DECEMBER 2020

SCOTT RIVER ACTION PLAN

A Report Prepared by the Lower Blackwood Land Conservation District Committee

"RIPARIAN"

is derived from the Latin term riparius, which means "at the water's edge" and refers to the narrow green zones of land adjacent to streams, rivers and other surface waters.

This Plan was prepared by the Lower Blackwood LCDC's staff and committee members:

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- Nicole Siemon (Nicole Siemon and Associates): Foreshore Condition Assessment
- Dr Laura Stocker and Dr Gary Burke (Production Function): Literature Review, Aboriginal Heritage and Engagement Process, European heritage, Land Use, Legislative Framework, Climate Change
- Nick Cox: Drainage
- Jeffrey John: Dairy Effluent Management Systems
- Yasaman Mohammadi: Rainfall Analysis
- Simon Neville (Ecotones & Associates): GIS data analysis.
- Dr. Peter Howard and Dr. Ann Larson (Social Dimensions): review.

Many thanks to the consultants for their contribution to this Action Plan.

This project has been guided by the following members of the Scott River Action Plan Advisory Group:

Chair:	Hon. Barry House AM
Community members:	Jasper Grugeon
	Andrew McNab
	Shannon Fox
Industry Members:	Davin Gibellini (WAPRES)
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Department of Primary Industries and Regional Development:	Peta Richards
Department of Biodiversity Conservation and Attractions:	Clare Forward and Tracy Sonneman

Special thanks to the following:

- Iszaac, Wayne and Nadine Webb from Undalup Association Inc. and William and Nina Webb and Joel Chapman from the Bibulmen Mia Aboriginal Corporation
- The landholders that participated in and contributed to the Plan through interviews, on-site visits, information sharing and review, feedback, meetings and discussions.

This project has been funded by the Regional Estuaries Initiative, a four-year, $20 million Royalties for Regions program to improve the health of six Western Australian estuaries being delivered in partnership with the Department of Water and Environmental Regulation.

All maps in this document have been prepared by the Lower Blackwood LCDC with data provided by government agencies.
Photo credit for left hand cover photo and photo on pages I-II: Brett Dennis

Lower Blackwood Catchment
Land Conservation District Committee

REGIONAL ESTUARIES INITIATIVE

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Water and Environmental Regulation**

Department of **Primary Industries and Regional Development**

FOREWORD

The Scott River Catchment is a unique and special place loved to those that farm there and those that travel and holiday in the national park. It is also a special place for the Wa(r)dandi-Pibelmen people since ancient times. It is essential that this area of high value, highly productive farm land is preserved and cared for by all those that use it and have an interest in food security for Western Australia into the future.

The Scott River Catchment's agricultural potential is vast and at present, its current use is only scratching the surface. But with the farmers' ingenuity and support and assistance from Federal, State and local government departments, I am confident that its potential to feed Western Australians and earn export dollars can be achieved without damage to the unique environment. Indeed, with cooperation between all parties in good faith, I firmly believe it can be enhanced. However, it must not be forgotten this land is prime agricultural land and its productivity must be maintained and improved for future generations.

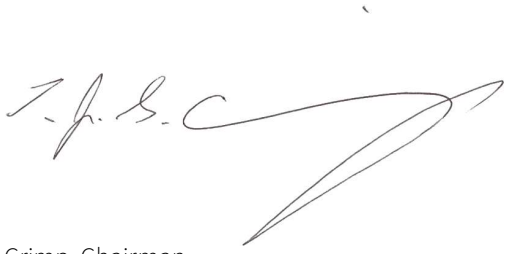
The Lower Blackwood Land Conservation District Committee is made up of local landholders and representatives from State and Local governments and rural industry grower groups under the auspice of the Soil Commissioner to conduct work that both protects and improves farming practices and land in our unique environment in a sustainable manner, where sustainability is measured in economic, social and environment terms. This is the reason we have taken on this task of preparing this document.

The Scott River Action Plan is focused on the Scott River Catchment (divided into seven sub-catchments) and is a body of information, worked on for 3 years, to:

- Collate the historical and current science and relevant studies into one document.
- Identify critical issues and management actions.
- Support the State Government to achieve the water quality targets for the Scott River and the Hardy Inlet.
- Support local farmers and industries to remain profitable, while helping them to reduce nutrient losses.
- Demonstrate an efficient and workable relationship between the State Government Agencies and the Lower Blackwood LCDC.
- Demonstrate the Lower Blackwood LCDC's capacity as a reputable intermediary between Government and land users.
- Be a source of information for future funding to operate "on ground trials" with land users.
- A reference point for Governments and landholders to allocate resources and funds to the best "on ground activities" to achieve meaningful environmental and economic benefits.

On behalf of the Lower Blackwood LCDC, I would like to thank the Department of Water and Environmental Regulation for the funding and guidance and, in particular, placing trust in an effective, committed local organisation to conduct the research, collate the information, liaise with landholders and other stakeholders.

Thanks to the landholders, government agencies, LCDC staff, stakeholders and the Advisory Committee for their input.
This comprehensive, but readable Plan returns that trust and, hopefully, won't sit on the shelf but will become the central management tool into future years of effective management of the Scott River Catchment.



Tim Crimp, Chairman

Lower Blackwood LCDC

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ACRONYMS

LBLCDC - Lower Blackwood Land Conservation District Committee
SRAP - Scott River Action Plan
DBCA - Department of Biodiversity, Conservation and Attractions
DWER - Department of Water and Environmental Regulation
DPIRD - Department of Primary Industries and Regional Development
DIA - Department of Indigenous Affairs
TP – Total Phosphorous
TN – Total Nitrogen
HIWQIP – Hardy Inlet Water Quality Improvement Plan
REI - Regional Estuaries Initiative
SRAG - Scott River (Action Plan) Advisory Group
NRM – Natural Resource Management
AMRCCE – Augusta Margaret River Clean Community Energy
LiDAR - Light Detection and Ranging
SWCC – South West Catchments Council
SWALSC - South West Aboriginal Land and Sea Council
EPBC (Act) - Environment Protection and Biodiversity Conservation Act
IBRA - Interim Biogeographic Regionalisation for Australia
DPAW - Department of Parks and Wildlife
IUCN - International Union for Conservation of Nature
ESAs - Environmentally Sensitive Areas
ASS - Acid sulfate soils
UDR - Unauthorised Discharges Regulations
AHIS - Aboriginal Heritage Inquiry System
DPLH - Department of Planning Lands Heritage
ACMC - Aboriginal Cultural Material Committee
PRG - Sustainable Agriculture Project Reference Group
TEC - Threatened Ecological Community
PEC – Priority Ecological Community
UCL – Unallocated Crown Land
AHD – Australian Height Datum
DAFWA – Department of Agriculture and Food Western Australia
PRI - Phosphorus Retention Index
PER - Phosphorus Export Risk
DIDMS - Dieback Information Delivery and Management System
BoM – Bureau of Meteorology
FCA – Foreshore Condition Assessment
ANZECC - Australian and New Zealand Environment and Conservation Council
GPS - Geographic Positioning Systems
SWIRC - South West Index of River Condition
WMG - Water Management Guidelines
WFNM - Whole Farm Nutrient Mapping
LBVMPG - Lower Blackwood Vertebrate Pest Management Group
CALM – Conservation and Land Management
CAPAD - Collaborative Australian Protected Areas Database

CONSERVATION CODE	
Threatened flora (T)	"Is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora ".
Critically endangered species (CR)	"Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under Section 19(1)(a) of the BC Act in accordance with the criteria set out in Section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora".
Endangered species (EN)	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under Section 19(1)(b) of the BC Act in accordance with the criteria set out in Section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.
Vulnerable species (VU)	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under Section 19(1)(c) of the BC Act in accordance with the criteria set out in Section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.
PRIORITY SPECIES	
Priority 1:	Poorly-known species species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2:	Poorly-known species species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3:	Poorly-known species species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4	Rare, Near Threatened and other species in need of monitoring (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

SUMMARY

Introduction

The Scott River Catchment is an important and productive agricultural area. Covering approximately 64,276ha, it stretches from Molloy Island to Jangardup Rd north-west of Lake Jasper and is divided between the Shire of Augusta Margaret River in the west and the Shire of Nannup in the east. Approximately 43% of the total Catchment area is farmland which includes dairy, beef, sheep and bluegum plantations. The remaining area of this unique Catchment is comprised of reserves (53%) and unallocated crown land, rich in biodiversity.

Prepared in collaboration with the Scott River farming community, local industries, Traditional Owners and government agencies this condition assessment and Action Plan presents a framework to protect and enhance the health of waterways of the Scott River Catchment without impacting on current and future agricultural productivity.

The Plan recognises that nutrients, particularly phosphorus, introduced to the Scott River by upstream agricultural activities have negative impacts on the health of the Catchment and the Hardy Inlet. This plan describes the current status of the Catchment with regard to water quality, health of waterways and riparian zone and provides a set of clear recommendations aimed at maintaining and improving catchment health while facilitating current and future farm and agricultural production.

An important aim of this report is to establish a collaborative framework so that landholders can work in a full partnership with the Government and its agencies to achieve water quality objectives, whilst maintaining productive and sustainable agriculture in what is one of the prime agricultural areas in Australia. As set out in the recommendations it is suggested that the Lower Blackwood Land Conservation District Committee could be the link between Government and landholders to achieve the ongoing partnership.

The work presented here was commissioned by the Western Australia Department of Water and Environmental Regulation through the Regional Estuaries Initiative and undertaken by the Lower Blackwood Land Conservation District Committee (LBLCDC).

Justification for the study

Reliable data exists which charts the changes occurring to the Scott River Catchment over the last 50 years and these changes are considered the primary causes of the decline in water quality throughout the Catchment and Inlet.

This report and its Action Plan draw on existing studies, standards for waterway health, and on two earlier reports: the Scott Coastal Plain a Strategy for a Sustainable Future (Department of Agriculture and Food, 2001); and the Hardy Inlet Water Quality Improvement Plan Stage One - the Scott River Catchment (White, 2012). While these earlier studies identified nutrient runoff, loss of vegetation, some agricultural and

farming practices and poor drainage management as primary causes of water quality decline, and articulated how these threats should be managed, many of the recommendations provided in these studies have not been actioned.

This has emphasised the urgency to prepare an action plan through a collaborative partnership between landholders, industry, government agencies and the Lower Blackwood Land Conservation District Committee. A Plan which encourages a coordinated and strategic approach to nutrient management at the catchment scale as well as at the farm scale through farm mapping and trials.

In addition, this Plan addresses the lack of information on waterway condition by undertaking a detailed condition assessment of the many tributaries and smaller waterways which have been shown to be the main pathway for the movement of nutrients from paddocks to the Scott River.

Aims and objectives

Drawing on previous work, industry best practices and current needs and priorities of landholders and industry in the Catchment, this work seeks to:

1. Integrate previous data with those collected and analysed in the current study to provide a current snapshot of Scott River catchment condition
2. In collaboration with landholders and industry groups, identify methods and opportunities to improve Catchment health
3. Strengthen collaboration and ownership between those invested in the health of the Catchment. Specifically, Scott River landholders, government agencies, traditional owners, and NRM groups
4. Identify knowledge gaps
5. Provide a clear set of recommendations
6. Develop an Action Plan by which those recommendations can be met.

To achieve this, new research was commissioned to:

1. Establish a baseline foreshore condition assessment for Scott River tributaries within priority sub-catchments
2. Provide an update on water quality targets for the Catchment
3. Identify those areas where there is a paucity of knowledge on catchment health and impacting human activities
4. Investigate current nutrient management practices and opportunities for improvement with a focus on dairy effluent systems, drainage, fertiliser applications and waterway condition.
5. Identify landholders' values and priorities with regard to catchment health and water quality
6. Develop a comprehensive spatial dataset to be used in future planning

Methods

To complete this report and to develop the Action Plan presented here, work was undertaken in four stages:

Stage 1: Scoping

The Scott River Action Plan Advisory Group formed to oversee and guide the development of the Plan. The Advisory Group consisted of representatives from landholder and industry groups, the Lower Blackwood Land Conservation District Committee and government agencies viz., Department of Water and Environmental Regulation, Department of Biodiversity, Conservation and Attractions, the Department of Primary Industries and Regional Development.

Lower Blackwood Land Conservation District Committee undertook a desktop study and with the assistance of other agencies collated spatial data for the Catchment.

Stage 2: Literature review

Literature and reports detailing socio-economic, cultural and ecological values and activities attached to the Scott River landscape along with relevant legislative and regulatory instruments were collated and assessed. These included reports of algal blooms, fish kills, water quality, changes and projected changes in land use, changes in rainfall and anticipated impacts of climate change.

Stage 3: Community Engagement

The third stage was undertaken by the Lower Blackwood Land Conservation District Committee to engage the Scott farming community, local industries, and Traditional Owners in preparation of the Plan.

The Lower Blackwood Land Conservation District Committee used open-ended interviewing (thirteen out of twenty-one landholders) to assess attitudes, values and practices related to:

1. waterway health
2. vegetation and animals
3. land
4. climate
5. infrastructure
6. nutrient management practice (effluent systems, drainage, fertiliser management and soil health)

Stage 4: The Consultant Reports

The final component of this study are three consultant reports commissioned by the Lower Blackwood Land Conservation District Committee. These reports are:

- **Dairy effluent management:** a social study of farmer perceptions of dairy effluent and its management (Jeffrey John)
- **Foreshore condition assessment:** an assessment of foreshore condition of priority waterways and management recommendations (Nicole Siemon and Associates). Key

threats to river health and priority areas for rehabilitation work were identified and mapped using a GIS mapping software. The Lower Blackwood Land Conservation District Committee is the (only) data custodian of the foreshore condition assessment map layers and associated datasets. The maps created through this process show key priority areas for future environmental work and together with the recommendations developed for each Section will be used in the implementation planning stage.

- **Drain management:** an investigation of drainage type and function in the Scott River Catchment, the likely impacts on nutrient runoff, appropriate design guidelines and improvement works (Nick Cox)
- **The Fertiliser management and soil health** section is a short summary (not a new study) of soil testing programs and fertiliser trials carried out in the Scott River Catchment (Lower Blackwood Land Conservation District Committee).

Key findings

Waterway condition

1. Approximately 90% of the waterways assessed (~120Km of a total of 185Km of waterways) were rated as degraded or severely degraded due to the absence or limited vegetation cover in the riparian zones, significant bank erosion and weed infestations.
2. The sub-catchments Governor Broome, Upper Scott, Four Acres and Middle Scott (upper reaches) had more than 85% of waterways assessed rating D[1] ; the Dennis catchment had almost 50% of the waterways assessed rating C. The sub catchments with waterways in better conditions were the Middle Scott Lower Reaches and the Lower Scott.
3. The majority of minor waterways and tributaries assessed have lost much of the endemic flora and fauna. These findings match those of the Department of Water and Environmental Regulation's Healthy Rivers Program which consists of detailed waterway assessments (using a different methodology) at key sites in the Catchment.
4. A few properties have patches of native bush of high biodiversity value but these are not always fenced off to exclude stock.
5. Several widespread weeds were recorded. Two declared species (Apple of Sodom and Cape Tulip) and some woody weeds. No Arum lily or Blackberry (***Rubus fruticosus***) were recorded in the Catchment.
6. The biodiversity in the main channel is in good condition in terms of the number and diversity of flora and fauna species although there are signs of stress associated with upstream nutrient runoff along some Sections.

Biodiversity

7. The Catchment contains two Threatened Ecological Communities (being the Scott River Ironstone Association Threatened Ecological Community, the Federal Coastal Saltmarsh Threatened Ecological Community (also a State Priority Ecological Community) and one Priority Ecological Community (salt marsh). The Catchment also supports almost 60 listed species of flora of which five are threatened and one considered extinct. Twelve of the catchments

1 The Pen and Scott rating Rates A for river embankments and floodways that are entirely vegetated by native plants; B for foreshore areas where weeds have become a significant component of the understorey vegetation. The regeneration of all components of the native plant community is threatened and not all species are persisting within the community. There are some localised areas of erosion associated with weed dominated zones. C where trees and occasional large shrubs persist along the waterways but the understorey consists almost entirely of weeds, particularly annual grasses. The trees are generally long-lived species but there is little or no evidence of young trees or tree seedlings. Physical disturbances to the soil tend to disturb the expose soil, making it vulnerable to erosion. D for foreshore areas where there is not enough fringing vegetation to control erosion. While some trees and shrubs remain and slow the rate of erosion in localised areas, they are likely to be undermined. It is likely that the course of river flow will increasingly fluctuate in the future.

listed species are endemic to the catchment, with all of those being found in the catchments highly cleared western extent.

8. 26 species of fauna are listed as threatened, priority or under protection within the Catchment. Some well-known species are the Forest Red-Tailed Black Cockatoo (***Calyptorhynchus banksia*** - Vulnerable); the Australian Fairy Tern (vulnerable); the Carnaby's Black Cockatoo (***Calyptorhynchus latirostris*** - Endangered) and the rainbow bee-eater (***Merops ornatus)***. The Red-tailed cockatoo is listed as vulnerable (EPB Act). The Carnaby's Cockatoo and Baudin's Cockatoo are listed both in the state and federal Acts as endangered. The northern part of the Catchment provides more habitat for roosting and main channel for foraging.
9. Invasive plants are widespread in the Catchment. There are several common ones and some are declared pest (DP). Widespread weeds of greatest concern include Redshank (***Persicaria maculosa***), Fleabane (***Conyza spp.***) and Spear Thistle (***Cirsium vulgare***). Weeds of greatest concern that are present in relatively small numbers include one-leaf cape tulip (***Homeria flaccida***) (DP), Apple of sodom (***Solanum linnaeanum***) (DP), Stinkwort (***Dittrichia graveolens***), Loosestrife (***Lythrum hysoppifolia***), Sydney golden wattle (***Acacia longifolia)***, ***Persicaria maculosa***, Marshmallow (***Malva parviflora***), Wavy gladiolus (***Gladiolus undulatus***), African feather grass (***Pennisetum macrourum***) and African love grass (***Ehrharta calycina***). Arum lily has not been recorded in the Catchment.
10. Anecdotal evidence indicates that feral pigs, foxes, rabbits and feral cats are widespread in the Catchment.

Water Quality

11. In 2019 the Department of Water and Environmental Regulation water quality monitoring data showed an overall improvement of around 20% for total phosphorous compared to 2007 to 2009 for the catchment. For total nitrogen a decline of 10%. Total phosphorous concentrations in 2019 were 0.12mg/L, still above the established water quality target of 0.10mg/L.
12. Total phosphorous concentrations in 2019 were above the target of 0.1 mg/L at five monitoring sites out of nine: at S-Bend, Electric Fence, Woodhouse, Milyeannup Bridge and Brennan's Ford. There was a slight improvement at Milyeannup Bridge (still over the target), Brennan's Ford (still over the target), and Governor Broome (below the target). The S-Bend had extremely high values, far in excess of all other sites and orders of magnitude higher than the target. Governor Broome Road and 4 Acres had median values below the targets, and for Governor Broome Road this represented a much lower median concentration than for the period 2007-09.
13. The above results indicate some successes in reducing the presence of nutrients in samples taken in the Catchment, although why this has occurred is not fully understood. Changed land use and better fertilizer application regimes are posited as possible reasons, although measurement and/or sampling anomalies may also be involved.

Landholders' perceptions, attitudes and priorities:

14. In general, landholders are well aware of the impacts of past and current agricultural activities on waterway health in the Catchment and the need to address these issues. Nutrient run off, specifically phosphorus from fertiliser use, effluent from dairy farms, the number of drains and the loss of riparian vegetation as result of clearing and prolonged unrestricted stock grazing are widely understood by stakeholders to be the primary cause. Collaboration between landholders to address water quality issues at the sub catchment level has been fairly limited.
15. Interviewing of stakeholders identified three distinct sets of attitudes towards water quality improvement. In the first group were a small number of people who, despite showing a good understanding of the environmental impacts of poor nutrient management decisions, were not currently making any changes to farming practices. In this group private property rights and the risk/cost of changing familiar farming practices have a higher priority over wider environmental and public health benefits and collaboration with neighbouring farms is limited. The second and largest group comprised of people who showed some degree of interest in improving the current situation however barriers such as large expenditures, potential loss of productive land and government interference still persist. A third smaller group of people are undertaking work (either privately funded or with assistance from government funded programs) such as fencing and revegetation of riparian land and fertiliser trials.
16. While there is currently widespread agreement amongst landholders on what is causing the loss of water quality there are several barriers to its improvement such as lack of adequate financial support for major improvement works (for drainage and effluent upgrades); cynicism about government agencies approaches and methodologies (for example lack of farm-scale soil type data for the catchment and confusing industry standards), fear of losing grazing land (for example if land is fenced off and waterways protected) and overall fear of government interventions.
17. A smaller group, although acknowledging the threats posed by climate change, did not feel it warranted a

change to their current land management practices. In fact, some of that group felt graziers may benefit from the anticipated decreases in rainfall.

Traditional Owners:

18. The traditional owners west of the Blackwood River are the Wa(r)dandi and east of the Blackwood (including Scott River) are the Pibelmen. Several important sites were visited including the Kybra rock site where the LBLCDC learned about the animal track engravings, a 'water tree' that held fresh drinking water, an entwined marri and jarrah 'marriage tree' that was used for marriage ceremonies and a freshwater point that had been turned into a permanent well by previous landholders. These groups were represented by the Undalup Association Inc and Bibulmen Mia Aboriginal Corporation. From our discussions with them we understand that:
    - Traditional owners place extremely high social, cultural and economic values on Country or boodjar.
    - There are many sites within the catchment of traditional, local and national significance.

Fertiliser management:

19. Reducing fertiliser application rates on grazing lands in the catchment is seen as the easiest and most cost-effective approach for landholders and will achieve the greatest overall reduction in P levels in the waterway.
20. The majority of landholders interviewed said they undertook soil testing via the Department of Primary Industries and Regional Development Whole Farm Nutrient Mapping initiative or through an accredited agronomist and that their application rates have changed accordingly. Those who don't, said that they are happy with what they have been doing for many years and don't see the need to change.
21. Approximately half of the landholders interviewed were willing to share their soil test results with the Lower Blackwood Land Conservation District Committee.
22. There is some interest in regenerative agriculture systems that use fewer agricultural inputs and effective at improving soil fertility, water retention and in inhibiting erosion and salination. Some are being trialled in the Catchment.

Dairy Effluent systems:

23. Dairy effluent management systems in the catchment are typically inadequate. Most landholders are fully aware of these inadequacies and of the impacts that current effluent management practice have on the environment and water quality in the Catchment.
24. The majority of the dairy landholders were in favour of improving effluent management systems through the adoption of newer technologies or upgrades of existing infrastructure however, they felt there is insufficient local research and financial incentives to warrant the large initial capital outlay and financial risks associated with the building and maintaining this infrastructure.
25. There is limited use of valuable effluent resource on farm because:
    - landholders are unable to effectively apply effluent to pastures due to lack of suitable infrastructure and equipment;
    - there are high maintenance requirements due to inappropriate equipment; solids and sands causing blockages and abrasion in equipment; and
    - seasonal rainfall makes irrigation problematic during winter months.
26. A recent study on available technologies has been prepared for southwest Western Australia. Funded by the Regional Estuaries Initiative program and prepared by Janine Price of Scolexia and Dr Stephen Tait of the University of Southern Queensland (Price and Tait, 2019); it provides a range of management solutions ranging from the simple to more complex and costly. It emphasises the need for 'whole farm' approaches and makes good recommendations about potential system components which could be installed successfully in southwest WA.
27. A six-month trial of a commercial effluent separator, the Z-Filter is being carried out on the largest dairy in the Scott River Plain. The objective of the project is to improve farm soils that have been depleted over the years, reduce nutrient run-off and generally improve the productivity and viability of the farm. The final report is being prepared, but initial results have shown an impressive ability to remove phosphorous and nitrogen (>70% and >40% respectively) from dairy effluent and to provide a stackable cake from dilute effluent streams.
28. The Western Australia Government is working collaboratively with Western Dairy and South West Dairy farmers to improve current practice in Western Australia through the Regional Estuaries Initiative. This includes a Sustainable Agriculture Strategy, which responds to the intensification of agriculture and the increased potential for nutrient run-off from agricultural land into southwest estuaries (Regional Estuaries Initiative 2019) with a key focus being dairy effluent management.

Drains:

29. Surface drains are important to landholders in the Scott River Catchment as they divert water away from farm land, landholders saw this as essential for maintaining a production.
30. The presence of a vast network of agriculture drains accelerates nutrient transport from farms into waterways

and then the main channel.

31. Drains appear to have been built to address individual issues rather than in a coordinated manner that would result from farm and drainage planning.
32. The intensification and deepening of the drainage system, in many cases, at least partially achieve the objectives of some landholders but it is unclear as to how much it has contributed to an overall increase in phosphorous export.
33. A majority of landholders interviewed said drains were built without necessarily following construction guidelines or considering potential environmental impacts. While some landholders said they were willing in principle to upgrade their drains the costs of doing so were too high and financial support not available for this type of remedial work.
34. Not all landholders were comfortable talking about agricultural drains on their farms fearing government interventions at some point in the future.
35. While restoring riparian functions along waterways by removing stock and revegetating is a recognized approach to improving water quality it is not always popular because of the perceived losses of access to farming land. Further, drains are often constructed to remove water from farm land, riparian zone restoration is perceived as having the potential retain water on farms.

Riparian management:

36. The current condition of waterways indicate that land that is highly valued for grazing is prioritised over riparian management considerations.
37. In general landholders would prefer to fence off and graze periodically or leave a small buffer (under 10m) between the fence and the waterway. Such practices fall substantially below recognised riparian zone protection guidelines and would not qualify for funding under current guidelines.
38. Recently some Catchment landholders have undertaken riparian zone restoration work. Monitoring these sites over the next few years will build knowledge with regard to buffer sizes, site preparation requirements, species retention, etc.

Figure 1: A section of the Scott River

Summary of Recommendations

Below is a summary of recommendations for each key dimension addressed in the Plan (riparian management, drainage, effluent systems, and fertiliser practice and soil health) and for future engagement and collaboration. The recommendations are divided in recommendations for landholders and recommendations for supporting organisations. A short explanation/justification is provided for each recommendation as well as some key management actions.

For Landholders:

1. **Identify and adopt optimum fertiliser rates and applications that maintains productivity levels whilst minimising nutrient loss (for all land uses):** If soil contains excess P adding more P will not increase productivity but may add P to waterways contributing to algal blooms. Finding the optimum fertiliser application is predicted to substantially reduce phosphorus loads from the Scott River and help meeting the water quality target of P 0.10 (mg/L). Soil testing should be carried out by accredited agronomists. Detailed farm-scale mapping can help identify soils that are more prone to nutrient leaching and guide more accurate fertiliser applications to paddocks. Partnership projects are available in the Southwest to assist landholders to undertake fertiliser trials and soil mapping.

2. **Identify and implement farm-specific best practice solutions for upgrading effluent systems (dairy):** The majority of nutrient problems in a dairy are derived from diffuse nutrient transport from the farm. Improving effluent management is estimated to reduce P exports to the estuary by 0.11 t/yr. A number of feasible options for effluent system upgrade relevant to the Scott Catchment can be found in the 2019 Price and Tait report and from innovative trials carried out in the area. These options need to be assessed based on farm specifics. It is important that existing effluent infrastructure (e.g. ponds) are maintained in working order to ensure operational efficacy. Feasibility of upgrading existing infrastructure should be considered first. Farm planning is an important tool that can help identify point and non-point sources of P and surface water pathways. Take advantage of information and field demonstrations provided by the local LCDC or government agencies or industry bodies to learn about the benefits (including economic) of more efficient effluent systems.

3. **Protect or Improve the condition of riparian land: Healthy riparian land adds value to a farm by providing a number of benefits:** from enhancing aesthetic qualities and providing habitat for flora and fauna to improving water quality and sediment trapping. Importantly a vegetated waterway that is not disturbed provides water temperature regulation functions limiting limit algal blooms hence providing a vital role in community health and wellbeing. When planning riparian restoration work the objectives of the project have to be clear and achievable. Consider the overall impacts/benefits at the sub-catchment level because what happens upstream affects what happens downstream and linear contiguity matters. Collaboration with neighbouring farms can be more effective from an environmental point of view but also from a financial one. Again, a whole farm plan can help to identify main water bodies, native bushlands and riparian areas. Integrate and review the information from this Plan Foreshore Condition Assessment and prepare a restoration plan with all project details. Financial support is typically available for fencing and revegetation project through state government funding programs.

4. **Adopt sustainable surface water drainage design and management practice to reduce nutrient export, while maintaining essential drainage functions:** Although necessary in some situations to enable agriculture activities, drains can be a considerable pathway for phosphorus (P) loss (especially the dissolved form) from the field to surface water bodies. Constructions of new drains should be planned carefully particularly in 'hotspot' sub catchments where nutrient export into waterways is high. Section 5.3. of this Plan provides guidelines on how to design a surface water drain in the Scott Catchment. A farm scale drainage should be designed for the intended land uses. Land use specific water management guidelines were prepared in 2001 as part of the Scott Coastal Plain Strategy and they are still relevant today (general principles are outlined in Section 5.1). It is important to coordinate drainage between neighbours so as to protect and make the most of the catchment scale drainage network. Whole farm maps can help to identify the location of the various land uses and P inputs in proximity to drainage and to identify priority drains that need improvement work. Some priority drains have been already identified in this Plan in the foreshore condition assessment surveyed areas. Consideration should be given to relocating land uses away from drainage and flooding areas and realigning artificial waterways/drains around pivots instead of through. Diverting large drains would be too costly. Use shallow drains that can be revegetated to retain their stability and that will not drain groundwater.

For Supporting Organisations:

5. **Continue to investigate Catchment conditions and waterway health:** The Plan findings clearly emphasise the need to continue water quality monitoring in the Catchment with additional monitoring sites being considered. Further research should be conducted to fully understand the correlation between nutrient concentrations, rainfall, temperatures, and environmental flows over, informing the issue of recurrent algal blooms in the Hardy Inlet. In-flows and out-flows monitoring at key locations can help assess nutrient water quality and nutrient budgets and the impacts of farming activities on nutrient values.

6. **Support the identification and implementation of best practice fertiliser management.**

7. **Support the identification and implementation of farm-specific, best practice solutions for designing or upgrading effluent systems.**

8. **Support landholders to protect or improve the condition of riparian land.**

9. **Support a strategic and coordinate catchment scale approach to drainage management.**

10. **Support farm-scale best management practice for drainage:**
    Some key management actions for recommendations 6 to 9 include:
    - Continue to engage landholders in discussions about the benefits of adopting best nutrient management practice in particular economic ones with local specific examples and analysis. Farm planning is a useful tool to enable these discussions to unfold and to identify priority actions at the farm scale.
    - Continue programs (trials, grants, research) which support landholders make more informed nutrient management decisions and implement recommendations from this Plan. Driving large scale changes to farming and agricultural practices is challenging. Typically, successful programs are those that can demonstrate improved profitability and work within the value set of landholders. Successful extension programs also take time, the sooner they start the earlier the benefits accrue.
    - Review and share the outcomes of trial projects and support new trials in the Catchment.

11. **Foster on-going and meaningful engagement and knowledge sharing opportunities with landholders, Aboriginal groups, industry and government. This can be achieved by:**
    - Delivering a long-term local, strategic landholder and industry engagement process to build confidence in nutrient management recommendations and encourage landholders to implement management practice that optimises productivity and minimises nutrient loss. Designing future engagement programs should take into account the social fabric of the Catchment and its potential changes identified in this Plan.
    - Seeking information about landholders' priorities and needs and maintaining up to date datasets from government agencies as they become available. This information should be incorporated into the LCDC GIS database already developed for the preparation of this Plan and used to support landholders in the Catchment
    - Undertaking on going consultation and engagement with local Aboriginal groups regarding the health and management of the river and its waterways and other Aboriginal heritage sites. Seek advice early in the process of project planning.
    - On-going gathering data on landholders' values and priority using the sustainability framework analysis and mapping.

12. **Strengthen collaboration and project ownership among landholders, government agencies, land managers, traditional owners and NRM groups for further research and implementation of the SRAP recommendations:** While the Scott River Action Plan does not carry the weight of a statutory planning instrument, it demonstrates a clear collaborative partnership has been established between stakeholders in the Scott River Catchment on what is sought in terms of water quality and sustainable agriculture objectives. These collaborative partnerships should be strengthened to best support the implementation of this Plan. This can be achieved by:
    - Engaging key stakeholders such as landholders, industry and NRM groups in the design of government programs and in their evaluation.
    - Considering the benefits of best nutrient management practice both at the catchment and farm scales for a more

strategic and coordinated (but still farm specific) approach.

- Encouraging the two local governments to play an active and ongoing role in providing support for landholders in the Catchment
- Developing a communication strategy for the SRAP to disseminate information about the health of the Catchment, works implemented and lessons learnt. Share lessons learnt from a network of landholders who are involved in innovation and conducting many different trials, through workshops, farm field days and provision of information.
- Designating the LBLCDC as the lead agency for developing and coordinating the implementation of the SRAP. The LBLCDC is to work in partnership with the agencies with land management responsibilities in the Scott River Catchment and the local farming community. Ensure the LBLCDC is properly resourced to implement the Plan.
- Establishing a Scott River implementation reference group or continue the existing SRAG.
- Developing an Implementation Plan that includes further details on targets, timeframes, funding sources and partnerships to ensure efficient delivery of recommended management actions.

A Strategic Approach

The Scott River Action Plan covers a lot of ground and makes a relatively large number of recommendations which at first glance might seem unconnected and potentially complex. However, all parts of the report and the recommendations are connected and add up to a strategic approach that can begin to be implemented in the short term and continued in the medium to long term.

The key elements in this strategic approach include:

- **The importance of a collaborative-based governance framework that brings landholders, industry and government together in a full partnership to achieve agreed joint objectives, with Lower Blackwood LCDC supported to play a leadership role.**
- **The need for a 'knowledge hub' to retain and make information about all aspects of management and land use accessible, along with collaborative processes to share and exchange information and ideas.**
- **A series of practical recommendations and practical learning tools, including for further work, for management of the main land uses to support landholders in cost effective ways, including the dairy and beef industries. This includes support for landholders to optimise their fertiliser programs and reduce nutrient loss, and more cost-effective ways to make use of valuable dairy effluent.**
- **A landscape approach across the Catchment that identifies the best way to manage the existing drainage system across farms and sub catchments.**
- **The identification of streams, drains, remnant vegetation and wetlands, which still have valuable vegetation that can be fenced and restored if necessary, to support the amenity, biodiversity and water quality of the Catchment.**
- **Clear identification of the scale of problems with feral animals, especially feral pigs, that can lead to more strategic approaches to dealing with these pests.**
- **Introduction of the idea of 'Whole Farm Mapping' as a service to landholders to bring together all of the elements of sustainable and productive farming in a sub-catchment and whole of landscape approach.**

While it is not a statutory plan or government policy, the Scott River Action Plan is the beginning of a collaborative partnership approach to achieve agreed water quality and sustainable agriculture objectives

STRUCTURE OF THE REPORT

Introduction states the background, aims and notes of previous studies and the Methods Section outlines the methodology used for the preparation of the Plan.

Following is **Methods** which provides the methodology used for the formulation of action plan.

Catchment Overview describes both the socio-economic landscape of the Catchment as well as the environmental values/ drivers, including water quality and most up to date information on river health.

The process of stakeholder engagement and its findings is outlined in **Engagement and Consultation Process.** A component of the engagement process is the **Knowledge Sharing and Value Mapping** study which covers landholder and community views on the elements of water, vegetation, land use and climate. This is an important study, because through interviews and mapping the farming community shared their views, concerns and priorities. In turn this helps develop a broader understanding and assists implementation of agreed management measures.

Catchment Condition Assessment is the Section of the report that looks at the key aspects of water quality management: Dairy Effluent Management, Riparian Management, Drain Management, and Fertiliser Management & Soil Health. Last comes the final recommendation Tables in the actual **Action Plan.**

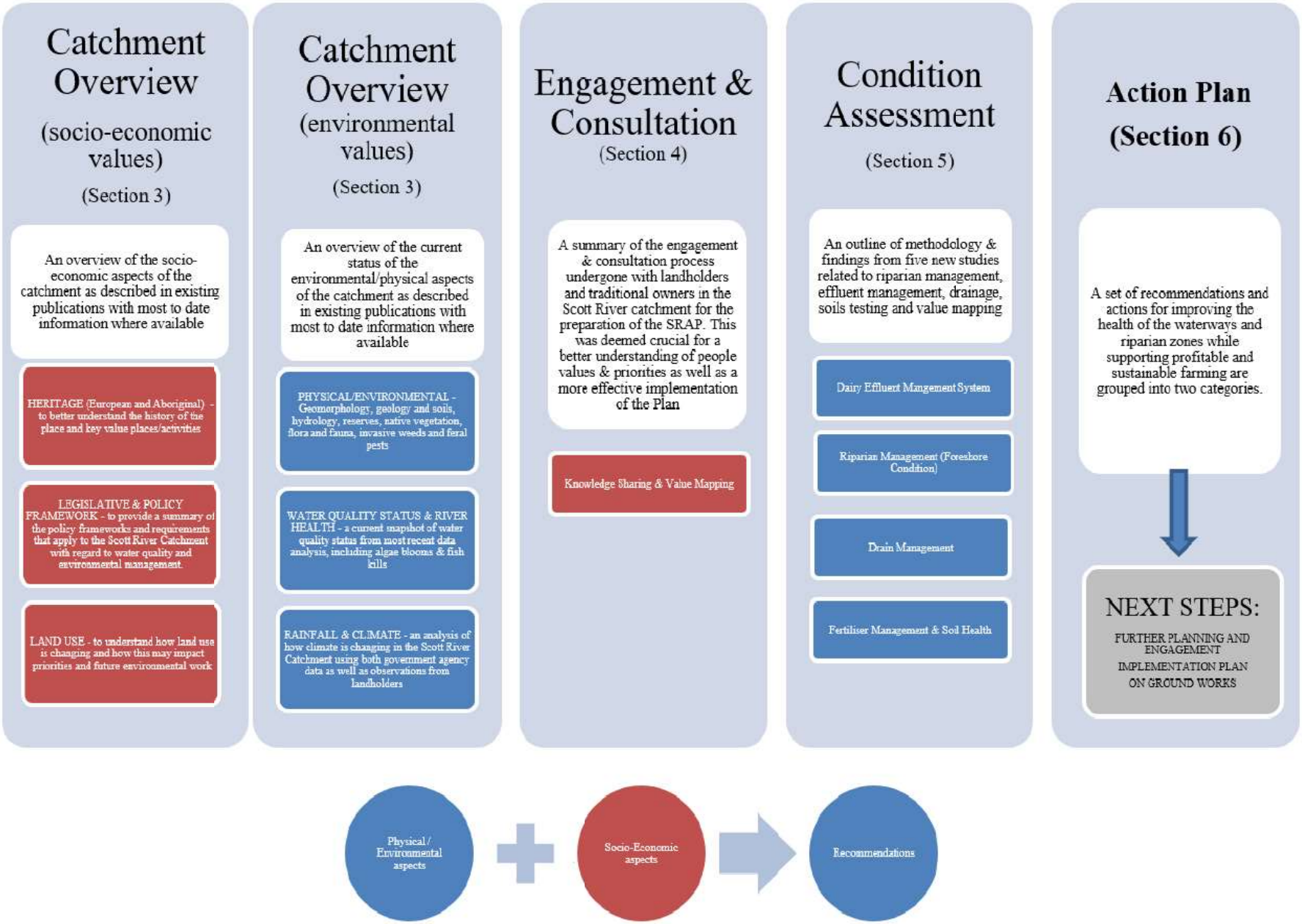


Figure 2: SRAP Structure and Links

1. INTRODUCTION

1.1 Background

The Scott River Catchment is divided between the Shire of Augusta Margaret River (AMRS) and the Shire of Nannup (SN) in the southwest of Western Australia. The Catchment has undergone significant modifications over the last 50 years as a result of land clearing and drainage for agriculture activities and other land uses such as tree farming. These activities and changes to the landscape and waterways have been a contributing factor (in some areas more than others) to the degradation or loss of riparian zones, loss of biodiversity, and decline in water quality. A major concern with regard to water quality is nutrient enrichment (particularly phosphorus) of the waterways, generated from agriculture-related activities. If the Catchment is not managed in a proper and timely manner, intensification of certain land uses may exacerbate the nutrient inputs into the Catchment and impact even further on the health of the river system and inlet.

In 2012, the Department of Water and Environmental Regulation (DWER) released the Hardy Inlet Water Quality Improvement Plan, Stage 1 – the Scott River Catchment (HIWQIP [White 2012]), an investment plan to provide for the long-term improvement and protection of water quality in the Hardy Inlet. The HIWQIP identified that excess levels of phosphorous (P) are a critical factor in the decline of water quality in the Scott River Catchment and in the development and proliferation of algae blooms in the Hardy Inlet. The sub catchments that back in 2012 were found to be generating the highest P runoff were Four Acres, Middle Scott and Dennis. This P derives from applied inorganic fertilisers that are dissolved by rainfall and transported from the catchment by runoff and seepage. Feedlot manure, compost and effluent are also sources of nutrients. The HIWQIP also identified that, in order to meet the P target to prevent Lyngbya algal blooms from occurring (0.1 mg/L), P load had to reduce of about 28%. In 2012 P load measured 0.15mg/L.

The Scott River Action Plan (SRAP) emerged from a shared stakeholder desire to address these water quality issues in light of a trend towards increasing productivity and intensification of the agricultural industry in the Catchment. In addition, the SRAP was prepared to address the following aspects:

a) The fact that if the Catchment is not managed in a proper and timely manner, intensification of certain land uses may exacerbate the nutrient inputs and impact even further on the health of the river system and Inlet.
b) Limited implementation of best nutrient management recommendations put forward from

previous studies.

c) Lack of baseline data on waterway foreshore condition particularly of tributaries of the Scott River flowing through private property.
d) The need for an up to date status of the health of the catchment and water quality since the last one in 2011.
e) The need for stronger collaboration between landholders, industry groups, the government and the Lower Blackwood Land Conservation District Committee (LBLCDC) to encourage and support the implementation of best nutrient management practices.
f) The lack of strategic planning at the sub-catchment scale but also at the farm scale with limited whole farm planning occurring.
g) Low uptake of funding opportunities for improving nutrient management practice.

The SRAP is funded by DWER and led by the LBLCDC who are the primary facilitators, working with landholders and independent experts to identify key priorities and opportunities and develop management recommendations. The Scott River (Action Plan) Advisory Group (SRAG) was formed to oversee and guide the development of the Plan. Members of the SRAG include representatives of each land use industry, DWER, Department of Biodiversity, Conservation and Attractions (DBCA), and the Department of Primary Industries and Regional Development (DPIRD).

Two key ingredients in the preparation of the SRAP were: a thorough and on-going engagement with landholders from each agricultural sector and with local indigenous groups; and a strong collaborative approach with relevant government agencies. Much work went into determining landholder interest in the river systems, identifying gaps in existing knowledge, establishing priority areas for the Foreshore Condition Assessment (FCA), and enhancing local support for this project. Innovative methods were used to enable learning from local landholders about their values, priorities, and concerns. The purpose of this approach was to accomplish a meaningful integration of local knowledge and perspectives into the Plan (particularly in the development of management recommendations) to foster ownership and implementation.

The SRAP is not intended to be a one-off document but a first step towards a continuing process of data acquisition and analysis and working in partnership with landholders.

1.2 Study Aims

The overall goal of the SRAP is to protect and enhance the environmental health and community benefit of the Catchment by improving water quality, condition of waterways and riparian areas, and soil health without impacting current and future agricultural productivity.

The broad aims of the SRAP are:

1. To continue to improve the understanding of the status of the Catchment with a focus on waterway and riparian zone health.
2. To produce a set of practical management recommendations and actions (Action Plan) for improving the health of the Scott River and its waterways.
3. To provide a sound technical basis for future funding or project submissions.
4. To identify key knowledge gaps for a greater and ongoing understanding of the health status of the Catchment.
5. To continue to improve the understanding of landholders' values and priorities concerning waterways health and land management practices for better environmental outcomes; and
6. To strengthen collaboration and project ownership among landholders, government agencies, land managers, traditional owners, and Natural Resource Management (NRM) groups to achieve effective and long-term improvement practices in water quality and soil health.

The SRAP saw the LBLCDC working with landholders and government agencies to produce a set of recommendations that may benefit:

- Landholders by achieving more sustainable management of their land and;
- Government agencies and NRM groups whose roles are to support and facilitate the implementation of the management recommendations.

1.3 Study Area

The Scott River Catchment has an area of 691 km^2 and is divided into the following seven sub-catchments (Figure 3):

- Four Acres
- Dennis
- Governor Broome
- Lower Scott
- Middle Scott

- Upper Scott.
- Molloy Island

The network of waterways in the Catchment is approximately 185km long of which approximately 75 km is classified as main river and the remaining smaller tributaries and minor watercourses. The first ~22km of the river is a defined channel whilst the upper half consists of braided channels, swamps, and wetlands. Recent LiDAR mapping has identified a more complex network of minor watercourses and drains extending for 1,500km.

The Study area covers the whole of the Scott River Catchment except for Molloy Island. The foreshore condition assessment was carried out along 152km of waterways giving priority to:

1. Waterways that flow through / generate from the hot spot sub-catchments for P (Four Acres, Middle Scott and Dennis).
2. Waterways that flow through properties with land uses that have shown to be the highest contributors of P (irrigated dairy, irrigated beef and beef dryland).
3. Waterways that have been identified as highly degraded in previous desktop condition assessments work; and
4. Waterways that flow through areas of high ecological importance.

