **Figure 7-1 Effective SCA drop structure**

The morphology of the middle sub-reach is that of an incised creek within a relatively broad flat floored valley. The meander pattern of this sub-reach continues to evolve with ongoing bank erosion forming extremely tight radii of curvature on some bends. Attempts have been made to tackle the deep incision process with considerable lengths of fencing and verge plantings. Unfortunately, little was done to arrest the primary problem of head cutting with numerous nick points observed in the clay bed. Bedload consists of fine silts, sands and gravels. Whilst the current bed, downstream of the break in grade, appears to be aggrading it is more likely to be dynamic and highly prone to reactivation during wetter conditions. A series of grade control structures should be inserted to arrest the insidious bed erosion process and to encourage the stream to infill, stabilise and revegetate. Similarly, groynes or other techniques to protect bank toes should be considered to provide further bank protection and stabilisation. Continuation of revegetation into the bed using robust and hardy sedges and rushes should also be trialled.

Upstream of the T2/1 junction the stream steepens further and starts to intersect colluvium. A cobble load starts to appear in the bed and several overbank flow paths from lateral valleys are showing signs of unaddressed incision. It is through this upper sub-reach that a series of single and double row pile fields have been installed. As was the case with the tributaries of Spring Creek these pile fields are now deteriorating with outflanking, downstream scouring and reinvigorated incision processes all observed. As with the Spring Creek tributaries, all these structures will need a detailed appraisal and the initiation of a new works program to ensure that major bed erosion problems are arrested before they start. Bank erosion is exacerbated through this upper sub-reach by uncontrolled stock access. The very upper end of the reach has had a large armoured twin re-entry channel and chute installed to try and arrest the erosion head. Whilst this structure initially failed due to incorrect rock size, the current structure appears to be relatively stable. Unfortunately a critical grade control structure on T2/2 and northern most tributary is also failing. This structure should be reconstructed urgently to prevent headward erosion running up T2/2.

- **Figure 7-2 Outflanked pile field**

- **Figure 7-3 Twin pile field**

The upper tributaries all run up very steep valleys in steeply dissected and rocky hill country. This area of the upper catchment is devoid of any significant cover except for a sparse grass cover. There are a series of sediment fans at the lower end of the smaller valleys where they join the main valley. This shows that the weathering and sediment transport rates are still high and adds to the general sheet erosion of the less steep but grazed foothills. The extended drought has not helped in the maintenance of grass cover.

7.3 Vegetation

Current EVC mapping indicates that vegetation in this reach includes five vegetation communities. Table 7-1 indicates the specific EVCs that have been previously recorded within the study reach and the general vicinity of occurrence.

The vegetation along the mainstem of the reach generally consists of narrow and discontinuous and at times sparse strips of riparian vegetation, mostly of which is either River Red Gum or planted natives. The riparian vegetation consisted mainly of River Red Gums over a groundcover of exotic pasture grasses and weed species such as Phalaris and Spiny Rush. The in-stream vegetation is almost non-existent in most parts of the mainstem and this coincides with bare eroding banks.

Only a few sections along the mainstem have some scattered individuals of emergent macrophytes including native rushes, sedges and native grasses. With the combination of hyper-saline conditions and highly fragile banks with little or no topsoil, it has been difficult for native groundcover to establish or survive. This is evident along most of the reach. The most dominant species in-stream is Spiny Rush, where it has taken advantage of saline base flows. However, due to the hyper-saline conditions in some sections along the reach, soil salting is too excessive and Spiny Rush falls outside its natural tolerance (refer to Figure 7-4). These areas are bare with vegetation and the banks being unstable, highly dispersive and actively eroding.

Except for some revegetation of the upper slope verges, most of the mainstem and ephemeral tributaries are essentially without groundcover and midstorey vegetation.

- **Table 7-1 Current Vegetation Attributes (EVC) Reach T2**

Current EVC Remaining in Reach (DSE, 2005)	Remaining Character	Location
22 - Grassy Dry Forest	Found along the upper reaches of T2.2.	Range of slopes and altitudes outside of the riparian zone.
23 - Herb-rich Foothill Forest	Found along the upper reaches of T2/3	Relatively fertile, moderately well drained soils. Easterly and southerly aspects of lower slopes and gullies.
67 - Alluvial Terraces Herb-rich Woodland	Located along the upper reaches of the main stem, T2/2 and T2/3.	Range of slopes and altitudes outside of the riparian zone.

68 – Creekline Grassy Woodland	Located along the lower reaches of the main stem.	Drainage lines and adjoining flats.
76 – Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	Found along the lower to middle reaches of the main stem.	Intermediate slopes between the plains and more infertile upper slopes.

- **Figure 7-4 Hyper-saline conditions along the mid sections of Tuckers Creek (Reach T2)**

7.4 Habitat

The habitat of the mainstem is very poor due to the loss and modification of the riparian vegetation through grazing and very high saline conditions. There was no evidence of any permanent residual pools in the mainstem, except maybe following a wet sequence. Therefore, the presence of any permanent in-stream communities is unlikely to occur, but the normal range of ephemeral life forms may occur. Groundwater base flows in the gravel seams of the main stem have caused, in some instances, hyper saline conditions. Therefore only highly salt tolerant species could survive in these conditions. The discharge of saline groundwater exacerbates the lack of vegetation cover and highly saline water is unsuitable for aquatic fauna.

With the exception of a few sections along the mainstem, the habitat condition for most of the ephemeral tributaries is extremely poor with no appreciable significant habitat value.

7.5 Water Quality

As mentioned above this reach is affected by saline base flows. Although no qualitative water quality data was available for this reach salt levels at the junction of T2 and T2/1 were estimated to be in the vicinity of 20,000 µS range at the time of inspection.

Event flows from this catchment are likely to carry the salt loads down along with elevated suspended solids and turbidity arising from sheet, gully and stream erosion.

7.6 Flooding

Flooding is not major issue in this reach with no public or private assets subject to flooding. The flatter areas downstream of Spring Flat Road are likely to experience out of bank flows in the less frequent and more intense rainfall events. A series of old course are evident across this area. A flood breakaway is possible from Spring Creek about 200 m downstream of Spring Flat Road.

7.7 Threats and Priorities

THREAT	RISK
T2/2 Grade control structure in disrepair and could restart headward erosion	Urgent
Any loss of low gradient sections in lower section would result in increased export of erosion products to the Wimmera	Very High
Active bed and bank erosion in mid section of mainstem through lack of bed control structures	Very High
Reactivation of bed and erosion in the mainstem as a result of pile field failures or deterioration	Very High
Uncontrolled stock access to the upper section of the mainstem	Very High
Lack of bank and in channel vegetation adding to erosion and decline in stream values	High
Monitor recent stabilisation works for minor adjustment needs	High
Salinity and suspended solids export is high from the eroding lands and stream channels	High
Loss of mature trees in the catchment impacts on the long term health of the stream and landscape	High
Stream habitat values are depauperate across the catchment	Moderate

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