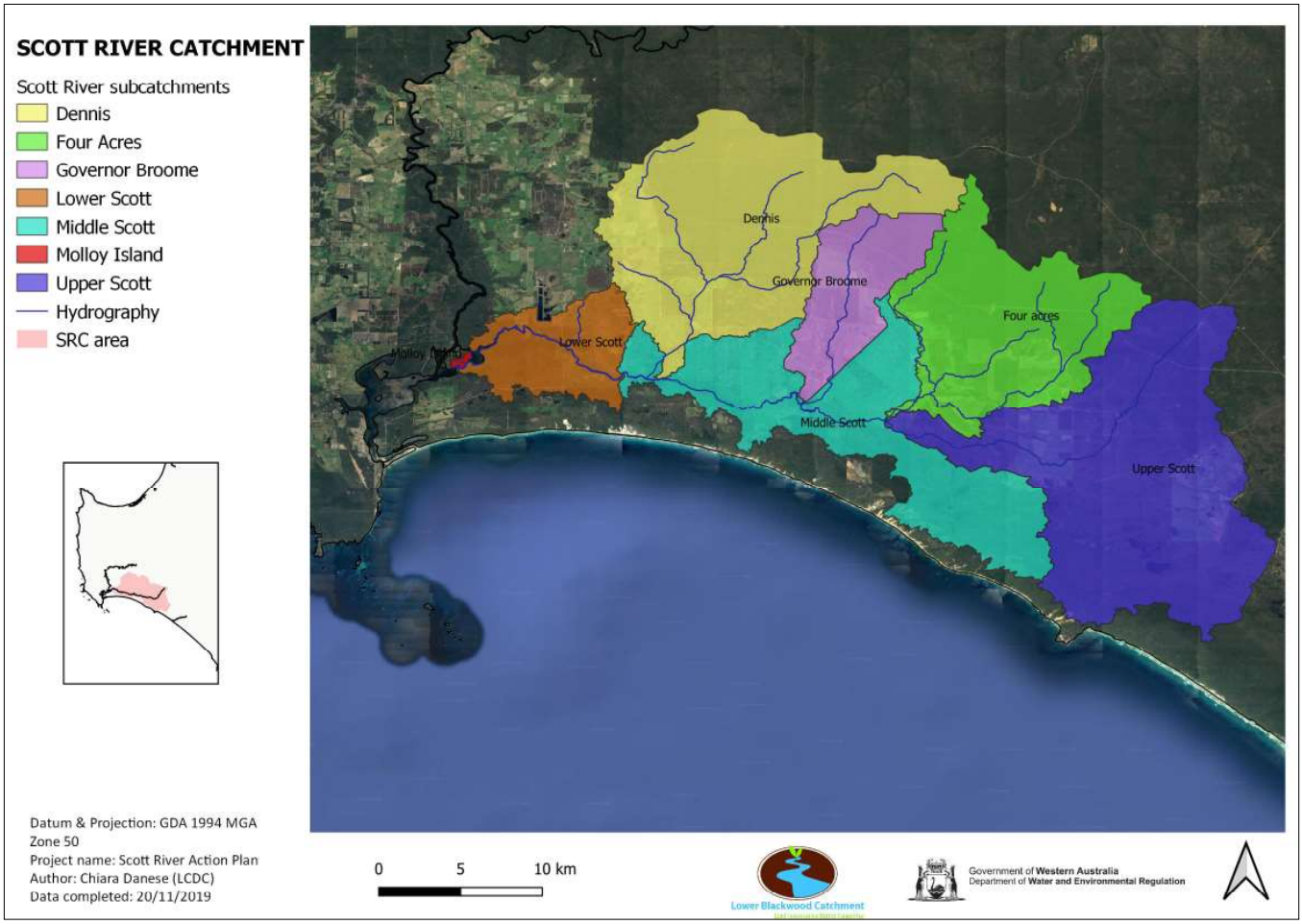


Figure 3: The Scott River Catchment and sub-catchments

To avoid confusion, it is important to explain that the Scott River Catchment area differs from the wider Scott Coastal Plain (SCP). The SCP consists of the area bordered by Brockman Hwy, Stewart Rd, Barlee Brook, Donnelly River, the Southern Ocean coastline, and the Blackwood River (Figure 4). The SCP is just over 105 000ha, of which approximately 41 000ha is in private ownership whilst the area of the Scott River Catchment is ca. 64 200 ha, of which approximately 27 000 ha is farmland (43%) (Table 1).

Table 1: Land tenure Scott River Catchment in 2020. Source: LCDC

Sub-catchment	Total Area (Ha)	Farm (%)	Reserve (%)	UCL (%)	Total
Dennis	14953	38%	62%	0%	100%
Four acres	10516	42%	57%	1%	100%
Governor Broome	4538	62%	38%	0%	100%
Lower Scott	4002	57%	42%	1%	100%
Middle Scott	11245	60%	39%	1%	100%
Molloy Island	55	0%	100%	0%	100%
Upper Scott	18967	29%	61%	9%	100%
Grand Total	**64 286 Ha**	**43%**	**54%**	**3%**	**100%**

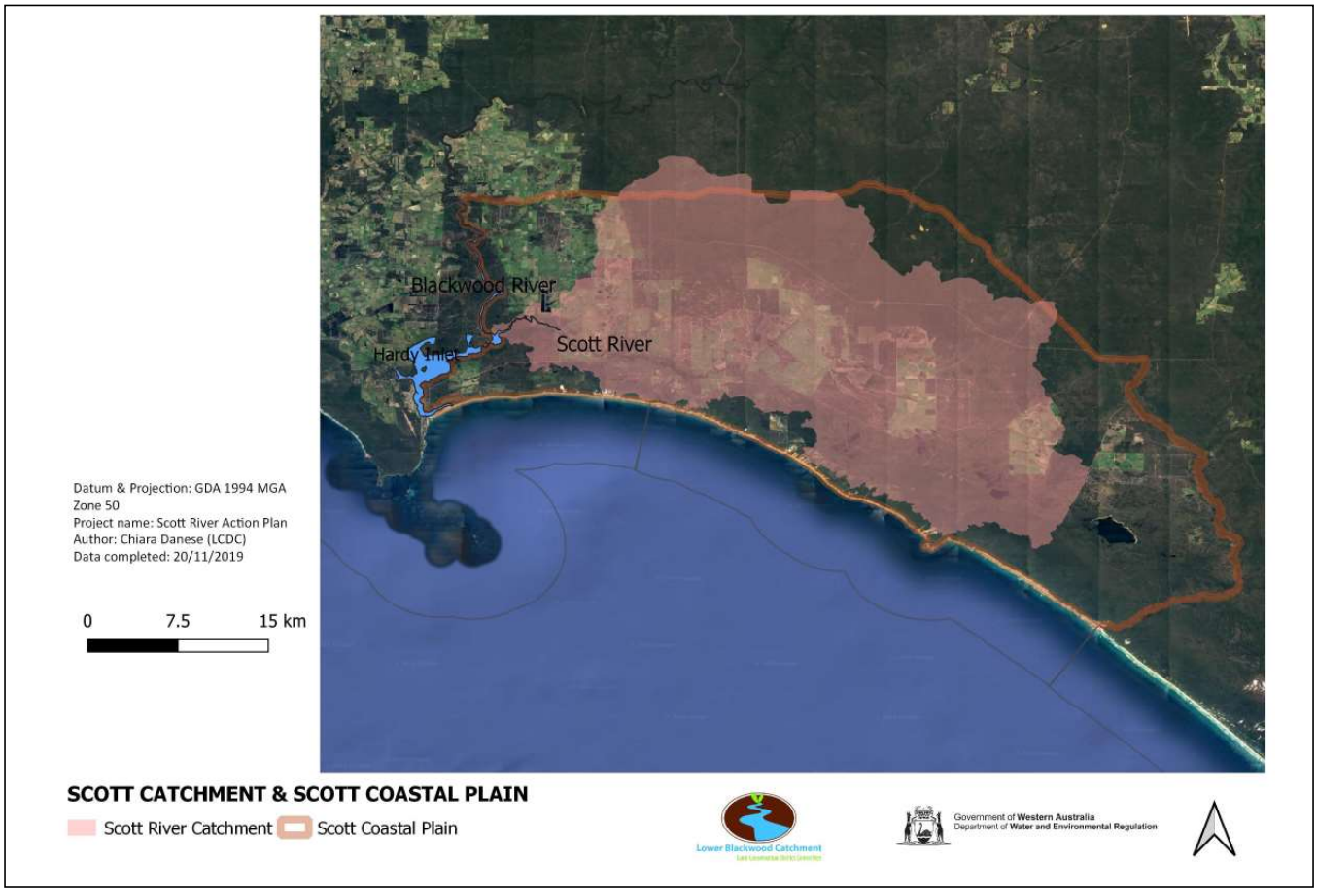


Figure 4: Scott River Catchment area vs Scott Coastal Plain area

1.4 Scope

An action plan has no legal status: it is not a statutory plan, government policy, or government regulation but it is the beginning of a collaborative partnership approach to achieve agreed water quality and sustainable agriculture outcomes.

As a river action plan, the SRAP provides:

- A record of foreshore condition along priority waterways.
- An indication of problem areas (e.g. weeds, bank erosion, sediment).
- Riparian management recommendations and actions concerning the above problem areas (including priority rating and implementation responsibility).

Also, the SRAP provides recommendations regarding:

- Ways to increase landholders'' uptake of best practice fertiliser strategies.
- Ways to reduce nutrient export.

The SRAP suggests the following topics for ongoing research, given that they could not be directly addressed within the scope of the current project:

- The correlation between nutrient concentrations, rainfall, temperatures, and environmental flows over the period 2000 to 2020, further informing the issue of recurrent algal blooms in the Hardy Inlet.
- The role of tannins in inhibiting algal blooms and reducing nutrients in low flows
- Interaction between surface water and groundwater systems leading to a better understanding of the overall water balance.
- Nutrient inflows and outflows balancing at the farm scale or across multiple farms.
- Trials and evaluation of management actions implemented, including the evaluation of the effect of revegetated riparian buffers on in-stream total phosphorus (TP) concentrations.

1.5 Previous Studies

Various environmental and water quality studies have been carried out for the Scott River Catchment and/or for the wider Scott Coastal Plain. Some of the findings and recommendations from those reports are still relevant and have been considered in the development of the SRAP. Previous studies about the Scott River Catchment and/or Scott Coastal Plain include:

1. Scott Coastal Plain – A Strategy for a Sustainable Future (Department of Agriculture and Food, 2001). The strategy is an integrated land and water management plan for the Scott Coastal Plain area. It provides:
    - a report on the agricultural potential of the Scott Coastal Plain
    - a report on the impacts on the environment of current and any future developments
    - formal planning and coordination process for the future management of the Scott Coastal Plain
    - make broad recommendations with regards to surface water management and drainage.
2. The Hardy Inlet Water Quality Improvement Plan (White, 2012). This plan brings together current scientific knowledge of the Hardy Inlet's water quality status for nutrient management planning and makes recommendations for the reduction of nutrients coming from the Scott River Catchment.
3. The Soil Doctor (Anderson, 2007). Growers were involved in a series of workshops initially trialled in the Scott River sub catchments in June-July 2002. The workshops involved instruction and discussions about the pros and cons of soil sampling, techniques for sampling accurately, placement and methods, what the results can mean, and feedback on initial results.
4. The Economic Study of the Scott River Value of Agriculture (Whitfield, 2019 unpublished). The study is an overview of agriculture in the Scott River area (DRAFT version in 2020).
5. Augusta Margaret River Clean Community Energy (AMCCE) Renewable Energy Project - Dairy Farmers Consultation (AgGrow Energy Resources, 2018). This project surveyed dairy farmers within the Scott and Blackwood Catchments to identify and document their concerns about effluent management systems and their current waste management practices and to gauge their interest in supplying their dairy waste to an aggregated biogas waste facility.
6. Hardy Inlet Estuary Condition Report 1999 to 2010: A summary of the health of the Hardy Inlet including algal blooms and fish deaths (Department of Water, 2013)

Management actions implemented prior to the SRAP:

Some of the recommended management actions outlined in the previous studies above have been implemented and some are yet to be.

Some examples of recommendations that have been implemented from the previous studies above are:

- Ongoing water quality monitoring by DWER.
- A sub-catchment planning approach was taken in the Governor Broome Rd Project to manage changes to and maintenance of drainage systems and streamlines and to avoid flooding and sedimentation problems on downstream properties.
- Erection of exclusion fences through various funding programs.
- Soil testing and soil mapping programs to help landholders on grazing properties interpret results and modify fertiliser practices if necessary.
- Regular educational opportunities provided to landholders to build a shared understanding of the benefits of fertiliser management and how to interpret soil-test results.
- Trials and case studies on the environmental, production, and economic benefits of improving fertiliser management.
- Cost-sharing arrangements to enable landholders implement or upgrade to best practice dairy effluent management (partly achieved).
- The benefits of effluent management and riparian management to landholders have been promoted through awareness programs and demonstrations (partly achieved).
- Research to evaluate dairy effluent management systems on waterlogged soils.
- Research the role of tannins in controlling algal blooms in the Scott basin.

Links to the Hardy Inlet WQIP

The full set of SRAP recommendations in this Plan (Section 6) are intended to follow and support the recommendations made in the Hardy Inlet WQIP (White, 2012), so that by working in partnership with landholders, the water quality targets set out in that report to protect the health of the rivers and the Hardy Inlet, can be achieved. Therefore, it is useful to reproduce those recommendations as a foundation for this report and the next steps and to show the progress that has been made. This is summarised in Table 2.

Table 2: Summary of Hardy Inlet WQIP recommendations with the SRAP update

HIWQIP (White, 2012) Recommendations	SRAP Updates
Implement best practice fertiliser management.	Soil testing through the REI and multiyear fertiliser trials have begun to establish farm and sub-catchment fertiliser management measures that should reduce nutrient losses. Landholders should work with accredited agronomists to use the optimum fertiliser mix for productivity and to minimise nutrient loss.
Investigate farm-scale nutrient hotspots.	Monitoring has identified which sub-catchments have potential hotspots and innovative work has led to a successful trial to separate dairy effluent solids to remove nutrient losses and produce valuable agricultural products.
Carefully evaluate proposals for further intensification of land uses to ensure that water quality improvement plan targets are met.	The report, The Economic Study of the Scott River Value of Agriculture – a Review (Draft) (Whitfield, 2019) and a 'Scott River Economic Study' being carried out by the Augusta Margaret River and Nannup Shires provide data to evaluate new and emerging agricultural industries along with checking Catchment activities.
Develop and implement a rural drainage management plan.	The DWER has utilised LiDAR technology to map the waterway network in the Catchment for more accurate planning. The next step is a sub-catchment across farm drainage mapping exercise in collaboration with landholders to identify priority areas for improvement work.
Develop and implement a river action plan for the Scott River Catchment.	A total of 158km of foreshore has been assessed as part of the SRAP.
Assess and upgrade effluent management at dairies.	Through the broader work of the overarching REI Dairy Care program, Western Dairy and DWER have been working in partnership to work towards dairy effluent management best practice and system upgrades throughout the South West, including the Scott River Catchment. Through the Dairy Care program, the AMRCCE has trialled a filter developed in WA (Z-Filter) that has shown that the solids and liquid from dairy effluent can be separated to become valuable products for irrigation and soil improvement. The Z-filter can also be used to treat legacy effluent in holding ponds. A report on a staged approach, using best practice for managing dairy effluent has been prepared for DWER and can be tested in the Scott River.
Undertake paddock scale trials of soil amendment.	The Uptake project funded by DWER will identify the optimum fertiliser regimes across different soils at paddock scales. Dairy solids from the Z-filter will be tested directly and composted, as soil amendments and slow-release fertilisers.
Undertake priority research projects to improve knowledge about the Hardy Inlet system and how best to manage nutrients in the Catchment.	The SRAP makes a number of targeted recommendations for priority research based on its collaborative approach working with landholders, government agencies, consultants, and scientists.
Undertake ongoing water quality monitoring in the Catchment.	Ongoing water quality monitoring since the 2012 stage one report has shown an apparent reduction in P coming from the Scott River Catchment (see Water Quality below). This emphasises the need to continue this vital work to determine if the sometimes-expensive Catchment management measures are succeeding.
Review progress towards implementation of management actions and water quality targets after five years.	Completion of the SRAP in part provides a review of the 2012 stage one report and provides the basis for ongoing work and review in a collaborative approach.

2. METHODS

The SRAP consists of a number of studies across different subject boundaries. For consistency, these studies are grouped in the categories identified in the HIWQIP (White, 2012) as being key for improving nutrient management in the Catchment. These categories are:

- Fertiliser management & soil health
- Dairy effluent management systems
- Riparian management
- Drain management

The preparation of the SRAP was overseen by the LBLCDC staff with the support of the SRAG and LCDC committee. Some of the studies were carried out by external consultants.

For the preparation of this Plan an extensive GIS mapping database was compiled with the help from government agencies and landholders. This database is crucial for the implementation of the report recommendations and for future planning.

The **Catchment Overview** (Section 3) was compiled using information from published reports and up to date information data made available to the LCDC by government agencies and landholders. It describes the cultural and socio-economic landscape of the Catchment exploring the significance of historic heritage (Aboriginal and European) and land-use changes (past and future). It also provides a succinct overview of legislative/regulatory frameworks relevant to environmental resource management and water management. This information is important because there are still misinformation and misconception about a certain aspect of legislation and regulations that could, in some cases, act as a deterrent to improved management in the area. The second part of the Catchment Overview Section describes the natural values in the Catchment. It also provides an update on water quality status, on algal blooms and fish kills, and an overview of rainfall trends and potential changes to climatic conditions in the study area. The water quality status update was prepared with the assistance of DWER.

The **Engagement and Consultation Process** (Section 4) describes the methodology used for engaging and communicating with the farming community, industries, and the local Aboriginal groups throughout the preparation of the Plan. The **Knowledge sharing and value mapping** was conducted by the LBLCDC of landholders' values, attitudes, and priorities concerning nutrient management practices, waterways health, and overall Catchment's community wellbeing gathered through one-on-one interviews and value mapping exercise.

The body of the Report (Section 5) contains a summary for each of the following studies:

- **Dairy effluent management**: a social study of

landholder perceptions of dairy effluent and the merits of different systems (Section 5.1)

- **Riparian Management**: a foreshore condition assessment of priority waterways and management recommendations for each Section. Section 5.2 for methods and findings and Appendix A for management recommendations (Tables and maps). Please note the individual property lot numbers in the FCA tables are coded for privacy considerations.
- **Drain management**: a study to gain a better understanding of the types of drainage systems currently present in the Catchment and to develop strategic as well as feasible and cost-effective management options to improve the quality of water that passes through these systems (Section 5.3).
- **Fertiliser management and soil health**: a short summary of soil testing programs and fertiliser trials carried out in the Scott River Catchment (Section 5.4).

Each study presents a number of key recommendations which are also collated in the **Action Plan** (Section 6) of this report.

Linkages to other studies

An important part of the SRAP and its support of the HIWQIP (White, 2012) are the links between the DWER water quality monitoring program, the DWER Healthy Rivers Assessment, and the SRAP FCA (Figure 5). Taken together, this work leads to priorities for work with landholders for the most appropriate rehabilitation and management of the waterways and the most effective management of fertilisers and effluent. These key links are:

1. The Healthy River Assessment uses the South West Index of River Condition to provide a detailed assessment of river health (which is comparable). This assessment has been carried out at different locations in the Catchment (Figure 4).
2. The SRAP FCA uses the Pen and Scott methodology to assess river condition on a wider scale. The assessment was carried out along priority waterways.
3. The DWER Water Quality Monitoring Program provides a benchmark and consequent updates on how the catchment is performing concerning nutrient management. The implementation of the SRAP and its evaluation should be carried out with water quality targets and monitoring data in mind.

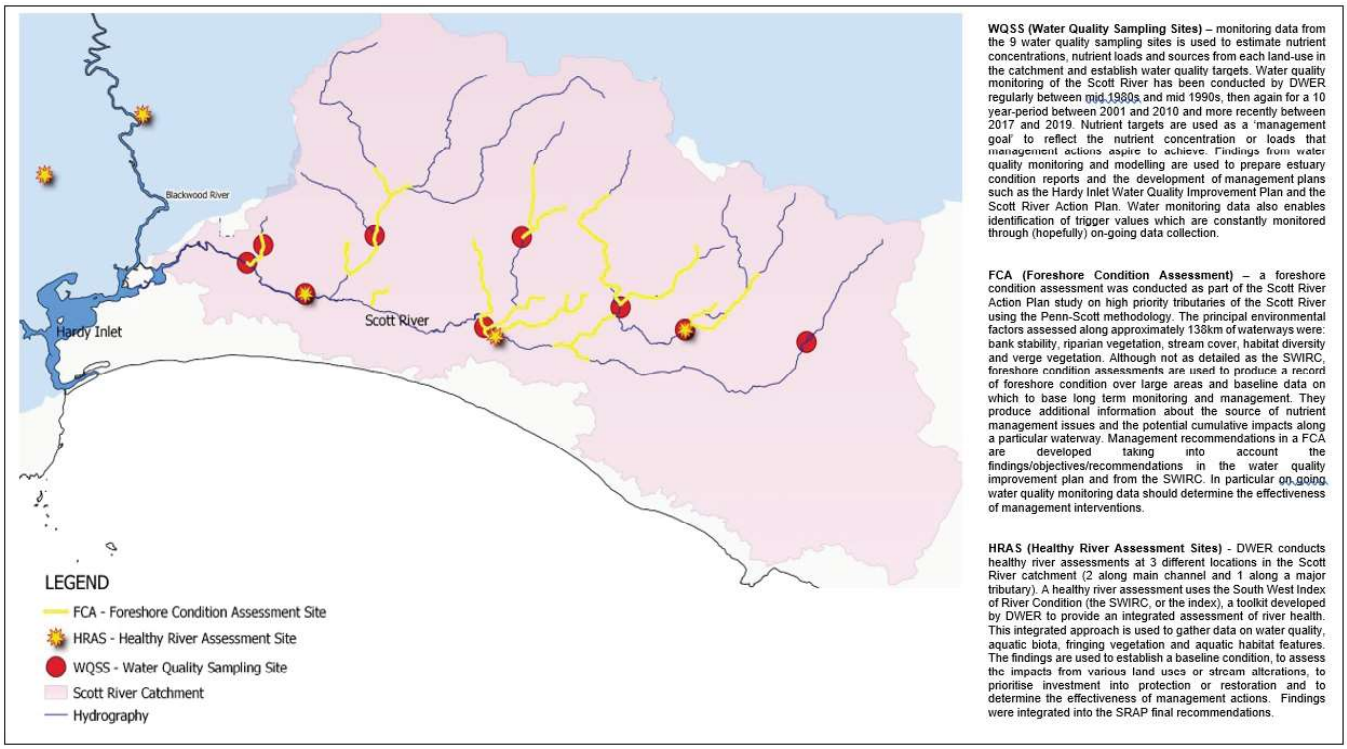


Figure 5: Scott River Catchment map demonstrating links between key studies and reports

3. CATCHMENT OVERVIEW

3.1 Catchment Overview: Socio-Economic Values

The first part of the Overview Section provides an overview of the socio-economic landscape of the Catchment as described in existing publications with additional components from research commissioned by the LBLCDC and carried out by external consultants. It includes:

- Catchment Description
- Aboriginal Heritage
- European Heritage
- Economic Values and Land Use
- Legislative & Regulatory Frameworks

3.2 Catchment Description

The Scott River Catchment covers an area of approximately 643 km^2 stretching from Molloy Island to Jangardup Rd north-west of Lake Jasper and it drains into the Blackwood River 5-6km north of the Hardy Inlet river mouth. The Catchment is divided between the Shire of Augusta Margaret River in the west and the Shire of Nannup in the east. At its widest (south to north) the Catchment is about 20 kilometres. The Catchment is divided into seven sub-catchments: Lower Scott, Middle Scott, Four Acres, Dennis, Governor Broome, Upper Scott, Molloy Island (Figure 5).

The Scott River flows from east to west running parallel to the south coast and flows into the inlet via a wide shallow basin around Molloy Island. The main channel is approximately 60 km long with the first ~22km being a defined channel with the upper half consisting of braided channels, swamps, and wetlands. The network of dominant tributaries, that flow into the main channel is approximately 185km long. However, recent LiDAR mapping and ground-truthing by DWER has identified a much more extensive network of watercourses and drains up to 1,500km.

3.2.1 Aboriginal Heritage

Noongar people are the traditional Aboriginal owners for the entire southwest of WA. Within this larger language group, the traditional owners west of the Blackwood River are the Wa(r)dandi and east of the Blackwood (including Scott River) are the Pibelmen. The Blackwood River forms the boundary between these two groups who crossed it regularly for trade and social activities.

Traditional owners value their Country or boodjar both

spiritually and economically[2]. The Blackwood River, or Gorbilyup, was created by the Wagyl. Its dreaming story extends from Uluru to Wave Rock (or Katter Kich) to Wyadup Rocks (Wyadup named after the Dreaming Serpent) and describes the whole of the Blackwood Catchment including Scott River. It is all an interconnected sacred mythological site. The waterways are also economically important to Wa(r) dandi-Pibelmen people for campsites, food collection, and water supply.

Archaeological evidence suggests that humans were in the area by 48 000 BP. Hearths, bones, stone artefacts, campsites, painted hand stencils, a Peppermint 'killing stick', the Kybra rock engravings, and several other Aboriginal sites on the Scott Plain reveal the culture of the first inhabitants in the region.[3]

At the time of settlement, there were probably around 25-50 people /100 km^2 in the Scott River Plain. Despite early attempts to co-exist peacefully, Aboriginal numbers in the area were decimated by European disease and killings, and the politics of control also impacted heavily on Aboriginal identity and culture. Recent years have seen a revival of Aboriginal culture and population in the South West.

Under the Settlement process led by the South West Aboriginal Land and Sea Council (SWALSC), the Southwest Boojarah #2 Indigenous Land Use Agreement has been negotiated with the Wardandi-Pibelmen people; it resolves all other Native Title claims on the area in exchange for a package of benefits. The Undalup Association and the Bibelmen Mia Aboriginal Corporation (BMAC) are two current Aboriginal entities that speak on behalf of this Country.

3.2.2 European Heritage

Agricultural development began in the Scott River Plain in the 1860s when cattle runs were established by the Dunnet, Brockman, and Longbottom families. Clearing began in the early 1900s and fertiliser trials were underway as early as 1919. On the western side of the Scott Coastal Plain, some land was made available under the government's Group Settlement Scheme in the 1920s and 1930s which brought British migrants into farming in WA. The land around Milyeannup was also opened up for agriculture in the 1920s and 1930s (Whitfield, 2019).

From the early 1900s, horsemen drove cattle from Nannup to the coastal runs on the Scott River plains and built huts to live in over the summer. The Nannup dairy farmers typically aggregated several herds to sum about 100 cattle and drove them with six horsemen to Scott River, having two or three camping stopovers on the way down. The cattle grazed the pasture over the summer months and when they were nearly ready to calve, they were taken back to Nannup and milked over the winter. The cattle wore bells which were distinctive so that each farmer knew where his cattle were. Wild cattle roamed the bush in rougher parts of the region and could only be mustered on horseback. The horseback droves finished in the late 1960s. After this, farmers trucked their dairy cattle in by road.[4]

3.2.3 Economic Values & Land Use

A comprehensive analysis of the current and potential economic landscape for the Scott River Region (not just the Catchment area) will be available upon the release of the report the ***Scott River Sustainable Economic Strategy*** (Marketrade, 2020) commissioned in 2020 by the AMRS and SN with support from the South West Development Commission, Bunbury Fibre Plantations, Western Dairy and the Lower South West Growers Group.

The Scott River Catchment is zoned General Agriculture (AMRS) and Priority Agriculture (Shire of Nannup) and is an important agricultural production area (Whitfield, 2019) with the potential for production growth and intensification.

The Scott River Catchment is approximately 64,276ha, of which approximately 43% (27 000 ha) is farmland, 53% (34 700 ha) reserves, and 3% unallocated crown land (UCL) (DWER 2019 land use data).

There is a total of 53 properties used for agriculture or lifestyle purposes in the Catchment. There are six dairy farms, one just dryland and five both irrigated and dryland. Three of the six dairy farms are managed by four family-owned businesses and one corporate company managing the other farms.

The other industries are beef and sheep, blue gum plantations, and native vegetation (White, 2012 and Whitfield, 2019).

The Scott River Catchment landscape was originally

2 Aboriginal people very much value Country economically both historically and currently. Historically, they managed the landscape and ecosystem as a resource and asset with very strict rules around their practices and specific territories.

3 Specific registered sites (the Aboriginal Heritage Register and Inquiry site has two categories: Registered Sites and Other Heritage Places in the Scott River Catchment include: The Aboriginal Heritage Register and Inquiry site has two categories: Registered Sites and Other Heritage Places.

- All of the Blackwood River and its tributaries
- Hardy Inlet: Artefact scatter, camp
- Scott River Trench: Artefact scatter, camp
- Brennan Ford/Scott River: Artefact scatter, camps
- Stewart Rd: Artefact scatter
- Kybra: Ceremonial, rock engraving
- Scott River Burial site: Skeletal material, burial.

Other heritage places include:

- Milyeanup Coast Road Scarred Tree
- Milyeannup Road Water Tree
- Scott River Road Ochre Deposit.

4 Landholder's comment

Table 3: Comparison of land use 2012-2019. 2011 data is from the HIWQIP (2012) and 2019 data is from DWER.

Land Use	Landuse Area 2011 (ha)	Landuse Area 2019 (ha)	% tot landuse area 2011	% tot landuse area 2019	Difference (%)
Bluegums (established)	5890	8574.0	9.2	13.3	45.57
Bluegums (non-established)	3970	1571.1	6.2	2.4	-60.43
Bluegums total	9860	10145.1	15.3	15.8	2.89
Beef dryland / mixed grazing	7320	8900.0	11.4	13.8	21.58
Beef (irrigated)	200	202.6	0.3	0.3	1.32
Beef Total	7520	9102.6	11.7	14.2	21.05
Dairy dryland	1260	1436.4	2.0	2.2	14.00
Dairy Irrigated	1460	1393.5	2.3	2.2	-4.55
Dairy total	2720	2829.9	4.2	4.4	4.04
Native vegetation	46230	42145.2	71.9	65.6	-8.84

dominated by a series of vegetated wetlands with low dense heat and pockets of tall open forest on more drained areas. The Catchment was used for dairy grazing in the early 1900s then was gradually developed and cleared for beef grazing.

As of 2011, beef farming occupied nearly 11%: dryland beef accounted for 7,320 ha and irrigated beef for 200 ha (White, 2012). This percentage has declined from nearly 17% in 2007, and nearly 20% in 2000. Table 4 shows that in 2019 beef farming has increased occupying 14% of the Catchment (9100 ha). Both areas occupied by dryland beef/mixed grazing and irrigated beef have increased, 21%, and 1.3% respectively.

Stock rates for the Catchment are not available. According to Whitfield (2019) in 2019 in the Scott Coastal Plain there were approximately 9150 livestock dairy cattle, 12 535 livestock meat cattle 4,000 sheep, and lambs across 16 farm businesses. These numbers were obtained through estimations of the percentage of the area the Scott River covers in two statistical areas (Augusta and Pemberton) reported by ABS. However, landholders who were interviewed commented that these numbers are fairly conservative (especially for dairy and sheep[5]).

Blue gums were first planted in Scott River Catchment by the WA Forests Department in the very late 1980s. Bluegum plantations have increased from 5,000ha in 2000 to over 10,000ha in 2019 occupying around 15% of the total area of the Catchment with a sharper increase between 2000 and 2010. Over the past decade the bluegum plantation landuse has increased only marginally (~2.9%) (Table 3). The DWER land use data shows a 45% increase in the land area occupied by mature plantations since 2011 and a 60% decline in the land area occupied by immature plantations. This shows that plantations are being re-converted into land for grazing. Forestry is managed by three corporate entities.

The most recent major industry is dairy. Dairies were first developed in the Scott Catchment in the early 1990s. Land use for dairies has increased to nearly 5% of the since then, including around 1910 ha of irrigated pasture and 1390 ha of dryland dairy. In 2011 irrigated and dryland dairy together 4.2% of the total Catchment area. In 2019 the area occupied by irrigated has had a decline of 4% and dryland beef an increase of 15% (DWER data).

Several studies have looked at the potential for intensification of various land uses in the Catchment (Department of Agriculture and Food, 2001; Thompson & Trompf 2013; Whitfield, 2019; Marketrade, 2020). The key findings are:

- **Sheep**: according to Thompson & Trompf (2013) there is "significant scope to increase lamb production" in the High Rainfall Zone of WA which includes the Scott River Catchment. The report identifies that a combination strategy of supporting existing producers in extension programs to increase their production and working with potential producers to identify the barriers and potential solutions to incorporating sheep into their farm businesses could be a possible way forward to

5 LCDC interviews with landholders in the Catchment (2019).

increase lamb production in those areas. Future market conditions will also impact on the numbers of sheep grazed and lambs produced in the Scott River area.

- **Beef**: with regards to grazing for beef, future production would be higher with irrigation. Indeed, irrigation can potentially enable a doubling of beef production. However, although land is capable of beef grazing, it might be limited in its future suitability by reduced access to water licenses. Dryland beef is a thriving industry in Scott River, and by definition is not irrigated. Some dryland beef farmers neither drain nor irrigate, forgoing grazing on the waterlogged areas in the winter in exchange for having moister soils in the summer. This could potentially be one way forward for beef farming in a drier, hotter climate if less water extraction is permitted.
- **Dairy**: with regards to grazing for dairy, some of the same factors apply as for beef. Again, land capability is good but there are constraints to suitability in terms of access to water and dairy waste concerns. Dairy needs a cooler, wetter climate than beef. Managing animal effluent is paramount if intensification was to increase.
- **Plantations**: The Scott River Catchment is deemed by growers to be suitable for long-term tree growing. Expanding markets into China and India will see demand increase further and local companies are well positioned from a shipping perspective to take advantage of these markets. The sustainability of plantation grown timber and carbon sequestration is becoming more of a focal point and this is also improving sales. There are also Australian government requirements to meet carbon benchmarks and the plantation industry will play a major part in this into the future. The plantation business is therefore well positioned to meet global demand into the future. There is potential for some non-irrigated beef farms to be planted with blue gums.
- **Horticulture**: approximately 39000 ha of land in the Scott River area is suitable or moderately suitable for both annual and perennial horticulture[6] (of this 27000 is suitable or moderately for annual horticulture and approximately 6170ha has >70% of land has moderate to high capability and >70% high capability for perennial horticulture). The trend towards vegetarian and vegan diets is likely to result in more demand for the vegetable ingredients of meat replacement products such as pulses (edible seeds of legumes, such as lentils, beans and chickpeas which may require irrigation for successful crops), fungi, hemp etc. These represent possible market opportunities for horticulture in the Catchment. More familiar annual horticulture crops suitable in the area are broccoli, cauliflower, potatoes (ware and seed), Chinese cabbage, cabbage, lettuce, beetroot, rocket, onions and celery. Future suitability depends again on water availability and access to markets. Area under annual horticulture production can vary significantly and quickly depending on season and prices. More information is needed to determine how these crops could be rotated with existing centre-point irrigation uses.

Irrigated perennial horticulture such as avocados and citrus are another option. Citrus is well suited to a Mediterranean climate. Several other new crops have been identified by DPIRD (Whitfield 2019) as having potential in the Scott, including amaranth, lebeckia and hemp, as well as crops for summer cattle grazing (as mentioned above, e.g. fodder beets, maize or corn). Amaranth is currently being trialled as a nutritious fodder crop. It can be processed like silage and fed to livestock and fish. Amaranth oil can be used to manage heart disease and hypertension[7], and the seeds are high in protein. Lebeckia is a very drought tolerant fodder crop that thrives in low nutrient sandy soils. An assessment of potential weediness is important before introducing such a crop. Discussions and trials around hemp growing are well advanced. All parts of the hemp plant can be used to create a variety of products such as paper, textiles, building material, oil, fuel, protein and cosmetics. It is a summer crop with a growing period of around four months. It requires water supply in early stages of germination and growth. Overall water requirements are as good or better than cereal crops. Without rainfall the hemp crop may require 3–6 ML of irrigation water per hectare. Productivity is likely to be very good in the Catchment, compared with other parts of WA. Although capable of growing across a range of soils, hemp grows best on well-drained loams that are high in organic matter and low in acidity. Fertiliser requirements of hemp is not clear. Further large horticultural trials are needed in the Scott River to identify crops that are economic, resilient to climate change and low impact. Overall:

- Irrigated land is not fully utilized. There

6 This is according to the DPIRD soil mapping datasets which is indicative and not detailed. It's at a scale that gives a general view suitable for purposes such as planning and was never designed to replace the need to individually assess each property or paddock. It's based on aerial photography scale and a limited number of site visits.

7 https://lipidworld.biomedcentral.com/articles/10.1186/1476-511X-6-1

is an opportunity to make better use of irrigated areas that are not currently fully utilised, for example, cropping during fallow periods.
    - Irrigation could be established on cleared land.
    - Forestry plantation could be converted into fodder or food production.
- **Regenerative agriculture** is an emerging practical approach to farming systems that focuses on harnessing the subsoil microbes to enhance soil fertility, water retention and inhibit erosion and salination. It is a whole-of-ecosystem, cost-effective conservation and rehabilitation approach to food and farming systems developed by farmers for farmers who are experiencing the gradual degradation of their family properties. It involves working with natural water flows, plant life cycles to maintain and improve soils, carbon, biodiversity and nutrients. It's principles also include farm business profitability and farmer wellbeing. Some landholders in the Scott Catchment have already begun using regenerative approaches and found they can generate environmental and economic benefits. It is a continual learning approach that enables adaptation to changing circumstances. Regenerative agricultural practices include:
    - Keeping soil covered (e.g. Year-round ground cover, minimising herbicide use)
    - Maintain living roots year-round (e.g. Cover crops, incorporating perennials into the pasture system)
    - Minimising soil disturbance (e.g. Minimum till)
    - Integrating livestock (e.g. Holistic grazing)
    - Maximising biodiversity (e.g increasing plant diversity, minimising pesticide use, planting shelter belts and native corridors)

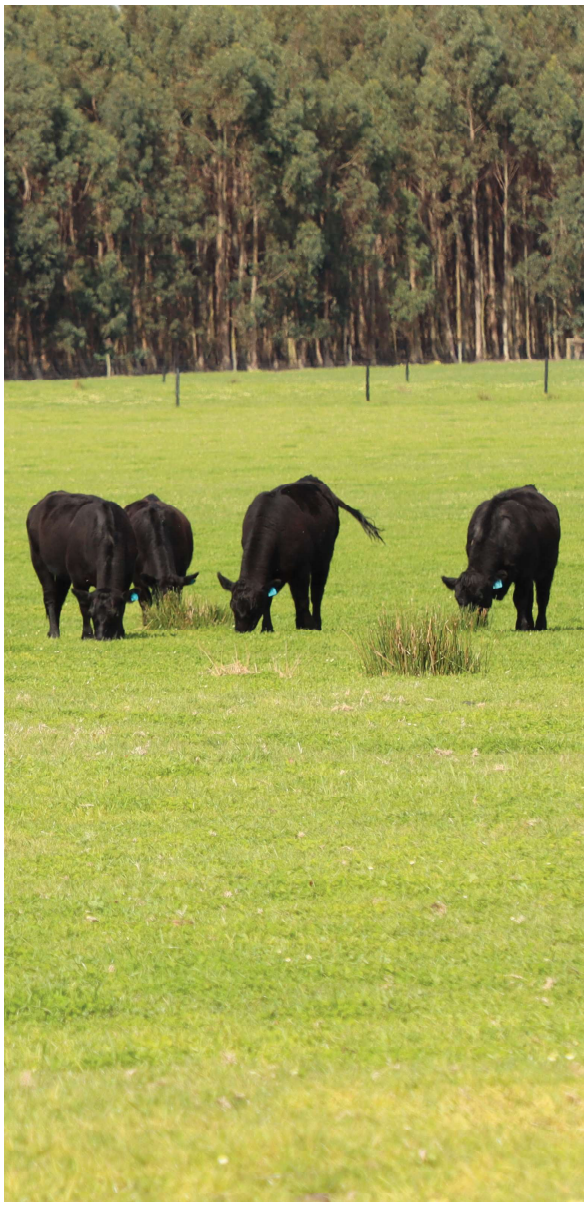


Figure 6: Beef cattle grazing on a property in the Catchment

Figure 7: An example of a diverse summer mix crop often utilisd in regenerative agriculture practices

- **Diversification** of land use is one means for a farmer to hedge their bets against an uncertain future. Some landholders have already tried this with plantations, grazing and horticulture on a single property. The benefits of diversification are likely to increase as time goes by[8].

To note that higher productivity can increase overall economic gains but also incurs site-specific social and environmental costs.

A recent economic study (Whitfield 2019) points out that further intensification of agriculture in the Catchment would require major upgrades to roads, power supply[9], and mobile reception.

There are several mineral sand exploration and mining tenements in the Scott River Catchment. There is renewed interest in sand mining in the area but concerns have been expressed about acid sulphate soils being exposed again.

Biodiversity values are high in the Scott River Catchment. This is not because there has been an increase in land for conservation over time. Rather it is because of the continued loss of biodiversity that the remaining vegetation has become of increasing importance. Further, as species' distributions reduce with increasing land clearing (and other threats), the remaining habitat is of increasing importance.

3.2.4 Legislative & Regulatory Frameworks

This Section is included to document and inform landholders of the range of legislation and requirements that may apply to their land and provide a better understanding of how current legislative, policy, and voluntary frameworks guide farm and environmental management in the Scott River Catchment and the role of government agencies in administering it.

There are several considerations relevant to land management, and water resource management in the Scott River Catchment for which a range of legislation, policies, and regulations apply. The key considerations are:

- Environmentally Sensitive Areas (ESAs) of Native Vegetation
- Threatened Species (Flora and Fauna) and Ecological Communities (Commonwealth listed)
- Threatened Species (Flora and Fauna), Ecological Communities and Threatening processes (State listed)
- Priority Ecological Communities (State listed)
- Areas mapped as potential fauna habitat (Fauna Habitat Zones, DBCA)
- Waste and emissions including discharges
- Contaminated sites
- Clearing of native vegetation
- Wetlands
- Ecological linkages
- Water Resources Management
- Department of Planning, Lands & Heritage (Aboriginal Affairs) Sites and Other Heritage Places
- Soil Conservation
- Land drainage
- Acid Sulphate Soils

3.2.4.1 Environmental Protection

Commonwealth

The ***Environment Protection and Biodiversity Conservation Act 1999*** (EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as "matters of national environmental significance". EPBC listed threatened species and Threatened Ecological Communities (TEC) can be searched from the Department of Agriculture, Water and the Environment website: Threatened Species and Ecological Communities page. The listing of threatened species and communities identifies species that are at greater threat and risk of extinction.

The EPBC Act also provide guidance with regard to Acid Sulfate Soils (ASS).

8 https://www.sciencedirect.com/science/article/pii/S0308521X18312095

9 Improved power supply – this could be an opportunity for renewable energy (e.g. wind) and would make a big difference to profitability and to reduction of carbon emissions.

State Government

The three pieces of state legislation that protect environmental assets and that are relevant to the Scott River Catchment are the ***Biodiversity Conservation Act 2016,*** the ***Environmental Protection Act 1986*** and the ***Conservation and Land Management Act 1984.***

The ***Biodiversity Conservation Act 2016*** provides for the listing of threatened native plants (flora), threatened native animals (fauna) and threatened ecological communities that are in need of greater protection. Those listed as being critically endangered, endangered or vulnerable species are under increased identifiable threat of extinction (species) or collapse (ecological communities). Threatened, Extinct and Specially Protected fauna or flora are species which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such. Possible threatened species or ecological communities that do not meet survey criteria are added to DBCA's Priority Species and Ecological Community lists. The Act also provides for, or outlines the process for (e.g. what is in them and how they are approved), recovery plans and other modern features of biodiversity conservation and management. The Biodiversity Conservation Act 2016 applies to all tenure in the State. The Act also provides for recovery plans and other modern features of biodiversity conservation and management. The Biodiversity Conservation Act 2016 applies to all tenure in the State.

The ***Wildlife Conservation (Specially Protected Fauna) Notice 2018*** and the ***Wildlife Conservation (Rare Flora) Notice 2018*** have been transitioned under regulations 170, 171 and 172 of the ***Biodiversity Conservation Regulations 2018*** to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the ***2016 Act***. According to these regulations, it is an offence to "take" or disturb threatened species (flora and fauna) (any species but fines are greater for damage or disturbance to threatened species) or their critical habitats unless the person is authorised (by the Minister) under Section 40 and complies with the conditions.

The ***Conservation and Land Management Act 1984*** (WA), applies to DBCA managed land only, and establishes a comprehensive set of legislative provisions dealing with state conservation and land management matters.

Department of Biodiversity, Conservation and Attractions (DBCA)

DBCA administers a number of Acts and associated regulations including the abovementioned ***Conservation and Land Management Act 1984*** and the ***Biodiversity Conservation Act 2016***. DBCA promotes biodiversity and conservation through sustainable management of WA's species, ecosystems, lands and the attractions in its care. DBCA has responsibility for on-ground management of CALM Act lands (DBCA-managed lands).

DBCA provides specialist advice and information on biodiversity and offsets to the EPA for its assessments under Part IV of the EP Act, to the Commonwealth Department of the Environment and Energy under the Commonwealth ***Environment Protection and Biodiversity Conservation Act 1999*** and to proponents. DBCA may also implement offsets that arise as outcomes of these processes.

Clearing provisions of the Environmental Protection Act 1986 (EP Act) are administered by DWER with advice sought from DBCA.

Department of Water & Environmental Regulation (DWER)

DWER also has responsibilities related to the protection of the environment. These responsibilities are set out below.

Clearing of native vegetation: Under Section 51C of the Environmental Protection Act 1986 (EP Act), clearing of native vegetation is an offence unless undertaken under the authority of a clearing permit, or the clearing is subject to an exemption. Clearing is not permitted in Environmentally Sensitive Areas (ESAs) except for maintenance of existing railways or roads, or in accordance with the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. The Scott River Catchment is an ESA. ESAs are declared by the Minister for Environment under Section 51B of the EP Act.

Prescribed premises (managing emissions to land or water) Under Section 51C of the ***Environmental Protection Act 1986*** (EP Act), it is an offence to undertake any work which causes a premised to become, or become capable of being, a Prescribe Premises unless the work is undertaken in accordance with a works approval. It is also an offence under the EP Act to cause an emission or alter the nature or volume of waste, noise, or odour from the Prescribed Premises, unless done so in accordance with a works approval or licence or a registration (for operation) is held for the premises. Prescribed Premises are identified in Schedule 1 of the ***Environmental Protection Regulations 1987 (part of the Environmental Protection Act 1986)***, and include a number of activities that may be associated with agricultural activities.

Contaminated sites: The ***Contaminated Sites Act 2003*** (CS Act) is administered to ensure contamination is identified, recorded, managed, and remediated. Under the CS Act, landowners,

occupiers, and persons who caused contamination must report known or suspected contaminated sites. Anyone else may report suspected contamination. DWER assesses each report and determines the appropriate classification for the site in consultation with the Department of Health.

Acid Sulfate Soil (ASS): DBCA has produced guidelines to assist with the assessment and management of acid sulfate soils in Western Australia. If ASSs are not managed appropriately, environmental harm may be caused, as defined in the ***Environmental Protection Act 1986*** (EP Act), and may therefore be an offence under Section 51C of the EP Act. ASS are naturally occurring soils, sediments and peats that contain iron sulfides, predominately in the form of pyrite materials. These soils are commonly found in low-lying land bordering the coast or estuarine and saline wetlands and freshwater groundwater-dependent wetlands throughout Western Australia. Much of the Scott Coastal Plain is identified as having a high to moderate risk of ASS occurring within 3m of the natural surface. In an anoxic state, these materials remain benign and do not pose a significant risk to human health or the environment. However, disturbing ASS, and exposing it to oxygen, has the potential to cause significant environmental and economic impacts including:

- fish kill and loss of biodiversity in wetlands and waterways;
- contamination of groundwater resources by acid, arsenic, heavy metals, and other contaminants;
- loss of agricultural productivity; and
- corrosion of concrete and steel infrastructure by acidic soil and water.

Projects involving the disturbance of ASS must therefore assess the risk associated with disturbance by considering potential impacts. However, there is little evidence to date of ASS impacting on agricultural productivity in the Scott River Catchment.

Unauthorised discharges: Under the ***Environmental Protection (Unauthorised Discharges Regulations 2004)*** (UDR), it is an offence to cause or allow certain materials to enter the environment in connection with a commercial or business activity. The purpose of the UDR is to cover discharges into the environment from business or commercial activities; which individually are not serious enough to cause pollution and breach the provisions of the ***Environmental Protection Act 1986*** but cumulatively can cause harm. The UDR are intended to ensure that all people engaged in a commercial activity take responsibility for preventing the escape of contaminants from their business into the environment.

Department of Primary Industries and Regional Development (DPIRD)

DPIRD set its priorities for declared pests by a declaration under the ***Biosecurity and Agriculture Management Act 2007*** (BAM Act) through the Minister for Agriculture. All species that were declared under the ***Agriculture and Related Resources Protection Act 1976*** have been transitioned to have equivalent declarations under the BAM Act. Regulation 7 of the ***Biosecurity and Agriculture Management Regulations 2013*** allows for the establishment of categories of declared pests for both animals and plants (Appendix 7 - Table 7.12). Regulations have been implemented since May 2013.

It is the landholders' legal obligation to manage/control invasive species (weeds and feral animals) on their land. Under the Act, there is a greater responsibility for the community and industry to identify, prioritise, and control already established biosecurity threats, with the support of DPIRD. The new focus of the Department will be on preventing the emergence of new pests and diseases within WA and controlling those that do slip in.

Local Government

The Scott River Catchment sits in both the Shire of Augusta-Margaret River (AMRS) and the Shire of Nannup (SN).

The AMRS local profile (AMRS, 2017) states that "The south-west of Western Australia is internationally recognised as one of thirty-four global hotspots of biodiversity and the Busselton–Augusta region has also been identified as one of fifteen biodiversity hotspots within Australia" (ARMS, 2017 Section 1.5). AMRS's Community Strategic Plan 2033 (2015) identifies "Valuing the natural environment" as one of its key goals with a subsequent outcome being "Healthy waterways and foreshores' and a key strategy identified as developing "… partnerships to maintain and improve the quality of beaches, waterways, rivers, and wetlands" (AMRS, 2015 p. 20).

The SN's Community Strategic Plan 2017-2027 (Shire of Nannup, 2017), identifies a key focus point of protecting "our amazing nature, magnificent forests, managed bushland, rivers, agriculture and our pristine coastline".

Both Local Government's local planning schemes identify the natural environment as an important asset that needs to be protected and well managed. These documents also identify priority areas for agriculture including the Scott River Catchment.

Both Local Governments are also jointly undertaking an

economic study of the wider Scott River area, supported by several industry groups. This aims to identify and prioritise possible growth and investment areas and opportunities, improve vital infrastructure such as roads and communications and consider ways to assist the Scott River Community in becoming more resilient, robust, and vibrant.

Both local governments have representatives that are active LBLCDC committee members.

3.2.4.2 Water Resources Management

State Government

The ***Water Agencies (Powers) Act 1984*** is the lead legislation for water resources management: coordinating across government: conserving, protecting and managing water resources; assessing water resources; planning for the use of water resources; promoting the efficient use of water resources; promoting the efficient provision of water services; preparing plans for and providing advice on flood management.

The ***Rights in Water and Irrigation Act 1914*** (as amended) provides for the regulation, management, use, and protection of water resources. Under Division 1A (Ownership and control of waters) of this Act, the right to the use and flow, and the control, of the water at any time in any watercourse, wetland or underground water source is vested in the Crown (Division 1, 5A of the Act). The Act provides for a licensing system for taking water; and a permitting system for activities that may damage, obstruct or interfere with water flow or the beds and banks of watercourses and wetlands in proclaimed rivers, surface water management areas, and irrigation districts.

Licensing only applies to certain watercourses in WA that are proclaimed under the Act. In relation to the Scott River and its tributaries, this Catchment is unproclaimed and there is no licensing regime in place currently. However, there are general restrictions that apply to these areas under the legislation; for example, owners of riparian land may only take water to the extent that flow in the watercourse is not sensibly diminished (Sec. 20, 1, c of the Act).

A permit is required to interfere with waters or bed and banks of the watercourse where the river is situated on Crown land. It is also an offence to obstruct the watercourse on Crown land, including the discharge of mud, earth, gravel etc. into the watercourse without authorisation. Landholders do not require a permit for works where the river is on freehold property.

This Act provides for the power to prohibit drainage works that are likely to affect the water in a watercourse, wetland or underground water source.

Department of Water and Environmental Regulation (DWER)

Relevant to this Plan is the legislation, regulations and by-laws dealing with waterways and groundwater which are administered by DWER. The Department of Water assists the Minister for Water in administering current legislation.

The WA Department of Water and Environmental Regulation (DWER) issues licences and permits under the ***Rights in Water and Irrigation Act 1914 to***

- Take water
- Construct wells (including bores and soaks)
- Interfere with the bed and banks of a watercourse.[10] [11]

DWER looks at the potential risks of each groundwater license application on a case by case basis in deciding whether to grant or refuse a licence, and also the terms and conditions that may be imposed. To mitigate risks to water resources or the environment associated with the take and use of water, DWER often require that licencees monitor and report on their abstraction activities and where necessary implement contingency programmes where trigger levels are exceeded or unexpected changes to water quality or aquifer response are observed. Water monitoring and reporting requirements for Scott River landholders are established on an individual basis.

Generally, commercial water users are required to implement a monitoring program which includes metering their abstraction volumes and monitoring both surface water (where relevant) and groundwater quality. In terms of groundwater quality both the pumping aquifer and shallow groundwater up and down hydraulic gradient of the water use activity are considered.

3.2.4.3 Drainage, Salinity and Soil Conservation

The principal Act is the Soil and Land Conservation Act 1945. This can be used to create covenants to protect vegetation in foreshore areas.

Concerning land drainage for the purpose of controlling salinity, SLC Regulations (1992) which sits under the SLC Act (1945) require owners or occupiers to notify the Commissioner of Soil and Land Conservation before any groundwater drainage takes place. The Commissioner does not approve

10 http://www.water.wa.gov.au/licensing/water-licensing/types-of-licenses
11 Note. DWER also grants permits under the Country Areas Water Supply Act 1947 to clear native vegetation near water. http://www.water.wa.gov.au/licensing/water-licensing/types-of-licenses#caws

Figure 8: Scott River Spider Orchid (Calendia sp.)

drainage. The Commissioner will either object or not object based on the assessment of the proposed works. To date, the Act has been used concerning drainage linked to salinity concerns in the Wheatbelt rather than to coastal situations. Drainage that does not need to be notified for most surface water management.

Department of Primary Industries and Regional Development (DPIRD).

Legislation dealing with the land surrounding the waterways is administered by DPIRD.

The Department of Primary Industries and Regional Development (DPIRD) carries out the requirements of the ***Soil and Land Conservation Act 1945*** to mitigate and prevent land degradation throughout Western Australia.

3.2.4.4 Heritage

Aboriginal heritage sites are afforded protection under statutory law[12]. Under the ***Aboriginal Heritage Act, 1972***, the Department of Planning Lands Heritage (this used to be a competency of the former Department of Indigenous Affairs) (DPLH) works with Aboriginal people to protect and manage places of significance.

Department of Planning Lands Heritage (DPLH)

The DPLH provides advice to the public and private sectors and the community about Aboriginal heritage management and maintains a Register of Aboriginal sites. The Department's role is to ensure that Aboriginal heritage and engagement with Aboriginal people is built into planning and management processes. Information about heritage sites can be obtained through the Aboriginal Heritage Inquiry System (AHIS), an internet-based search tool. The AHIS provide details about the location, extent, and assessment status of each place under the Aboriginal Heritage Act 1972. Statutory requirements for undertaking specific works in registered areas apply.

Landholders who own the land where an Aboriginal site (registered or not) is present and who want to use this land e.g. for development, may need to apply for consent from the Minister for Indigenous Affairs to do so under Section 18 of the ***Aboriginal Heritage Act 1972***. After the Minister considers the recommendations of the Aboriginal Cultural Material Committee (ACMC) and also regards the general interest of the community, he or she will either grant consent to the use of the land for the purpose sought or decline to give consent to the use. If the Minister consents, conditions may be attached to the use of the Section of land. "Where land users conclude that impact to a site is unavoidable, the consent of the Minister must be sought under Section 18 (s18) of the Act. Notice must be given to the Aboriginal Cultural Material Committee (ACMC) accompanied by the information as to the intended use of the land and sites on the land." Also: If you are planning to enter, excavate, examine or remove anything on an Aboriginal site, you are required to seek authorisation under Section 16 (s16) of the Act.

3.2.5 Non-Mandatory Guidelines

3.2.5.1 Codes of Conduct

Following is a summary of the key current industry or government codes/best management practices for nutrient management or fertiliser applications that apply to the four land-use types currently present in the Scott River Catchment. The full report, available on request, provides more detailed information.

12 An Aboriginal site means any place to which the AHA applies by operation of Section 5 of the AHA. The Act is currently under review. https://www.dplh.wa.gov.au/information-and-services/aboriginal-heritage/protection-under-the-aboriginal-heritage-act-1972

For the dairy industries the WA Practice for Dairy Shed Effluent (Western Dairy, 2012) is voluntary. It is part of their Dairying for Tomorrow initiative which supports dairy farmers to increase their farm productivity while at the same time reducing their environmental footprint.

The current Western Australian code of practice outlines five main objectives for effective effluent management (Western Dairy, 2012):

1. Effluent from a dairy shed will be prevented from entering surface waters or groundwater.
2. All dairy sheds will have an effective effluent management system.
3. Effluent management systems will be monitored, maintained and reviewed.
4. All dairies will maximise water use efficiency.
5. Dairy shed effluent will be reused on farm.

Dairying for Tomorrow has also outlined the important principles for a successful dairy effluent system (Dairy Australia, 2013):

- All effluent from the dairy, feed pads, standoff areas, underpasses, and tracks must be contained and reused (most commonly spread back on pastures and crops).
- Effluent must not enter surface waters (including billabongs, canals, springs, swamps, natural or artificial channels, lakes, lagoons, creeks, and rivers).
- Runoff containing effluent must not leave the property boundary.
- Effluent must not enter ground waters either directly or through infiltration.
- Effluent must not contaminate land (that is, avoid nutrient overload).
- It is important to note that the environment protection frameworks and associated policies across Australia place the onus of environment protection on those that manage the land and water resources.
- Offensive odours must not impact beyond property boundaries.

The plantation industry has a Code of Practice with guidelines to regulations and legislation specific to WA. This is the Code of Practice for Timber Plantations in Western Australia. Some requirements are mandatory and others are voluntary. The purpose of this Code is to provide goals and guidelines to plantation managers so that plantation operations in Western Australia are conducted in a manner that is in accordance with accepted principles for good plantation management, whilst recognising that a primary aim of plantations is to be economically competitive and sustainable. Standards also include the Forestry Stewardship Council (FSC) Standard (FSC, 2018) and the Australian Standard for Sustainable Forest Management (AS 4708) (AFS, 2013) which provides forest managers with economic, social, environmental and cultural criteria.

With respect to nutrient management, there are no formal Codes of Conduct or Best Practice guidelines for beef production. However, one irrigated beef respondent has referred to the Draft Best practice for nutrient management of livestock grazing systems at Scott River (DoA, 2001, Appendix 8).

3.2.6 (DBCA) Conservation Programs

Roadside Conservation Program

Roadside vegetation plays an important role in the conservation of Western Australia's plants and animals and particularly in the Scott River where there are many species only existing in these thin remnant strips, making the native vegetation in roadsides here far more important than in other areas.

The Scott River Rd, Governor Broome Rd, Black Point Rd, Fouracres Rd and Milyeannup Coast Road are flora roads[13] under the DBCA Off Reserve Conservation Program. Governor Broome and Millyeannup Coast road reserves are important in representing the range of vegetation that used to exist prior to extensive clearing and supports many populations of listed flora. Millyeannup Coast road with its wide, continuous and good condition road reserve vegetation is of particularly high conservation value, currently known to support over 30 populations of nine different listed species. For example, the small portion of Scott River Rd that bisects the National Park, within 100m either side of the road there over 22 populations of 13 different threatened and priority flora species can be found. In addition to this, Millyeannup Coast Rd reserve contains an intact, connected series of vegetation types across the western Scott Plain. This is the only such transect across the western Scott Coastal Plain (it used to exist in the Scott River Road reserve but with degradation large Sections of this catena have been lost).

In heavily cleared landscapes, the vegetation in the road reserve acts as a wildlife highway, enabling animal movement between large patches of bush. It also provides essential habitat to flora and fauna. The visibility of roadside vegetation can provide locals with a defined sense of place based on easily identifiable characteristics they recognise as "home". Roads cut across the landscape, giving a cross Section of vegetation communities within the landscape. Thus, wide road reserves fulfil dual roles: transport and conservation.[14]

Nature Conservation Covenant Program

The Nature Conservation Covenants Program began in 1998 in the Scott River area. DBCA offers landowners the opportunity to use conservation covenants to protect the nature conservation values of their properties. The Nature Conservation Covenant is a voluntary, legally binding document that has provisions restricting activities that might threaten the land's conservation values. There are also non-voluntary covenants. Every conservation covenant is individually negotiated between DBCA and the landowner, and aims to maintain the conservation values of the bushland whilst allowing for flexibility to reflect the landowner's wishes for the land. Typically, there are restrictions such as no clearing, mining, grazing or cats and dogs must be on leashes. Often no one is allowed to enter property. The landholder may get a tax concession and in some cases a rate concession. There are currently two DBCA covenants within the Scott River Catchment: 5 ha, 10 ha, respectively.

DBCA Land for Wildlife

DBCA's Land for Wildlife program began in 1997. There are three registered Land for Wildlife properties in the Scott River Catchment. One supports 200ha excellent quality banksia heathland and jarrah forest (however less than a few % of this block falls within the Catchment area); the other supports 62ha good to excellent quality jarrah-marri forest and another one about 14ha.

Soil and Land Commission Conservation

Landowners who wish to protect and manage native vegetation on their property may enter into an agreement (covenant) with the Commissioner of Soil and Land Conservation under s30 of the ***Soil and Land Conservation Act 1945***.

The Soil and Land Conservation Act provides for 2 types of covenants:

- Conservation Covenant which is irrevocable. The term of these covenants is usually specified for perpetuity or a period of time. Once finalised, the Commissioner does not have statutory authority to vary or discharge these covenants.

- Agreement to Reserve (ATR) which is not expressed as irrevocable. These covenants may be in perpetuity or for a specified time and may be varied or discharged by the Commissioner.

The first covenant was established in 1995 and further covenants were added until 2000. There are now approximately 1000 ha of covenants on 10 properties in Scott River catchments. All are Agreement to Reserve and all are in perpetuity.

3.3 Catchment Overview: Ecological & Environmental Values

The information summarised in this Section is sourced from published reports and maps however, where possible, the information has been updated to reflect recent changes and knowledge. More detailed versions of the climate change report are included in the Appendices, wherein references can also be found. For more detailed information the key reports are:

- Hardy Inlet Water Quality Improvement Plan Stage one – the Scott River Catchment (White, 2012).
- Scott River Catchment Hydrological and Nutrient Modelling (Hall, 2010).
- Economic Study of the Scott River Value of Agriculture (Whitfield, 2019).
- The Soil Doctor Preliminary Report (Anderson, 2002).
- Revisiting the Blackwood River and Hardy Inlet (Brearley, 2013).
- Scott River Catchment: Current Status and Future Condition (DoW, 2009).
- Leeuwin-Naturaliste capes area parks and reserves management plan (DPAW, 2015).
- Scott Coastal Plain – A Strategy for a Sustainable Future (DFWA, 2001).
- Scott River Sustainable Economic Strategy DRAFT (Marketride, 2020).
- Hardy Inlet Estuary Condition Report 1999 to 2010 (DoW, 2013).
- Scott River Ironstone Association, Interim Recovery Plan 2015-2020 (DPAW, 2015).
- Field Summary of Review Conditions (Rennie, 2017).
- Hardy Inlet Condition Statement (Forbes, 2006).
- Hardy Inlet Condition Statement – Update report to the community (Forbes, 2010).

3.3.1 Geomorphology

The centre of the Scott River Catchment is low lying and subject to waterlogging during the winter months, whilst the north of the Catchment is a flat to gently undulating plain formed on Quaternary sediments (Whitfield, 2019 and DFWA, 2001). The southern boundaries of the Catchment are defined by a narrow strip of coastal dunes. The land south of the coastal ridge does not drain in the Scott River and therefore is not part of the Catchment. The northern part of the Catchment towards the Barlee Scarp rises to about 80 m (Australian Height Datum - AHD) (Brearley, 2013). This northern part of the Catchment is still mostly forested and the watercourses are in near pristine condition although the land is poorly drained with waterways characterised by low flows. At the foot of the scarp, the Catchment has an elevation of about 30 m (AHD) reducing to about 5 m (AHD) in the 10 km to 15 km distance southwest towards the river. The geomorphology of the area around Molloy Island (a narrow channel which flows into a restricted basin) influences flows and nutrient concentrations (White, 2012).

3.3.2 Geology and Soils

Most of the Scott River Catchment lies in the Perth Basin which consists predominantly of sedimentary rock such as sandstone, siltstone, mudstone, claystone, and, in places, coal. “Surface soils in the Catchment vary from fine white, brown, and grey sands to coffee rock and clay” (White, 2012). Table 4 and Figure 9 show the main soil mapping units occurring in the Scott River Catchment based on the broad soil description and classification compiled by the DFWA in the early 90s (Tille, 1990). Local landholders say, based on local knowledge, that the soils are more complex, with areas of more fertile loams and heavier soils (Engagement Section 6.1.3 topic 3: land soil and land use).

Table 4: Soil mapping units in the Scott River Catchment (Tille, 1990).

Catchment area	Zone		Description
North of Catchment	214	Np	NL1 - Pale grey mottled (Mungite) soils NLw- small narrow V-shaped drainage depressions NLvw - small broad U-shaped drainage depressions with swampy floor CE - Broad divides with restricted drainage, soils are mainly deep sands, sandy earths and wet soils. JN - Broad undulating plain on deeply weathered mantle over Mesozoic sediments; Yellow duplex soils and humus podzols; Tall jarrah-marri woodland K1 - Broad undulating lateritic crests and divides over sedimentary rocks, relief 5-20 m, slopes 1-10%. Soils are sandy gravels with some deep sands.
Centre / south of Catchment	215	Sr	Srd - Flats with high water Tables and deep bleached siliceous sands SRd2 - Low dunes and rises with deep bleached siliceous sands SRwd - Poorly drained flats with deep organic stained siliceous sands SRwi - Poorly drained flats with shallow sands over laterite (bog iron ore). BL1 - Flats with a variety of deep (mainly sandy) soils. BLf - Flats, mainly with deep yellow loamy soils (i.e. Marybrook Yellow Sandy Loam).

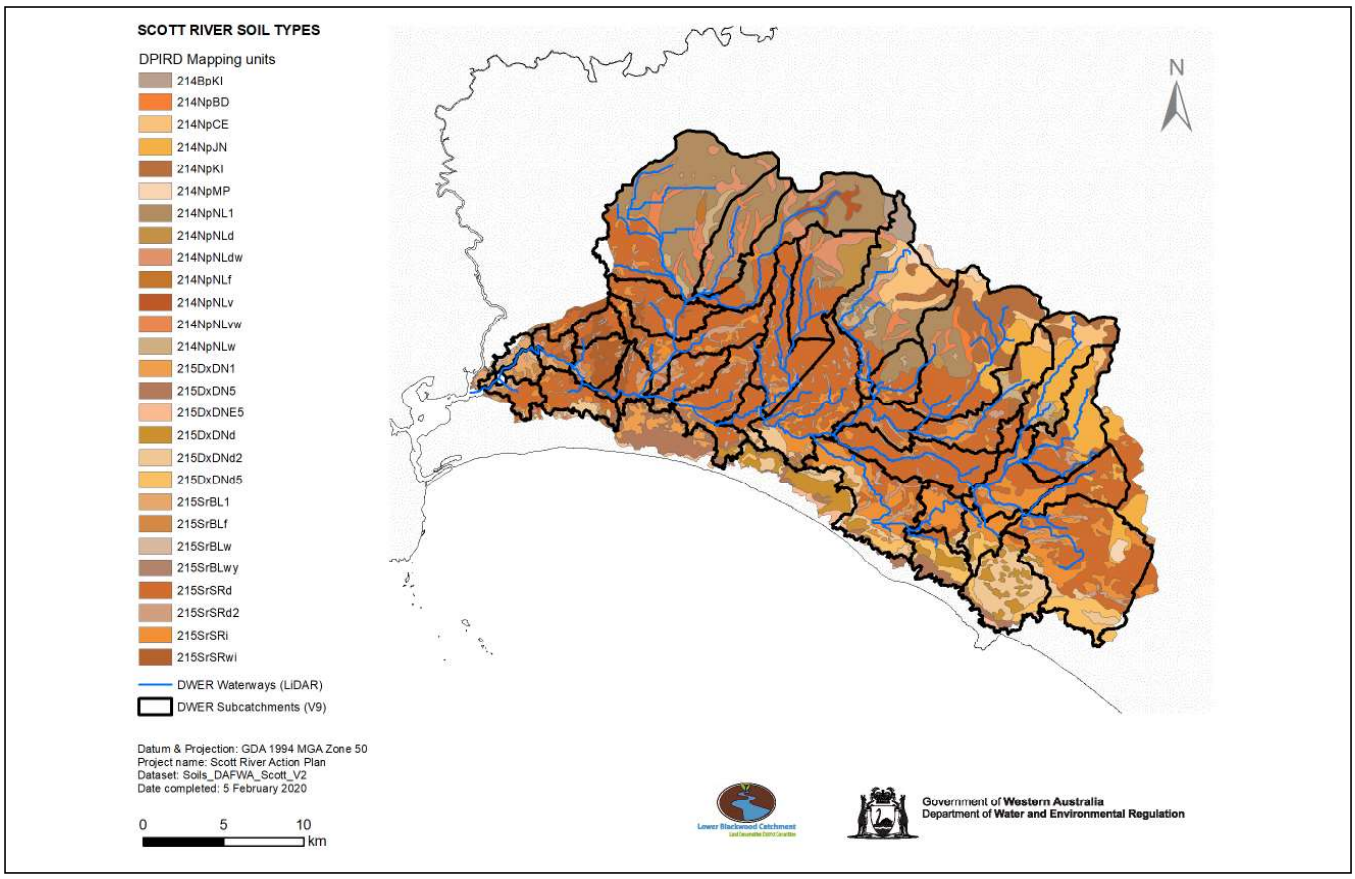


Figure 9: Soil Types. Data: DPIRD

At depths below a metre, a range of fine and coarse sands are found as well as rock, clay, sandstone, coffee rock, shale, quartz, gravel and basalt. Field assessment undertaken for the selected waterways in the Scott River Catchment found exposed areas with white/grey or yellow sands deposited on the stream bed with occasional granite exposed on the immediate valley sides. Dark brown 'coffee-rock' is also exposed in some locations. The soils in the Scott River Catchment are mostly very acidic (4-5pH) but there is little evidence of salt accumulation (Brearley, 2013).

The sandy soils in the Scott River Catchment have a very low capacity to retain phosphorus (Phosphorus Retention Index[15]) and have a high phosphorus export risk (Phosphorus Export Risk[16]) (Figure 10). In the Scott River Catchment phosphorus is easily lost as run-off and leached from the soils into groundwater (DAFWA, 2001; DWER 2003 & 2009; White, 2012). "Phosphorus export hazard refers to the likelihood that P (usually applied as fertiliser), moves from a given land unit to where it can contribute to eutrophication of surface water. The phosphorus can move either dissolved in water or attached to soil particles" (van Goole, Tille and Moore, 2005, p.34). One of the factors that influence P export is water movement across the landscape because when water moves rapidly contact time between soil particles and P is insufficient for sorption. Where uniform sands occur "PRI assumes greater importance, because if water moves rapidly, contact time between soil particles and P may be insufficient for sorption to occur" (van Goole, Tille and Moore, 2005, p.34). More than 55 % of the land in the Scott River Catchment contains soils with high to extreme P risk hazard, with the highest P export risk hazard in the Governor Broome and Middle Scott sub-catchments (Table 6).

15 Phosphorus Retention Index (PRI) is a direct measure of P-sorption and involves mixing a quantity of soil in solution with a single amount of P for a set period of time. The amount of P remaining in solution measures the soil's ability to fix phosphorus.
16 Phosphorus Export Risk (PER) refers to the likelihood that P (usually applied as fertiliser), moves from a given land unit to where it can contribute to eutrophication of surface water. The phosphorus can move either dissolved in water or attached to soil particles" (van Goole, Tille and Moore, 2005).

Table 5: Phosphorus Export Risk Hazard in the Scott River Catchment

Phosphorus Export Risk Hazard (PER)	Scott River Catchment (ha)	Scott River Catchment Area (%)
<3% of the map unit has a high to extreme hazard	284	0.4%
3-10% of the map unit has a high to extreme hazard	10,258	16.0%
10-30% of the map unit has a high to extreme hazard	3,929	6.1%
30-50% of the map unit has a high to extreme hazard	8,642	13.4%
50-70% of the map unit has a high to extreme hazard	5,688	8.8%
>70% of the map unit has a high to extreme hazard	35,476	55.2%
Grand Total over entire Catchment	64,276	

Table 6: Phosphorus Export Risk Hazard for each sub-catchment

Phosphorus Export Risk Hazard	Dennis	Four acres	Gov-ernor	Lower Scott	Middle Scott	Molloy Island	Upper Scott
<3% of the map unit has a high to extreme hazard	0%	2%	0%	0%	0%	0%	1%
3-10% of the map unit has a high to extreme hazard	44%	24%	9%	20%	0%	76%	0%
10-30% of the map unit has a high to extreme hazard	1%	17%	0%	1%	5%	0%	7%
30-50% of the map unit has a high to extreme hazard	6%	22%	0%	22%	8%	0%	20%
50-70% of the map unit has a high to extreme hazard	7%	3%	2%	8%	13%	0%	13%
>70% of the map unit has a high to extreme hazard	42%	34%	89%	49%	75%	24%	59%
Grand Total	100%	100%	100%	100%	100%	100%	100%

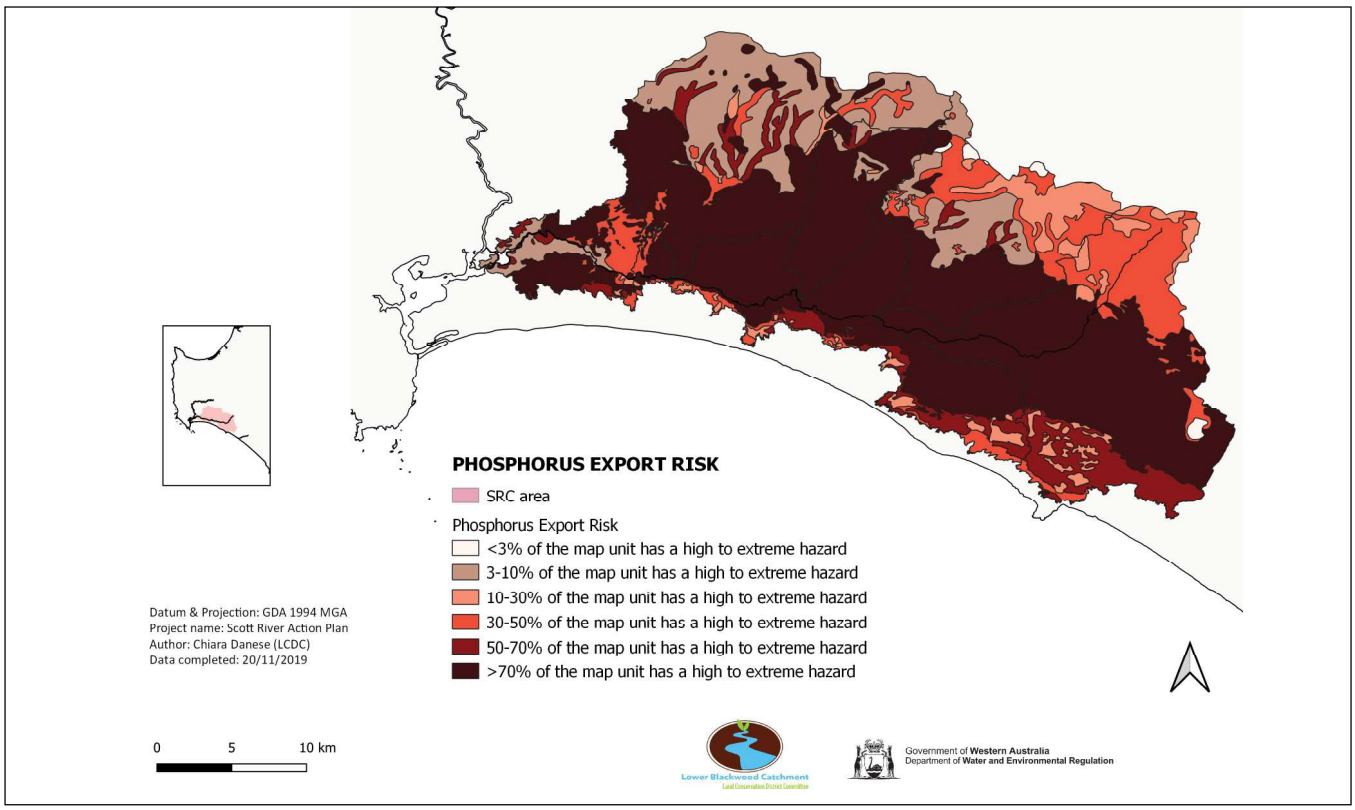


Figure 10: Phosphorus Export Hazard Risk in the Scott River Catchment. Data: DPIRD

3.3.3 Acid Sulfate Soils

ASS occur naturally in the Scott River Catchment primarily in low-lying coastal and seasonally inundated areas (White, 2012 and Brearley, 2013) (Figure 11) According to Degans (2009) 34% of the Scott Catchment contains potential ASS. These soils contain iron sulphides. Potential acid sulfate soils should not be disturbed as this could potentially cause impacts on the health of the Hardy Inlet. Once this is detected the acidification could be too high to be able to remediate. Unfortunately, some of the waterways in the Scott River Catchment have already shown a decline trend in pH (White, 2012 and Brearley, 2013). Soil acidity affects nutrient availability, animal growth, mobilises toxic metals and corrodes structures. The consequences for agricultural production and for the environment could be substantial. However, there is little evidence to date of ASS impacting on agricultural productivity in the Scott River Catchment.

ASS maps are not intended to provide site-specific acid sulfate soil information but rather a broad scale identification of where the ASS layers are present. The data derived from the maps cannot be used to determine whether a specific property is affected by ASS but should be used to trigger site-specific investigations and management strategies for ASS soil disturbance and/or lowering of the water Table. Advice should be sought from the Acid Sulfate Soils Planning Guidelines (WAPC, 2008) and the Contaminated Sites Branch of the DWER. This will be an important consideration should nutrient stripping basins or equivalent constructed wetlands be considered in the future. Tables 7 and 8 below show that Governor Broome, Middle Scott, and Upper Scott carry a high to moderate risk of ASS. Molloy Island carries a moderate to low risk.

Table 7: Acid Sulfate soil risk for each sub-catchment (ha).

Risk Category	Dennis (ha)	Four acres (ha)	Governor Broome (ha)	Lower Scott (ha)	Middle Scott (ha)	Molloy Island (ha)	Upper Scott (ha)	Grand Total (ha)
High to moderate risk	5325	3209	3125	2998	9045	13	11571	35286
Moderate to low risk	881	806	522	852	765	42	512	4380
No risk identified	8747	6501	890	153	1435		6884	24610
Grand Total	14953	10516	4538	4002	11245	55	18967	64276

Table 8: Acid Sulfate soil risk for each sub-catchment (% total area).

Risk Category	Dennis	Four acres	Governor Broome	Lower Scott	Middle Scott	Molloy Island	Upper Scott	Grand Total
High to moderate risk	36%	31%	69%	75%	80%	24%	61%	55%
Moderate to low risk	6%	8%	12%	21%	7%	76%	3%	7%
No risk identified	58%	62%	20%	4%	13%	0%	36%	38%
Grand Total	100%	100%	100%	100%	100%	100%	100%	100%

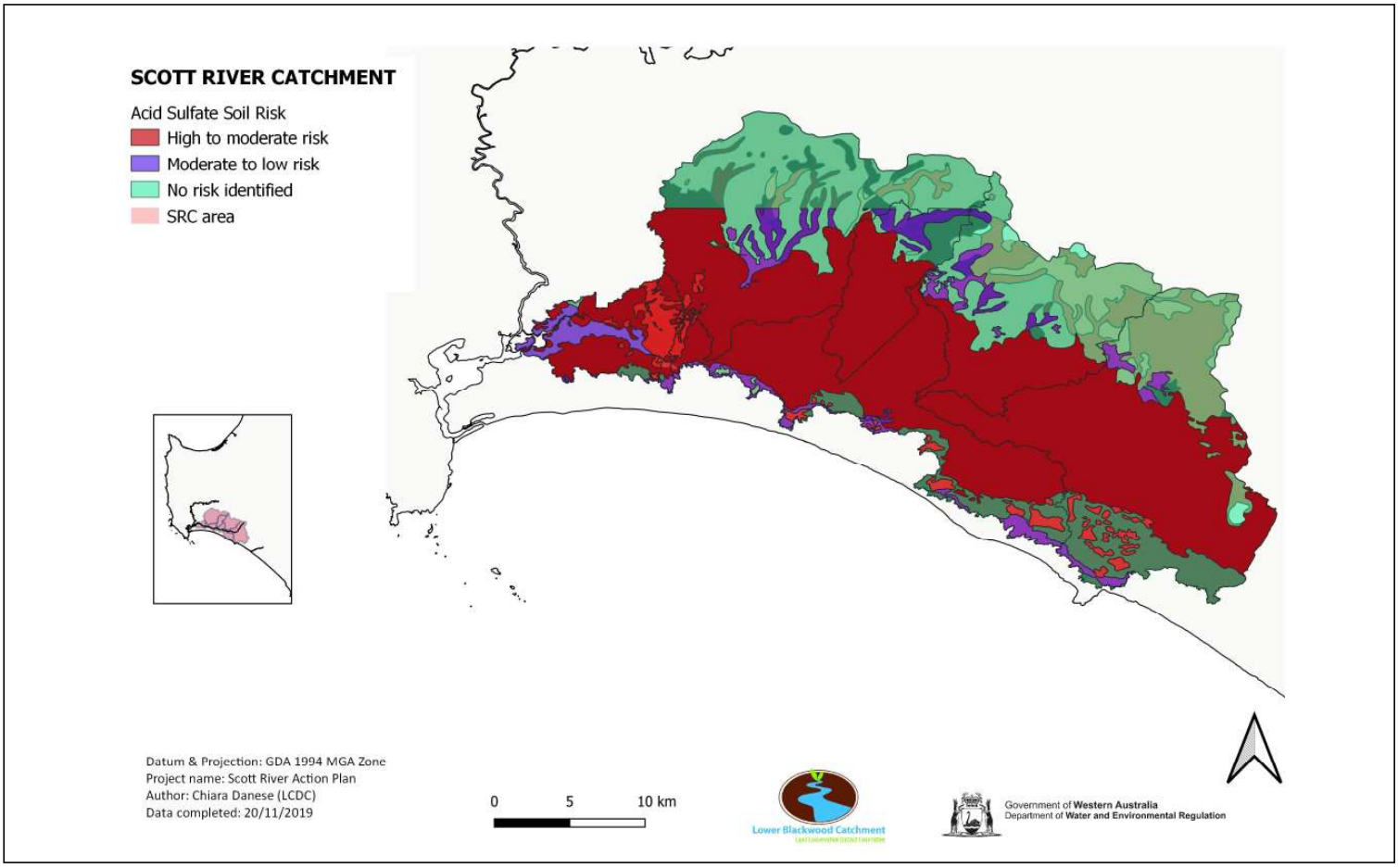


Figure 11: Acid Sulfate soil risk in the Scott River Catchment. Date: DPIRD

3.3.4 Surface and Groundwater Hydrology

The Scott River Catchment sits atop a very deep and complex sedimentary basin containing large and productive aquifers (Irwin, 2007). For understanding water management related impacts, though, we need to look no further than the superficial or upper unconfined aquifer. The superficial aquifer resides mostly in the Quaternary Sands that vary in thickness from 0 m to 30 m across the Scott River Catchment (Water Corporation, 2005). The aquifer is thicker where the land rises up or the floor of the aquifer falls away, and thinner near depressions, watercourses or where the floor of the aquifer rises. Being sandy in texture the superficial aquifer is moderate to highly permeable and is referred to as having a high transmissivity which means it can move a lot of groundwater laterally. The floor of the aquifer comprises coffee rock mostly 1 m to 5 m thick and/or shales and clays which reduce the exchange or leakage of groundwater between the superficial and underlying aquifers.

The Scott River Catchment is characterised by bifurcating and discontinuous watercourses which incorporate swamps, sumps, and other features associated with poor surface drainage. The average slope of the plain from north to south is about 2.5 m/km and east to west, less than 1 m/km. A variety of natural and augmented natural drainage systems traverse the Scott River Catchment mainly from north to south that conveys streamflow from the forested Barlee Scarp to the river. Drains have not been built in a coordinated way in the Catchment but in response to land use needs and the most prolific drainage seems to be associated with plantation establishment. Table 9 provides more detail of the stream hierarchy structure of the creeks and the length of each stream hierarchy within each sub-catchment. Just over half of the length of the entire stream network is classified as major (66km), significant stream (62km), or minor rivers (40km). Minor tributaries are very limited and at a paddock scale.

Table 9: An analysis of the stream hierarchy per sub-catchment

	Mainstream	Major river	Minor river	Significant stream	Major trib	Minor trib	Grand Total (Km)
Molloy Island	0.24	0.73					0.98
Lower Scott	0.14	18.00				4.11	22.24
Dennis		0.09	22.27	22.97	5.79		51.11
Four Acres		0.03	16.05	24.34	6.49		46.91
Middle Scott		23.94	2.00	2.38			28.33
Upper Scott		23.99		0.44			24.43
Governor Broome				11.75			11.75
Grand Tot (Km)	0.38	66.78	40.32	61.88	12.28	4.11	185.75

Flow data is collected at two sites in the Scott River Catchment: at Brennan's Ford (AWRC reference 609002) and historically at Milyeannup Bridge (AWRC reference 609026), approximately 12 km upstream of the Brennan's Ford gauging station (White, 2012). Flow at Brennan's Ford (609002) has been collected since 1969 and at Milyeannup Bridge since 1996 but ceased in 1998 (Hall, 2010). The average annual flow for the period 1969-2018 is 88.5GL a further decrease from the average of the period 1969-2009 which was 94.7 GL showing a further decline in flow (Figure 12). Between 1970-1999 the average flow is 106GL and the average 2000-2019 flow is 61GL, which shows a 42% reduction post-2000. 2019 was the fourth lowest flow on record.

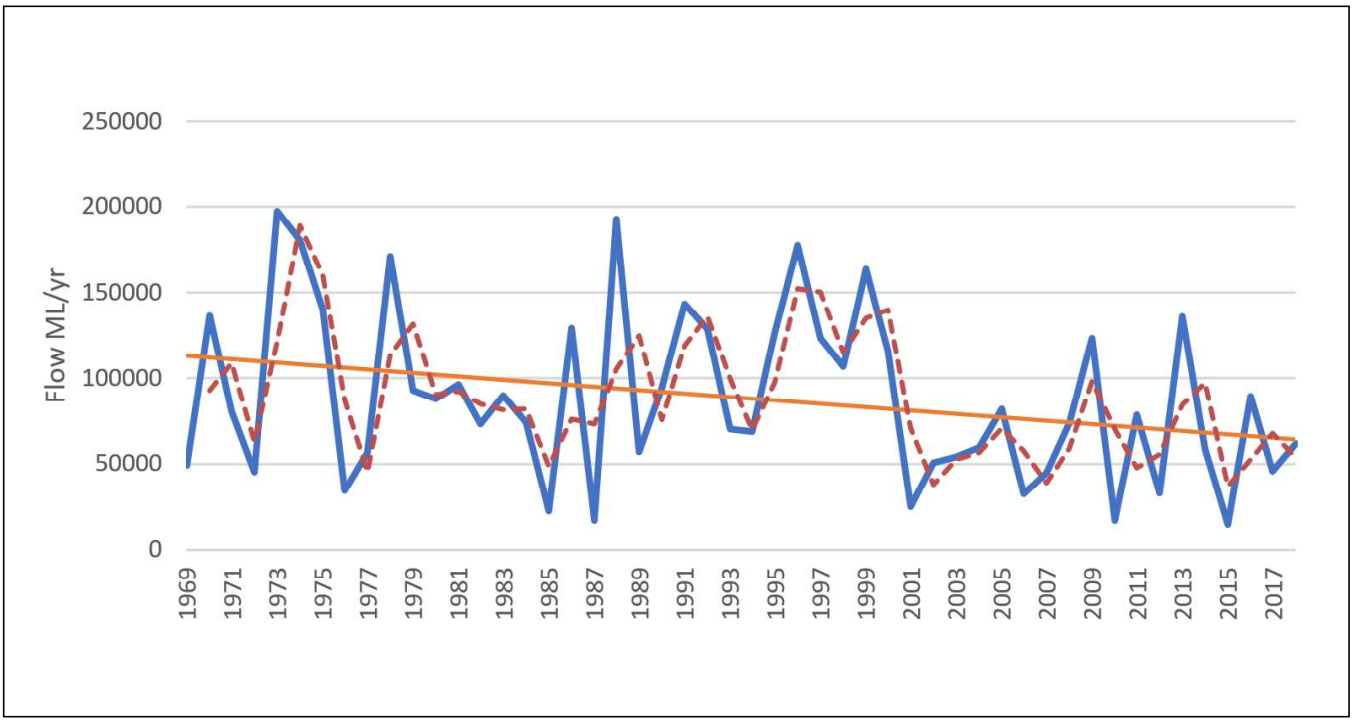


Figure 12: Annual flow at Brennan's Ford (600902) for the years 1969-2018. Trendline and moving average show reduction in flow for the period analysed.

3.3.5 Reserves

The Scott River Catchment contains several reserves (classified as nature reserves, national parks, and state forest, local govt reserves and other crown reserves) covering an area of 34,082ha (54% of the Catchment). Of this area, 14,440ha is state forest (Figure 13). Seven reserves are vested with the two Shires (areas designated as a camping area or gravel yard), 13 are managed by DBCA and others managed by other departments (Water Corporation and DPLH).

The Gingilup Swamps Nature Reserve (4091.4ha) is a significant reserve rich in biodiversity including a TEC. The D'Entrecasteaux National Park and the Scott National Park are also are rich in biodiversity covering an area of 6827.7ha (area within the Scott River Catchment's boundary) and 1482ha respectively (Table 10).

Farmland in the Scott River Catchment covers approximately 43% of the Catchment (Table 11). Of this area, approximately 34 % has been cleared for agriculture (Table 12). Table 12 also shows the proportion of private land (farmland), reserves and unallocated crown land in each sub-catchment. For example, for the Governor Broome sub-catchment:

- 3.4% of the sub-catchment is vegetated farmland, 58.1% is cleared farmland;
- 37.1% of the sub-catchment is vegetated reserve, 0.9% is cleared reserve;
- 41% of the total sub-catchment is vegetated, 59% is cleared.

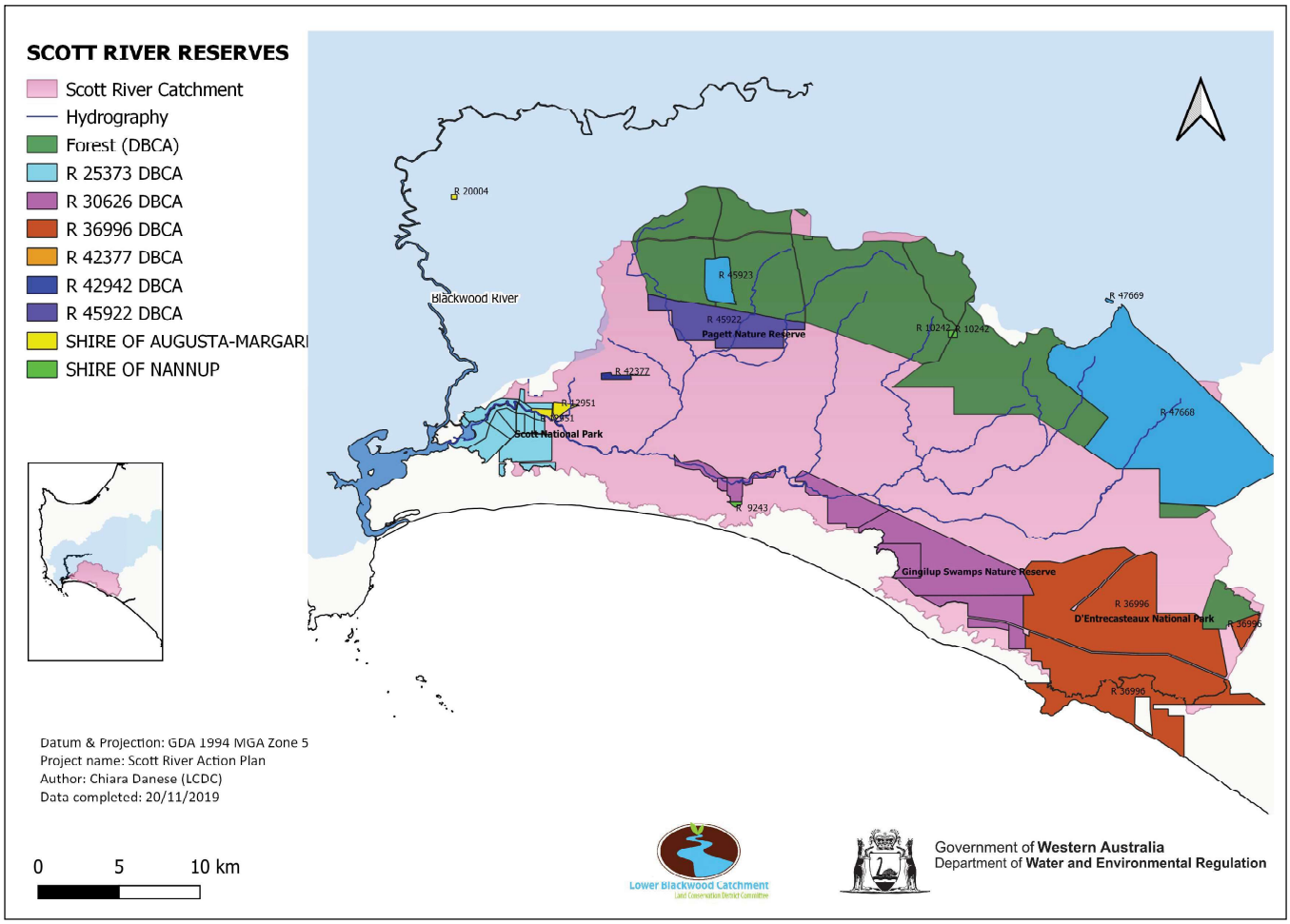


Figure 13: Reserves in the Scott River Catchment. Data: DWER

Table 10: Size of 'well known' reserves (managed by DBCA) in the Scott River Catchment.

Reserve number	Name	Category	Area (ha) within the Scott Catchment
R 36996	D'Entrecasteaux National Park	National Park	6827.7
R 30626	Gingilup Swamps Nature Reserve	Nature Reserve	4091.4
R 25373	Scott National Park	National Park	1544.8
R 45922	Pagett Nature Reserve	Nature Reserve	1397.9

Table 11: Extent of Reserve, Crown land and private ownership in each sub-catchment.

Sub Catchment	Area (ha)	Farm (%)	Reserve (%)	UCL (%)	Total
Upper Scott	18967	29%	61%	9%	100%
Dennis	14953	38%	62%	0%	100%
Middle Scott	11245	60%	39%	1%	100%
Four acres	10516	42%	57%	1%	100%
Governor Broome	4538	62%	38%	0%	100%
Lower Scott	4002	57%	42%	1%	100%
Molloy Island	55	0%	100%	0%	100%
Grand Total Scott River Catchment	64,276	43%	54%	3%	100%

Table 12: % area cleared and vegetated in each sub-catchment.

Sub catchment	Farm		Reserve		UCL		Total	
	Vegetated	Cleared	Vegetated	Cleared	Vegetated	Cleared	Vegetated	Cleared
Dennis	4.5%	32.9%	61.1%	0.9%	0.0%	0.0%	66.2%	33.8%
Four acres	7.1%	34.5%	55.4%	1.3%	1.4%	0.1%	64.1%	35.9%
Governor Broome	3.4%	58.1%	37.1%	0.9%	0.0%	0.0%	41.0%	59.0%
Lower Scott	13.4%	40.8%	42.2%	0.5%	0.9%	0.1%	58.6%	41.4%
Middle Scott	17.1%	41.7%	38.1%	0.8%	0.5%	0.0%	57.4%	42.6%
Molloy Island	0.0%	0.0%	44.8%	2.0%	0.0%	0.0%	98.0%	2.0%
Upper Scott	3.6%	24.9%	57.8%	1.7%	9.1%	0.1%	73.3%	26.7%
Grand total	17.4%	34.6%	52.3%	1.2%	3.1%	0.1%	64.2%	35.8%

3.3.6 Wetlands

There are two nationally important wetland systems recognized within the study area: the Blackwood River (Lower Reaches) & Tributaries System and the Gingilup-Jasper Wetland System (Table 13) (Environment Australia, 2001).

Nationally important wetlands are defined according to the following criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles or provides a refuge when adverse conditions such as drought prevail.
4. The wetland supports 1% or more of the national populations of any native plant or animal taxa.
5. The wetland supports native vegetation or animal taxa or communities which are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance.

Table 13: Nationally important wetlands

Nationally Important Wetlands	Jurisdiction	Hectares	Criteria
Blackwood River (Lower Reaches) & Tributaries System	WA	325.08	1, 3, 4, 5, 6
Gingilup-Jasper Wetland System	WA	2,766.05	1, 2, 3, 4, 6

The Scott River Catchment contains a large diversity of wetland types which provide habitat for flora and fauna but also has functions such as bio filtering of sediments and nutrients, flood mitigation, groundwater discharge, and erosion control (Figure 14). The Gingilup swamps and Lake Quitjup are important wetland subsystems to the broader Gingilup-Jasper wetland system which extends eastwards over the boundaries of the Scott River Catchment (White, 2012). There are no RAMSAR wetlands in Scott River Catchment, but the Gingilup-Jasper system is recognised as a Wetland of National Significance (Department of Environment, 2015). The Scott River ironstone flats are characterised by extensive areas of wetland.

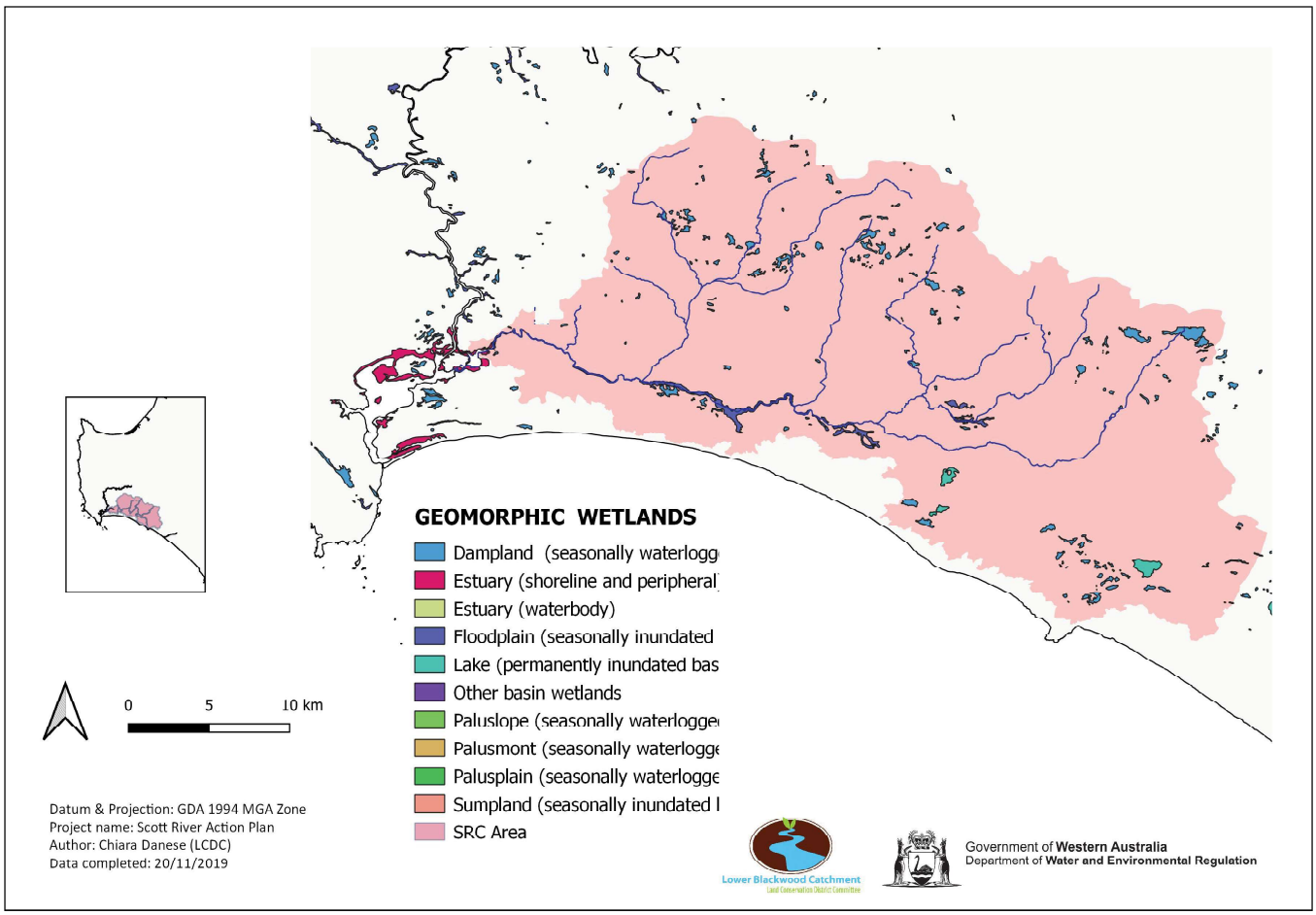


Figure 14: Geomorphic Wetlands (Source: DBCA).

The Semenuik & Semenuik (2011) classifications for the Scott River Catchment are provided below (Table 14).

Table 14: Geomorphic wetland classification.

Classification	Area (ha)
Floodplain (seasonally inundated flat)	127.49
Dampland (seasonally waterlogged basin)	151.63
Sumpland (seasonally inundated basin)	684.33

3.3.7 Vegetation, Flora & Fauna

The Scott River Catchment is of considerable botanic interest and has a number of endemic species[17] (Brearley, 2013). Approximately 64% of the Catchment remains under native vegetation cover (Table 11) the majority of which is in the northern Section of the Catchment (forested), along the coastal ridge (a rich mosaic of wetland and dunal vegetation associations) and in the south-eastern Section of the Catchment in reserves and national parks (forest and woodlands which vary from small pockets to broad zones).

Along the main channel (except a few small Sections) riparian vegetation and structure remain almost intact whilst riparian vegetation along tributaries is either very degraded or totally absent as a result of weed infestation, stock access and historical clearing (White, 2012; Rennie 2019).

The Scott River Catchment lies on the border between two biogeographic vegetation classifications[18]: The ***Southern Jarrah Forest*** and the ***Warren*** subdistricts (Darling District) of the South West Botanical Province (DAWE, 2012). The dominant and most widespread is Warren (WAR01) - 23568 Ha and a small portion of Jarrah Forest / Southern Jarrah Forest (JAF02) - 21185 Ha. Both Jarrah / Marri forests and WA Peppermint woodlands occur adjacent to riparian zones.

Aligned within these bioregions are more detailed vegetation associations based on Beard's classification[19] (1964-1981; Beard, 2013). Within the Scott River Catchment, there are 25 vegetation associations that are classified according to structure, physiognomy, floristics and in some cases ecological and regional attributes (Figure 15). However, the vegetation complex mapping of the Scott Coastal Catchment, particularly the mapping of the Sd complex (Scott), does not reflect the floristic differences that exist between the eastern and western ends of the Catchment. In fact, the western end of the Catchment (from approximately Molloy Island to Millyeannup Coast Road) is highly cleared, with wetland mosaic vegetation only remaining in a few private holdings, some public reserves and in road reserve vegetation (Gibson et al., 2001).

The Australian Government routinely collects information from state and territory governments and other protected area managers about the location and management of protected areas in four governance categories—public reserves; Indigenous Protected Areas; protected areas on private lands; and shared management reserves. This information is collated and stored as the Collaborative Australian Protected Areas Database (CAPAD).

To note that the majority of the Scott Coastal Plain is an Environmentally Sensitive Area[20] (ESA). In ESAs exemptions for clearing of native vegetation do not apply.

17 Endemic species are especially likely to develop on geographically and biologically isolated areas such as islands and remote island groups.
18 Interim Biogeographic Regionalisation for Australia (IBRA).

19 State-wide mapping carried out by John Beard between 1964 and 1981, which was been digitised at the 1:250,000 scale.
20 An environmentally sensitive area (ESA) is a type of designation for area which needs special protection for a variety of reasons such as presence of a wetland, threatened species or ecological communities or because of historical value.

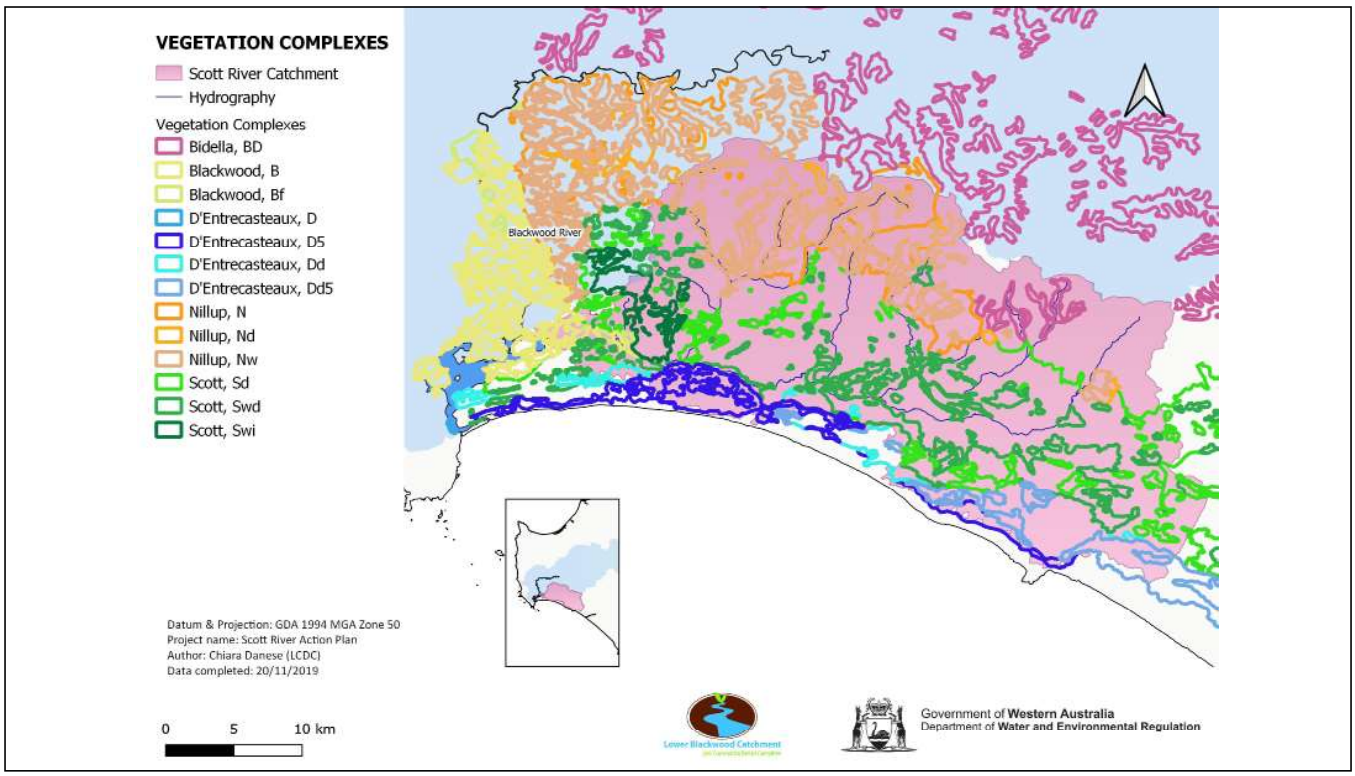


Figure 15: Vegetation Complexes in the Scott River Catchment.

3.3.8 Threatened and Priority Flora & Ecological Communities

The Scott River Catchment contains two TECs (being the Scott River Ironstone Association TEC, the Federal Coastal Saltmarsh TEC (also a State PEC) and one PECs (salt marsh). In addition to ecological communities, the Catchment also supports almost 60 listed flora species of which five are threatened and one considered extinct. Twelve of the catchments listed species are endemic to the catchment, with all of those being found in the catchments highly cleared western extent.

Five threatened flora (T), eight Priority 1, nine Priority 2 taxa, 20 Priority 3 and 14 Priority 4 can be found in the Catchment, many of which do not occur on DBCA-managed lands but rather on roadsides and private property. This means that it is up to the landholders to protect these species and the vegetation they occur within.

Appendix B lists flora and fauna species and communities that occur or are likely occur in the Catchment based on a desktop search.

3.3.9 Threatened and Priority Fauna

Information on fauna likely to occur in the Catchment was obtained from the following sources:

- Protected Matters database – a national interactive tool to identify species of fauna of national environmental significance that potentially occur within the area, and are protected under the ***EPBC Act (1999).***

- NatureMap – DBCA's and WAM's interactive map to identify scheduled and threatened species as well as potential vertebrate and invertebrate fauna within the Catchment.

The Protected Matters database report identifies 26 fauna species listed as threatened, priority or under protection within the Catchment area (see full Tables in Appendix B). Some well-known species present in the Catchment are the Forest Red-Tailed Black Cockatoo (***Calyptorhynchus banksia*** - Vulnerable); the Australian Fairy Tern (vulnerable); the Carnaby's Black Cockatoo (***Calyptorhynchus latirostris*** - Endangered) and the rainbow bee-eater (***Merops ornatus***) which have been sighted very occasionally, feeding in the

floodplain in the last 10 years. Seven threatened or priority mammals are identified of which two are likely to pass through or visit the foreshore reserves. Four threatened fish species are likely to occur. Two invertebrate species, a burrowing crayfish and Carter's freshwater mussel. One threatened reptile has been recorded within the FCA survey area. In addition, one migratory marine bird and seven migratory wetland birds are listed. These species may utilize the Catchment due to the presence of suitable habitat.

The NatureMap desktop search identified a number of species that occur in the Catchment. This included four birds (Masked owl and Barking owl; Peregrine falcon and the Hooded plover), one reptile (Short-nosed snake), four mammals (Quenda, Western brush wallaby, Rakali and the Brushed-tailed phascogale). It is likely that micro-habitat requirements would be met for these species in the well-vegetated remnant vegetation zones.

Cockatoo Habitat

The Red-tailed cockatoo is listed as vulnerable (EPB Act). The Carnaby's Cockatoo and Baudin's Cockatoo are listed both in the state and federal Acts as endangered. Given that it takes from 180 to 250 years for a tree to create a hollow it is important to identify and protect old trees which can provide roosting habitat as well as vegetation such as banksia that provide foraging habitat for cockatoos. The northern part of the Catchment provides more habitat for roosting and main channel for foraging.

Frogs

The terrestrial habitat requirements for frogs include dense riparian vegetation which helps them avoid predators and desiccation and also provide a large range of invertebrates (such as insects) for food (Rutherford ***et al.*** 1999). The WA Museum app "Frogwatch" (WAM 2013) has been designed to provide people with information on all aspects of Western Australian frogs including calls to help public identify the species they are hearing. It lists all the frogs present in seven regions of WA. For each species it provides information on their appearance, biology, distribution and habitat preference.

The cool wet forests of the South West corner of WA are home to over 20 species of frog including six species which are endemic (only found in this region) (WAM 2013. The Scott River Catchment is likely to be home to the most common frogs (Appendix B) but there are no records of three of WA's most threatened frogs: the white-bellied frog, the orange-bellied frog and the sunset frog). More surveys should be carried out to assess presence of rare frogs. ***Litoria moorei*** was the only frog species recorded during the DWER Healthy River Assessments.

3.3.10 Aquatic vegetation

Few aquatic plants were observed during the field surveys of the FCA as the majority of waterways were dry and those that were flowing or retained pools, were turbid.

Water ribbons ***Cycnogeton huegelii*** (previously ***Triglochin***) was present in the main Scott River channel at the western end of the (FCA) survey area. ***Persicaria decipiens*** (Slender Knotweed) and Common villarsia (***Ornduffia parnassifolia***) are present in limited areas.

Figure 16: Motorbike Frog (Litoria moorei). Image Source: DWER Healthy Rivers 2020

3.3.11 Aquatic fauna

The lower Scott River flows retains permanent pools that provide critical habitat including breeding habitat and drought refuge for fish and crayfish species. The riparian zone is also habitat for many more native birds and animals.

A number of endemic aquatic species of fish and crayfish expected to be found in the Scott River Catchment are: *Cherax quinquecarinatus*, gilgie (endemic freshwater crayfish, south-west WA); *Cherax cainii*, smooth marron (endemic freshwater crayfish, south-west WA); *Cherax preissii,* koonac (endemic freshwater crayfish, south-west WA); *Nannoperca vittata*, western pygmy perch (endemic freshwater fish, south-west WA); *Galaxias occidentalis*, western minnow (endemic freshwater fish, south-west WA); *Bostockia porosa,* nightfish (endemic freshwater fish, south-west WA); *Pseudogobius olorum*, Swan River goby (native freshwater-estuarine fish); *Afurcagobius suppositus,* blue-spot goby (native freshwater-estuarine fish); *Nannatherina balstoni,* Balstons pygmy perch (endemic freshwater fish, south-west WA); *Lepidogalaxias salamandroides,* salamanderfish (endemic freshwater fish, south-west WA) and *Galaxiella nigrostriata,* black-stripe minnow.

The DWER Healthy River Assessments recorded only a few of the species above at the survey sites with the most abundant being the gilgie, the western pigmy perch, the western minnow and the nightfish. A few exotic species such as Gambusia holbrooki and Cherax destructor (exotic crayfish) were recorded. The presence of exotic species is a reflection of some degree of ecological degradation.

3.3.12 Dieback, marri canker and myrtle rust

Phytophthora dieback is caused by the plant pathogen, *Phytophthora cinnamomi*, which kills susceptible plants, such as banksias, jarrah and grass trees, by attacking their root systems.

Dieback extent has been mapped to identify areas infested with Dieback and engage stakeholder in landscape-scale management of the pathogen across all land tenures. The Dieback Information Delivery and Management System (DIDMS) mapping tool uses "Disease Confidence Mapping *P. cinnamomi* to June 2008" data. The Phytophthora disease boundaries and categories portrayed in this dataset are a composite of survey data collected at varying times over 30 years. The dataset comprises various scales of survey intensity and various levels of interpretation confidence. The extent of infestations is underestimated, as not all areas have been surveyed and disease boundaries are likely to extend into mapped disease-free areas since surveys were conducted. DBCA also has an active program to detect, diagnose and map the occurrence of dieback on DBCA managed land. This includes interpreting and mapping areas for Phytophthora dieback prior to disturbance operations to manage or contain the spread of dieback.

In the Scott River Catchment, the extent of infestations is underestimated, as not all areas have been surveyed and disease boundaries are likely to extend into mapped disease-free areas since surveys were conducted (in 2008). To note that Phytophthora Dieback disease information is considered current up to 12 months within its survey date capture for uninfested areas and 3 years for infested areas. Areas that have not been mapped may still be infested, until stated otherwise by a "Registered Phytophthora Dieback Interpreter". Given that Dieback is transported by water it is likely that it is present in the Scott River Catchment. It is therefore important to assume that there is and that measures are taken to avoid the spread or to keep areas dieback free. Information on what measures to take can be found on the DBCA website.

The marri (*Corymbia calophylla*) **canker disease** is caused by the fungal pathogen Quambalaria coyrecup. The fungus enters through wounds or cracks in the bark and results in the death of areas of bark and the cortex tissue below. Cankers can occur on the trunk, branches or twigs of the trees and can result in limb fall and even death of the whole tree if the canker ringbarks the limb or trunk. It is likely that this disease is causing the decline of marri trees in the Scott River Catchment. There are no definitive recommendations on management to protect trees from marri decline. Undertaking management that will protect and enhance the environmental conditions surrounding affected marri trees may help. This includes restricting stock access, planting understorey species, mulching and watering where appropriate. Fungicide and nutrient treatments, as outlined below, can also be used to boost the defences of marri trees (Source: Nature Conservation Margaret River brochure).

Myrtle rust (*Puccinia psidii sensu lato*), is a serious fungal disease that attacks and kills many plants belonging to the Myrtaceae family. To date, myrtle rust has not been detected in Western Australia however, it is making its way over from the eastern states.

The likely impacts of myrtle rust in Western Australia are unknown, possibly worse than Dieback for native trees. It is possible that myrtle rust could devastate jarrah, karri,

tuart and wandoo forests and other native habitats, including species already at high risk (particularly threatened plants). It is important that landholders keep an eye out for:

- Infection on young growing shoots, leaves, flower buds and fruits.
- Masses of powdery bright yellow or orange-yellow spores on the infected area.
- Leaves that become buckled or twisted and die as a result of the infection.

3.3.13 Environmental Weeds

Invasive plants are widespread in the Catchment. There are several common ones and some are declared pest (DP). A plant that is declared under the BAM ACT means that landholders are legally obliged to control it.

The most widespread weeds throughout the Catchment are curly and swamp dock (***Rumex*** spp.), redshank (***Persicaria maculosa***), pennyroyal (***Mentha pulegium***), blackberry nightshade (***Solanum nigrum***), victorian teatree (***Leptospermum laevigatum)*** along with pasture species such as kikuyu (***Pennisetum clandestinum***).

Widespread weeds of greatest concern include Redshank (***Persicaria maculosa***), Fleabane ***(Conyza spp.) and*** Spear Thistle (***Cirsium vulgare***). Weeds of greatest concern that are present in relatively small numbers include

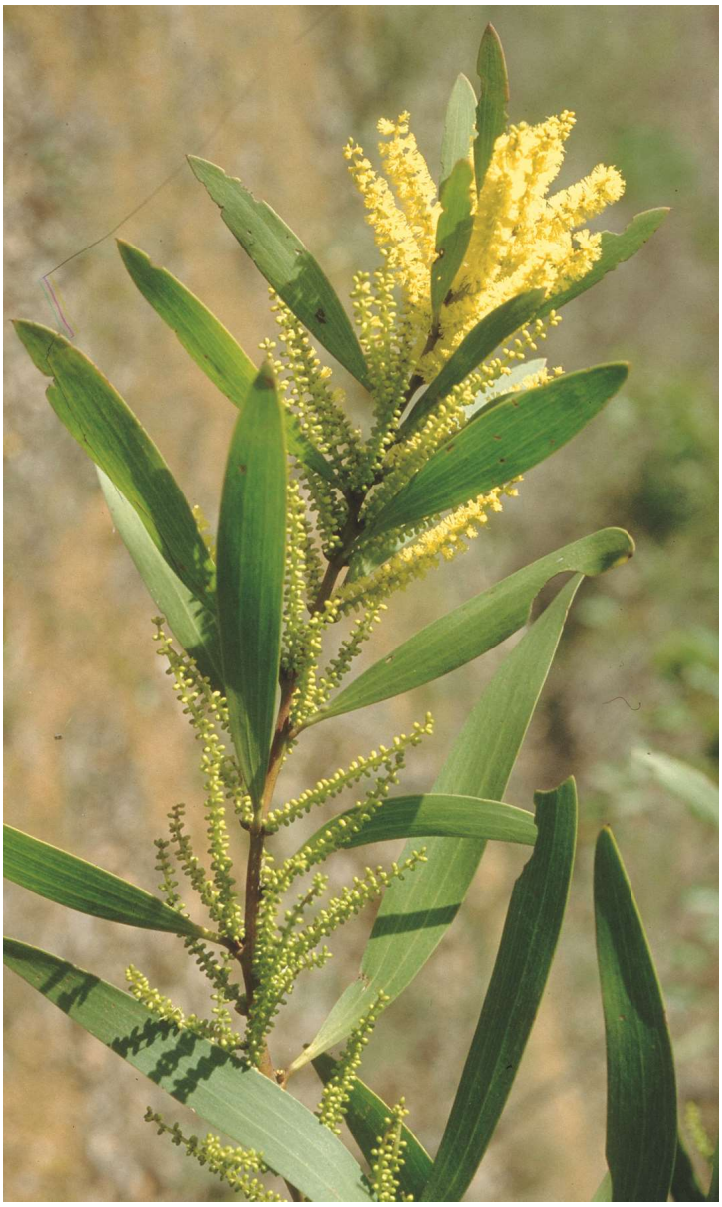


Figure 17: Sydney golden wattle (Acacia longifolia). Image Source: DPIRD 2020

one-leaf cape tulip (***Homeria flaccida***) (DP), Apple of sodom (***Solanum linnaeanum***) (DP), Stinkwort (***Dittrichia graveolens***), Loosestrife (***Lythrum hysoppifolia***), Sydney golden wattle (***Acacia longifolia***), ***Persicaria maculosa,*** Marshmallow (***Malva parviflora***), Wavy gladiolus (***Gladiolus undulatus***), African feather grass (***Pennisetum macrourum***) and African love grass (***Ehrharta calycina***). Arum lily has not been recorded in the Catchment.

Known distributions are provided in the sub catchment descriptions (Appendix B) however some species are listed based on feedback from landholders.

Roadside weeds currently threaten a number of roadside threatened flora populations (as well as roadside clearing which causes even more damage). Regular control around these populations is occurring and should continue. New weed incursions should be monitored in plantations and as livestock are moved between properties. This will be increasingly important with hay importation following dry winters for landholders with insufficient feed stores.

Features of some of the most common weeds are:

- Black wattle (***Acacia melanoxylon***) and Sydney golden wattle (***Acacia longifolia***) are native to eastern Australia and have been used in re-vegetation projects in Western Australia. They reproduce vigorously through seed and root suckers. Their long-lived seed bank responds strongly to fire and burnt adult trees will regenerate from root suckers.
- Loosestrife (***Lythrum hysoppifolia***) is toxic to stock and currently has a limited distribution and should be targeted before the population becomes more extensive.
- Stinkwort (***Dittrichia graveolens***) causes contact dermatitis, can taint milk and is poisonous to stock. This species currently has a limited distribution and should be targeted before the population becomes more extensive.
- One leaf cape tulip ***(Moraea flaccida)*** (DP) was also observed in the Catchment, mainly along road verges but also invading some fenced riparian zones. These plants reproduce with numerous small corms that break off from the parent corm when the plants are pulled out. These also occur in verge vegetation of the lower reaches assessed in fieldwork, and DWER managed reserve according to advice from the landholders.
- Kikuyu (***Pennisetum clandestinum***) is a weed in well-vegetated waterways along with other pasture weeds. However, Kikuyu may also have some positive effects including the potential to stabilise banks, strip nutrients and filter sediment.

Figure 18: One leaf cape tulip (Moraea flaccida). Image Source: DPIRD 2020

3.3.14 Invasive Fauna

Anecdotal evidence indicates that there is a widespread of feral pigs, foxes, rabbits and feral cats in the Catchment. Funding for pest control programs is intermittently provided by the government through local NRM groups. Although a lot of animal control occurs at the farm level, it is widely recognised that a landscape-approach to invasive species management is most effective. More information on initiatives for invasive animal control can be found in Section 5.2.4 of this Plan.

3.3.15 Rainfall and Climatic Changes

The Bureau of Meteorology (BoM) weather station "Scott River 9926" recorded daily rainfall data for the Scott Catchment from 1974 to 2008 when it ceased to be operational. Station 9926 was located on Milyeannup Coast Road and observations were recorded by a local landholder. In 2012 the Department of Primary Industries and Regional Development (DPIRD) installed three automatic weather stations in the Scott River Catchment, located approximately eleven km apart. To date, the stations are the only automatic weather stations operational in the Scott River. Outside the Scott River Catchment, the BoM weather stations are located at Nannup (9585), Cape Leeuwin (9518), and Alexander Bridge (9801). At all these locations the weather data shows a decline in rainfall since 1900.

The LBLCDC worked with several landholders in the Scott River Catchment that had kept long term rainfall data to see if an observation regarding rainfall trends could be made in

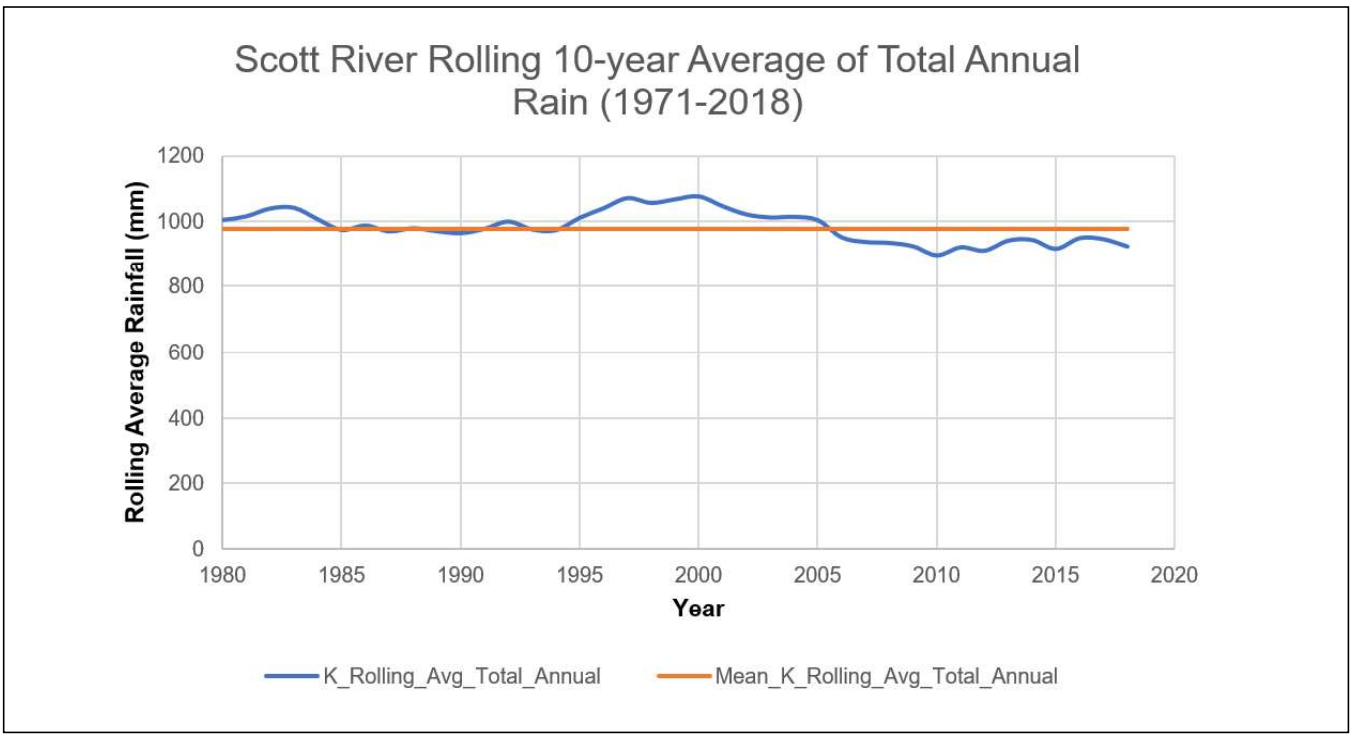


Figure 19: Rolling 10-year average of total rainfall graph of collected Scott River Landholder rainfall data

addition to the trend calculated using the BoM weather data.

The collected information from landholders showed a steady decline of 18mm per year in annual rainfall between 2001 to 2010, and continuous lower than long-term average (by 46mm) annual rainfall every year since 2006 on those farms in the Scott River Catchment (Figure 19). The continuation of rainfall data collection and comparative analysis of the area with government weather station data for the region would be useful to allow for further long-term trend analysis and study.

According to the ***CSIRO State of the Climate Report 2018*** (CSIRO-BoM, 2018) between 1910 and 2013 average annual temperature in the southwest of WA increased by 1.1°C, with similar increases in average daily maxima and minima. However, seasonal onshore winds moderate temperatures in southern coastal areas, and some Scott River landholders have reported cool summers recently.

Below is the most significant projection of climatic changes expected in the South-Western Flatlands West (SSWFW) sub-cluster as per the CSIRO's report ***Climate Change in Australia. Information for Australia's Natural Resource Management Regions: Technical Report (2015)***:

- Average temperatures will continue to increase in all seasons.
- More hot days, extreme temperatures, and warm spells.
- Decreasing winter and spring rainfall.
- Increased intensity of extreme rainfall events.
- A decrease in winter mean wind speed.
- Reduced relative humidity in winter and spring.
- A confluence of factors leading to a harsher fire-weather climate: extreme heat events, drought and bushfires.

Further, DFWA prepared a summary presentation in 2012 for the South-West about the likely climate changes and implications for landholders. Much of the content from these two sources is relevant to the Scott River Catchment and key points are set out below.

- Time spent in drought may increase.
- Growing seasons may shorten, with delayed starts, false breaks and unreliable shoulders.
- Water tables may decline in places.
- Waterlogged areas may become productive.
- Frost events may impact crops in the short-medium term.
- Reductions in milk production from heat stress during heat waves may occur.
- Warmer, drier conditions may favour insects and plant pests and diseases.
- Soil organic carbon may breakdown faster, reducing available nitrogen and increasing soil acidification.
- Evaporation rates may increase; soil moisture may decrease, and runoff may decrease.

- Bushfire frequency and intensity may increase.
- Human health may suffer due to more heat-related stress.
- Mental health may worsen.
- Water supply, utilities, asset management, environmental management and insurance may all be affected.
- Maintaining water supply may be a significant issue.
- Biodiversity may be impacted.

To note, these projections are for the wider South West area, not specifically the Scott River Catchment. Landholders in the Scott River Catchment commented that extreme weather in the Catchment is moderated by the proximity of the ocean so the abovementioned projections may be not as significant. Further, some landholders mentioned the fact that some of these changes could be beneficial for some landuses as more land becomes available.

3.3.16 Algae Blooms

The occurrence of Phytoplankton blooms, macroalgal blooms (various species) and fish kills in the Hardy Inlet since January 2005 has been the cause of growing community concern about the inlet's health and the overall water quality of the Blackwood and Scott River systems. Water quality condition reports and health warning issues released between 2005 and 2010 describe the appearance of potentially toxic algae events as being a 'recurrent' and 'frequent' issue in the Hardy inlet requiring urgent management (Forbes, 2010; DWER 2009; White, 2012). Before 2005 Phytoplankton blooms and small summer of outbreaks of green algae in the Hardy Inlet were not regarded with concern.

Most recent records show that between 2005 and 2010 there has been a total of three fish kills in the Lower Blackwood River; two of those near the Augusta townsite and the outlet to the ocean, and one near Molloy Island in late May 2006. The latter was a sizable event (~1000 bream, mullet, whiting and tarwhine), caused by a sudden drop in oxygen in the water following the collapse of algal bloom (DoW, 2013). This "was linked to a cycle of events of rainfall, nutrient supply, phytoplankton blooms, and the rapid depletion of dissolved oxygen" (DoW, 2013; p22).

Cyanobacteria (blue-green) species ***Lyngbya aestuarii*** can be toxic and has been recorded around Molloy Island at the confluence of the Blackwood River and Scott River every summer from 2005 until 2008 and then only once, in 2018, since then (Forbes, 2010).

While winter phosphorus is the Scott River is important, the hydrodynamics of the area is also likely to play a major role in initiating the bloom and allowing large mats of floating Lyngbya to accumulate. Salinity, anoxia, climate, and ecological factors are also likely to be drivers.

3.3.17 Water Quality and River Health

The P issue

Understanding the source and movement of nutrients (N & P) in the Scott River Catchment is important for the long-term protection and improvement of water quality in the Hardy Inlet (White, 2012). Although both N and P levels need to be managed, excess levels of P are a critical factor in promoting the intensity of cyanobacteria and related blooms. The role that sediments play in the release of nutrients under hypoxic and anoxic conditions is also crucial and needs to be taken into consideration in the development of management recommendations.

P entrained in streamflow can comprise (Moore 1998):

- Inorganic P dissolved in groundwater and surface runoff; mostly from applied fertilisers and chemicals.
- Organic P from the environment; manures and the breakdown of organic matter.
- P absorbed to soil particles; transported in silt and sediment from surface soil erosion and eroding channels.

Stream and river nutrient monitoring by DWER show the greatest amount of P originates from dissolved inorganic P that discharges from the catchment during early to mid-winter (Hall, 2011). This P is most likely from applied inorganic fertilisers that are dissolved by rainfall and transported from the catchment by runoff and seepage.

Although the relative contributions may change through the season (from year to year from and depending on the dominant land uses), it is clear from aerial photography that P and other nutrients can find their way into streamflow through:

- Eroded watercourses, gullies and drains with no buffers or riparian vegetation
- Cattle accessing and wallowing in the pools of degraded watercourses
- Plantations where mounding has continued through streams and drains
- Intensive irrigation areas with lakes and inundation within them
- Leaking effluent ponds near drains and waterways
- Intensive irrigation areas with major watercourses

passing through them

- Farms where waterways are used as tracks in summer
- Drains that run to the neighbours' fence and stop.
- Where drains and streams are used for turning around at the end of row operations.

These activities lead to the direct application of inorganic P to the beds and banks of watercourses and drains, deposit organic P directly into waterways and disturb and damage the beds, banks and terraces of waterways causing erosion, and mobilising silt and sediment.

Similarly, P concentrations will inevitably be increasing under intensive dairies. The excrement from a 1500 head dairy (13 kg/ head/yr, Moore 1998) contains a similar level of P as that produced by a 'sewered' townsite almost the size of Margaret River. Although the annual P inputs for intensive dairy are probably less than a quarter of those of horticulture, calculations can show that only about 10 T/yr of P is removed in the produce (milk). This is less than 10% of the reported annual P input across the SRC for this enterprise (White 2012).

Water Quality Monitoring

Water quality sampling in the Scott River Catchment (Figure 13) has been carried out by DWER every fortnight since the mid-'90s when the waterways are flowing (at Brennan's Ford since 1984 with a gap between 2011 and 2016). A total of nine sampling sites (Figure 20) have been recording long term data on nutrient concentrations for P and N. The only gauging site, located at Brennan's Ford, enabled flows and nutrient loads to be calculated. Nutrient concentrations are provided as an average over three-year winter periods. It is important to note that not all sub-catchments in the Scott River Catchment have a sampling site and that the sampling sites are not always located at the base of each sub-catchment meaning that data from some monitoring sites may not truly reflect the water quality status of the entire sub-catchment (White, 2012).

Several sites were also assessed for water quality sampling and river condition by DWER through the ***Healthy Rivers Program.*** The assessments show that overall, the main river channel is in good condition with regard to riparian vegetation species and

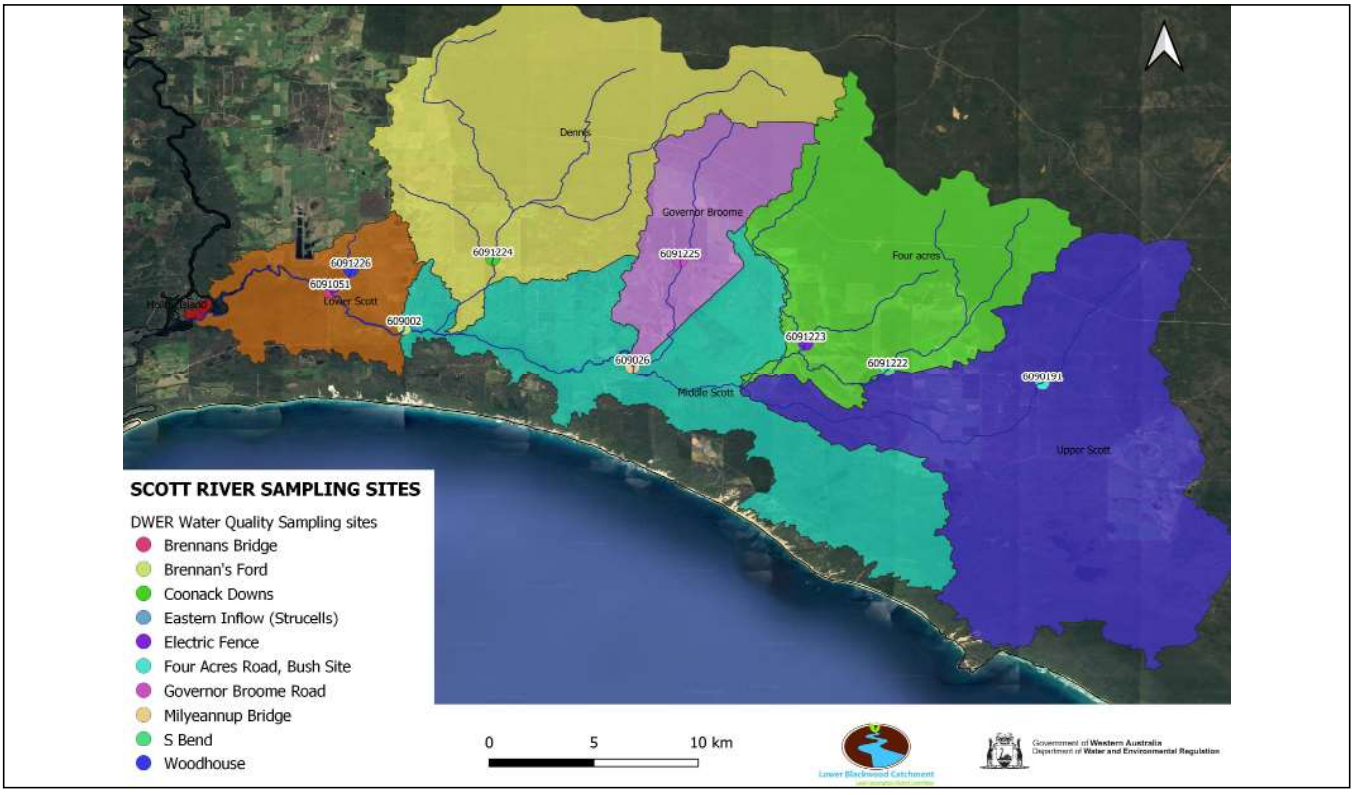


Figure 20: DWER water quality monitoring sites. Data: DWER

fauna species, whilst the tributaries are the most impacted by agricultural uses. The recommendations from the DWER reports have been incorporated into the FCA assessment recommendations.

The findings of the first ten years of water quality monitoring data are summarised in the Hardy Inlet Water Quality Improvement Plan (White, 2012). In 2009 the key findings with regard to P were:

- For the period 1984-2009 at Brennan's Ford (609002), the station with longest records, an increase in the winter median TP concentrations with values just over the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (0.065 mg/L) in the early 1990s and then exceeding the ANZECC guidelines after the year 2000 showing the impact of agricultural intensification on water quality.
- For the period 2007-2009 winter median TP concentrations show high levels of P exceeding the WQIP TP target of 0.1 mg/L at 6 monitoring sites (Coonack Downs was below) with S-Bend being the highest.
- In 2009 nutrient loads (calculated for each sub-catchment using a water quality modelling software) show the highest P loads at Four Acres Road (from irrigated dairy) followed by Middle Scott (dryland beef and irrigated dairy) then Dennis (dryland beef and irrigated dairy).
- In 2009 the winter median TP concentration was 0.15 Mg/L (TP target is 0.1 mg/L), whilst the average annual load was 11.2 t/yr (target of 8.1 t/yr). In 2009 the required target was a reduction in P of 28 % recommended through better nutrient management practice.

In 2009 the key findings with regard to N were:

- A high nitrogen rate is required for viable agricultural production. It was noted that a source of N in the Catchment is native vegetation and that N can be fixed by pasture clover as well as cyanobacteria.
- For the period 2007-2009 high winter median TN concentrations were recorded at Woodhouse, S-Bend and Governor Broome.
- For the period 2007-2009, a total of 5 monitoring sites recorded TN concentrations above the ANZECC guidelines (for TN 1.2 mg/L).
- THE highest N loads were recorded coming from the Middle Scott (dryland beef, irrigated dairy and native vegetation), the Dennis (dryland beef, irrigated dairy) and the Four Acres (immature blue gums, irrigated dairy and dryland beef).
- In 2009 the average annual load of 78.1 t/yr met the target for TN.

Recent data collected by DWER through the REI allows comparison between the winter median TP concentrations of the period 2007-2009 with the period 2016-2018 (Figure 21). It is important to note that loads for each sub-catchment were calculated only for the period 2007-2009, therefore comparison between the two data collection periods can only be undertaken using concentrations. For the period 2016-2018 the key findings were:

- Overall TP concentrations are above the WQIP target of 0.1 mg/L at five sites out of nine at S-Bend, Electric Fence, Woodhouse, Milyeannup Bridge and Brennan's Ford.
- Site 6090191 was added in 2016 to assess the amount of nutrients that comes from native forest. Brennans Bridge was also added as it was closest to the bottom of the Catchment.
- A slight improvement at Milyeannup Bridge (still over the target), Brennan's Ford (still over the target), and Governor Broome (below the target).
- The S-Bend has extremely high values, far in excess of all other sites and orders of magnitude higher than the WQIP target.
- Governor Broome Road and 4 Acres had median values below the WQIP targets, and for Governor Broome Road this represented a much lower median concentration than for the period 2007-09.

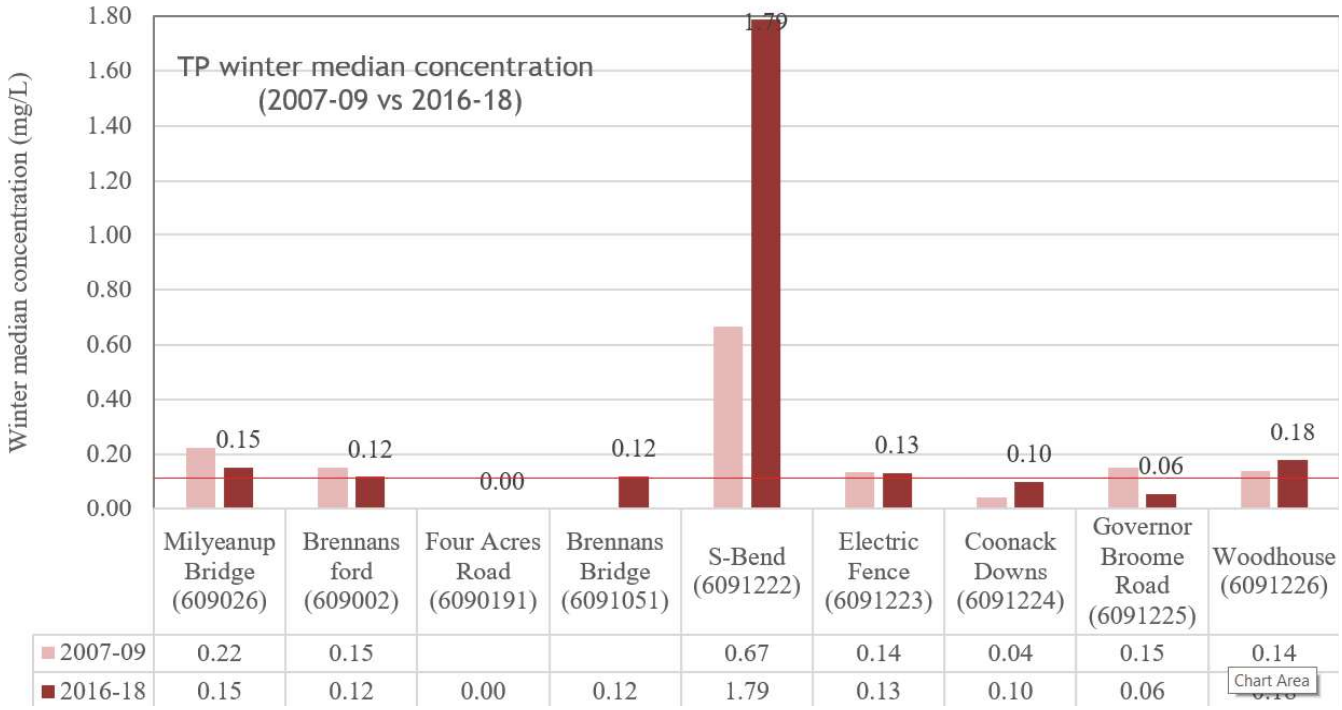


Figure 21: Data comparison between the periods 2007-2009 and 2016-2018 for winter median TP concentrations. Data analysis: DWER

Please note: When reading Figures 15 and 16, refer to Figure 14 for the location of the monitoring sites.

Figure 22 shows data comparison between the periods 2007-2009 and 2016-2018 for winter median TN concentrations. For the period 2016-2018:

- Overall TN concentrations remain above the WQIP target of 1.2 mg/L at four sites out of nine at Woodhouse, S-Bend, Electric Fence and Governor Broome Road.
- A slight improvement at Milyeannup bridge (below target) and Governor Broome Road (over target).
- Higher concentrations in the 2016-18 period at Coonack Downs (although right on target) and S-Bend is much higher in the recent period and extremely high (by far the highest concentrations).

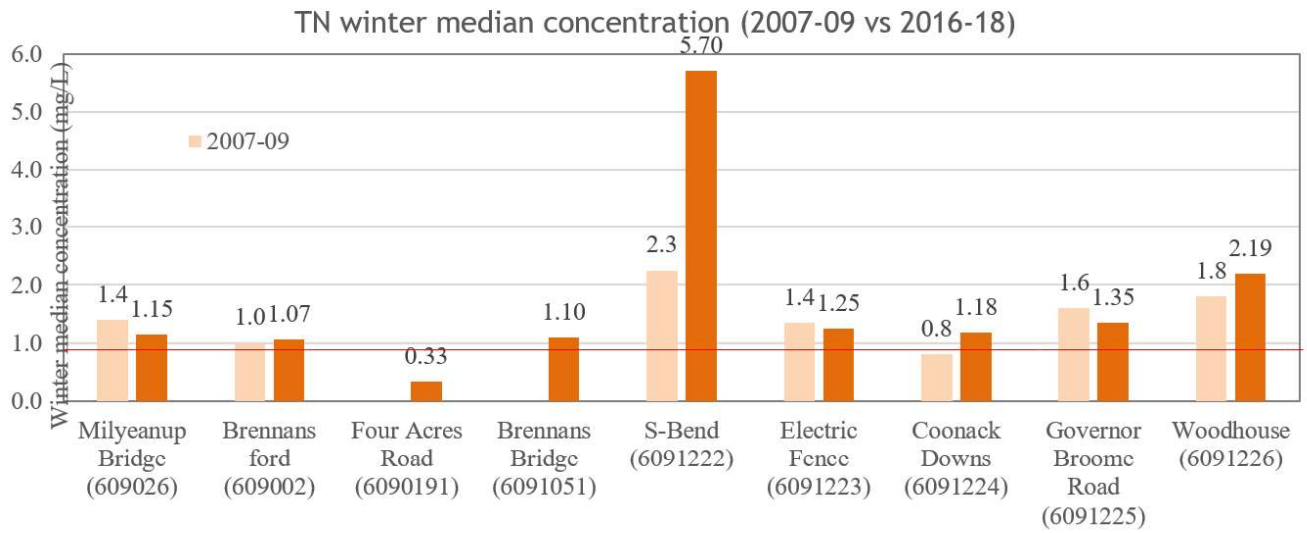


Figure 22: TN Median concentrations 2007-2009 vs 2016-2018. Data analysis: DWER.

Table 15 shows how the Scott River Catchment is performing against established targets. For TP there is an improvement of around 20 % compared to 2007 to 2009. For TN the new concentrations show a decline of 10 %.

Table 15: TN and TP targets vs current values. Data: DWER

Nutrient	**Winter Median Concentration (mg/L) 2007-2009**		**Winter Median Concentration (mg/L) 2016-2018**	
	Value	**Target**	**Value**	**Target**
TP	0.15	0.10	0.12	0.10
TN	1.0	1.0	1.1	1.0

These are interesting results and may indicate some improvement due to Catchment management, including best practice fertiliser management and riparian revegetation, however, they could also be due to land-use changes in the Catchment or measurement noise in the data.

In any event, they reinforce the need to follow the "critical management measures" in the HIWQIP (White, 2012) namely:

1. Implement best practice fertiliser management across the sub-catchments.
2. Investigate farm-scale nutrient hotspots in the sub-catchments.
3. Carefully evaluate proposals for further intensification of land uses in the Catchment to ensure that water quality improvement plan targets are met.

Work through the REI is leading to improved ways of meeting these recommendations and this Plan sets out methods and recommendations to work collaboratively with landholders and all sectors to achieve better water quality, whilst improving farm practices and productivity.

4. ENGAGEMENT & CONSULTATION

Methods

A crucial component of the SRAP was a meaningful and representative engagement of the Scott River Catchment farming community, industries and the local Aboriginal groups to inform the preparation and to maximise uptake of the Plan. The vision of the LBLCDC is that this engagement process with the Scott River Catchment communities is a continual process and not a one-off exercise.

Engagement

There were numerous occasions for landholders and other key stakeholders to share their knowledge and engage in a meaningful and collaborative engagement process (Table 16). These occasions were:

1. Through open-ended interviewing (thirteen out of twenty-one landholders) to assess landholders' attitudes, values and practices as part of the Knowledge Sharing and Value Mapping study (Section 4.2). The interviews were carried out by LBLCDC staff with help from a consultant. 13 landholders were interviewed (out of 23), being three dairy farmers, eight beef farmers and the plantation industry representative on the SRAG. The final number of people interviewed was dictated by resources availability and by people willingness to participate. Findings were used for the development of the final recommendations and stored in the LCDC GIS database.
2. During the foreshore condition assessment site visits. This process was carried out by the consultant with a total of 19 properties visited and 10 landholders engaged. The information gathered from on-site discussions was used in the development of the FCA management recommendations (Appendix A) and final recommendations.
3. For the preparation of the multi-disciplinary studies. 21 landholders and stakeholders (government agencies representatives) were contacted.
4. During the on-country visits with the local Aboriginal groups. The on-country process was recommended by a consultant and carried out by LBLCDC staff.
5. Through the representation of Scott River producers and industry representatives on the SRAG.
6. The landholder workshop to get landholder feedback on Draft FCA Maps (nine landholders attended)

Table 16: Stakeholders interviewed for background studies.

Stakeholder	No. people interviewed for background information on Aboriginal heritage and values, Legislation, Land Use and Climate Change	No. of people interviewed for Knowledge Sharing and Value Mapping	No. of site visits by consultant for the foreshore condition assessment	No. of people interviewed for Dairy effluent study
Dairy	2	3	4	4
Irrigated beef	1	1	1	
Dryland beef	1	8	6	
Plantations	3	1	8	
Horticulture	1			
Aboriginal custodians	5			
Local government	2			
State government	6			
Total	21	13	19 (10 landholders)	4

Aboriginal engagement

The LBLCDC undertook on-country trips to the Scott River with both the Undalup Association Inc and Bibulmen Mia Aboriginal Corporation.

In November 2019, LBLCDC Staff and Committee members joined Iszaac, Wayne and Nadine Webb from Undalup Association Inc. to learn about the cultural significance of the area; appreciate the importance of the environmental health of the Catchment; and understand how local Aboriginal people historically moved across, interacted with, cared for as custodians of the land and lived on the landscape. This included their food collection, water use, fire management and working with the seasons. Several important sites were visited including the Kybra rock site where the LBLCDC learned about the animal track engravings, a 'water tree' that held fresh drinking water, an entwined marri and jarrah 'marriage tree' that was used for marriage ceremonies and a freshwater point that had been turned into a permanent well by previous landholders.

In December 2019, William and Nina Webb and Joel Chapman from the Bibulmen Mia Aboriginal Corporation also took LBLCDC Staff and Committee members on a separate on-country trip. The group stopped first at the Blackwood River to learn about Aboriginal history, the use and significance of the river system, and the importance of maintaining the health of the river. The group then visited the Kybra rock site to view the engravings and hear about their history, and learn more about the Aboriginal six seasons and their role in improving Catchment health.

The LBLCDC wishes to continue this engagement so the local Aboriginal groups can further inform and support the implementation of the SRAP.

Communication

The communication process with the Scott River Community has been to inform and to involve. This was achieved through the following actions:

- Initial mail out to the Scott River community informing them of the proposed project and inviting them to an initial community consultation session to discuss the proposed project
- Project webpage on the LBLCDC website.
- Representation on the Project Advisory Group by Scott River producers and industry representatives.
- Various interviews and site visits as outlined in Table 16.
- Email updates to the Scott River Community on the project progress.
- Individual phone calls, emails, and meetings with members of the Scott River Community by project staff and consultants
- Information in local media.

4.2 Knowledge Sharing & Value Mapping

Preservation of biodiversity, water quality and continued provision of ecosystem services increasingly relies on environmental conservation on private land. In some cases, low uptake of best management practices discloses that behavioural change by landholders requires multidimensional and dynamic approaches that support adaptive learning.

For this reason, it was deemed important to collected landholders' values, attitudes and priorities with regard to nutrient management practices, waterways health and overall Catchment's community wellbeing.

The findings from the interview process may help identify some key constraints to capacity of landholders to manage natural resources sustainably without impacting on productivity.

4.2.1 Methods

Thirteen semi-structured 'interviews' were conducted with landholders and managers for each land-use type.

Not all landholders were interviewed due to time and resource constraints. Ten landholders did not want to be interviewed. Some of the reasons provided by the people who refused to take part in the study include:

- Lack of trust in the organisations behind the project (particularly government).
- Dissatisfaction with previous attempts to carry out studies or advice.
- Fear of 'having to commit' to do something.
- Concerns over people accessing their property.
- Bad timing.
- Perception that there is nothing wrong in the Catchment and therefore this (the project) is a waste of time.

The interview process aimed to have a genuine discussion and knowledge exchange about:

- the value of waterways and riparian systems,
- current and future farming approaches and practices that (may) affect the health of riparian systems, and
- barriers and opportunities for the adoption of more

sustainable practices for nutrient management and riparian restoration,

To enable the conversation to flow, the questions were open-ended, and addressed the main aspects of production:

1. waterway health
2. vegetation and animals
3. land
4. climate
5. infrastructure

During the interviews a sustainability framework was used to assess all sustainability impacts (positive and negative) for each aspect discussed (Table 17). The sustainability impacts were:

- *Economic functions.* The life cycle of production, consumption and waste disposal/ recycling; includes technology for production and environmental management e.g., irrigation and effluent disposal.
- *Environmental functions.* The local ecosystems, functions and physical elements; includes biodiversity, habitat, carbon fixing.
- *Social functions.* Where and how people create social fabric and 'belonging'; includes meeting places, recreational sites.
- *Cultural functions.* Where and how people maintain traditions and make meaning of their world; includes places of special meaning, heritage and historical sites.

This was used in the analysis of the responses to have a better understanding of what are the key drivers and 'world views' behind current farming practice in the Catchment. The findings were then used to prepare the recommendations and particularly to inform future landholder engagement strategies in the Catchment.

A methodology called 'Participatory Mapping' was used to acquire and display the information captured during the discussions. Participatory mapping means the creation and use of maps by local communities – often with the involvement of supporting organisations including governments, NGOs or other actors engaged in the development or land-related planning. Participatory mapping is useful for understanding how and where stakeholders benefit from ecosystem services and to prompt discussion of perceived future changes. It can be used to gather objective local ecological knowledge or to reveal stakeholders' perceptions and experiences of ecosystem services.

The mapping process using Google Earth Pro enabled the identification of priority "hotspots" which are "place-marked"; forming an important dataset for ongoing discussions with landholders about management practices. Permission was asked to map the key functions and to store the information within the LBLCDC for future use. During the discussions, a physical map of the farm was also laid on the kitchen table to show the big picture of the property. Mapping using the computer was not possible in every session due to logistics.

Table 17: Template used for sustainability analysis.

ASPECTS OF PRIMARY PRODUCTION	SUB-ASPECT	LOCATION (DRAW ON MAP) Y/N	FARMER'S DESCRIPTION	ECONOMIC IMPACTS (+ & –); High Medium, Low	ENVIRONMENTAL IMPACTS (+ & –); High Medium, Low	SOCIAL IMPACTS (+ & –); High Medium, Low	CULTURAL IMPACTS (+ & –; High Medium, Low)	CHANGE AND MONITORING OF SUBCATEGORIES	MANAGEMENT OF SUBCATEGORIES; PAST, CURRENT, FUTURE OPTIONS
WATER	Permanent natural wetlands								
	Watercourses (official and owner's)								
	Drainage network: shallow or deep drains; agricultural drains and boundary drains								

4.2.2 Findings

The interviews showed that the topic of nutrient management and waterways health on farm and overall, in the Catchment, is complex and multi-dimensional. Landholders' worldviews and their relationships with farming practices govern their priorities and ultimately influence whether water quality improvement works are considered as value-adding or not. There are also many factors ultimately determining (and shaping) their execution.

For analysis purposes landholders' responses can be grouped in:

1. PEOPLE NOT CURRENTLY INTERESTED IN CHANGING THE STATUS QUO

This small group, despite showing a good understanding of the environmental impacts of poor nutrient management decisions, were not currently making any changes to farming practices. These people typically prioritise economic values over environmental ones. The right to private property in the sense of doing what is best for the business prevail over local and catchment wide environmental health benefits. Some landholders did not give permission to access their portion of foreshore to conduct the FCA survey. Government support is perceived as being inadequate and support (including the SRAP process) imposed. Vertical linkages between land managers and government agencies are weak. Distrust in government is strong. However, these people did participate in the interview process and the majority did give access to their farms so there is potential for future dialogue.

2. AWARE, INTERESTED BUT CAUTIOUS

Landholders for whom environmental impacts due to current farming/nutrient management practices are a concern but still not a high on the agenda.

There is an openness to change but people are not sure on what to do and what to prioritise. The economic benefits of protecting the environment are still not fully understood. There is a general interest in farm mapping but no commitment. This category was the most represented.

3. ADAPTABLE, INTERESTED, INNOVATIVE

Landholders who make farming decisions taking into consideration environmental and social aspects of land management as well as economic.

The economic, environmental and social benefits of protecting the environment are well-understood. Waterway restoration and fertiliser trials are carried out and will continue to be high on the agenda.

The following interview analysis (divided into five topics) provides further insights into the knowledge and challenges of waterway and land management.

Topic 1: Waterway health

The majority of people interviewed were aware of the recurrent issue of algal blooms in the Hardy Inlet and of high P levels flowing from the Scott River Catchment and seemed genuinely concerned. They showed good knowledge of what makes a waterway healthy and whether the waterways on their farm was in good environmental condition or not. Overall, landholders' attitudes to waterways vary depending on waterway definition and also on the presence/absence of native vegetation. Heavily modified waterways or dug channels with no vegetation cover were seen as drains rather than waterways. However, where a waterway has some degree of vegetation cover, and landholders perceive it to be in a poor or unmanaged condition, they are then more willing to protect or restore it. This attitude is common across all land-use types including blue-gum plantations.

Additional findings are:

- Some landholders are either unaware and/or do not prioritise the ecological functions their waterways can provide. These landholders believe their farm is performing well and there are no nutrients or other water quality-related issues caused by their farming operations. Where waterways don't support ecological values (because fully degraded), these landholders' view is that waterways perform another important function which is to drain water off the farm. However, there is openness to change if site-specific information and examples of successful low-cost local initiatives are provided.
- For the majority of people interviewed there is a degree of awareness / concern about the degraded condition of waterways and/or of the impacts that their farming operations have on water quality. Improvement work is acceptable as long as productivity and more importantly profits are not impacted. As the central purpose of farming, strong economic imperatives can be a deterrent to achieving environmental/ecological outcomes. Strategies to reduce costs or avoid loss of productive land are the main priorities, particularly amongst young farmers new to the area, farm managers and corporate farmers who are attracted by strong, short-term economic returns. The older generation of farmers typically have a stronger attachment to environmental aspects of the farm and are more willing to protect or restore them.
- A number of landholders interviewed are interested in and willing to embrace innovative and sustainable approaches on their farm. These people are crucial to driving behavioral change as they can provide examples of locally applied innovation to a common problem. It's important to support these landholders in the future with resources for on-ground work and evaluation; continue to engage and showcase good work. A number of respondents are concerned about the water quality impacts caused by dairy farming particularly as production intensifies. They believe that dairy farming is causing higher impacts than other land uses and that the government is not doing enough to support practice change on those farms. Some landholders also mentioned the potential impacts of plantations on water flows and fertiliser applications. However, the majority agree that more information is needed to verify some of these claims.

Figure 23: Example of a waterway restoration project in the Catchment

- Overall, willingness to collaborate with neighbours to improve understanding or action on waterways health is low. Most landholders believe that their farming practices are already much better than in the past and the common feedback was that it is other land managers who do not do the right thing. Several landholders discussed situations where modifications to the land and watercourses have caused impacts downstream on a neighbouring farm or a reserve. In some cases, restoration work was undertaken but it is not always the case. For several landholders, collaboration across farms was considered a good approach but whether this is something that they are prepared to be engaged with in the future would need to be assesses through further engagement.

- Watercourses, springs, annual swamps, vegetated watercourses and patches of native bushland were high values by some landholders. Several landholders recognised that wetlands have much broader values in the landscape than just water quality improvement. These include: reducing water velocity and flood mitigation; storing and transferring water; nutrient cycling; biodiversity and connectivity; ecological processes such as breeding and recruitment of fish; carbon storage; and local climate adaptation. This is a very positive result, although many small swamps and wetlands remained unfenced.

Topic 2: Vegetation and animals

- *Protection of native vegetation*: The Scott River Catchment includes a few properties that have patches of native bush of high biodiversity value but these are, in some cases, not fenced off to exclude stock. For many landholders fencing native bush is not a high priority currently due to a range of factors. A few landholders are not aware of the conservation value of areas of remnant vegetation on their farm. The majority of people interviewed were concerned about losing productive land and that fencing would require changes in the shape of the paddocks. "We would like to do more but fitting it in is difficult. We would have to change the shape of the paddock to fit in fencing". However, many were in favour of boundary fencing to reduce wildlife from paddocks. One landholder commented that fencing needs to take into consideration the issue of the high population of kangaroos. "It's very important to put in vermin proof fencing". The foreshore condition assessment is an important tool to help these landholders identify areas that they can fence and protect without compromising agricultural land.

- *Ecological corridors*: several landholders commented that they did not want to establish ecological corridors because that would mean loss of productive land or it would be too costly. Landholders reported that cover crops also provide habitat for birds and insects and therefore multiple crop types is an important component of biodiversity.

- *Invasive species*: almost everyone mentioned the issue of weeds, especially woody weeds in native bushland. Pests like kangaroos, foxes, emus and wild pigs were also mentioned as being an issue in the Catchment. One landholder commented that "Emus wreck fences and grass by crapping on it. They are riddled with intestinal worms. Kangaroos eat areas of bush. We have created pasture for them and now with all the pasture we get joeys all year round. One kangaroo is equivalent to one sheep. Foxes used to keep emu numbers down. Chuditches also kept emu chicks down in numbers. Now we bait foxes and DPAW baits foxes there is no predator and every emu chick live. We have a professional kangaroo shooter but they can only shoot where numbers are high." There could be a potential opportunity for private enterprise to establish markets for pest animal products. Animals were also mentioned as an important biodiversity indicator. One landholder reported positive changes to wildlife as a result of management of invasive species "A big plus on our farm is the birdlife. When we came here there were hardly any ducks or swans even. Now we have egrets, spoonbills and swans. They nest in swamps every year. The birdlife is unreal. It wasn't here before because all ducks have to pitch in on water and in the early days the ponds were covered in scrub. The swans have to have a clear area to build a nest in the middle of water and nothing worries their chicks. In winter they have a foot of water for three months. After a storm, they build the nests up. We sit on the veranda and watch them. Spoonbills were not here till we cleared some of the swamps and now they spend a lot of time here".

- *Restoration efforts*: several revegetation projects in the past in the Scott River Catchment have shown poor results. Some people expressed concern over their success in the Catchment and questioned the expertise and local knowledge of NRM groups such as SWCC and the LBLCDC. Lack of project evaluation for revegetation projects in the Scott River Catchment was also mentioned.

Topic 3: Land (soil and land use)

Many inter-related factors are behind the choices of fertiliser regimes applied in the Scott River Catchment since the 70s which have contributed to the excessive nutrient loadings into waterways. Some of these factors were described by landholders as being the high cost of fertilisers and their application, traditional practices used elsewhere and applied in the Scott River Catchment, lack of farm specific soil type data and confusing industry standards. Some of these factors are still current barriers to the adoption of more sustainable practices.

Figure 24: Example of bluegums in the Catchment

The majority of people interviewed said that they now carry out soil testing and fertiliser trials through their own fertiliser company, an accredited agronomist or government programs. The methodology adopted by the government for fertiliser trials was seen as less accurate by landholders who were a little sceptical of the results and of the interpretation given. Farm specific soil type mapping should be updated as the current mapping does not reflect the soil diversity at the farm level. One person reported that on their farm they have done trials looking at compost and amended compost. Others commented that at the moment their soil is poor in nutrients and they are trying to find the right balance. One landholder noted that higher nutrient levels are coming into their property than leaving it and that this should prompt more in-and-out nutrient budget studies.

A couple of landholders reported to have switched (over time) to liquid fertiliser which can be used by plants immediately. Many also reported being more careful with the timing and frequency of fertiliser application: multiple times rather than once a year, and not close to rainfall events. Application of soil amendments like lime or liquid dolomite to lift pH is also more common and is widely accepted as being good practice. Approximately half of the landholders interviewed were willing to share their soil test results with the LBLCDC.

Concerning current land uses, some people are concerned that the intensification of dairy is an issue that is causing serious environmental impacts, while dairy farmers themselves are willing to improve their effluent management if a cost-effective system can be found. Several people commented that the plantation industry requires low levels of employment, which translates into fewer jobs in the area, causing families who currently live in the Catchment to become even more socially isolated. These will all depend on the market which will drive change to a large extent. Several people mentioned that given that plantations don't require a licence in WA if the plantation sector goes through another expansion period this may cause significant environmental impacts (as opposed to land uses that can apply regenerative practices) and these potential impacts should be carefully understood before approving further plantation activities. On the other hand, plantation managers reported they operate to high environmental standards and are continually improving their environmental performance and see the Scott River Catchment as an ideal location for plantations. Concerning the future, people thought that the Scott River is capable of a range of land use options including sheep, cattle, dairy, plantations, and diverse and interesting new crops.

Figure 25: Beef cattle on a Scott River Catchment property

Topic 4: Climate

Perceptions of landholders about climate change are not always consistent with official historical records. Older landholders are more aware of long-term climatic changes but not of the 'big picture' causes and effects.

Several landholders reported that there are a few signs of a changing climate as observed through changing weather patterns. For example, landholders commented that the wet season is starting later and extending into the spring months and that farms are experiencing more days of frost, more intense rainfall events and different wind patterns.

In relation to rainfall, most landholders view the Scott River as a highly reliable rainfall area subject to minimal climatic changes but with a lot of local variability. The official records show a trend towards a drying climate. However, there is a limited amount of on-farm long-term data in the Scott River Catchment. Rainfall records do not cover a long period, are not complete and climate analysis has been fairly general.

Landholders who believe climate change is happening and is human-induced also reported greater concern about climate-related risk. However, concerns about climate-related risk vary depending on the system of agricultural production: for dryland beef farmers, shorter rainfall seasons represent more favourable conditions than the 'traditional' rainfall patterns, whilst for dairy farmers, intense rainfall events and shorter rain seasons represent more unfavourable conditions.

Topic 5: Infrastructure (Drainage and effluents)

Not all landholders were comfortable talking about agricultural drains on their farms. The majority agreed that drains were built 'as needed' to drain water from their farms without necessarily following construction guidelines or considering potential environmental impacts. One landholder commented that 'not everyone knows how to make a good drain that you can drive across and not cause erosion. Where neighbours do small drains we end up with the sediment on our property and we try to fix that problem.' Some landholders are willing in principle to fix their drains but the costs are too high and financial support not available for this type of work. The required width for fencing off drains was discussed and most landholders are not happy with the idea of creating buffers wider than 5-8 m.

Dairy farmers are well aware of the need to improve effluent management systems, in terms of environmental impact and community trust in the industry. Dairy farmers face several challenges, however, that work against more widespread uptake of appropriate technology. The high groundwater levels and flat topography make the effluent pond system impractical. The isolation makes it difficult for farmers to get expert and logistic support. And importantly, the dairy industry itself is at a crisis point and profitability is too low to warrant much financial risk-taking; there are concerns about the high capital and maintenance costs of new systems.

Overall, with regard to opportunities for restoration works (improving effluents, drainage, optimise fertiliser applications) several landholders acknowledged that restoring ecosystem functions and optimising fertiliser input can contribute to more sustainable agriculture. However, when asked if these actions have been taken on their farm the key concerns and barrier to uptake were (please note these are landholders' perceptions):

1) These works will decrease farm productivity and reduce economic return.
2) There are high costs associated with certain works and the allocation of responsibility (for example for effluent upgrades, drainage upgrades) to an individual landholder, and/or group of landholders and/or the government is unclear.
3) There is a lack of local examples of positive impacts on water quality following upgrades.
4) Risks of project failure (e.g. revegetation works, effluent systems) are high.
5) Funding is not adequate to undertake certain types of work (particularly for drainage and effluent management).
6) There is a lack of technical expertise (particularly for revegetation and effluent management).
7) There is a lack of trust in government agencies and concern about being controlled once the project is completed.
8) There is a lack of tools to base decisions on (farm mapping, budgets, etc.).

4.2.3 Recommendations

Recommendation: Foster on-going and meaningful engagement and knowledge sharing opportunities with landholders, aboriginal groups, industry and government.

Below are a number of actions for more effective engagement activities based on the interview findings.

Overall:

- Support local governments to play an active and ongoing role in protecting and improving the Scott River Catchment and its waterways including linking the work of the LBLCDC to other studies such as the Scott River Economic Study.
- Continue gathering data on landholders' values and priority using the sustainability framework analysis and mapping.
- Develop a communication strategy for the SRAP to disseminate information about the health of the Catchment, works implemented and lessons learnt. Share lessons learnt from a network of landholders who are involved in innovation and conducting many different trials, through workshops, farm field days and provision of information.
- Future funding and engagement should focus on Groups 2 and 3 (listed below) to enable the implementation of successful demonstrations, case studies and profiles etc. Individuals within these groups have a higher likelihood of becoming advocates for practice change and consequently can become key influencers for behavioural change in Group 1.

Based on landholder groups:

Not currently interested in changing the status quo. (Group 1)

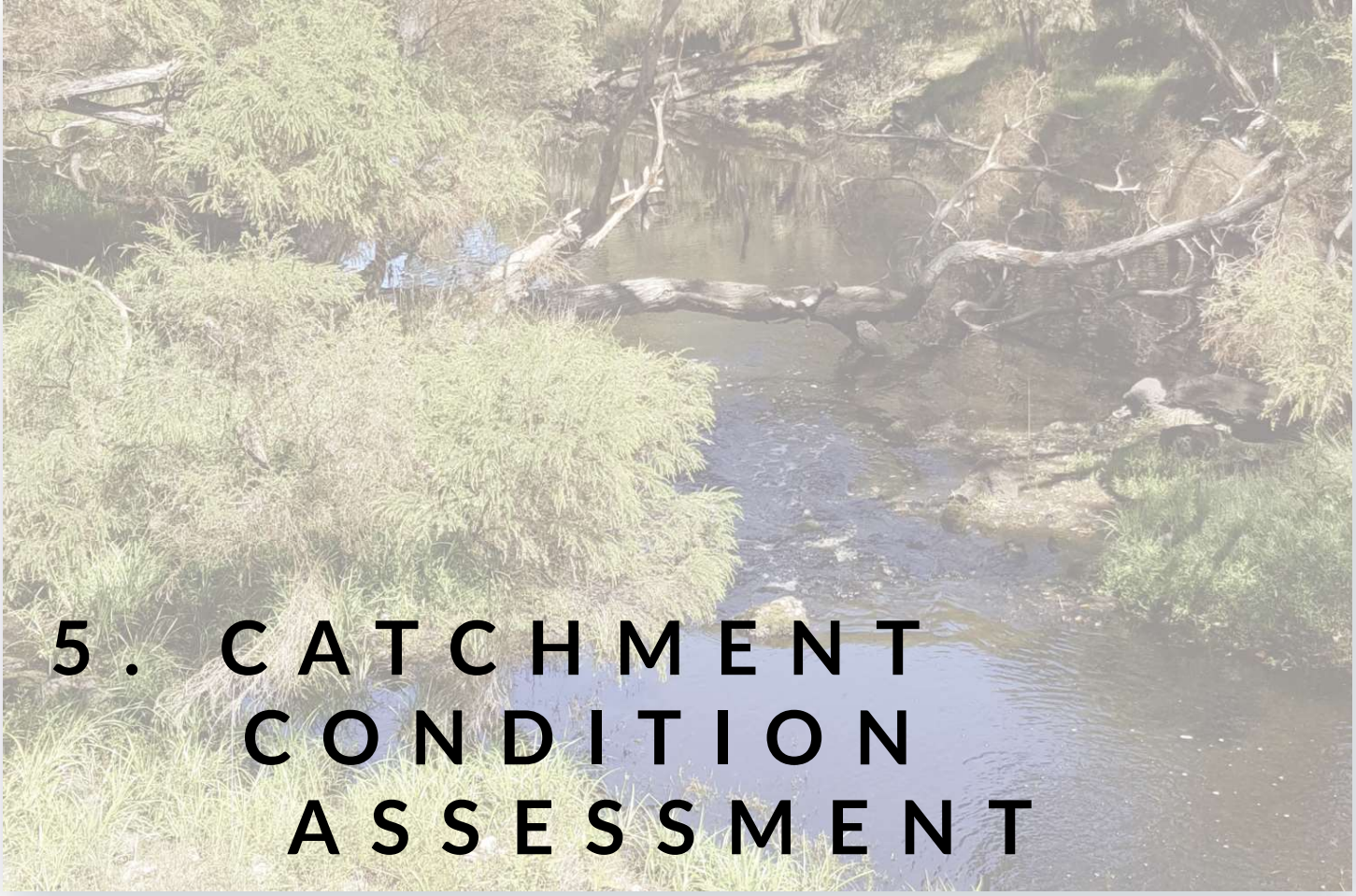
- Keep dialogue open with landholders to strengthen build trust.
- Find effective ways of communicating with landholders for example, the use of key influencers in existing formal or informal networks and involve friends and families in knowledge exchange activities.
- Identify and work with groups/individuals/ organisations/advisors that are most trusted and likely to be effective as enabling capacity.
- Continue to improve landholders' understanding of ecosystem services and functions provided by the riparian zone and discuss the multiple benefits that healthier waterways provide to the farm such as healthier stock, healthier farms overall and a healthier bottom line, and offer strong incentives to complete projects in accordance with best practice.
- Invite to participate in sub catchment planning. Explain the benefits of working together on shared goals.
- Provide support to landholders to build awareness of best practice new technology.

Aware and interested but cautious (Group 2)

- Involve landholders in scoping future studies so that key knowledge gaps are addressed and they can learn from the process and findings.
- Seek funding for whole-farm and sub catchment scale planning programs as a way to collaborate across farms and for a more holistic management of farm and bring together information, advice and action from the recommendations in the SRAP.
- Provide support to landholders to build awareness of best practice new technology.
- Provide ways to prove the value of adopting the new tools and practices that are recommended. Encourage the use of on-farm safe-to-fail areas for trialing new practices. Active demonstrations (e.g. field days, workshops) are also a good way to do this, as well as collating evidence from long-term studies that prove benefits to a landholder's bottom line, or other aspects of their farm business. Share the lessons learnt from a network of landholders who are involved in innovation.

Innovative, willing to collaborate and share (Group 3)

- Involve in collaborative partnership projects to leverage funding for sub-catchment scale projects (based on priorities identified in the Plan).
- Use projects and initiatives and examples of sustainable farming approaches.
- Continue raising awareness of the key priorities with community and key stakeholders through engagement forums and media.



5. CATCHMENT CONDITION ASSESSMENT

The Catchment Condition Assessment explores in further detail the actions, challenges, and values associated with the four on-ground management strategies identified as being key to improving nutrient management in the Scott River Catchment (White, 2012). These strategies are:

- Dairy effluent management
- Riparian management
- Drain management
- Fertiliser management & soil health

A detailed discussion of each of these management strategies is provided in the following Sections.

5.1 Dairy effluent management

5.1.1 Background

Dairy shed effluent has high nutrient concentrations and has been identified as a significant point source of nutrients entering the Scott River Catchment (White, 2012). Nutrients runoff from effluent applied to relatively small areas of pasture, overflow, and leach from ponds. Nutrient leaching also occurs from excessive fertiliser application on pastures (White, 2012).

The Scott River Catchment is a prime location for large scale dairy operations as property sizes, water availability and climate are favourable. As a result, the Catchment is home to the state's largest dairy operations (Whitfield, 2019). There are currently six dairies (dryland and irrigated) operating within the Scott River Catchment. These farms have a number of common characteristics: all are relatively large, with average herd sizes between 500 and 1,300 cows which are milked twice daily. Each farm operates between five and eight pivot irrigation systems on a seasonal basis. All Scott River dairies manage pasture-based herds with imported fodder supplementing pasture to increase carrying capacity and manage production. Several dairies now milk over 1000 head and cows spend around four hours per day in the dairy which produces a large amount of effluent and storage of effluent has always been a challenge.

Efforts to improve the current state are challenged by the nature of the region itself and by the high capital cost carried by system improvements (White, 2012). The Catchment is characterised by having predominantly sandy, leaching soils and very flat uniform topography with generally high groundwater. Many areas have seasonal wetlands and all farms have seasonal watercourses or tributaries, some within very close proximity to existing dairy sites and effluent storage ponds. This combined with high seasonal rainfall makes it

difficult to contain effluent and prevent nutrient runoff over the property. The lack of elevation reduces the ability to utilise gravity to create passive effluent systems and many

landholders have had negative experiences trying to actively transport effluent using pumps. Lack of elevation also makes containing and transporting effluent difficult and the proximity of seasonal wetlands, tributaries and shallow groundwater only exacerbates the issue.

Principles for best practice dairy effluent management

All Australian states and territories have set minimum standards for effluent management that include state and industry legislation, codes of practice, guidelines and planning provisions to prevent any adverse impact from dairy effluent. Effluent management regulation is also now becoming more consistent across states through dairy food-safety audits (Dairy Australia 2013).

The Western Australian state legislation is the Environmental Protection Act 1986 and the current industry code of practice has been prepared by Western Dairy. Dairy Australia's 'Dairying for Tomorrow' also outlines the important principles for a successful dairy effluent system (Dairy Australia 2013).

Current research on best management practice

Under REI, a collaborative initiative between DWER, DPIRD, Western Dairy and south west farmers has produced a *Sustainable Agriculture Strategy*[21] which focuses on improving fertiliser and effluent management practice in the southwest estuaries to respond to increased potential for nutrient run-off from agricultural land from further intensification of agriculture.[22] Further, a recent review on available technologies has been prepared for southwest WA; it provides a range of management solutions ranging from the simple to more complex and costly. The study emphasises the need for 'whole farm' approaches and makes good recommendations about potential system components that could be installed successfully in southwest WA (Price and Tait 2019).

5.1.2 Methods

This study compiled information regarding the current state of effluent management practice in the Catchment as well as local dairy industry perceptions on this issue gathered through literature reviews, site visits (during the value mapping exercise and FCA surveys) and landholder interviews (four dairy farmers).

5.1.3 Findings

Best practice and alternative methods for the reduction of nutrient leaching

Nutrient runoff can be reduced not only by improvements to point source management but by continued improvement of nutrient application through fertiliser and manure at levels consistent with pasture requirements and by tailoring applications according to factors such as timing and location. There must also be an awareness of phosphorous sensitive soil profiles in relation to runoff and erosion control options for managing nutrient leaching into freshwater systems (Sharpley et. al. 1994). This combined with introducing cover crops and the zoning of buffer strips around waterways can be an appropriate way of mitigating agricultural nutrient losses into waterways (Dairy Australia 2013; Taylor, He and Hiscock 2016).

Passive methods of controlling nutrient concentrations in effluent could be another method in which nutrient runoff is reduced. P concentrations within effluent can be controlled through a number of different strategies (Lewis, Wurtsbaugh and Paerl 2011). Nutrient concentrations in effluent vary greatly with feeding patterns so adjustments to the nutritional inputs to cows need to investigated (Dairy Australia 2013). Overall dairy effluent nutrient inputs can be reduced through optimising nutritional plans for herds. Nutritional strategies are now being adopted in Europe to reduce greenhouse gas emissions so dairies are optimising inputs by controlling protein ratios in feed; adjustments to herd age are being investigated (Van Wesemael 2018). While these techniques are designed to minimise ammonia pollution whilst maintaining commercial productivity they could be investigated in an Australian context. These novel strategies along with optimisations in dairy shed effluent management have the potential to significantly improve nutrient leaching and offer some economic advantages to the farming system. The ***Nutrients from effluent and sludge calculator*** developed by Dairy Australia helps to estimate the potential nutrient savings from effluent application.

Following the survey of dairies carried out for the Augusta Margaret River Clean Community Energy group (AgGrow Energy Resources 2018), the group has obtained funding for a six-month trial of a commercial effluent separator, the Z-Filter. This is being carried out on the largest dairy in the Scott River area. Initial results have shown an impressive ability to remove phosphorous and nitrogen from dairy effluent and to provide a stackable cake from dilute effluent streams (Cristoffanini et al. 2019). The ability to remove large amounts of phosphorous from dilute effluent streams could have great implications to potential winter storage issues presented by the Scott river catchment. The modular and compact design of the Z filter could potentially also add flexible solutions to smaller scale operations by transporting a unit between farms (taking into consideration biosecurity requirements), which could make capital expenditure more efficient and provide cost effective practical solutions to winter storage issues.

Following is additional information about the Z-filter trial.

21 The two key areas of focus of this Strategy are fertiliser and dairy effluent management. Based on these, DairyCare and fertiliser management programs have been established under the guidance of a Sustainable Agriculture Project Reference Group (PRG) direction.
22 At the time of publishing, the REI funded Dairy Care program had not yet completed.

CASE STUDY: THE Z FILTER

The AMRCCE group has obtained funding for a six-month trial of a commercial effluent separator, the Z-Filter (Figure 26). This is being carried out on the largest dairy in the Scott River Plain. The participating farmer is keen to improve farm soils that have been depleted over the years, reduce nutrient run-off and generally improve the productivity and viability of the farm.

The final report is being prepared, but initial results have shown an impressive ability to remove phosphorous and nitrogen (>70% and >40% respectively) from dairy effluent and to provide a stackable cake from dilute effluent streams.

Figure 26: The Z-filter at the Scott River dairy trial site.

At the end of the trial, the farmer decided to purchase the Z-Filter and is currently using the liquid fraction as fertiliser through his irrigation system and composting the solids as a soil amendment and fertiliser. The farmer advised the volume of solids allows him to produce a larger quantity of compost each year than what he had been buying and he commented "apart from saving $130,000 a year, I know what's in it". In addition, the liquid component could be worth around $50,000 in fertiliser saved.

The modular and compact design of the Z filter could potentially also add flexible solutions to smaller-scale operations by transporting a unit between farms (taking into consideration biosecurity requirements), which could make capital expenditure more efficient and possibly provide cost-effective practical solutions to winter storage issues.

Perceptions and barriers

The majority of dairy farmers are, in principle, in favour of improving systems and feel a responsibility towards protecting the environment. Landholders are aware of the potential hazards in the mismanagement of nutrients and are concerned about the environmental implications of effluent runoff. Landholders also reported that some good work with regard to fertiliser application has already been carried out through the application of phosphorous- and nitrogen-based fertilisers at rates established by soil testing and tissue analysis, with advice from consultants (both independent and industry representatives). However, still too little has been done to improve effluent systems in the Catchment.

The key barriers to the upgrade of current effluent management systems in the Scott River Catchment are:

- The Scott River Catchment is a relatively remote agricultural area and landholders have recognised that it is very difficult to get support in terms of expertise and labour.
- The current economic climate, especially the milk price relative to the cost of production, is challenging the viability of the industry locally. The long-term sustainability of the dairy industry is viewed by landholders as being under threat as the average cost of milk production (51.6 c/L) is currently higher than the average milk price (51.3 c/L) (Dairy Australia, 2018/19). This is a barrier to broadscale proactive change and in this context costly effluent management is still a low priority (AgGrow Energy Resources, 2018).
- The large capital cost and overwhelming logistics of some large-scale effluent upgrade recommendations combined with the lack of investment resources available to make large capital expenditure on effluent management form the major roadblock to any improvements.
- Ongoing and potentially costly maintenance of large equipment.
- Although innovative and potentially practical systems are known to have been implemented in other countries, Scott River dairy farmers feel there is insufficient support, trials and local research and development to warrant taking huge financial risks with these systems.

Effluent itself, as a resource, is given a low priority in the Scott River Catchment. Some landholders believe the current costs associated with utilising effluent through spreading are again too high to be of any real productive value, whilst others commented that they would be interested in spreading liquid effluent through modified irrigation systems (AgGrow Energy Resources, 2018). Landholders recognise that this would require improved solid separation systems to enable efficient utilisation of liquid effluent. The key barriers to the use of valuable effluent resource on farm are:

- landholders unable to effectively apply effluent to pastures due to lack of suitable infrastructure and equipment;
- high maintenance requirements due to inappropriate equipment; solids and sands causing blockages and abrasion in equipment; and
- seasonal rainfall making irrigation problematic during winter months.
- the ability to separate the solids from the liquid in the dairy effluent. This is because of the difficulty in handling the large volumes of effluent that result from wash down in dairies and because of the value of the nutrients in the effluent that are currently going to waste. One landholder estimated that the liquid component alone could be worth around $80,000 in fertiliser saved.

5.1.4 Recommendations

As discussed earlier, landholders are in favour of improving effluent management systems if they can be shown to be cost effective and if they can recover the value of the nutrients in the effluent. They are also willing to participate in on farm revegetation projects and soil testing, and many have already undertaken restoration projects on their own merit. With this in mind ongoing support and two-way communication is recommended for the ongoing success of the industry and the protection of the environment. It is imperative landholders have access to independent advice they can trust and information which is up to date and practically feasible. The following recommendations and related management actions for next steps will facilitate positive change for all stakeholders and ensure a sustainable future for the dairy industry in the Scott River Catchment.

Recommendation: Identify and implement farm-specific, best practice solutions for designing or upgrading effluent systems (irrigated dairy).

Overall:

- Adopt best fertiliser management practice (fertiliser and manure are at levels consistent with pasture requirements) and tailor applications according to factors such as timing and location.
- A number of feasible options for effluent system upgrade relevant to the Scott River Catchment can be found in the 2019 Price and Tait report[23] (Price and Tait, 2019) and from innovative trials carried out in the area. The feasibility of the suggested options should assessed be based on local conditions and situations.
- Consider the option of controlling nutrient concentrations to reduce overall P through adjustments to the nutritional inputs to cows. This would require investigation of applicability of this method in the Scott River Catchment. Research quantifying local effluent nutrient concentrations and daily input volumes to assist decision making on best practice solutions and cost benefit analysis against conventional fertilisers (AMRCCE trial).

Consideration of local conditions and situations:

- Design of system upgrades needs be adaptable and specific to each farm situation. A 'one size fits all' approach would deter landholders from implementing any improvements. An outcomes-based approach is more effective than looking at components individually.
- Existing infrastructure and operational procedures need to be taken into account as well as plans for future operations when promoting improvements. One of the most efficient ways of doing this is by upgrading existing infrastructure or by retrofitting components and ensuring systems are well managed and operating efficiently.
- Ponds should be maintained to ensure operational efficacy. Provide advice or services for effluent pond testing to assess nutrient components concentrations for more effective reuse.
- Determine the agronomic value of effluent for specific farms.
- Adopt a whole farm approach: prepare a whole farm plan which includes all aspects of capturing, storing and reusing dairy shed effluent to protect water quality and reduce the need and cost of fertiliser on areas where effluent is applied. The Plan should help assess feasible options as per point 2.3 and incorporate findings from the FCA survey
- Track upstream vs downstream nutrient concentrations on irrigated properties to establish an effective monitoring program that can benchmark and measure the success of proposed improvements.

Recommendation: Support the identification and implementation of farm-specific, best practice solutions for designing or upgrading effluent systems (supporting organisations).

Support and R&D:

- Develop farm friendly toolkits or check lists to understand current system and potential shortfalls.
- Funding and technical support need to be flexible enough to offer solutions that are practical for landholders in the area to implement and maintain. System upgrades or new systems need to be simple to operate, be low maintenance, and have realistic operational costs including cost savings from fertiliser. Any best practice management that requires high capital and maintenance spending needs to be justified through cost-benefit analysis for landholders to adopt.
- Provide independent consulting for the

23 Currently in DRAFT form

development of case by case business plans to analyse cost effective solutions, conduct cost benefit analysis and communicate capital investment proposals to potential lenders or investors. A risk analysis should be incorporated to identify the potential risks of current systems and the potential economic gains in effectively utilising effluent on farm.

- Continue to conduct research and development on, and local support for, low-cost options (even marginal improvements to current systems).
- Provide support for effluent system designers to propose specific solutions that suit landholders' aspirations and needs and to assist with on farm decisions around system components and characterising input volumes and constraints.
- Continue to provide information to landholders on paybacks of different application methods compared to benefits in order to generate a business case to fund the equipment.
- Support contractors in the area to gain economic efficiency for portable equipment.
- Review and share the outcomes of the AMRCCE case study on the Z-filter with Scott River landholders.

<u>Engagement and collaboration</u>

- Organise workshops to discuss potential options, share success stories in the region and novel ideas.
- Provide presentations from independent experts and industry representatives to discuss best practice techniques and offer advice on local farming issues
- Provide bus tours for landholders to see implemented systems in practice and discuss suitability for their own applications.
- Educate landholders around the potential risks of current systems and the potential economic gains in effectively utilising effluent on farm.
- Establish a point of contact and a comprehensive list of service providers for the Scott River Establish demonstrations of available technologies and components to assist decision making about practical local solutions.

Figure 27: A section of the Scott RIver

5.2 Riparian Management

5.2.1 Background

Healthy[24] riparian land adds value to a farm by providing a number of benefits: from enhancing aesthetic qualities and providing habitat for flora and fauna to improving water quality and sediment trapping. Importantly a vegetated waterway that is not disturbed provides water temperature regulation functions limiting limit algal blooms (O'Toole et. al, 2013).

Riparian management consists of a series of actions that aim to protect or improve the condition of riparian land so that the above functions are provided. These actions vary depending on the objectives of the project but typically involve site preparation works (e.g. weed control, soil preparation, sediment trapping) and planting of native species. In some cases, bank erosion control methods are required.

Permanent exclusion of stock from the riparian area is important and usually a requirement in the terms and conditions of government grants. Allowing grazing in the revegetated area even for short periods of time can have significant impacts on a newly revegetated area such as loss of native vegetation species (due to selected grazing), soil compaction, bank erosion and weed invasion post as a consequence of initial damage. In some cases, weak points long a fenceline such as double gates or old fences enable cattle to push through and enter the riparian areas.

Where the removal of P is a key objective of a riparian project, characteristics related to flow, soil, landform, vegetation,

24 Healthy waterways are those that conserve key ecological values such as water quality, fauna and flora, flow, etc. The DWER uses a range of indicators to assess the health of waterways and to determine appropriate management requirements.

Figure 28: A section of the Scott River

nutrients and their interactions need to be well understood (O'Toole et. al, 2013; Lammers and Bledsoe, 2017). These factors can vary significantly from catchment to catchment and from site to site. This is why effective removal of P from waterways is not a simple task. On this, literature indicates that the most effective way for improving water quality is to reduce P inputs to streams (e.g. through improved fertiliser practices, upgraded effluent management systems, etc.) followed by the restoration of riparian functions. It is important to note that under certain conditions, the ability of riparian vegetation at P removal may be less effective, however vegetated riparian areas always bring additional benefits mentioned above.

Foreshore condition assessments (FCA) are carried out to collect information on the state or condition of the foreshore area of a waterway and to identify priority areas for rehabilitation work. FCAs consider elements such as vegetation health, presence of weeds, livestock access and fencing status, potential for erosion, and bank steepness. Foreshores are given a grade reflecting the level of degradation found.

5.2.2 Methods – Foreshore Condition Assessment

The FCA consisted of a desktop assessment and field surveys. Where possible landholders were met on site with the consultant to get information on current or past processes and/or disturbances may have altered or impaired some river ecological functions.

The total length of waterways in the Catchment (based on DWER data[25]) is 185km, of which 75km is classified as major river (main channel). The FCA assessed 130 km of tributaries (minor rivers, drains, minor tributaries, etc) and 20km of main channel (Figure 29). Of this 150km, approximately 50km were assessed using aerial photos.

The priority waterways were chosen based on the following criteria:

- Waterways that flow through / generate from hot spot sub catchments for nutrients as identified in the HIWQIP (White 2012).
- Waterways that have been identified as highly degraded in stream condition assessments carried out previously in the area (DWER, 1999).
- Waterways that flow through areas of high ecological importance.

Waterways were rated in accordance with the Pen-Scott Foreshore Condition Assessment (Pen and Scott, 1999) methodology.

25 This data was provided by DWER to the LCDC for the purpose of this study. Layer: BlackwoodRiver_HydroHeirarchy_HRWQIP_2018

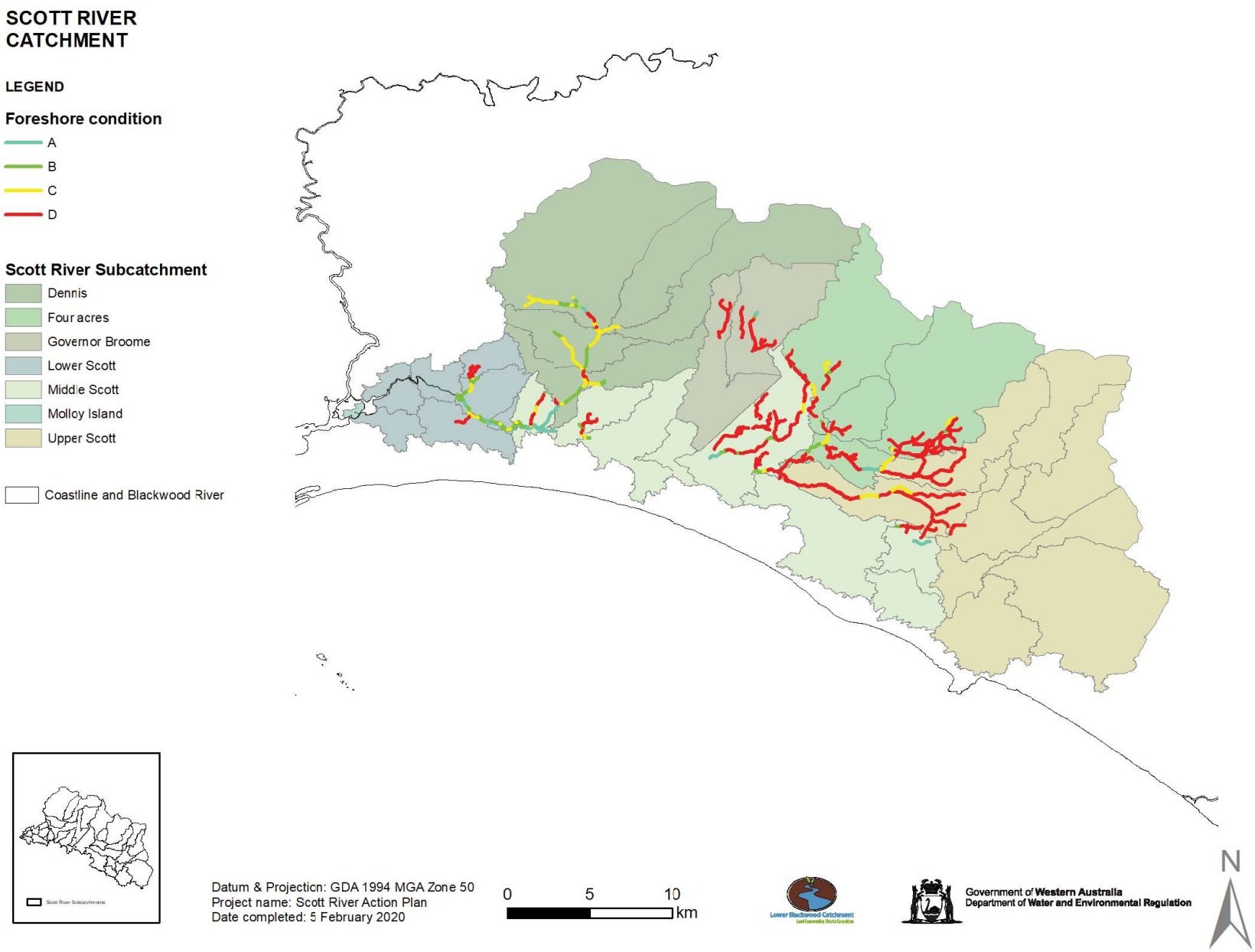


Figure 29: Foreshore Condition Assessment area.

5.2.2.1 Desktop assessment

Before undertaking the fieldwork, background datasets were interrogated to determine key parameters and features to look for during the fieldwork. The data was overlayed with the tenure dataset. Several data sources were utilised to identify remnants, assess priority areas of vegetation that are not adequately protected in reserves and identify locations with specific species listed as critically endangered, endangered, vulnerable or priority.

The data sets are the 2018 South West Vegetation Complex Statistics (Government of Western Australia, 2019), the TECs database from the DBCA Species and Communities Branch and NatureMap: Mapping Western Australia's Biodiversity (DBCA, 2020). The most up to date spatial layers were provided by the LCDC to the consultant for the desktop assessment. The background aerial imagery of the map was taken in 2017 (Leeuwin and Nannup).

Information about known populations of Flora Species and TEC within the FCA study area was sought through the NatureMap database and the DBCA TECs database. This information was overlaid on GIS layers about the study area, firstly to determine if any specimens were recorded on the FCA survey sites, and secondly to assess whether it was likely that habitat for adjacent threatened and priority species occurred within the study area.

5.2.2.2 Field survey

The Pen and Scott FCA proforma (Pen and Scott, 1999) was originally developed to enable community groups to assess waterway condition in rural areas. It is a simple standardised methodology to collect one-off environmental data. The idea of the foreshore assessment survey process is to ensure consistency of information gathered over time, allowing the information collected from multiple surveys by various people to be collated. The accumulated information can then be used to prepare a management plan and identify priority areas for on-ground actions. The results can also be used to monitor changes over time and to compare different foreshore areas. The information can also be shared amongst State and local government authorities and the community.

The foreshore areas were traversed and divided into relatively homogeneous Sections of similar vegetation and land use. A survey was conducted for each of these Sections and the condition of the foreshore parameters determined. Finally, the overall Stream Condition Index was determined. In areas where foreshore vegetation was very dense on both banks, both sides were surveyed separately. On highly degraded waterways where the foreshore along both banks was easily observed from one side, and the vegetation and disturbance factors were similar, documentation covered both.

Aerial photographs showing cadastral boundaries were printed and laminated to improve spatial awareness and accuracy in the field and to enable cross-referencing with Geographic Positioning Systems (GPS) data. GPS coordinates were recorded for key features in the physical characteristics of the waterways such as bed-rock and pools, dominant weeds and infrastructure of interest. Fences, disturbance factors and remedial works were also noted.

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

The principal environmental factors assessed to determine Stream Condition Index were:

- Bank stability
- Riparian vegetation
- Stream cover
- Habitat diversity (including weeds)
- Verge vegetation (floodplain)

Stream Sections were accessed on foot wherever access permission was granted and field observations recorded. Laminated aerial photographs were used for navigation in the field and for annotating.

The data was recorded as follows:

- Metadata – Observations defining the location, owner and property details of each Section as well as date, time and recorders name.

- Section character data – Observations about the stream Section as a whole (rather than at the representative site). For example, adjacent land use, fencing status and condition, modifications, flood plain and channel condition, disturbance factors, erosion and sedimentation features and more.

- Biological data – native riparian and buffer vegetation width, floodplain and channel width, Pen-Scott ratings, bank, bed stability, in-stream features, form and habitat, dominant vegetation species, vegetation abundance and health, fauna habitats and breeding sites, etc.

The length of the waterways was driven (where shallow drains) and/or the recorder walked along the entire waterway length to document any variations in key attributes.

Verge vegetation is included in the summary table for each river Section, however, was not included in the overall rating due to the paucity of cover throughout the majority of the sub Catchments.

The foreshore condition assessment survey work was undertaken in May – July 2019 following a prolonged dry spring and summer. The diversity of weeds identified and mapped is therefore limited although landholder interviews indicated species of concern, and some species are present in very small numbers and should be controlled before they spread.

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

A grade foreshore

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

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

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

B grade foreshore

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

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

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

C grade foreshore

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

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

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

D grade foreshore

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

This also includes portions of lower order, small runnels at the paddock scale, where although perennial grasses are present, the area is grazed.

Rating	Key features
D1 Eroding ditch	Weeds dominate the understorey and there is little or no native vegetation. Significant areas of bare soil occur on the banks and there is widespread evidence of bank collapse and undermining.
D2 Freely eroding ditch	Vegetation cover, either native or exotic, is insufficient to protect the banks and floodway from sediment movement.
D3	Simple drain.

The overall Stream Condition Index is a summary of the environmental parameters and is an indication of the overall stream condition.

Colour code (map)	Parameter Rating	Description
A - Blue	Very Good	All parameters rated Blue.
B - Green	Moderate	Two to four parameters rated Green or better with only one to two parameters rated Yellow and no Red ratings.
C - Yellow	Poor	Three parameters rated Yellow or better with no more than one Red.
D – Red	Very Poor	Three to all parameters rated Red.

The results compiled from the foreshore surveys were collated and a series of maps produced (Appendix A).

5.2.2.3 Data collation and analysis

On completion of the fieldwork, the GPS data was transferred into a GIS. The data was sorted into shapefiles and consolidated by issue or attribute, as required. These were overlaid on aerial photographs. Digital photographs were downloaded and re-named to reflect the site code. Other notes gathered from landholders and a review of relevant literature and government databases were also included.

Foreshore Condition Assessment Maps

A series of maps were developed that show the entire sub-catchment, cadastral boundaries and the foreshore condition overview for the sites assessed through both fieldwork and aerial photograph interpretation.

The maps are provided for the priority six sub-catchments.

The first map is a keymap for the portion of the sub-catchment being reviewed, survey type and remnant vegetation communities and the second shows foreshore condition (as assessed using the Pen-Scott method). Key features such as erosion hotspots, infrastructure and priority native vegetation that is in private ownership (freehold) only.

The third map shows the fencing status where possible (left and right banks), weeds using priority coding rather than specific species and key management actions. Note that the definition of left and right banks is based on the assumption that the map reader is looking upstream. Legends are provided on all map types.

The tables for each Section summarise each reach with background information, the current condition of the survey sites along with action response recommendations in terms of weeds, erosion and fencing. The advice is generic and intended for use by landholders and non-government organisations seeking grant funding to assist with land management.

5.2.2.4 Limitations of the study

Interrogation of both the desktop analysis and field data was based on the GIS shapefiles provided to the consultant in April 2019 by the LBLCDC. During the fieldwork, some knowledge gaps were identified in the waterway data and further work was undertaken by DWER to resolve these discrepancies.

Aligning the new sub-catchment boundaries and assessing the more recently identified additional waterways, would have required a substantial amount of additional fieldwork and desktop analysis. Budget constraints meant that this report is based on the baseline data provided in April 2019 with supplementary aerial photograph interpretation. The updated LIDAR data can now be used in future assessments and provide a valuable new baseline for the Catchment and its waterways.

The project was focused on assessing foreshore condition in freehold land. The majority of the sites were accessible and the landholders or a representative often wanted to attend during the assessment where the waterways passed through open paddocks.

A review of aerial photography suggested that three primary limitations may be encountered. These were:

- Paddock access may be difficult because of farm management requirements, such as pivots under crop, presence of bulls or current lambing.
- The time required to walk the entire length while accompanied by the landholder or their representative was too long to enable comprehensive mapping.
- Landholders denied permission to walk the entire waterway or a portion.

Some portions of the waterways within selected properties could only be observed at a distance and vegetation condition assessment included a reliance on aerial photograph interpretation. Where access was completely denied, the condition is entirely inferred from aerial photographs.

As a result, the diversity of weeds was limited (Arum and Paterson's curse were not identified and perennial plants willows or blackberry were not sighted) and seasonal aquatic invertebrates could not be assessed except where shells or exoskeletons indicated presence. The final property assessment was in early July 2019.

5.2.3 Findings

Perceptions and barriers

The reasons most frequently cited by the landholders interviewed but also of those met on site during the filed survey as to why they did or would like to undertake the riparian management works were:

- to improve the health of the waterway.
- to provide an attractive landscape for improving farm values.

- to protect from stream bank erosion and trap sediment.

Overall, landholders' attitudes to waterways vary depending on waterway definition and also on the presence/absence of native vegetation. Where a waterway has some degree of vegetation cover landholders perceive it to be in a poor or unmanaged condition and are then more willing to protect or restore it. This attitude is common across all land-use types including blue-gum plantations.

A number of respondents indicated that they were already doing riparian works or other revegetation works on their farm, independently of the various funding programs available. For others, the resources that the LBLCDC has provided to riparian works have enabled to either increase the extent or the rate at which they undertake riparian works. However, several respondents expressed frustration about the lack of success of riparian projects in particular with planting and success of weed removal. This feedback was difficult to follow-up given the lack of project evaluation of past restoration projects.

Condition of riparian land

Results from the foreshore assessment show that less than one-quarter of the foreshores assessed were rated as A or B foreshore condition, with two-thirds rated as D condition (Table 18). More specifically:

- ~13km of waterways (8%) were rated A (river embankments and floodways that are entirely vegetated by native plants).
- ~17.5km (11%) of waterways rated B (foreshore areas where weeds have become a significant component of the understorey vegetation and some areas showing erosion);
- ~20km (12%) rated C (trees are present and generally long-lived species but there is little or no evidence of young trees or tree seedlings and soils are disturbed);
- ~102km of waterways (68%) were rated D (not enough fringing vegetation to control erosion).

Table 18: Condition rating.

Condition rating		Riparian foreshore length (km)
A	Km	12.11
	%	8.07
B	Km	16.456
	%	10.98
C	Km	18.701
	%	12.46
D	Km	102.471
	%	68.48
Total		**150.026**

Table 19 shows that the Governor Broome, Upper Scott, Four Acres and Middle Scott (Upper reaches) sub-catchment have more than 85% of waterways assessed rating D; The Dennis catchment has almost 50% of the waterways assessed rating C. The sub catchments with waterways in better conditions are the Middle Scott Lower Reaches and the Lower Scott.

Table 19: Tot Km of foreshore assessed in each sub-catchment and condition assessment rating

Sub catchment	A	%	B	%	C	%	D	%	Foreshore condition
	(Km)		(Km)		(Km)		(Km)		Km
Lower Scott	3.36	27%	4.89	39%	1.38	11%	2.8	23%	12.43
Middle Scott Lower Reaches	3.48	45%	1.366	18%	0.72	9%	2.215	28%	7.781
Middle Scott Upper Reaches	0.737	2%	1.98	6%	1.07	3%	27.596	88%	31.383
Dennis	3.1	16%	5.5	28%	9.3	47%	2	10%	19.9
Governor Broome	0.364	4%	0.119	1%	0.29	3%	9.6	93%	10.373
Four Acres (all)	1.067	2%	2.48	5%	3.66	8%	40.13	85%	47.337
Upper Scott	0	0%	0.141	1%	2.281	11%	18.4	88%	20.822
Tot Km assessed (aerial and survey)									150.026

Additional assessments of waterway health carried out at key locations and every three years, by DWER as part of the Healthy Rivers Program[26] made similar conclusions: the health of the Catchment: biodiversity within the main channel is good with high representation of flora and fauna species, however, signs of stress from several factors associated with Catchment land use are present. Instead, the health of smaller waterways particularly of those downstream of irrigated land uses are in serious degraded conditions.

26 The Healthy Rivers Program uses the South West Index of River Condition (SWIRC). The SWIRC incorporates standardised methods for collecting field and desktop data, and a suite of indicators designed to describe and interpret river condition. The information obtained through the assessment is directly comparable with the FCA, such as intactness of vegetation layers through the river corridor, assessment of erosion, sedimentation, and characterisation of aquatic habitat provided by riparian vegetation. The FCA was chosen as the preferred methodology for the SRAP the aim was to assess a greater length of waterways. This data is intended to support other longitudinal studies that track environmental changes after setting protocols for data collection in baseline studies. It guides further collection of the same type of data, over time, such as water quality studies undertaken in projects by DWER.

Weeds and pest animals

Weed control is essential to conserve and enhance biological diversity. Weed removal is crucial pre and post plating of native species as it increases the survival rate of native tree and shrub plantings.

During the fieldwork, some discussion was held to identify landholders' current priorities, resources and level of control activity. This has helped to identify where additional effort is required and where support is needed for those who are taking responsibility for managing invasive species on their land (for declared species it is a legal requirement under the BAM Act). The one-on-one interactions that have occurred during the development of the plan may have widened community awareness of the issues associated with invasive species.

Weeds most commonly found in the Catchment are listed in Section 3.3.13; weeds found during the FCA survey are listed in Appendix A and suggestion for their control method in Appendix B.

Feral pigs, rabbits and foxes are a problem within the catchment which requires on-going control. According to the interviews rabbits and foxes are dealt with by the landholders through a combination of methods with the main one being shooting and trapping. Feral pigs in particular are a serious environmental and agricultural pest across the Catchment.

The Lower Blackwood Vertebrate Pest Management Group (LBVMPG) was established to reduce the feral pig population and its impact on the Lower Blackwood's unique environment and agricultural industry. The LBVPMG is comprised of landholders, DBCA, DPIRD, LBLCDC and also works with local government working across 610,000 hectares that comprise the Lower Blackwood Feral Animal Control Area (Figure 19) and covering three local government areas (the City of Busselton, Shire of Augusta-Margaret River and the Shire of Nannup).

The LBVMPG engages experienced and qualified field operators to work collaboratively with landholders and other stakeholders to undertake feral pig control activities. Landholders are able to contact the LBVMPG directly who can then coordinate field officers to work with landholders and undertake feral pig control activities. Currently, the LBVPMG relies of grant funding and support from local government to be able to continue its operations and continuity of this funding for the LBVMPG is key to ensure that field officers are engaged to continue their work.

5.2.4 Recommendations

Recommendation: Protect or improve the condition of riparian land.

Ecological restoration

- Undertake prioritised remedial works identified in this Plan through the FCA, see Appendix A (maps and tables).
- Prepare a whole farm plan. Whole farm plans show the natural and man-made features on the farm and the connections between them and they help prioritise riparian works and perhaps additional activities such as watering points for stock and infrastructure required for paddocks realignment (if required).
- In combination with a farm plan prepare a Restoration Plan. A restoration Plan provides a clear and tangible framework for the project incorporating expert local knowledge (including Aboriginal knowledge where available), realistic timeframes and state-of-the-art practice. A restoration plan would ensure that projects are designed following appropriate processes of planning, implementation, monitoring and evaluation to improve the chances of achieving the desired restoration outcomes. It also allows to implement an adaptive and reflexive management approach by gauging the progress of projects, learning what's working and what isn't, and fixing those that are underperforming. Key components of a Restoration Plan are outlined in Table 19.
- Look at the issues/benefits at the sub-catchment as a whole because what happens upstream affects what happens downstream and linear contiguity matters. Collaboration with neighbouring farms could be more effective from an environmental point of view but also from a financial one. The best way to go about it would be to assess the issue along an entire waterway, map the various management measures and then prioritise and cost the work required.
- Provide riparian habitats for wildlife (ecological corridors). Work with neighbouring landholders within a catchment to identify important habitat Sections and implement restoration work.
- Undertake trials and evaluation of management actions implemented, including the evaluation of the effect of revegetated riparian buffers on achieving the project objectives.
- Identify harvest schedules and determine the likelihood of future land use back to other agriculture and if so, identify possible fencing projects of waterways and remnant vegetation to undertake as part of the transition (plantations).
- Access riparian management funding provided by DWER through the Healthy Estuaries WA (previously REI) and project assistance from the LBCDC. The advantage of these programs, besides the 50% cost share, is the availability of technical support to landholders. Ensure the project adheres to the funding guidelines which guide the establishment and delivery of restoration projects. Guidelines provide some important advice with regard to width of riparian buffers and fencing requirements.

P removal (as a specific goal):

- Each project should consider the entire sub-catchment situation but also site-specific conditions (soil type, landscape characteristics, etc.) and contexts (landholders' objectives, stock access, fertiliser regimes, etc.). Improving water quality may just require to address a portion of the waterway rather than the entire length depending on the characteristic of soil, flow and slope in that sub-catchment (DWER, 2020).
- The riparian zone's phosphorus removal capacity can be improved by:
    - improving soils through soil amendment
    - lining stream beds with phosphorus-binding amendments
    - introducing or maintaining native aquatic plants (e.g. Cycnogeton sp.) to streams
    - re-engineering drains to become wider and shallower, and to provide some highly P-retentive material in the bottom sediments to reduce P export through in-stream retention.
    - fencing off existing riparian vegetation to reduce disturbance to existing riparian vegetation and prevent sediment disturbance and consequent release of nutrients into the stream.
- Long-term monitoring is essential as there is always a significant lag time between the completion of restoration projects and observed improvements. Monitoring should be well planned with the objectives and water quality targets in mind. Assessing the before and after P levels requires the measurement of P upstream as nutrients leave the paddocks. Measuring the runoff requires filtration immediately on-site to avoid sediment capturing the P on the trip to the laboratory and confusing the result.
- Alternative vegetation type such as perennial grasses could be an effective mechanism for removing nutrients and weeds from the landscape (McKergow et. al, 2005) as long as there is horizontal flow. Grasses are most effective at removing particulates from surface flow and the subsurface flows are not likely to intersect the shallow roots of grasses (Vought et al. 2005). Although periodic grazing seems a convenient option (and useful for weed suppression), grazing (even for short periods) can cause significant damage. A case by case approach or pilot studies should be

undertaken to assess the effectiveness of nutrient stripping buffers in the Scott River Catchment.

Weed control

- Target Declared or serious environmental weeds within high-quality remnants or their margins.

- For plantations: monitor weed populations to ensure any new incursions are managed prior to the weed populations becoming established and spreading from these point sources.
- For plantations: encourage 'Clean on Entry' approaches to machinery moving around the sub-catchments.
- Inquire about financial and technical support for weed control through the LBLCD. For more information on weed control and funding availability visit the LBLCDC website.
- Ensure that Arum lily and Blackberry (Rubus fruticosus) are not introduced/spread through the Catchment are controlled in all private and public land (including road reserves) in the catchment so that the seeds don't get spread by birds. Seeds can be dropped up to 5km from seed source although literature says that the majority of the seeds are dropped by birds within 100m of the seed source. Hence, a buffer of 100m is therefore a high priority but a buffer of 5km is needed to ensure protection.

Suggestions for weed control methods for the weeds found in the Catchment are outlined in Appendix B.

Pest animal control

- Contact the LBVMPG who can coordinate field officers to undertake feral pig control activities.

- Liaise with neighbouring landholders for a cooperative approach to feral animal control on a regular basis, particularly feral pigs, foxes and rabbits.

Other important recommended management actions are:

- Exclude stock from the riparian area once fenced off and planting has been carried out.
- Ensure the width of native riparian buffers is at least 10m each side of the waterway.
- Continue to maintain and replace old fences along the riparian zone including the tributaries and seepage areas to restrict stock access.
- Encourage protection of remnant wetland vegetation.
- Review options to slow the velocity of water from tributaries into the main channel to avoid further undermining of riparian vegetation and sediment discharge into the main river channel.
- Select plant species for revegetation that have been shown to work in similar site conditions.
- Use rock spillways as in-line sediment traps and crossing points, to enable sediment excavation if necessary, from a localised point.
- Protect threatened ecological communities through fencing, weed control and no clearing.
- Install adequate number of offline watering points for stock (dryland grazing).
- Reintroduce shelter belts to alleviate stock pressure on remnant vegetation and riparian zones (dryland grazing).
- Align new fences and the use of electric fencing to improve operational farm management and protect vegetation and riparian zones (dryland grazing).
- Increase setbacks from existing wetlands and waterways for new plantation plantings (plantations).

Recommendation: Support landholders to protect or improve the condition of riparian land.

- Develop an engagement program for landholders to demonstrate the benefits of adopting riparian works, particularly with local specific examples and analysis.

- Encourage and assist landholders to provide habitats for wildlife. Ecological corridors are highlighted in the foreshore condition assessment and sub-catchment planning would help prioritizing and costing works.
- Work with landholders and plantation manages to identify harvest schedules and determine the likelihood of future land use back to other agriculture and if so, identify possible fencing projects of waterways and remnant vegetation to undertake as part of the transition (plantations).
- Update / refine the GIS database as new information becomes available (LCDC)
- Using the FCA findings refine priority areas based on both weed species' management and asset-based management. This prioritisation work will provide a basis for seeking external grants to support the control effort at a regional scale. Liaise with Shire to control roadside weeds to prevent their establishment in the road reserves and passing through private property. Stakeholders to work together to implement a range of integrated control programs at different scales.

- Undertake trials and evaluation of management actions implemented, including the evaluation of the effect of revegetated riparian buffers on achieving the project objectives.

- Investigate the effectiveness of perennial pasture buffers for nutrient removal.

Table 20: Components of a riparian restoration plan

Riparian Restoration Plan: key components	
Objectives	Objectives should be clear from the beginning.
Site conditions	The Plan should include a detailed description of the site's physical and biological features such as soil type, landform, topography, hydrology/drainage, vegetation type and fauna, infrastructure. Also, the description should include the site's history, including recent/historical disturbance such as grazing and logging and existing site conditions that require remediation such as soil compaction, erosion, surface water diversion, weeds, insect pests (eg. Black beetles) and feral animals.
Site preparation	The Plan should identify if any site preparation works may be required before planting. These may include weed removal, soil ripping, slashing, fencing, placement of rock riffles and logs, etc. In some situations, a number of separate weed control events are required before planting begins to minimise weed competition with seedlings and prevent having to plant into dense grasses. Baiting might be required if rabbits are an issue. Fencing off stock is crucial to protect the new seedlings and reduce bank erosion.
Species list	A list of riparian plants that would grow well in the Scott River Catchment can be provided by the LBLCDC. Advice can be also sought locally (nurseries, contractors) or from SWCC or DBCA. However, it is recommended that a species list is site-specific and developed taking into consideration the site conditions and project objectives. Tree guards are often necessary in the Scott River Catchment where predation is high however they can be costly. Lessons learnt from projects carried out elsewhere in the Catchment (in similar conditions) should be considered. Choosing the right species can be difficult for a site where soils have changed due to intense agriculture activities over many years and native vegetation that originally was present in the area is long gone. Always take into consideration local knowledge about plants survival on other sites of the property. Check the case study below for some lessons learnt and examples.
Concept design (planting and other works layout)	A concept plan showing species placement and densities as well as in-stream works would provide more clarity to all stakeholders involved about plant layout once established and help with project evaluation. The most appropriate planting technique is crucial for high survival rates. Hand planting gives best possible results but it's slower hence more costly. Consider what can be afforded with the available budget and how important a high survival rate is for the site. Choosing the right density for the right species has to be done with the project objective(s) in mind but of course budget constraints can be an issue. Always document the reason why a certain amount of plants is planted and where. Increase planting density of sedges/rushes and target specific areas for planting as opposed to planting along the entirety of each creekline.
Action Plan	It's important to have a detailed action plan with timings and costings (including costs of follow-ups, monitoring and evaluation) which is agreed by all project partners. The challenge of a restoration project being a long-term project is that funding often runs out and support to the landholder ceases. A review timeframe should be agreed at the beginning of the project. The action plan should also identify the key risks, their likelihood and actions to take to mitigate those risks.
Monitoring	Monitoring is critical for the success of a riparian restoration project. A monitoring program allows to evaluate project success over time (this is easier in the case of habitat restoration, less easy is to determine the success of water quality improvement projects). The first step in establishing a fixed monitoring point is to determine where to take the photos. Monitoring points should be established just after the planting is completed (it seems obvious but the majority of planting projects in the Scott did not establish monitoring points). Photo point locations are recorded with GPS coordinates and described in detail so they can easily be found years later by other personnel. Permanent structures that can be easily described and located by others make good reference points for photo locations.

Riparian Restoration Plan: key components	
Maintenance	Maintenance work after planting is crucial. This may involve watering, removing tree guards, weed control and maintain the fencing in good condition. Double gates are a weak point along a fence and can be easily pushed open by cattle. If cattle can access the area the site is likely to be completely damaged with total loss of the newly planted seedlings. Cattle should not be re-introduced in the area once fenced off. Seasonal site inspections should be scheduled to allow for assessment of weed burden, insect damage, seedling predation and exclusion fencing. Based on these inspections, remediation works can be implemented to ensure maximum seedling survival. The survival of seedlings depends on many factors but weed presence and insects seem to be a big issue in the Scott. Minimising weed presence, particularly during periods of expected maximum seedling growth – spring and autumn – is the most important component to consider and manage during revegetation works. Schedule in follow up weed treatments in Spring, Summer and Autumn following planting for at least two years after the planting date. Grass selective herbicides can be used to prevent off-target damage and careful spot spraying of broadleaf species will ensure planted seedlings have the best opportunity to establish.
Evaluation	Evaluation can be carried out by the planting contractor the year following the planting or by the landholder or by the LBLCDC. Evaluating the success of a restoration project requires strong knowledge of local ecological processes and the dynamics that may have come into play. Evaluation expenses (time, travel costs, equipment, etc) should be budgeted for at the beginning of the project. It is important to collect the relevant information at the right time and also to ask the right questions before the monitoring is carried out. For more information on project evaluation check the DWER website. Recommendations about the success of the restoration, how to improve future activities, and/or the need for further rehabilitation measures (e.g. removal of weed species) should be shared with other landholders in the area (if possible). Below is an example of project evaluation for a restoration project carried out in the Scott River Catchment.

5.3 Drain management

A key target in the HIWQIP (White, 2012) is to reduce the average P load from the Scott River to the Estuary from 11.2 T/yr to 8.1 T/yr. This may be partially achievable through a better understanding and management of drainage systems in the Catchment. According to White (2012) drains in the Scott River catchment "have been constructed in a way that maximises opportunities for nutrient export to the main river system" (p. 59 White, 2012). The DWER report recommends improvement works on drains to be of value for reducing nutrient runoff into waterways however, such works need to be "carefully assessed and designed, and should not be undertaken on larger arterial drains" (p. 59 White, 2012).

The information provided in this study may help to improve knowledge of drainage type and function in the Scott River Catchment, the likely impacts on nutrient runoff, appropriate design guidelines and improvement works. This information can be linked to the more site-specific information and recommendations from the FCA (Section 5.2 and Appendix A).

5.3.1 Background

A variety of natural and augmented natural drainage systems traverse the Scott River Catchment mainly from north to south that conveys stream flow from the forested Barlee Scarp to the river. For the most part, the Scott River Catchment does not have a dense network of constructed and defined drainage.

There are three underlying reasons why landholders would build drains:

- Flooding: to stop runoff that has originated elsewhere from flowing onto their land.
- Inundation: to remove or reduce the area of standing water from above the land surface.
- Waterlogging: to lower the groundwater level by draining free water from the pore spaces of saturated soil.

Landholders in the Scott River Catchment have invested mainly in the use of surface water drainage probably in response to the visible flooding and inundation of their crops and pastures. Hence, drains appear to have been built to address individual issues rather than in a coordinated manner that would result from farm and drainage planning and the most prolific drainage are associated with plantation establishment. Of course, it is often possible to achieve one or more outcomes by addressing one of the others. For example, if waterlogging was caused by inundation as a result of flooding, preventing the flooding may alleviate both the inundation and waterlogging.

Constructed water surface drainage across the Catchment consists of anything from narrow backhoe ditches, parabolic spoon drains and 'W' drains at the paddock scale through to deepened, widened or eroded larger watercourses at the catchment scale. Most drainage serves to enhance the capacity of existing watercourses and by following the flow of water so avoiding the need for proper survey and design.

The intensification and deepening of the drainage system across the Scott River Catchment have, in many cases, at least partially achieved the objectives of some landholders but it is unclear as to how much it has contributed to an overall increase in P export (not quantified). With reference to Figure 30 below for example, this drainage may have among other things:

- Lowered the watertable but enabled P to be absorbed by the subsoil.
- Increased overland flow but led to improved grass cover.

There can be no argument that Figure 31represents a less than ideal landscape but for agriculture to persist on the Scott River Catchment at least some of the drainage attributes illustrated will need to be preserved.

5.3.2 Methods

The issue of drains construction in the Scott River Catchment: their objectives and design, their effectiveness and ultimately their environmental impact does not have a simple solution. For the preparation of this report, an expert consultant with strong knowledge of the Scott River Catchment was engaged to provide an overview of the current drainage systems occurring in the Catchment, common issues associated with these and potential design solutions. Information about current systems was also gathered during the FCA site visits and during the one-on-one interviews.

Due to budget constraints, it was not possible to map the drainage network of the Catchment with the necessary ground-truthing, although the GIS datasets do provide a good idea of where the main drain arteries are and what the potential impacts are based on the land use.

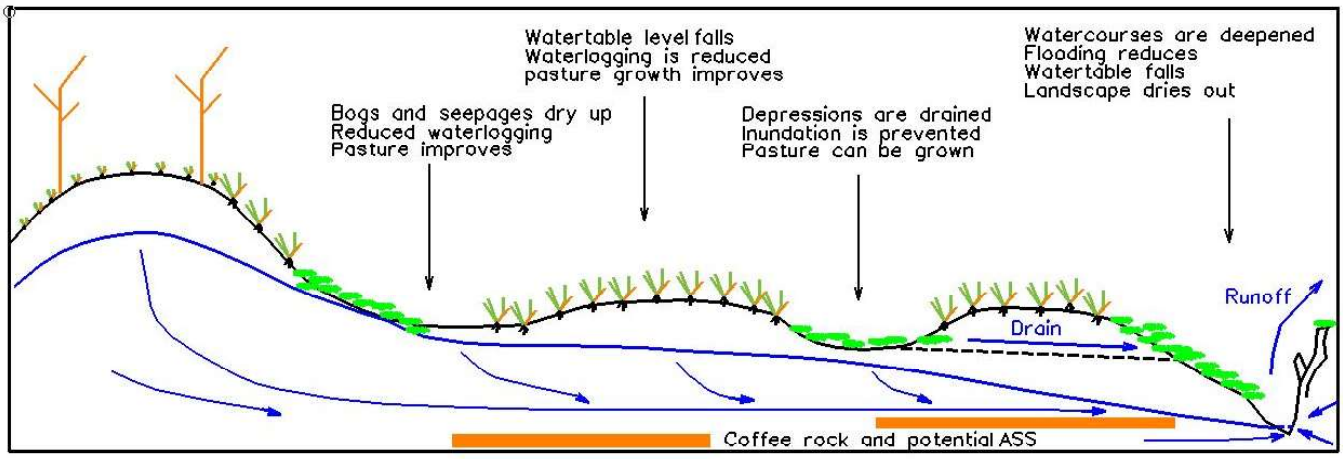


Figure 30: Conceptualised post-drainage in the Scott River Catchment.

5.3.3 Findings

Refer to Section 4.2.2 for landholders' responses on the topic of drains.

5.3.3.1 Drainage performance in the Scott River Catchment

Although it is not feasible to characterise the responses of drains and drainage systems to changes in land use and flow regimes across the entire Scott River Catchment it can be demonstrated why some erode while others do not.

At an average slope of 0.25% (2.5 m/km) flow in a bare sandy channel of 5 cm depth will achieve permissible velocity (speed above which there is a risk of erosion) of 0.3 m/s (Bligh, 1989; Hydrocalc, 2019). If the depth increases to more than 5 cm the floor and batters of the drain can erode. This means that even the bare sandy channel of a newly built 0.3 m deep paddock scale drain could erode before it has a chance to establish pasture cover to stabilise it.

Figure 31: Shallow trapezoidal drain collecting runoff from the paddock to the left of frame.

Once pasture cover and/or water weeds have established within and alongside the drain the permissible velocity is about 0.5 to 0.6 m/s at which the depth of flow is around 0.3 m. If the drain is about 0.3 m deep, like most paddock scale drains on the Scott River Catchment, the depth of flow will rarely exceed 0.3 m so the drain is unlikely to experience erosion if undisturbed.

This difference in erosion risk of a vegetated (pasture cover) as compared to non-vegetated drain highlights the benefits of leaving drain channels in as far as possible an undisturbed condition.

Plants and vegetation growing in the channels of drains and watercourses are as responsible for slowing the flow of water as protecting the channel surface. Before clearing occurred in the Catchment, the major watercourses were densely vegetated with a reduced speed at which the water could flow. Even at a depth of about 0.6 m, the speed of the water is about 0.3 m/s and 0.5 m/s at 1.3 m depth. Given such a well-vegetated watercourse has a permissible velocity of about 1.2 m/s the depth could be as much as about 4 m before causing erosion.

Issues arise when these stable vegetated watercourses become degraded, are cleared or channelised because once cleared to a bare sand permissible velocity is reduced to the 0.3 m/s at that safe depth of flow of 0.05 m just as for the paddock scale drains discussed above. The reduction in channel stability causes channel erosion, undercutting of the channel sides by erosion and seepage inflow, bank collapse and the headward erosion of inflowing watercourses. Once at this stage of degradation remedial measures are particularly difficult to implement in sandy waterlogged soils.

This brief analysis reveals how the changing vegetative (protective) status of a drain or watercourse with regard to the probability of experiencing an erosive streamflow event will determine the likelihood of erosion. A drain may remain stable with pasture cover for many years until inadvertently disturbed by spraying, cultivation or livestock grazing, setting in motion ongoing erosion and sedimentation.

5.3.3.2 Types of drains

Agricultural drainage and drainage infrastructure that is or could be used on the Scott River Catchment is the same as for most other low relief landscapes across Western Australia and fits into three broad categories:

- Levees and bunds: usually consist of strategically placed mounds and embankments to divert, confine or contain flows mostly above the land surface. Levees are mainly built to attenuate and divert flood flows above ground without the need for and cost of excavation to contain and convey the often-large flows they control (Figure 32).

- Surface water drains: are as their name suggests dug for the primary purpose of intercepting, collecting and/or conveying water from the land surface in an excavated channel. Surface water drains are up to 1.2 m deep and even more if required to 'cut' through elevated land to maintain the gradient of the channel. Surface drains are usually referred to by the shape of their channel (Figure 32): 'V', parabolic, trapezoidal (Figure 33), 'W' (Figure 34), etc., but they all serve the same purpose. Most surface water drains built on the Scott River Catchment are 0.3 m to 0.6 m deep although where these have eroded or were watercourses they may be deeper. Although unintended many surface water drains on the Scott River Catchment capture and drain groundwater because of the high-water table.

- Subsurface drains: are dug to a depth below the water table to drain groundwater and so reduce waterlogging. In inland areas, these drains are usually open steep-sided channels up to 3 m deep. Where the land is unstable, of high value, or channels would be intrusive buried slotted pipes referred to ag or tile drains are used (Figure 35). These subsurface drainage schemes are costly and require complex site investigation and design before construction. One landholder reported that there has been some trialling of subsurface drainage in the Scott River Catchment with no problems from ASS.

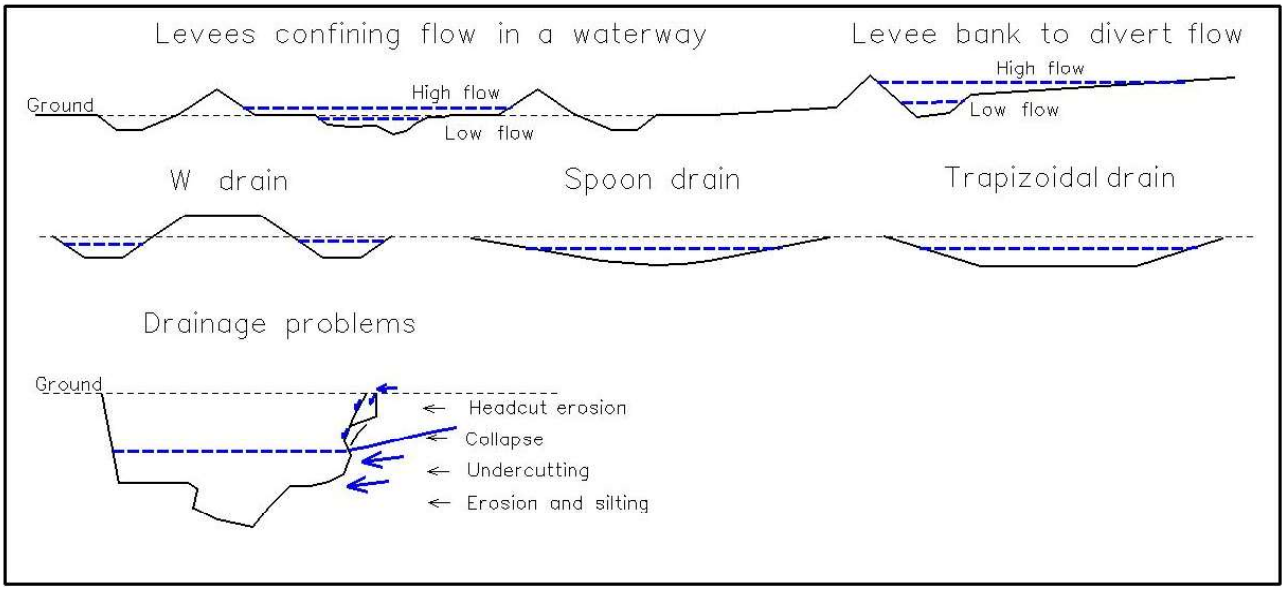


Figure 32: The use of levees, different types of surface water drains and problems experienced by drains.

Figure 33: A freshly dug trapezoidal shallow spoon drain (DAFWA).

Figure 34: Creek flow into the head of a 'W' drain (DAFWA).

Figure 35: Subsurface drains being installed with a gravel envelope (from TG Drainage).

5.3.4 Recommendations

Recommendation: Adopt sustainable surface water drainage design and management practice to reduce nutrient export, while maintaining essential drainage functions.

- Agricultural drainage and drainage infrastructure that is or could be used on the Scott River Catchment is the same as for most other low relief landscapes across Western Australia and fits into three broad categories identified in Section 5.3.3.2.
- Avoid constructions of new drains at hotspot sub catchments where nutrient loss into waterways is a key concern. Excavating land to construct drains can further expose acid sulphate soils and this risk should minimised across the whole Catchment.
- Adopt appropriate survey and design techniques for constructed drains. Regardless of their 'type' the performance of surface water channels should be evaluated or designed using an empirical mathematical equation, the Mannings formula (Bligh, 1989). The formula assesses the slope of the drain channel and the flow area to produce a velocity of flow and hence discharge rate. The common approach to designing a surface water drain (Bligh, 1989) in the Scott Catchment is to:
    - Calculate or estimate how much water the structure will need to convey. This may come from measurements of actual or from various methods of estimating runoff rates from the landscape. Understanding the consequences of failure is important which in drainage language means what happens if the capacity of the drain is exceeded. If the result is likely to be some temporary flooding a lower runoff estimate may suffice, resulting in a smaller drain. Conversely, if there is a risk of property damage a larger drain may be chosen to cope with a higher estimated flow.
    - Identify the receival point or safe outlet. Does it have the capacity to convey any extra water safely downstream?
    - Determine the alignment and measure the slope along it. The slope will be used in the equation to calculate the energy that needs to be dissipated to the channel perimeter from the flowing water to remain below permissible velocity
    - Select an appropriate channel 'shape' based on the soil and other important characteristics. The Scott River Catchment has mostly wet and unstable sandy soils drain batters so must be very flat if they are to remain stable. Batter slopes of or flatter than 1:5 (V:H) are recommended to avoid erosion and undercutting, and facilitate revegetation.
    - What will be the condition of the drain channel in terms of soil type, vegetation cover and other stabilising features such as rocks? From this evaluate and chose the safe speed at which water can flow in the channel before causing erosion; the permissible velocity of flow. The permissible velocity of a bare channel in the wet sandy soils of the Scott River Catchment is probably less than 0.3 m/s; that is a flow rate of more than this will cause erosion and the mobilisation of silt within the channel. Permissible velocity can be increased by stabilising the drain with the most cost-effective technique being establishing vegetative cover in and alongside the drain. The best vegetative cover will not only bind the soil surface but be laid flat during high flows so as to offer further protection to the channel surface. This makes grasses and reeds rather than trees and shrubs more suited to the role of stabilising drainage. The higher the permissible velocity the more water the drain can safely convey or the smaller the drain needed to carry the same volume of water.
    - Use the Mannings equation (Bligh, 1989) to calculate the safe depth of flow from the slope and permissible velocity of the channel. The resultant depth of flow multiplied by the velocity is used to calculate the drain width and discharge rate. As this can be an iterative process review the result and recalculate with new variables if needed.
- Design or redesign farm scale drainage for the intended land uses adopting land use specific Water Management Guidelines (WMGs). It is beyond the scope of this work to be recommending landuse-specific WMGs but there are generic actions that arise from this review that could be undertaken by all landholders that affect drainage and could contribute to lowering P loads and protecting the environment. These actions are:
    - Adopt appropriate survey and design techniques for constructed drains. Preference should be for shallower drains that can be revegetated to retain their stability and that will not drain groundwater.

- Coordinate drainage between neighbours so as to protect and make the most of the Catchment scale drainage network.
- Identify priorities drains that need improvement work with the aim of reducing nutrient export to the Scott River, while maintaining essential drainage functions. Some priority drains have already been identified in the FCA.
- Adopt a maximum depth of catchment scale drainage and waterways to reduce the risk of erosion and effect on draining groundwater and lowering the water table. Where possible use levees and bunds rather than excavated channels.
- Leave a buffer alongside all watercourses, drains, standing water and/or where standing water will develop. For larger watercourses (class 4+) a 30 m buffer along each side consisting of at least long grass, sedges, reeds and some shrubs. If the watercourse is already vegetated this should be maintained and protected from livestock browsing.
- Fence watercourses and waterbodies to stop livestock access to prevent the loss of protective vegetation, bank collapse, erosion, and direct application of nutrients from animal manures.
- Don't attempt to divert large watercourses. Large watercourses can be fenced off and revegetated. Revegetate channels and buffers where needed with perennial grasses, reeds, sedges and small shrubs
- Where livestock have access establish a fenced buffer at least 30 m (15m as a bare minimum) from each side of catchment scale (4th order) watercourses.
- Relocate intensive agricultural activities out of the watercourses.
- Avoid fertilising, cultivating or spraying areas that are known to convey drainage or to become inundated.
- Avoid using drains and watercourses as access roads, end of row turnarounds or stock routs unless designed to do so.
- Manage effluent to reduce drainage of nutrients into nearby waterways.

Recommendation: Adopt / support a strategic and coordinate catchment scale approach to drainage management.

- Consult with neighbours at the sub catchment scale before carrying out drainage work so as to protect and make the most of the Catchment scale drainage network (landholder).
- Provide input in the identification and mapping (lead by the LCDC or government agencies) of the routing of catchment scale waterways and their condition – for example by providing access to the property for ground truthing and review the maps produced. Priority locations for improvement work (hotspots) to be identified. The FCA provides already a first pass assessment (landholder).
- Prioritise fencing of vegetated watercourses where livestock have access and that discharge nearest to the lower reaches of the Scott River (landholder).
- Prioritise the stabilisation of degraded and denuded watercourses close to and that discharge directly into the Scott River channel (landholder).
- Establish a drainage management reference group for a strategic approach to drain management in the Catchment (LCDC).
- Further assess / refine the condition and stability of catchment scale waterways and update the LCDC GIS database (LCDC, DWER).

Recommendation: Adopt / support farm-scale best management practice for drainage.

- Prepare a whole farm map to identify the location of the various land uses and P inputs in proximity to drainage. With this information identify priority drains that need improvement work with the aim of reducing nutrient export to the Scott River, while maintaining essential drainage functions. Priority drains have been identified by the FCA within the study area (Appendix A) (landholder with support from LCDC).
- Support the implementation of prioritised restoration works based on recommendations in Appendix A – Foreshore Condition Assessment.
- Develop management plans for farm scale drainage (landholder with support from LCDC).
- Review WMGs produced for the Scott Coastal Plain (DAFWA, 2001) with landholders and supported by government agencies (supporting organisations).

5.4 Fertiliser management & Soil Health

The Section below is not a new study rather a summary of the key issues with regard to fertiliser management in the Catchment and recent initiatives and resources available to landholders for soil testing and fertiliser trials.

5.4.1 Background

There is unarguable evidence from scientific literature and industry research that a better understanding of optimum fertiliser levels for a specific land use and soil type allows landholders to maximise productivity while minimising losses of nutrients to local waterways.

The amount, type and frequency of fertiliser applications affects the amount of P and N that ultimately enter waterways. The HIWQIP report (White, 2012) states that improving fertiliser management on all grazing pasture in the Scott River Catchment "is likely to achieve the largest overall reduction in phosphorus load with the lowest capital cost". Further "Implementation of better fertiliser regimes in all grazing pasture in the Catchment is predicted to achieve nearly all (93) of the required total reduction in phosphorus load from the Scott River while also delivering a net financial benefit. Capital costs for implementation (the cost of fertiliser testing and technical advice) are more than offset by the savings in applied fertilisers. It is likely the large reduction in phosphorus export would reach 100% of the required target if this management tool was also implemented on other land uses in the catchment, such as blue gum plantations. Fertiliser management is likely to make the greatest impact in the Four Acres, Middle Scott and Dennis sub-catchments, where contributions from irrigated dairy pasture are significant" (p. 61 White, 2012).

In 2012 the DWER report suggested that there was scope for improvement in fertiliser management[27] in the Scott River Catchment and that the key barriers to implementation of "best fertiliser management practice" were:

1. Lack of nutrient-budgeting tools and consistent advice from the fertiliser industry.
2. Limited ongoing technical advice regarding nutrient management.
3. Limited knowledge about appropriate rates of fertilisation for blue gums.

However, recent DWER water quality data (see Section 3.2.10 of this Report) has shown that there has been an improvement in P levels in the Catchment potentially due to more landholders undertaking soil testing and choosing to trial better fertiliser levels. In fact, the majority of people interviewed for the preparation of the SRAP said that they now carry out soil testing and fertiliser trials through their own fertiliser company, an accredited agronomist or government programmes.

The following are important initiatives that have been offered to landholders in the Southwest of Western Australia (including in the Scott River) which may have helped to address at the least the first two barriers identified by DWER in 2012.

5.4.1.1 Soil Testing & Mapping

DPIRD has since 2009, been implementing a Whole Farm Nutrient Mapping (WFNM) Program across the South West region. WFNM mapping is aimed at graziers to support them in making informed nutrient management decisions by using soil test results to determine nutrient and pH status. As a result, nutrient use can be optimised to increase profitability and reduce nutrient run-off to nearby waterways. Since 2009, 1083 farms over 220,000ha in the South West have undertaken WFNM.

Since 2016, DPIRD has partnered with DWER to deliver its WFNM program annually through the REI Program which has provided incentives for soil testing and agronomic advice for grazing operations. The program has a panel of Fertcare® accredited agronomists available and landholders have the opportunity to work with an agronomist of their choice to develop a fertiliser plan for their property based on the soil testing results received. Six properties (beef and dairy) in the Scott River Catchment have taken part in the REI program since 2016 and 34 properties as at 2019 have been involved in WFNM.

Figure 36: 2019-20 WFNM participant workshop

27 A list of best management practice can be found in the HIWQIP (White, 2012) page 50.

5.4.1.2 Fertiliser Trials

Project uPtake is a current South West partnership project between:

- DWER
- DPIRD
- The six REI Catchment groups
- CSBP
- Summit
- Landmark
- University of Western Australia
- Murdoch University
- Fertilizer Australia
- South West Catchments Council
- South Coast NRM
- Western Beef Association Inc
- Western Dairy and Dairy Australia
- Meat and Livestock Australia

It is designed to improve nutrient use efficiency on grazing farms in South West Western Australia by improving farmer and industry knowledge, confidence and uptake of the science supporting fertiliser recommendations.

UPtake aims to:

- Establish at least 36 fertiliser trials across the South West over a range of soil types with contemporary pasture species to develop phosphorus response curves.
- Trial innovative technology to provide rapid feedback on pasture growth and soil nutrient status including drones, near-infrared and X-ray fluorescence.
- Build partnerships and capacity in industry, Catchment groups and landholders to work together to optimise productivity and minimise nutrient loss off the farm.

At the time of the preparation of the SRAP, there were two trials in progress in the Scott River Catchment.

The key recommendations to landholders from the Uptake Program[28] are:

1. Results from trials to date are showing the national critical values for P used to inform P fertiliser recommendations are relevant in SW WA. You can therefore have confidence in P recommendations based on the national data that are used by Fertcare® accredited agronomists.
2. If your P soil test shows that your soil contains excess P for your target production levels (i.e. above critical values) adding more P will not increase productivity but may add P to waterways contributing to algal blooms. If your P soil test is similar to critical values for P then maintenance P may be required to replace P removed by pasture growth.
3. Addressing limiting nutrients in your soil (e.g. nitrogen, sulphur, potassium, micro nutrients) and low pH can dramatically increase production and minimise unnecessary losses of nutrients to the environment.
4. Soil testing and comparison with critical values is critical to determine the nutrient requirements of your soil to meet your production targets.

Trials and demonstrations are a great behavior change tool for extension outreach (Lower Blackwood LCDC, 2020) as they:

- Provide an opportunity to see the results of the suggested practice first hand and what does and does not work in their local area.
- Lowers the risk threshold by allowing landholders to try a new idea on a small piece of land to make sure it works before they apply it to a wider area.

Figure 37: The uPtake project team measuring pasture cuts at a Scott River site 2020

28 From uPtake – summary trial results 2019. Visit: https://estuaries.dwer.wa.gov.au/uptake/trials/

5.4.2 Recommendations

Recommendation: Identify and adopt optimum fertiliser rates and applications that maintains productivity levels whilst minimising nutrient loss (for all land uses).

- Carry out soil testing using accredited agronomists to identify the optimum fertiliser mix for productivity and to minimise nutrient loss. Advice should be sought also about best timing and frequency of fertiliser application (landholder).
- Carry out soil mapping (for soil types) at a farm-scale level to identify soils more prone to nutrient leaching (landholder).
- Implement farm fencing and paddock management to mirror the more detailed soil type mapping – allowing for more accurate fertiliser applications to paddocks (landholder).
- Access tools like the DPIRD Whole farm nutrient mapping (WFNM) or project uPtake to:
  - collect a representative sample for every paddock on the farm
  - analyse each sample for phosphorus, potassium, sulfur, phosphorus buffering index and pH
  - assess the soil test data against nationally agreed critical values
  - prepare colour-coded maps to assist in fertiliser decision-making
  - get the nutrient delivery right
  - More information can be obtained from the DPIRD website or from the local LCDC.
- Take advantage of information, field demonstrations and trials of various soil ameliorants and fertilisers provided by the local LCDC or government agencies to improve the understanding of the benefits of fertiliser management and how to interpret soil-test results (landholder).
- Undertake paddock-scale fertiliser and amendment trials (landholder).
- Conduct fertiliser trials on soil types relevant to the Scott River catchment (plantations).

Recommendation: Support the identification and implementation of best practice fertiliser management.

- Continue to provide government programs to support landholders make more informed nutrient management decisions (e.g. the Whole Farm Nutrient Mapping, uPtake) (supporting organisations).
- Deliver a long-term local, strategic landholder and industry engagement process that promotes the benefits of improved fertiliser regimes and the usefulness of soil testing and mapping and that encourages landholders to implement fertiliser management practice that optimises productivity and minimises nutrient loss. The engagement process should include:
  - demonstrations and trials of various soil amendments and fertilisers (such as N, K and lime) to ground-truth concepts and build landholder confidence.
  - for plantations: assess optimum fertiliser on soil types relevant to the Scott River catchment. Arising from these trials develop high-level technical advice regarding nutrient requirements of blue gums to enable this industry to participate in best-practice fertiliser management programs.
  - whole farm plans which include soil type mapping to identify identifies soil types at a farm scale level.
  - Sharing of lessons learnt from trials and projects.
- Continue to provide an engagement and communication support role in project uPtake and WFNM program (LBLCDC).
- Attract and implement more demonstrations and trials of various soil ameliorants and fertilisers (such as N, K and lime) to ground-truth concepts and build landholder confidence (supporting organisations).
- Undertake a pilot sub-catchment soil type mapping project in collaboration with landholders that identifies soil types at a farm-scale level. Soil mapping should be conducted at the farm scale in order to identify at a more detailed level, soil types more prone to nutrient leaching (supporting organisations).
- Share the lessons learnt from a network of landholders who are involved in innovation and conducting many different trials, through workshops, farm field days and provision of information (LBLCDC).
- Buildings on the soil testing work of REI, conduct a study on the barriers to adoption of optimum fertiliser use practice by landholders in the Scott River Catchment and on the effectiveness of 'best practice' (LBLCDC).
- Provide regular technical support to landholders for most accurate interpretation of soil tests (supporting organisations).
- Work with accredited agronomists to optimise their fertilizer programs by soil type and by crop/pasture type to maximise productivity and minimize nutrient loss (supporting organisations).
- Incorporate new trials in LCDC GIS database (LBLCDC).
- Work with landholders to incorporate these measures into whole farm plans (LBLCDC).

6. RECOMMENDATIONS (ACTION PLAN)

The following recommendations and actions have been developed based on best practice riparian management, current understandin of waterway and riparian condition in the Catchment, recommendations from previous studies, and input from landholders and othe relevant stakeholders.

Recommendations and actions are grouped into:

- Recommendations for landholders.
- Recommendations for supporting organisations.

6.1 Recommendations for landholders

The following table (Table 21) outlines the management recommendations for the Scott River landholders.

Table 21: Recommendations for landholders

Recommendation 1: Identify and adopt optimum fertiliser rates and applications that maintains productivity levels whilst minimising nutrient loss (for all land uses): **Note**: If soil mapping shows that soil contains excess P for target production levels (i.e. above critical values) adding more P will not increase productivity but may add P to waterways contributing to algal blooms (DWER and DPIRD, 2019). If farm P soil test is similar to critical values for P then maintenance P may be required to replace P removed by pasture growth. Finding the optimum fertiliser application is predicted to substantially reduce phosphorus loads from the Scott River and help meeting the water quality target of P 0.10 (mg/L). Soil tests are compared with national critical values for P. P fertiliser recommendations that are used by Fertcare® accredited agronomists are based on the national data which is accurate and valid for the Catchment (White, 2012).		
Action		Priority
1.1	Carry out soil testing using accredited agronomists to identify the optimum fertiliser mix for productivity and to minimise nutrient loss. Advice should be sought also about best timing and frequency of fertiliser application.	H
1.2	Carry out soil mapping (for soil types) at a farm-scale level to identify soils more prone to nutrient leaching.	M
1.3	Access tools like the DPIRD Whole farm nutrient mapping (WFNM) or project uPtake to: • collect a representative sample for every paddock on the farm • analyse each sample for phosphorus, potassium, sulfur, phosphorus buffering index and pH • assess the soil test data against nationally agreed critical values • prepare colour-coded maps to assist in fertiliser decision-making • get the nutrient delivery right More information can be obtained from the DPIRD website or from the local LCDC.	H
1.4	Take advantage of information, field demonstrations and trials of various soil ameliorants and fertilisers provided by the local LCDC or government agencies to improve the understanding of the benefits of fertiliser management and how to interpret soil-test results.	H
1.5	Undertake paddock-scale fertiliser and amendment trials.	H
1.6	For plantations: conduct fertiliser trials on soil types relevant to the Scott River catchment.	M

Recommendation 2: Identify and implement farm-specific, best practice solutions for designing or upgrading effluent systems (dairy). **Note:** Approximately 10 to 15 per cent of nutrient problems arising from dairies are located in and around the dairy shed, with the remaining 85 to 90 per cent derived from diffuse nutrient transport from the farm (Keipert, 2007). For the Scott River catchment, improving effluent management is estimated to reduce P exports to the estuary by 0.11 t/yr (White, 2012). Although this is a relatively small quantity, the discharge has an extremely high concentration and is thus likely to affect local waterways. In addition, coliforms and other faecal contaminants are exported with dairy effluent, which can pose a threat to the environment and human health (White, 2012).		
Action		Priority
2.1	First of all: adopt best fertiliser management practice (fertiliser and manure are at levels consistent with pasture requirements) and tailor applications according to factors such as timing and location. This would ensure that the right amount of P is applied.	H
2.2	Adopt a whole farm approach: prepare a whole farm plan which includes all aspects of capturing, storing and reusing dairy shed effluent to protect water quality and reduce the need and cost of fertiliser on areas where effluent is applied. The Plan should help assess feasible options as per point 2.3 and incorporate findings from the FCA survey (Appendix A).	H
2.3	Identify farm-specific options for system upgrades based on Price and Tait (Price and Tait, 2019) recommendations and findings from innovative trials carried out in the area. Develop an effluent management plan that consider feasible options for expansion and modifications to the existing system.	H
2.4	Existing infrastructure should be maintained in working order to ensure operational efficacy.	H
2.5	Prepare a cost benefit analysis which takes into consideration budget, level of input, goals, needs and challenges. Seek information about the potential risks of current systems and the potential economic gains in effectively utilising effluent on farm. Determine the agronomic value of effluent for the farm. Develop a business case to fund the equipment.	H
2.6	Track upstream vs downstream nutrient concentrations on irrigated properties to establish an effective monitoring program that can benchmark and measure the success of proposed improvements	H
2.7	Consider feasibility of passive methods of controlling nutrient concentrations in effluent. Assess nutritional inputs required to meet production targets. The *Nutrients from Effluent and Sludge Calculator* developed by Dairy Australia can be a useful tool to estimate the potential nutrient savings from effluent application.	H

2.8	Participate in trials for effluent system upgrades (e.g. the Z Filter) or enquire about current trials and funding programs being carried out in the Catchment.	H
2.9	Take advantage of information and field demonstrations provided by the local LCDC or industry bodies or government agencies to improve the understanding of the benefits (including economic) of more efficient effluent systems.	H
Recommendation 3: Protect or improve the condition of riparian land. **Note:** Healthy riparian land provides a number of benefits to a farm including economic ones. Healthy waterways add value to a farm by enhancing aesthetic qualities and providing habitat for flora and fauna as well as improving water quality and sediment trapping. Importantly a vegetated waterway that is not disturbed provides water temperature regulation functions limiting limit algal blooms hence providing a vital role in community health and wellbeing.		
Action		Priority
3.1	Undertake prioritised remedial works identified in this Plan through the FCA, see Appendix A (maps and tables). Including support for pre and post planting works.	M
3.2	In combination with a farm plan prepare a Restoration Plan. A restoration Plan provides a clear and tangible framework for the project incorporating expert local knowledge (including Aboriginal knowledge where available), realistic timeframes and state-of-the-art practice. A restoration plan ensures that projects are designed following appropriate processes of planning, implementation, monitoring and evaluation to improve the chances of achieving the desired restoration outcomes.	M
3.3	Consider the overall impact / potential benefits of the project at the sub-catchment level because what happens upstream affects what happens downstream and linear contiguity matters. Collaboration with neighbouring farms could be more effective from an environmental point of view but also from a financial one.	H
3.4	Provide riparian habitats for wildlife (ecological corridors). Work with neighbouring landholders within a catchment to identify important habitat Sections and implement restoration work.	H

3.5	Identify harvest schedules and determine the likelihood of future land use back to other agriculture and if so, identify possible fencing projects of waterways and remnant vegetation to undertake as part of the transition (plantations).	M
3.6	Undertake trials and evaluation of management actions implemented, including the evaluation of the effect of revegetated riparian buffers on achieving the project objectives.	
3.7	Whether nutrient removal is an important aspect of the project consider the following actions for improving the riparian zone's P removal capacity: • improving soils through soil amendments • lining stream beds with phosphorus-binding amendments • introducing or maintaining native aquatic plants (e.g. Cycnogeton sp.) to streams • re-engineering drains to become wider and shallower, and to provide some highly P-retentive material in the bottom sediments to reduce P export through in-stream retention.	M
3.8	Enquire with the LCDC about funding for riparian management including weed control.	H
3.9	Target Declared or serious environmental weeds within high-quality remnants or their margins.	H
3.10	Ensure that Arum lily and Blackberry (*Rubus fruticosus*) don't spread in the Catchment.	H
3.11	Monitor within plantations for weed populations to ensure any new incursions are managed prior to the weed populations becoming established and spreading from these point sources.	H
3.12	Encourage 'Clean on Entry' approaches to machinery moving around the sub-catchments.	H
3.12	Contact the LBVMPG who can coordinate field officers to undertake feral pig control activities.	M
3.14	Liaise with neighbouring landholders for a cooperative approach to feral animal control on a regular basis, particularly feral pigs, foxes and rabbits.	M

Recommendation 4: Adopt sustainable surface water drainage design and management practice to reduce nutrient export, while maintaining essential drainage functions. **Note:** Surface water drains transport more water and more dissolved and particulate nutrients to the Scott River. Although necessary in some situations to enable agriculture activities, they are also likely to have contributed to larger nutrient loads from the catchment (White, 2012). 'Deep' drains have contributed to an increased rate of nutrient export in some sub catchments (e.g. Four Acres). Drain management and improved design of new drains is important to reduce transport of nutrients into the Scott River.		
Action		Priority
4.1	Provide input in the identification and mapping (lead by the LCDC or government agencies) of the routing of catchment scale waterways and their condition – for example by providing access to the property for ground truthing and review the maps produced. Priority locations for improvement work (hotspots) to be identified. The FCA provides already a first pass assessment.	M
4.2	Avoid constructions of new drains at hotspot sub catchments where nutrient loss into waterways is a key concern. Excavating land to construct drains can further expose acid sulphate soils and this risk should minimised across the whole Catchment.	H
4.3	Consult with neighbours at the sub catchment scale before carrying out drainage work so as to protect and make the most of the Catchment scale drainage network.	M
4.4	Prepare whole farm maps to identify the location of the various land uses and P inputs in proximity to drainage. With this information identify *priority drains* that need improvement work with the aim of reducing nutrient export to the Scott River, while maintaining essential drainage functions. Priority drains in some areas have been identified in this Plan (Appendix A).	M
4.5	Adopt appropriate survey and design techniques for constructed drains (see Section 5.3.3.2 pf this Plan).	H
4.6	Design or redesign farm scale drainage for the intended land uses. Land use specific water management guidelines (WMGs) were prepared in 2001 as part of the Scott Coastal Plain Strategy. These guidelines are still relevant today. Some generic WMG actions are: • *Adopt a maximum depth* of catchment scale drainage and waterways to reduce the risk of erosion and effect on draining groundwater and lowering the water table. Where possible use levees and bunds rather than excavated channels. • *Leave a buffer* alongside all watercourses, drains, standing water and/or where standing water will develop. For larger watercourses (class 4+) a 30 m buffer along each side consisting of at least long grass, sedges, reeds and some shrubs. If the watercourse is already vegetated this should be maintained and protected from livestock browsing.	M

	• *Fence watercourses and waterbodies* to stop livestock access to prevent the loss of protective vegetation, bank collapse, erosion, and direct application of nutrients from animal manures. • Don't attempt to divert large watercourses. Large watercourses can be fenced off and revegetated. Revegetate channels and buffers where needed with perennial grasses, reeds, sedges and small shrubs • Where livestock have access establish a fenced buffer at least 30 m (15m as a bare minimum) from each side of catchment scale (4th order) watercourses. • Relocate intensive agricultural activities out of the watercourses. • *Avoid fertilising, cultivating or spraying* areas that are known to convey drainage or to become inundated. • Avoid using drains and watercourses as *access roads, end of row turnarounds* or stock routs unless designed to do so. • *Manage effluent* to reduce drainage of nutrients into nearby waterways.	
4.7	Focus upgrade works on smaller watercourses. Stabilisation of major arterial drains is not recommended. Prioritise the stabilisation of degraded and denuded watercourses close to and that discharge directly into the Scott River channel.	M
4.8	Consider other land uses to minimise nutrient export for example the integration of tree plantations alongside irrigated farmland so as to maximise the absorption of groundwater and nutrient seepage.	M
4.9	Assess the feasibility of returning drains to more natural condition, and manage surface water in different ways within the farm taking into consideration how climate change may cause to change farm practises.	H

6.2 Recommendations for supporting organisations

Table 22: Recommendations for supporting organisations

Recommendation 5: Continue to investigate Catchment conditions and waterway health.				
Action		SRAP priority	Leading agency	Support agencies/stakeholders
5.1	Continue fortnightly water quality monitoring at the existing monitoring sites.	H	DWER	
5.2	Continue to assess river condition as part of the DWER Healthy Rivers Program.	H	DWER	LBLCDC
5.3	Review the water quality monitoring program, including the need for additional sites.	H	DWER	Scott River Catchment landholders, LBLCDC
5.4	Further investigate the correlation between nutrient concentrations, rainfall, temperatures, and environmental flows, informing the issue of recurrent algal blooms in the Hardy Inlet.	H	DWER, LBLCDC	
5.5	Investigate the role of tannins in inhibiting algal blooms and reducing nutrients in low flows	L	DWER, LBLCDC	
5.6	Carry out regular analyses of P and N concentrations and loads to monitor progress towards water targets.	H	DWER	
5.7	Investigate in-flows and out-flows at key sites to determine changes in nutrient water quality and nutrient budgets. This is to establish the source of nutrients at the farm scale (from milking sheds, from paddocks etc) and the impacts of farming activities on nutrient values. In light of the potential P export undertake some shallow groundwater sampling at intensive agricultural sites to better understand the nutrient levels, absorption capacity and potential for mobilisation in the future.	M	LBLCDC	DWER

5.8	Investigate the interaction between surface water and groundwater systems to enable assessment of the potential for combined impacts on river systems as a result of groundwater abstraction and rainfall decline. For example, will this be a factor in nutrient levels in river flows?	M	DWER	LBLCDC
5.9	Investigate the impact of blue-gum plantations on ground water, surface water (incl. water pH). It should also include mapping of existing plantations in relation to drains and groundwater flows.	M	DWER	LBLCDC
5.10	Maintain a record of implemented projects and actions.	H	LBLCDC	
5.11	Complete the assessment of foreshore condition along main channel.	L	LBLCDC	DWER, DBCA, DPIRD
5.12	Continue to collect rainfall data from landholders to allow for further long-term trend analysis and study.	H	LBLCDC	DWER, DPIRD
5.13	Building on the soil testing work of REI, conduct a study on the barriers to adoption of optimum fertiliser use practice by landholders and on the effectiveness of 'best practice'.	L	LBLCDC	DPIRD
5.14	Gather data on stock numbers.	M	LBLCDC	Landholders, DPIRD
5.15	Continue to conduct flora and fauna surveys targeting protected and threatened species.	L	DBCA, Landholders	
Recommendation 6: Support the identification and implementation of best practice fertiliser management.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
6.1	Continue to provide government programs, research and trials to support landholders to make more informed nutrient management decisions (e.g. the Whole Farm Nutrient Mapping, uPtake) that optimise productivity and minimise nutrient loss.	H	DPIRD	LBLCDC

6.2	Deliver a long-term local, strategic landholder and industry engagement process that promotes the benefits of improved fertiliser regimes and the usefulness of soil testing and mapping and that encourages landholders to implement fertiliser management practice that optimises productivity and minimises nutrient loss. The engagement process should include: i) demonstrations and trials of various soil amendments and fertilisers (such as N, K and lime) to ground-truth concepts and build landholder confidence. ii) <u>for plantations:</u> assess optimum fertiliser on soil types relevant to the Scott River catchment. Arising from these trials develop high-level technical advice regarding nutrient requirements of blue gums to enable this industry to participate in best-practice fertiliser management programs. iii) whole farm plans which include soil type mapping to identify identifies soil types at a farm scale level. iv) Sharing of lessons learnt from trials and projects.	H	LBLCDC	DPIRD, DWER
6.3	Support landholders to carry out farm fencing and paddock management that mirror the more detailed soil type mapping – allowing for more accurate fertiliser applications to paddocks.	M	LBLCDC	Scott River landholders
6.4	Continue to provide an engagement and communication support role in project uPtake and WFNM program.	M	LBLCDC	
6.5	Attract and implement more demonstrations and trials of various soil ameliorants and fertilisers (such as N, K and lime) to ground-truth concepts and build landholder confidence.	H	LBLCDC	
6.6	Undertake a pilot sub-catchment soil type mapping project in collaboration with landholders that identifies soil types at a farm-scale level. Soil mapping should be conducted at the farm scale in order to identify at a more detailed level, soil types more prone to nutrient leaching (supporting organisations).	H	LBLCDC	Scott River landholders
6.7	Share the lessons learnt from a network of landholders who are involved in innovation and conducting many different trials, through workshops, farm field days and provision of information (LBLCDC).	H	LBLCDC	Scott River landholders

6.8	Building on the soil testing work of REI, conduct a study on the barriers to adoption of optimum fertiliser use practice by landholders in the Scott River Catchment and on the effectiveness of 'best practice' (LBLCDC).	L	LBLCDC	
6.9	Provide regular technical support to landholders for most accurate interpretation of soil tests (supporting organisations).	M	LBLCDC	
Recommendation 7: Support the identification and implementation of farm-specific, best practice solutions for designing or upgrading effluent systems.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
7.1	Continue government programs that assist with on farm decisions around system components and characterising input volumes and constraints.	H	Western Dairy, LBLCDC	Universities, DWER
7.2	Provide support to dairy farmers for the development of business plans to analyse cost effective solutions, conduct cost benefit analysis and communicate capital investment proposals to potential lenders or investors.	H	Western Dairy	LBLCDC, DWER
7.3	Support/encourage the assessment of agronomic value of effluent for specific farms, including the benefits of separating the solid and liquid components.	H	Western Dairy	LBLCDC, DWER
7.4	Develop farm friendly toolkits or check lists to understand potential shortfalls and economic gains in effectively utilising effluent on farm.	H	Western Dairy, LBLCDC	LBLCDC, DWER
7.5	Review and share the outcomes of the AMRCCE case study on the Z-filter for the benefit of surrounding landholders. Use this farm as a demonstration site to share knowledge and new technology implemented.	H	AMRCCE	Western Dairy, LBLCDC, DWER
7.6	Provide advice or services to landholders for effluent pond testing to assess nutrient components concentrations for more effective reuse.	M	Western Dairy	

7.7	Monitor fertiliser applications so a detailed understanding of Catchment scale fertiliser use can inform future management strategies.	H	LBLCDC, DPIRD	DWER
7.8	Organise workshops and seminars with independent experts and industry representatives to help landholders identify potential options, best practice techniques, success stories in the region and novel ideas. (Follow LBLCDC Talking After Hours model). This format could also be used to look at some of the recommendations in the alternative technologies review (Price and Tait 2019) including low cost rainfall and sand diversions.	.H	Western Dairy	Industry, Universities, LBLCDC
7.9	Assist landholders to develop whole farm plans which include all aspects of capturing, storing and reusing dairy shed effluent to protect water quality and reduce the need and cost of fertiliser on areas where effluent is applied.	H	Landholders	LBLCDC, DWER
7.10	Establish a point of contact and comprehensive list of service providers for the Scott River Catchment. Preferably providers / local consultants should have received training in best practice effluent system design.	M	LBLCDC	Western Dairy
7.11	Support landholders to carry out on-going water quality monitoring to monitor the effects of the new effluent systems or upgrades.	H	LBLCDC, DWER	
Recommendation 8: Support landholders to protect or improve the condition of riparian land.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
8.1	Provide support to landholders to design/plan restoration projects so that they follow appropriate processes of planning, implementation, monitoring and evaluation to improve the chances of achieving the desired restoration outcomes.	H	LBLCDC	Landholders, DWER
8.2	Collaborate with landholders to implement recommended priority projects identified through the FCA (Appendix A).	H	LBLCDC	Landholders, DWER
8.3	Encourage and assist landholders to provide habitats for wildlife. Ecological corridors are highlighted in the foreshore condition assessment and sub-catchment planning would help prioritizing and costing works.	M	LBLCDC	Landholders, DWER

8.4	Engage landholders in further discussions about the benefits of adopting riparian works in particular economic ones with local specific examples and analysis.	H	LBLCDC	DWER, DPIRD
8.5	Work with landholders and plantation operators to identify harvest schedules and determine the likelihood of future land use back to other agriculture and if so, identify possible fencing projects of waterways and remnant vegetation to undertake as part of the transition (plantations)	M	LBLCDC, Plantation managers	DWER, DPIRD
8.6	Undertake trials and evaluation of management actions implemented, including the evaluation of the effect of revegetated riparian buffers on achieving the project objectives.	H	LBLCDC	DWER, DPIRD
8.7	Investigate the effectiveness of perennial pasture buffers for nutrient removal.	M	LBLCDC	DPIRD, DWER and landholders
8.8	Identify priority areas based on both weed species' management and asset-based management. This prioritisation work will provide a basis for seeking external grants to support the control effort at a regional scale.	H	LBLCDC	DBCA, landholders, Shires
8.9	Work together to implement a range of integrated weed control programs at different scales.	H	LBLCDC, DBCA, landholders, Shires	
8.10	Update / refine the GIS database as new information becomes available (LCDC)	H	LBLCDC	Landholders and government agencies.
Recommendation 9: Support a strategic and coordinated catchment scale approach to drainage management.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
9.1	Initiate a drainage management reference group for a strategic approach to drain management in the Catchment. This could become a function of the existing SRAG.	H	LBLCDC	DWER

9.2	Identify and map the routing of sub catchment scale waterways with landholders and land managers– and preferably with neighbours to facilitate strategic drainage planning and coordination. Include climate change considerations in the analysis.	H	LBLCDC, SRAG	DWER
9.3	Support landholders to identify priorities drains that need improvement work with the aim of reducing nutrient export, while maintaining essential drainage functions. Some priority drains have already been identified in the FCA. Update the LCDC GIS database.	H	LBLCDC, Scott River landholders	DWER, DPIRD
9.4	Support the implementation of prioritised restoration works based on recommendations from Section 5.2.4 and Appendix A – Foreshore Condition Assessment, Section 5.1.4 - Dairy effluent Management and Section 5.3.4 - Drain Management.	H	LBLCDC	DWER, Scott River landholders
9.5	Review the land use specific water management guidelines (WMG) provided in the Scott Coastal Plain Sustainability Strategy.	L	LBLCDC, SRAG	DWER, landholders
9.6	Develop a framework for prioritising waterways for management.	H	LBLCDC	DWER and landholders
Recommendation 10: Support farm-scale best management practice for drainage.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
10.1	Support landholders to prepare whole farm plans to identify the location of the various land uses and P inputs in proximity to drainage systems.	H	LBLCDC, Scott River landholders	DWER, DPIRD

10.2	Support landholders to develop management plans for farm scale drainage, including the design or redesign of farm scale drainage for the intended land uses.	M	LBLCDC, Scott River landholders	DWER, DPIRD
Recommendation 11: Foster on-going and meaningful engagement and knowledge sharing opportunities with landholders, aboriginal groups, industry and government.				
Action		SRAP Priority	Leading agency	Support agencies /stakeholders
11.1	Continue to improve collaboration and partnerships in the region by actively seeking information about landholders' priorities and needs and maintain up to date datasets from government agencies as they become available.	H	LBLCDC	Scott River community, government agencies.
11.2	Undertake on going consultation and engagement with local Aboriginal groups regarding the health and management of the river and its waterways and other Aboriginal heritage sites. Seek advice early in the process of project planning.	M	LBLCDC	Undalup Association Inc, Bibulmen Mia Aboriginal Corporation, SWALSC,
11.3	Map the Traditional Owner tangible and intangible cultural values along the full length of the Scott River and key tributaries.	M	LBLCDC	Undalup Association Inc, Bibulmen Mia Aboriginal Corporation, SWALSC,
11.4	Work with both the local governments (Augusta-Margaret River and Nannup) to develop a comprehensive invasive species map and prioritisation system to enable strategic control of highly invasive weed species and feral animals important to agriculture, conservation and DPIRD (biosecurity).	H	LBLCDC, Local Govt	DBCA
11.5	Support both local governments to incorporate findings from the SRAP into planning mechanisms to improve water quality outcomes, biodiversity and production for the river and Catchment.	H	LBLCDC	Local Govt

11.6	Develop a communication strategy for the SRAP to disseminate information about the health of the Catchment, works implemented and lessons learnt. Share lessons learnt from a network of landholders who are involved in innovation and conducting many different trials, through workshops, farm field days and provision of information.	H	LBLCDC	DWER, Local Govt, Augusta and Scott community
11.7	Utilise the recommendations from Section 4.2.3 (interviews recommendations).	H	LBLCDC	DWER, Local Govt, Augusta and Scott community
Recommendation 12: Strengthen collaboration and project ownership among landholders, government agencies, land managers, traditional owners and NRM groups for the implementation of the SRAP recommendations.				
Action		SRAP Priority	Leading agency	Support agencies/stakeholders
12.1	Designate the LBLCDC as the lead agency for developing and coordinating the implementation of the SRAP. The LBLCDC is to work in partnership with the agencies with land management responsibilities in the Scott River Catchment and the local farming community.	H	SRAG, LBLCDC	DWER, DPIRD, Western Dairy
12.2	Coordinate funding to ensure the LBLCDC is properly resourced to implement the Plan.	H	LBLCDC, SRAG	DWER, DPIRD, Western Dairy
12.3	Establish a Scott River implementation reference group or continue the existing SRAG. It could incorporate a sub-catchment specific group or an issue specific group (e.g. drains).	H	LBLCDC, DWER, Scott River landholders	Local Govt, DPIRD, Industry, DBCA
12.4	Develop an Implementation Strategy that includes further details on targets, timeframes, funding sources and partnerships to ensure efficient delivery of recommended management actions.	H	LBLCDC, DWER	Scott River landholders, DPIRD, DBCA, Local govt

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APPENDIX A

Foreshore Condition Assessment (Maps & Tables)

Using the maps

A series of maps has been developed that show the entire sub-catchment, cadastral boundaries and the foreshore condition overview for the sites assessed through both fieldwork and aerial photograph interpretation. The maps are based on the six priority sub-catchments.

The first map is a key map for the portion of the sub-catchment being reviewed, survey type and remnant vegetation communities and the second shows foreshore condition (as assessed using the Pen-Scott method). Key features such as erosion hotspots, infrastructure and priority native vegetation that is in private ownership (freehold) only.

The third map shows the fencing status where possible (left and right banks), weeds using priority coding rather than specific species and key management actions. Note that the definition of left and right banks is based on the assumption that the map reader is looking upstream. Legends are provided on all map types.

The background aerial imagery of the map was taken in 2017 (Leeuwin and Nannup).

7.1 Lower Scott

The description below refers to the most downstream reaches of the Scott River and its tributaries in the study area, on Scott River Road and extends approximately 3.6 kilometres upstream to the start of the Middle Scott sub-catchment. The main channel was walked entirely along the South Bank and for about two-thirds of the north bank. The upper and lower portions of the tributary were also assessed on foot, with the central bull paddocks inaccessible at the time of the survey. These portions were completed through aerial photograph interpretation.

Description for Sections LS01 to LS11

Feature	Comments
Landuse	Dryland and irrigated beef cattle grazing are the dominant land uses, with some remnant vegetation persisting in the paddocks and the majority of the riparian zone well vegetated. A dairy is located in the northern part of the tributary in Section 1.
Land tenure	The Scott River riparian zone is protected by two parcels of land. Immediately upstream of the Scott River Road Bridge is a Crown Reserve vested in the Shire of Augusta-Margaret River (R42942). The Reserve covers 3.96 Ha for the purpose of Conservation of Flora and Fauna. Upstream of R42942 is Vacant Crown Land covering 102.65 Ha. The freehold priority agriculture parcels that adjoin the river reserves are Lots A, B, C and D and Lots E and F. The northern tributary passes through Reserve R12951 which is vested in the Shire of Augusta-Margaret River for the purposes of water, camping and recreation. The assessment of the northern tributary terminates in Lot G.
Fencing	The waterway is fenced in Sections LS01 to LS02, partially fenced from LS02 – 03, fully fenced from LS02 – LS11 on the main channel. The northern tributary was predominantly unfenced as the waterway passes through Lots C and D. The upstream end of the waterway is entirely unfenced through Lot G.
Crossings	LS04 and LS05 enable flow beneath Governor Broome Road through single and double culverts. There is a rocky ford just downstream of the Department of Water and Environmental Regulation Weir (LS11 and MS1).
Stock watering	Where the northern waterway passes through pasture, stock has unrestricted access to the creek. Fencing prevents stock access to the main Scott River channel although gates are present at the boundary fence between Lots A and F.
Wastewater	There is a dairy overflow that runs parallel with the driveway into Lot G and re-joins the waterways assessed in this project within the road reserve. There is a degraded wetland that could be restored and/or converted into a more effective wastewater treatment wetland.
Remnant vegetation	There are seven vegetation communities that have less than 30% protected within the conservation estate in this sub-catchment. Of these, one vegetation community occurs only in private land and another has less than 10% of its original extent in conservation estate.

Condition for Sections LS01 to LS11

Feature	Comments
Vegetation	• The portion of the northern most tributary, upstream of Governor Broome Road retains isolated Freshwater paperbark (*Melaleuca rhaphiophylla*) over a chaotic weed assemblage and pasture. Where the waterway passes through pastures, there is no original vegetation remaining. • The margins of the main river channel are well vegetated and ranges from near pristine to good while the verge vegetation varies in extent and quality. • The riparian zone has a variable width overstorey dominated by Freshwater paperbark (*Melaleuca rhaphiophylla*) and Modong (*M. preissiana*) with continuous and patchy Bare twig rush (*Baumea juncea*) sedgeland with *Baumea riparia*, *Anarthria scabra* and *A. prolifera*, Sheath twig rush (*Baumea vaginalis*) with *Lobelia* and *Alternanthera nodiflora* persist intertwined among the other vegetation. Mosaics of dense homogenous stands of each of Loose flowered rush (*Juncus pauciflorus*), *Cytogonidium leptocarpoides, Taraxis grossa* and *Empodisma gracillimum* occur intermittently. • Upstream of the gauging station there are Grey honeymyrtle (*Melaleuca incana*), *Hovea*, *Hibbertia* and Balga (*Xanthorrhoea preissii*) with annual grasses and Prickly moses (*Acacia pulchella*) on the margins. • The verge vegetation is characterised by Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*), WA Peppermint (*Agonis flexuosa*) woodland over annual grasses with occasional patches of low shrubs and sedges including Prickly moses (*Acacia pulchella*), Zamia (*Macrozamia reidlei*), *Johnsonia* sp., *Lepidosperma* spp. and Bracken (*Pteridium esculentum*). • One variation at the downstream end of the reach is an overstorey including *Callistachyus lanceolata*, *Taxandria juniperina*, Blackbutt (*Eucalyptus patens*) with *Bossiaea linophylla* and *Astartea scoparia. C*ommon understorey plants including Tall kangaroo paw (*Anigozanthos flavidus*) and Weeping rice grass (*Microlaena stipoides*). Other parts are effectively parkland cleared with overstorey and limited persisting clumps of low shrubs and herbs. • The emergents *Ottelia ovalifolia* and *Ornduffia* occurred in some river pools. The turbidity reduced visual identification of aquatic plants.
Weeds	• While not evident at the time of survey, anecdotal evidence suggests that the Declared Plants One leaf Cape tulip (*Moraea flaccida*) is widespread and Apple of Sodom (*Solanum linnaeanum*) occur in small numbers. • Common weeds include Fleabane (*Conyza* spp), Docks (*Rumex crispus* and *Rumex conglomeratus*), Jersey cudweed (*Symphyotrichum luteoalbum*) and Common Centaurium (*Centaurium erythraea*) although their distribution is limited. The density of weeds is highly variable. • The riparian margins have populations of Redshank (*Persicaria maculata*) starting to dominate where there is mobile sediment. • Other widespread weeds were in the understorey include Pennyroyal (*Mentha pulegium*), Yorkshire fog (*Holcus lanatus*), Flat weeds (*Hypochaeris*) and Cape weed. The pasture species Kikuyu (*Pennisetum clandestinum*) is impacting on the margins in some places,

Feature	Comments
Bank stability and erosion	• Within the remnant vegetation and dense riparian zones, the Scott River banks and channel bed were stable. There are localised erosion points and headcuts where tributaries join the main channel (LS02). • There are some Sections of braided stream where the floodplain broadens. • Where the waterway passes through pasture, cattle movement and grazing is resulting in low levels of erosion of the banks and bank collapse, widening the waterway. Loss of perennial native vegetation and a transition to more annual species makes the risk of erosion greater over time. • Pasture grasses can provide a significant degree of stability to the bed and banks of the waterway; however, cover is easily lost or reduced through intensive grazing and seasonal dying off. This exposes the channel to a higher risk of flood erosion than in naturally vegetated areas.
Special features, other comments	• Some portions of the foreshore were not assessed on foot as permission was not granted. • The shells of a freshwater mussel were found on the banks of some river pools. • Investigations into joining Reserve R42942 to the Vacant Crown Land upstream could be considered to afford greater protection and management, in consultation with the adjoining landholders and the Shire of Augusta-Margaret River. • The potential to change the purpose of the vesting of R12951 from Water, Camping and Recreation to Conservation of Flora and Fauna could also be investigated.
Aquatic habitat	• The pools were generally stagnant and turbid. There was evidence of invertebrate activity in all pools in this Section. • Considerable woody debris and overhanging branches offer good stream cover and diverse habitat within the many pools.
Terrestrial Native fauna	• There was considerable evidence of water bird roosting sites including cormorants.
Terrestrial Invasive species	• Evidence of foxes and feral cats was found along the river length. Rabbit warrens were also present.

Management Priorities for Sections LS01-01 to LS11

Generalised management suggestions are:

- Stabilise the access into the DWER gauging station as track use is impacting upon track stability.
- Liaise with adjoining landholders about the use of stock to achieve fuel load reduction without compromising remnant vegetation integrity in the vacant Crown Land.
- Encourage control of roadside weeds to prevent their establishment in the road reserves and passing through R12951.
- Monitor fences along waterways and unfenced portions of waterways and seek to isolate from stock if possible, to aid with mustering, stock management and avoid erosion.
- Encourage landholders to prevent garden plant incursions into the Scott River Reserve, including Agapanthus (PP82).
- Liaise with landholder to target feral animals on a regular basis, particularly feral pigs, foxes and rabbits.

Key management actions for Sections LS01 to LS11

Issue	Issue Management Action/Advice
Terrestrial Invasive species	• Target the Declared Plants One leaf Cape tulip and Apple of Sodom consistently in the Vacant Crown land (DWER) and support action by the adjoining landholders in accordance with the BAM Act. • Consider controlling Redshank while its distribution is limited in the river reserve, to protect high quality riparian vegetation. • Control African lovegrass and Stinkwort while the populations are relatively contained. • Expand the survey to roadsides and other landholders to enable the development of a catchment-wide invasive species plan. • Encourage landholders, the LCDC, local government, local community and weed action groups to undertake weed management. • Encourage regular coordinated feral animal control through the catchment.
Fencing and loss of native vegetation	• Continue to maintain and replace old fences along the riparian zone including the tributaries and seepage areas to restrict stock access. • Encourage fencing to exclude stock from the channel floors and remnant vegetation throughout the property, and develop a program for weed control to encourage natural regeneration processes (PP12, PP13, PP16, PP18). • Encourage protection of the remnant wetland vegetation as recruitment of native plants is poor.
Water Quality	• Liaise with the landowner in collaboration with Western Dairy to discuss site specific solutions for effluent management and nutrient export to improve filtration of waste from the dairy and stockyards upstream of Governor Broome Road, prior to the water and manures being transported down the waterways and contributing to the Scott River (PP15). • Avoid stock access to the creek and seepage areas over winter and spring to reduce bed and bank erosion and nutrient transport downstream. As mentioned above, encourage the landholder to fence off the tributary and restrict stock access. • Protect dams and soaks from direct stock access and use off-line watering points where practicable.
Erosion management	• Review options to slow the velocity of water from tributaries into the main channel to avoid further undermining of riparian vegetation and sediment discharge into the main river channel (PP17). • Review DWER track access to gauging station and ensure it is adequately maintained to avoid erosion (PP84).

Sample photos from Sections LS01 to LS11

Plate 1: Evidence of mussels is present adjacent the waterways.

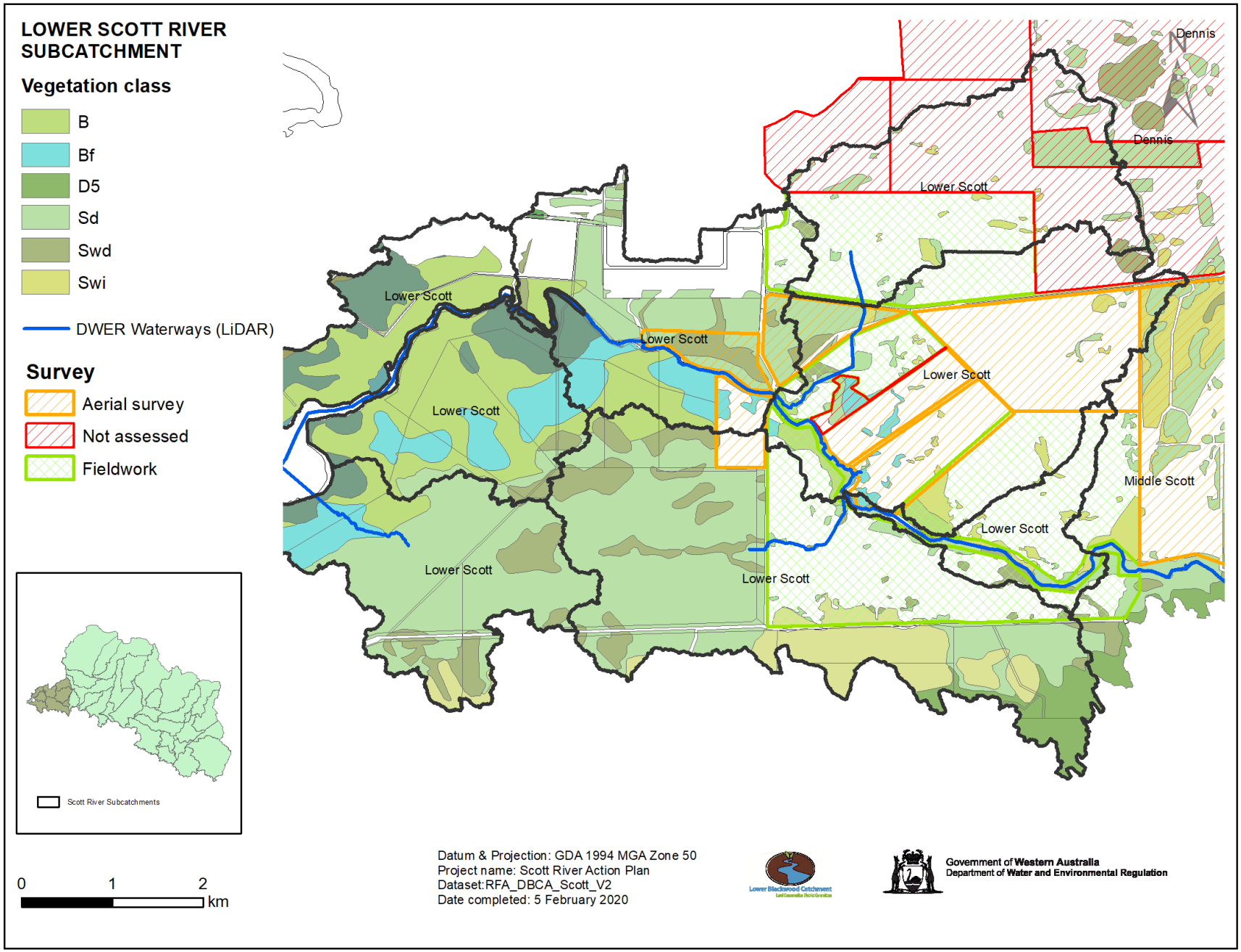
Plate 2: Stagnant pool with good remnant vegetation cover.

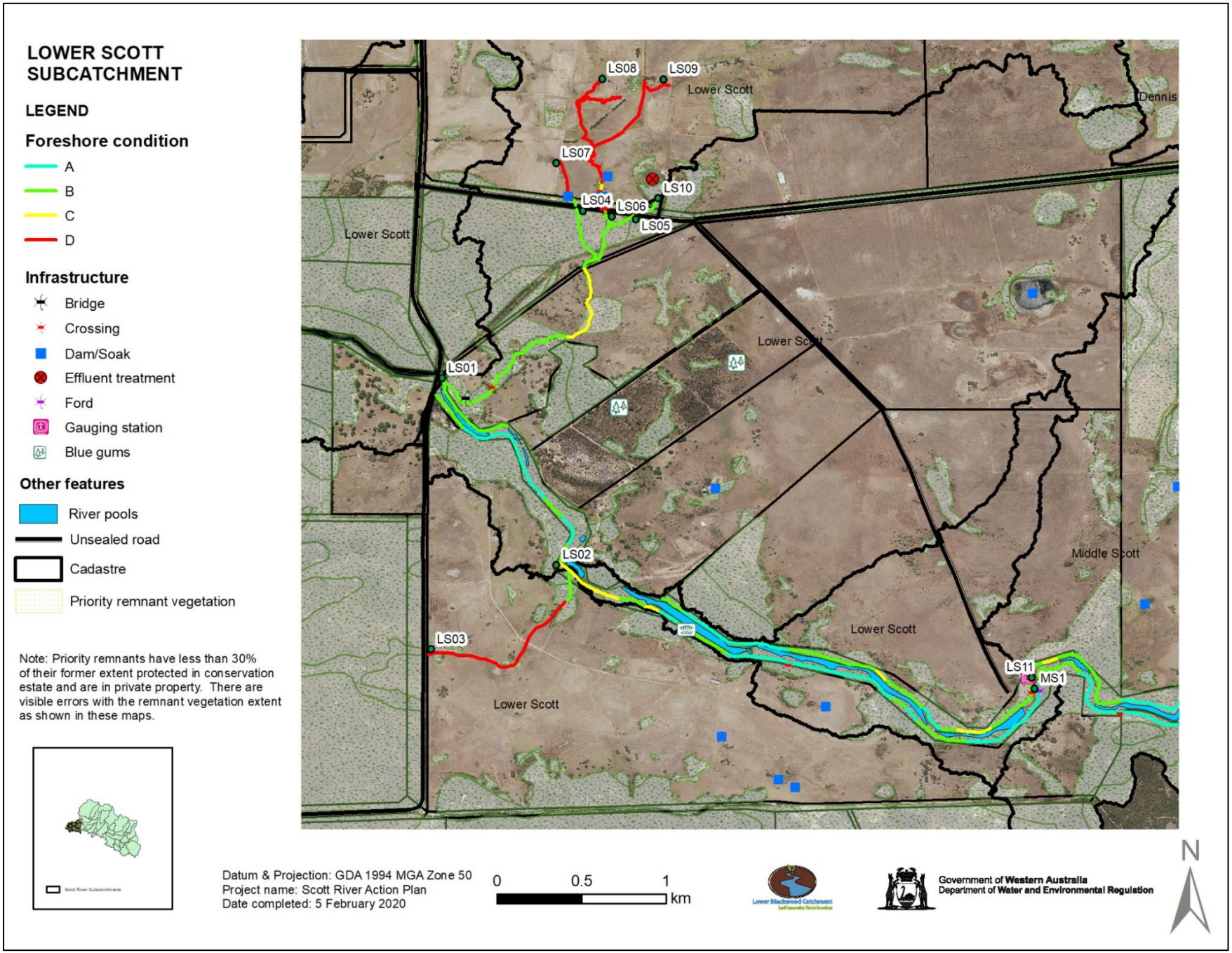
Plate 3: Excellent condition riparian zone.

Plate 4: Substantial river pool.

Plate 5: Narrow unstable tributary (LS02) showing undercut trees with exposed roots.

Plate 6: Grazing is impacting on the riparian zone.


LOWER SCOTT RIVER SUBCATCHMENT
Vegetation class
B
Bf
D5
Sd
Swd
Swi
DWER Waterways (LiDAR)
Survey
Aerial survey
Not assessed
Fieldwork
Scott River Subcatchments
0
1
2
km
Dennis
Dennis
Lower Scott
Lower Scott
Lower Scott
Lower Scott
Lower Scott
Lower Scott
Lower Scott
Lower Scott
Middle Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Dataset:RFA_DBCA_Scott_V2
Date completed: 5 February 2020
Government of Western Australia
Department of Water and Environmental Regulation


LOWER SCOTT SUBCATCHMENT
LEGEND
Foreshore condition
A
B
C
D
Infrastructure
Bridge
Crossing
Dam/Soak
Effluent treatment
Ford
Gauging station
Blue gums
Other features
River pools
Unsealed road
Cadastre
Priority remnant vegetation
Note: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.
LS08
LS09
Lower Scott
Dennis
LS07
LS10
LS04
LS06
LS05
Lower Scott
Lower Scott
LS01
LS02
Middle Scott
Lower Scott
LS03
LS11
MS1
Lower Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020
0
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km
Government of Western Australia
Department of Water and Environmental Regulation
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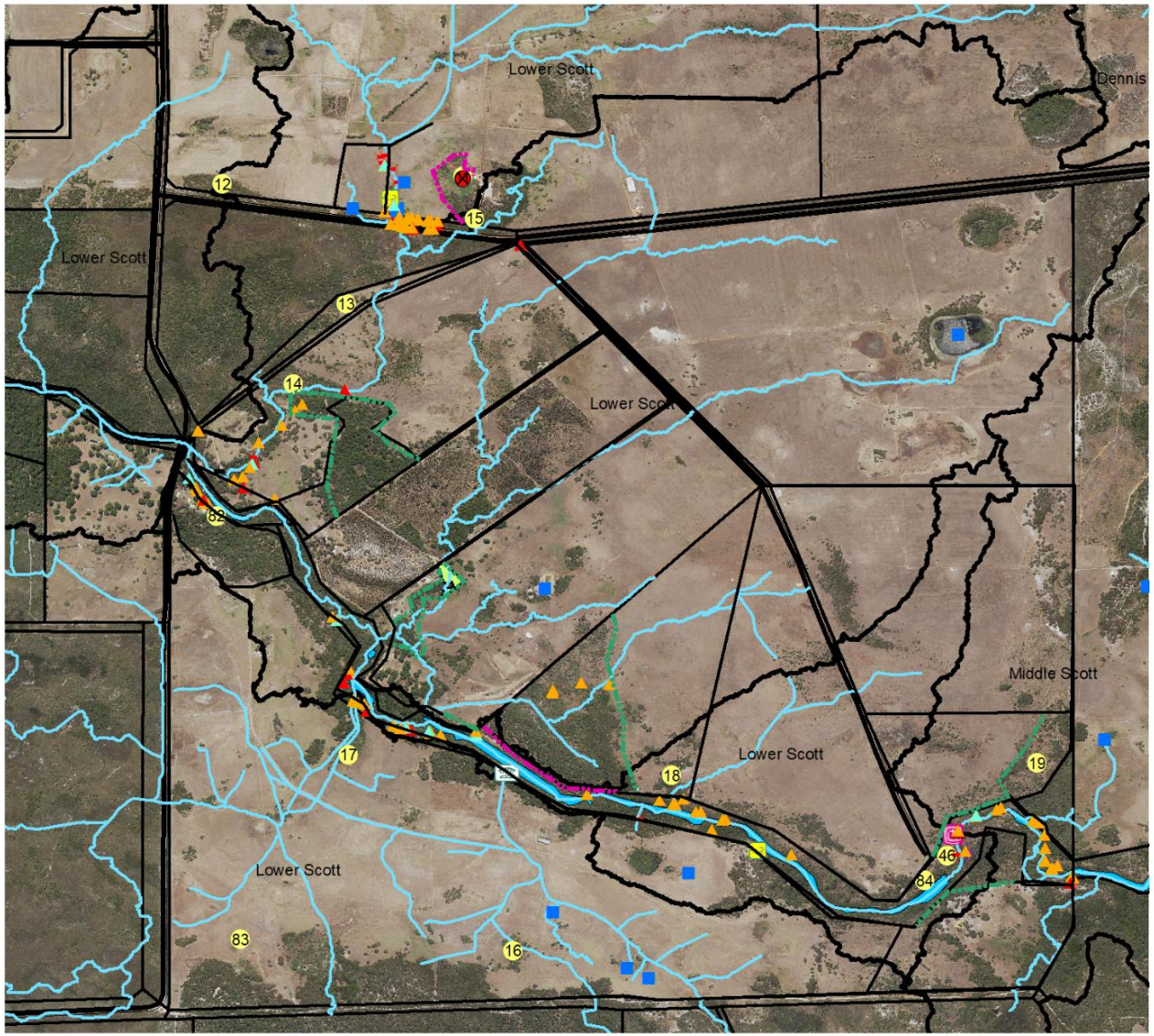
LOWER SCOTT SUBCATCHMENT



LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral animals
- Potential revegetation nodes
- Erosion

Fencing

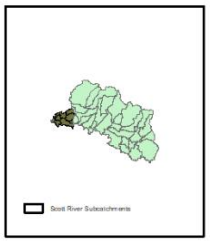
- Existing fence
- Potential fence
- Previous grant

Infrastructure

- Dam/Soak
- Crossing
- Effluent treatment
- Gauging station
- Ford
- Bridge

Other features

- DWER Waterways (v9)
- Subcatchment boundaries (v9)
- Cadastre
- Previous revegetation grant
- River pools



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

Government of Western Australia
Department of Water and Environmental Regulation

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7.2 Middle Scott – Lower Reaches

The description below covers the lower parts of the Middle Scott River sub-catchments from Lot Numbers A, H, JJ and a portion of Vacant Crown Land along the main Scott River channel. Two separate Sections of waterway comprise this description of the sub-catchment.

The westerly tributary was assessed through aerial photography and the easterly one, through field survey. The easterly sites have waterways that contribute to two sub-catchments – Middle Scott and Dennis.

Description for Sections MS1 to MS8

Feature	Comments
Landuse	Pivot cropping, irrigated dairy and dryland grazing all occur in these parcels.
Land tenure	The Sections of the main river channel and two tributaries assessed pass through Freehold land (Lots A, H and JJ)
Fencing	Both banks of the main Scott River channel from MS1 to MS2 are fenced within Lot A with a significant area of remnant vegetation on the verge and within the riparian zone. Aerial photograph interpretation suggests that the waterway is unfenced through Lot H for MS1 to MS2 and again from MS2 to MS3. Portions of the waterway in Lot JJ are fenced on one bank and facilitates direct access to parts of the waterway through the pivot system between crops (MS6 to MS7 and MS8). In Lot JJ, there is a boundary fence between the mixed farming areas and tree cropping zones.
Crossings	Compacted gravel over dual culverts are used throughout the blue gum plantation.
Stock watering	It appears from aerial photograph interpretation that stock have unrestricted access to the entire waterway length (MS2 to MS3) apart from the headwaters. Stock have direct access to some waterways through the property with only one side fenced in Lot JJ.
Remnant vegetation	There are four vegetation communities that have less than 30% protected within the conservation estate in this sub-catchment. One vegetation type only occurs in private land.

Condition for Sections MS1 to MS8

Feature	Comments
Vegetation	The riparian zone and the adjoining verge are intact in Sections MS1 to MS2 and MS2 to MS4. The overstorey is dominated by Freshwater paperbark (*Melaleuca rhaphiophylla*) and Modong (*M. preissiana*) with continuous and patchy Bare twig rush (*Baumea juncea*) sedgeland with *Baumea riparia*, *Anarthria scabra* and *A. prolifera*, Sheath twig rush

Feature	Comments
	(*Baumea vaginalis*) with. *Lobelia* and *Alternanthera nodiflora* persist intertwined among the other vegetation. Mosaics of dense homogenous stands of each of Loose flowered rush (*Juncus pauciflorus*), *Cytogonidium leptocarpoides, Taraxis grossa* and *Empodisma gracillimum* occur intermittently. The verge vegetation is characterised by Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*), WA Peppermint (*Agonis flexuosa*) woodland over annual grasses with occasional patches of low shrubs and sedges including Prickly moses (*Acacia pulchella*), Zamia (*Macrozamia reidlei*), *Johnsonia* sp., *Lepidosperma* spp. and Bracken (*Pteridium esculentum*). There appears to limited remnant vegetation between MS2 and MS3 along the waterway. There is no relic native vegetation where the headwaters of the waterways coincide with pivots in MS6 to MS7 and MS8. The southern end of Lot JJ near MS6, the remnant vegetation complexes varies from homogenous communities Freshwater paperbark (*Melaleuca rhaphiophylla*) and Scott River Cedar (*Taxandria juniperina*) to a mosaic of planted *Astartea scoparia*, Grey honeymyrtle (*Melaleuca incana*) and Bullich (*Eucalyptus megacarpa*). The understorey is highly degraded with infrequent clusters of Centella (*Centella asiatica*), Bare twig rush (*Baumea juncea*), Loose-flowered rush (*Juncus pauciflorus*) and *Alternanthera nodiflora*. Areas of lighter canopy cover supports denser weed assemblages than the densely shaded zones. Clearing of a substantial portion of wetland has occurred to facilitate tree cropping in the past, and there is evidence of waterlogging and natural regeneration where the crops appear to have failed.
Weeds	Dominant weeds include Pennyroyal (*Mentha pulegium*), Fleabane (*Conyza spp.*), Bushy starwort (*Symphyotrichum squamatum*) and Blackberry Nightshade (*Solanum nigrum*). Dock (*Rumex conglomeratus* and *R. crispus*) is widespread throughout the seasonally inundated floodplains. A large Black wattle (*Acacia melanoxylon*) is present close to the river reserve at the southern boundary. There are some Spear (Scotch) thistle plants (*Cirsium vulgare*) present.
Bank stability and erosion	Drains have been constructed and levees to manage flow throughout the property, with evidence in May 2019 of recent drain construction within the Freshwater paperbark (*Melaleuca rhaphiophylla*) woodland at the south of the land parcel. The main drain is up to 2 m wide with other trenches bucket width and 600 mm deep. There was a strong effluent odour in the newly constructed drainage lines. The main channel at the southern fenceline retains small isolated river pools however the channel bed is characterised by mobile coarse sand and appears to be becoming wider.

Feature	Comments
Special features, other comments	There are three dams in the southern portion of Lot JJ. There is an opportunity to enhance the relic wetland and perhaps explore a pilot program of a constructed wetland at the north-western side of the blue gum plantation, utilising the existing vegetation as a foundation and reinforcing it to trap effluent in Lot JJ. There was a well-maintained wedge tail eagle nest in one property. Feral pigs appear to access the wetlands along and adjoining the main Scott River channel. There was evidence of foxes and rabbits throughout.
Aquatic habitat	The drainage lines at the southern end of Lot JJ were filled with highly turbid and odorous water. No evidence of aquatic flora or fauna was observed.

To note that south of MS08 there is the DWER Healthy Rivers site. This site is described as being of high ecological value with a highly diverse community of native aquatic biota and no exotic species. In addition, there is evidence of successful recruitment with juveniles present as well as physiological signs of breeding found, indicating that this reach supports breeding. These high ecosystem values are linked to the integrity of the riparian zone and the size and quality of the broader vegetative buffer adjacent to the river. Degradation of this zone will likely impact on river health values, and therefore protecting this zone is very important to the health of this reach.

Key management Priorities for Sections MS1 to MS8

Generalised management suggestions are:

- Liaise with adjoining landholders about the potential to improve the long-term potential for the survival of the persisting remnant vegetation through selective weed management and revegetation.
- Continue a foreshore assessment survey of the main river channel between MS2 and MS5 looking for new weed incursions.
- Encourage wastewater treatment within property boundaries before water is discharged into the main river channel.
- Review boundary fencing alignments and modify if required (PP44).
- Investigate potential to reinstate former stock crossing (PP45) to provide for emergency and management access to the river reserve for weed control.

Key management actions for Sections MS1 to MS8

Issue	Issue Management Action/Advice
Terrestrial Invasive species	Develop a weed management plan to target the river reserve (MS1 to MS4) and seek funding support to manage Declared and serious environmental weeds. Liaise with the landholder to review and map the southern portion of Lot JJ and remove potentially significant weeds of the Scott River wetlands, such as Black wattle, Stinkwort, Loosestrife, Redshank and African lovegrass.

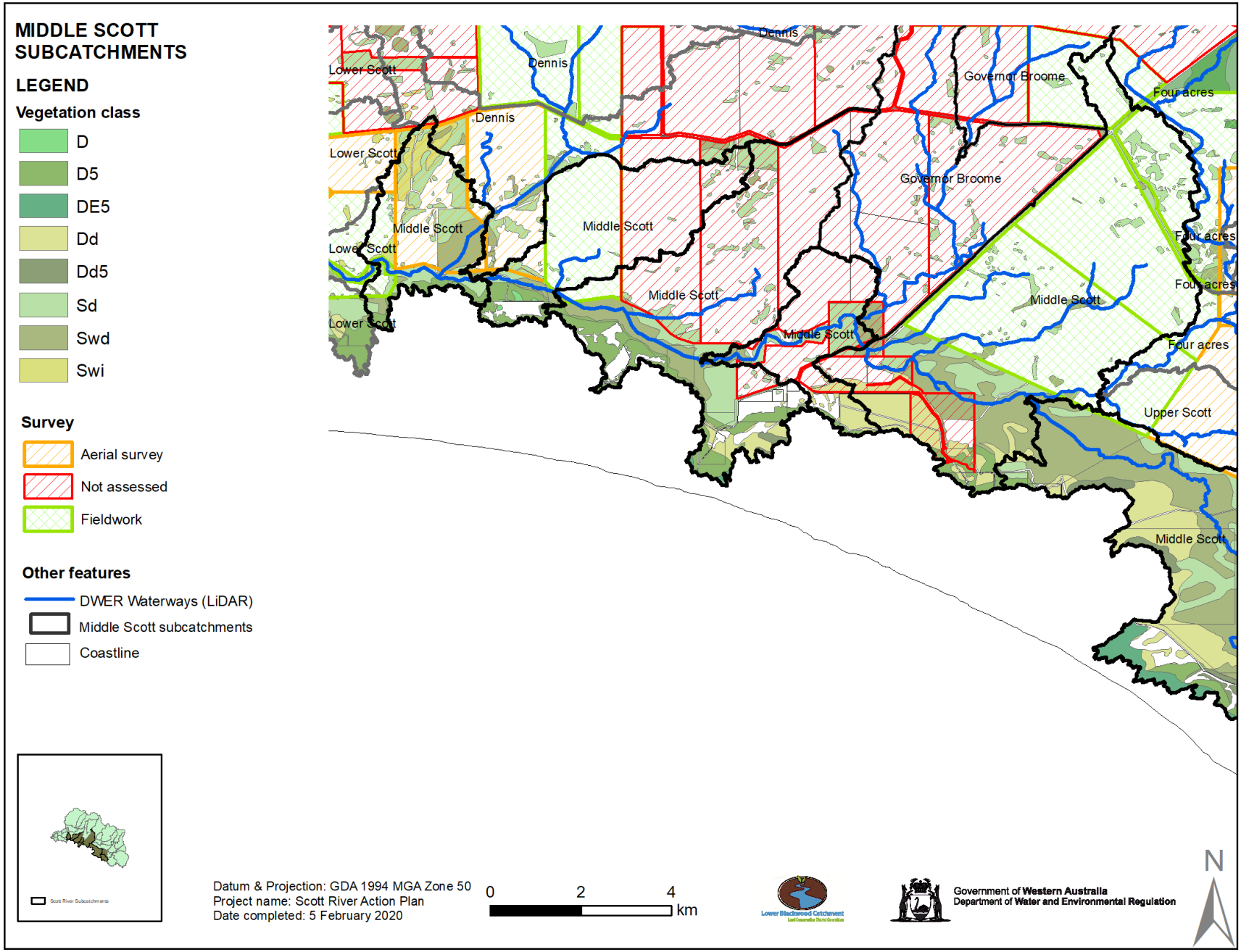
Issue	Issue Management Action/Advice
	Encourage coordinated control of feral pigs, foxes, feral cats and rabbits across the catchment and different land uses.
Fencing and loss of native vegetation	Encourage weed control and active management of the portions of land not used for farming to increase remnant vegetation value and improve water quality being discharged into the main river channel. Encourage the use of fencing to improve management capability for waterway Section MS2 – MS3, if not present (PP19). Liaise with the landholder about rehabilitating the wetland adjacent the dairy and stockyards and upstream of the blue gum plantation (PP22), to improve filtration of waste prior to the water and manures being transported down the waterways and contributing to the Scott River. Liaise with landholders about potential remnant vegetation fencing (PP20).
Water Quality	Encourage the landholder to trap water and improve filtration of faecal material, by exploring site specific solutions in collaboration with Western Dairy for effluent management and nutrient export, as there was a considerable odour associated with the water (PP21). Avoid stock access to the creek and seepage areas to reduce bed and bank erosion and nutrient transport downstream. As mentioned above, encourage the landholder to fully fence off the creek and restrict stock access. Review new drainage constructions through the blue gum plantation and seek to develop a more effective long-term solution to water and effluent management. Protect dams and soaks from direct stock access and use off-line watering points where practicable.
Bed and bank stabilisation	Monitor aerial photography to determine changes to channel health of the tributary MS2 to MS3. Should decline in bed and bank characteristics be noted, liaise with the landholder to encourage the other management actions listed above. Fence around the waterways to improve stock management options in Lot H and would reduce bank erosion, allow natural regeneration and or supplementary planting to be undertaken if required.

Sample photos from Sections MS1 to MS8

Plate 7: Shallow channel beneath Melaleuca rhaphiophylla.

Plate 8: Weed dominated waterway with remnant wetland in the background.

Plate 9: Chaotic weed assemblage beneath relic overstorey.


MIDDLE SCOTT SUBCATCHMENTS
LEGEND
Vegetation class
D
D5
DE5
Dd
Dd5
Sd
Swd
Swi
Survey
Aerial survey
Not assessed
Fieldwork
Other features
DWER Waterways (LiDAR)
Middle Scott subcatchments
Coastline
Lower Scott
Dennis
Governor Broome
Four acres
Middle Scott
Upper Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020
0
2
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km
Government of Western Australia
Department of Water and Environmental Regulation
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MIDDLE SCOTT SUBCATCHMENT

LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

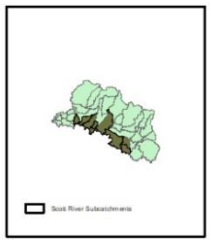
- Effluent treatment
- Dam/Soak
- Crossing
- Blue gums
- Erosion
- Gauging station

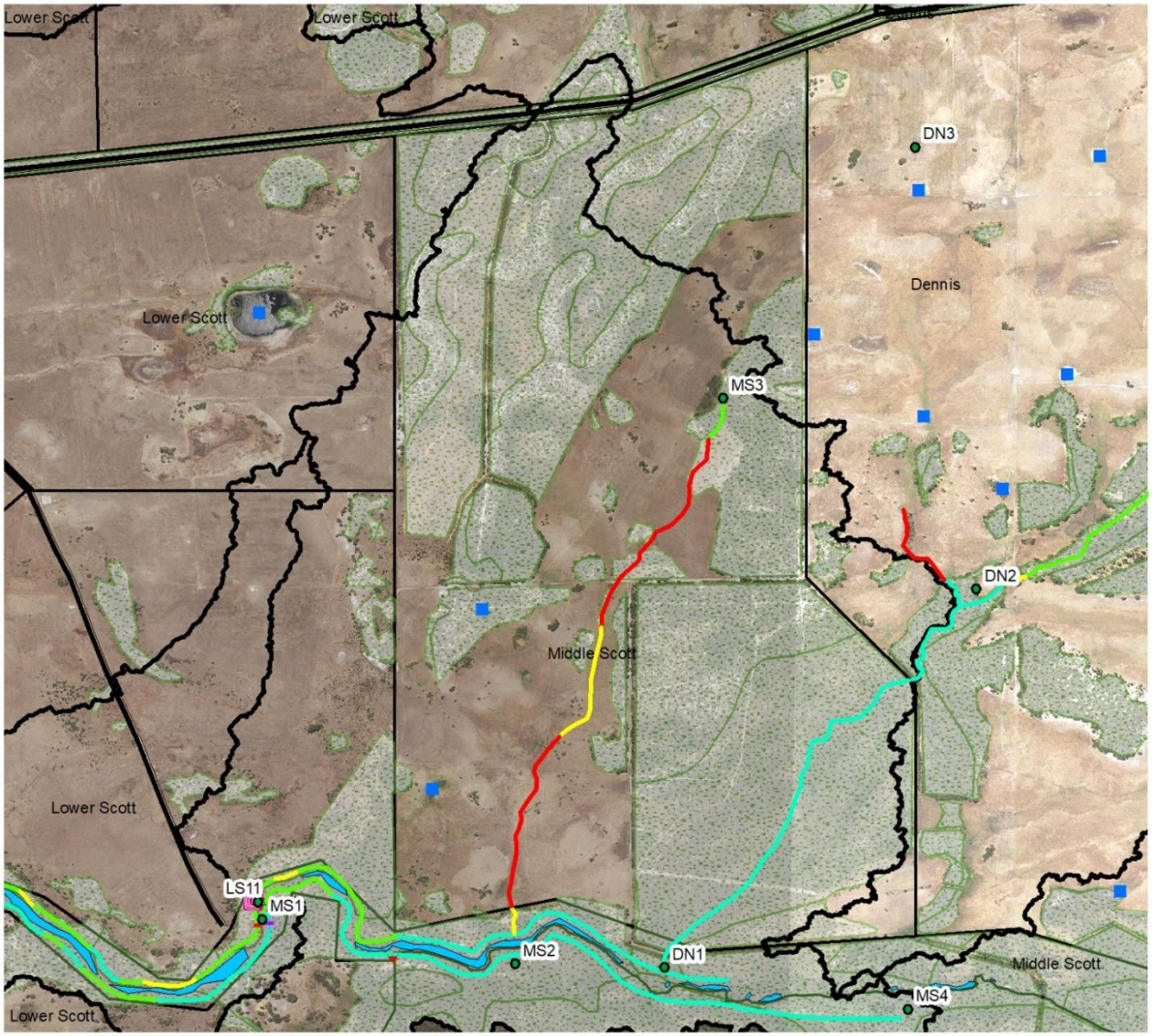
Other features

- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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Government of Western Australia
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N

MIDDLE SCOTT SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral_animals

Fencing

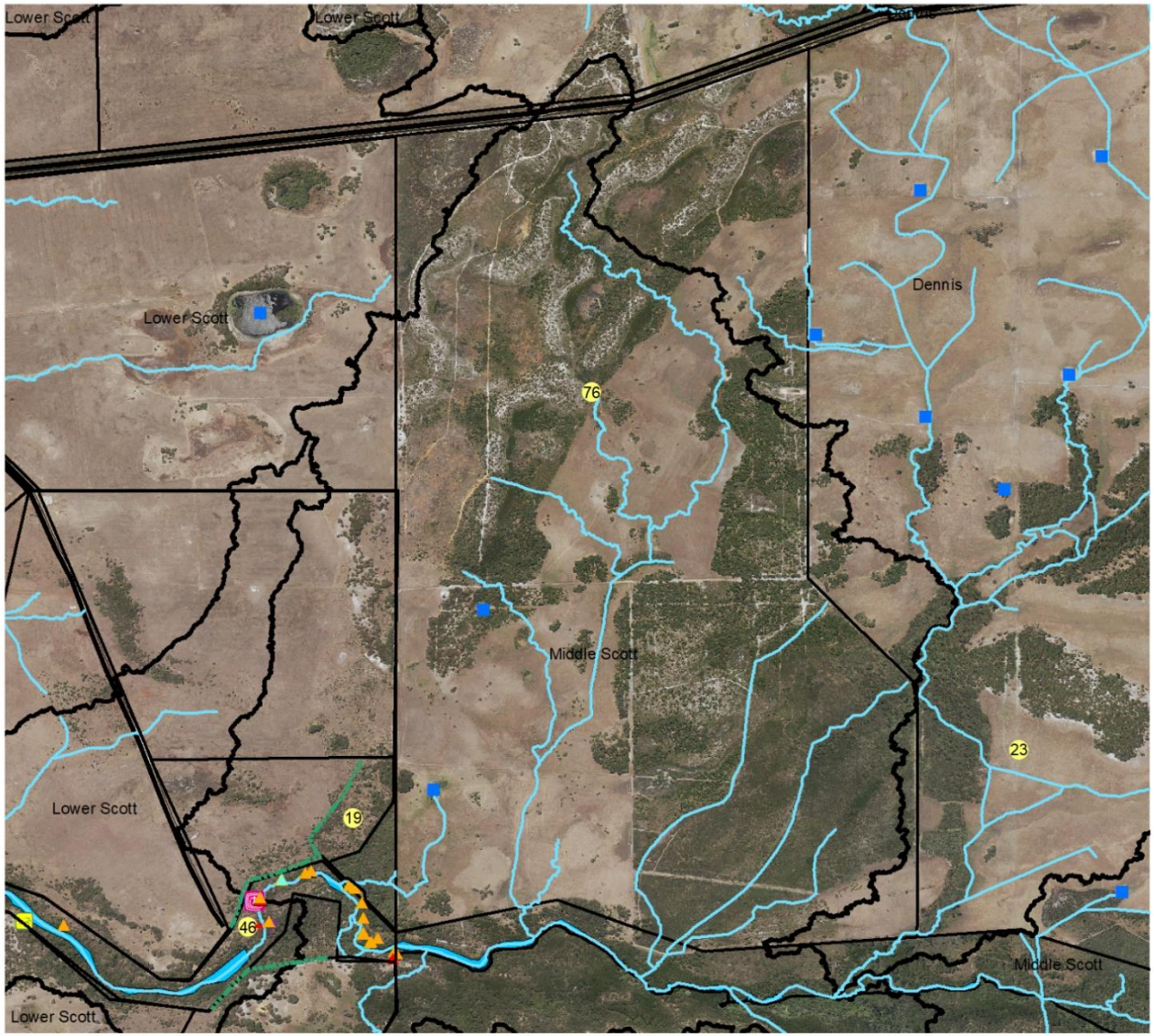
- Existing fence
- Previous grant

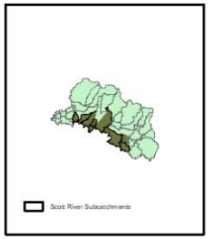
Infrastructure

- Dam/Soak
- Crossing
- Gauging station
- Ford

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre
- River pools





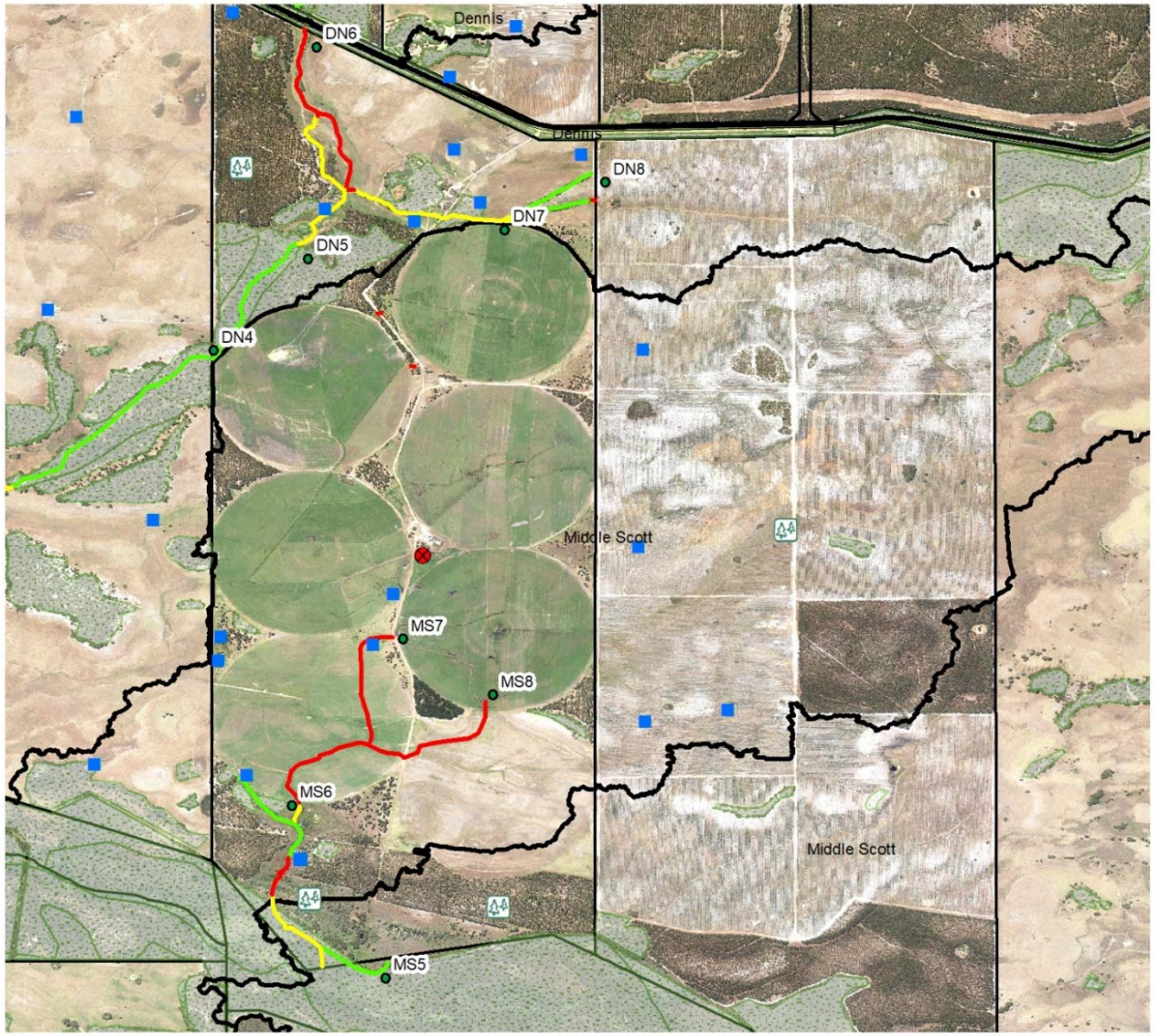
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

Government of Western Australia
Department of Water and Environmental Regulation

N

MIDDLE SCOTT SUBCATCHMENT



LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

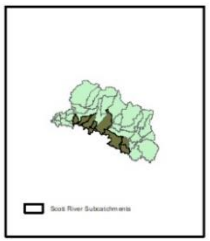
- Effluent treatment
- Dam/Soak
- Crossing
- Blue gums

Other features

- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

Government of Western Australia
Department of Water and Environmental Regulation

N

MIDDLE SCOTT SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects

Fencing

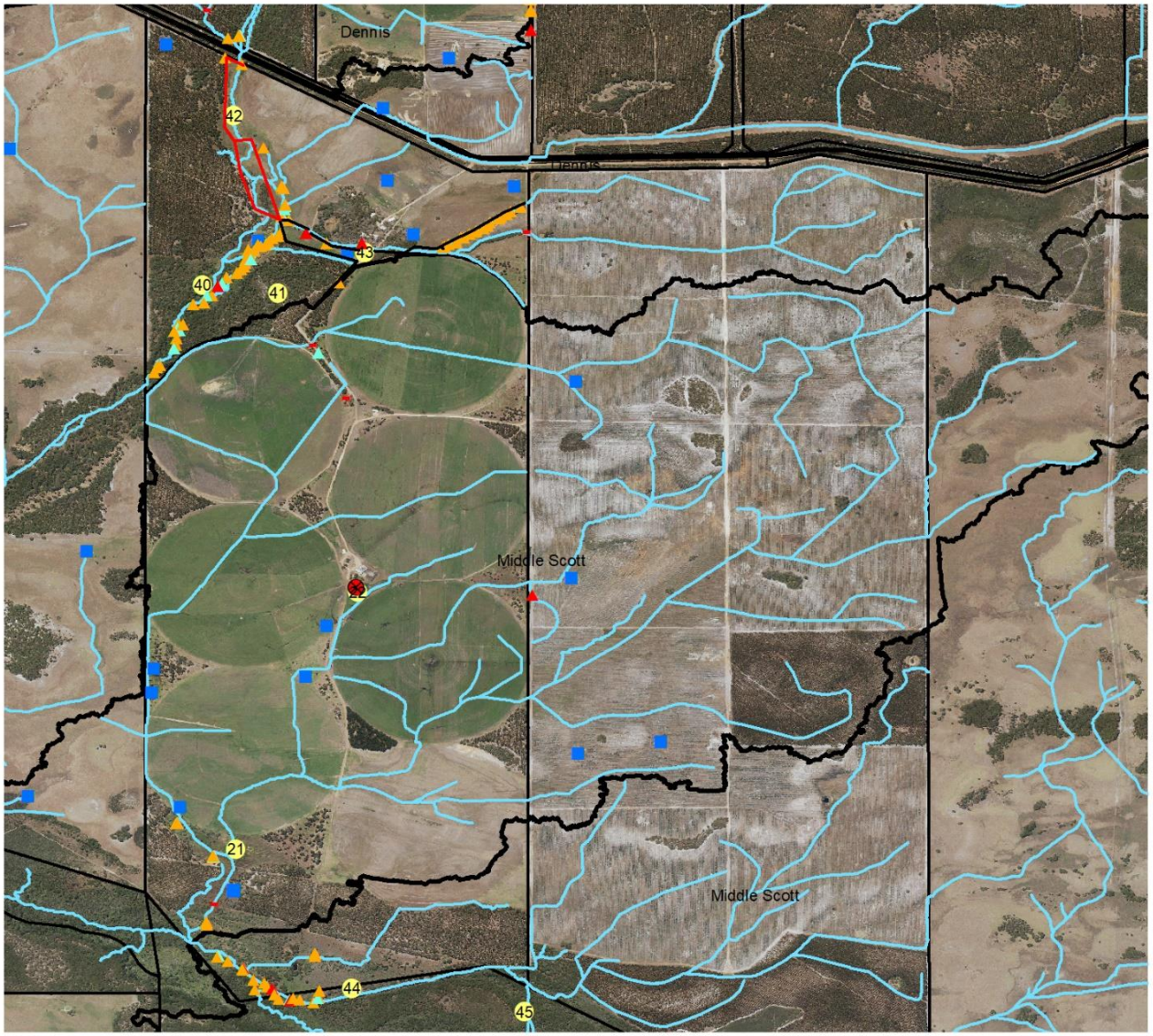
- Existing fence
- Fence maintenance required

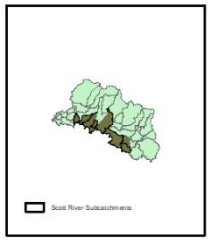
Infrastructure

- Dam/Soak
- Crossing
- Effluent treatment

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre
- Telecom cable crosses





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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Government of Western Australia
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7.3 Middle Scott – Upper Reaches

This Section covers the upper limits of the Middle Scott sub-catchments. The tributaries run through three properties that were assessed through the fieldwork. The description of eastern part of the land parcel is included in the Four Acres sub-catchment.

The downstream starting point was assessed through aerial photograph interpretation and the remainder through fieldwork.

Description for Sections MS8 to MS25

Feature	Comments
Landuse	The dominant landuse is dryland and irrigated beef (pivots) with some parcels of tree crop, particularly Tasmanian blue gum. A limited area of remnant vegetation persists along with some revegetation zones.
Land tenure	The properties are freehold and includes Lot J, K and a portion of L at the upper reaches. At the junction with the main Scott River channel, Lot M appears undeveloped.
Fencing	No substantial portions of the waterways and their buffers are fenced within Lots K and J, apart from an area upstream of MS23 leading to FA1. Within Lot L, a grant for fencing and revegetation has resulted in 550 metres being double fenced between MS20 and MS21.
Crossings	Crossings are generally single or double culverts with compacted gravel.
Stock watering	Stock generally have unrestricted access to the waterways within this Section.
Remnant vegetation	There are four vegetation communities that have less than 30% protected within the conservation estate in this sub-catchment. One vegetation type only occurs in private land.

Condition for Sections MS08 to MS25

Feature	Comments
Vegetation	Between M8 and MS09 the channel flows through wetland with a dense riparian zone and intact verge vegetation and floodplain. The characteristic overstorey is Freshwater paperbark (*Melaleuca rhaphiophylla*) over sedgeland with occasional Pennyroyal and Dock. Small patches of a homogenous overstorey of Scott River Cedar (*Taxandria juniperina*) persist over sparse *Astartea scoparia, Beaufortia sparsa, Leptocarpus scariosus*, Loose flowered rush (*Juncus pauciflorus*), Pale rush (*Juncus pallidus*) with Pithy rush (*Lepidosperma longitudinale*) and an unidentified rush sp. The understorey becomes increasingly sparse moving upstream from Lot M into Lot K with plantation surrounding the small wetland relic.

Feature	Comments
	The freshwater wetland between MS11 and MS13 is rated as being in B Condition and is fenced on the eastern boundary. It has a similar representative vegetation characteristics as the description above with Sheath twig rush (*Baumea vaginalis*) and Bare twig rush (*Baumea juncea*). There is no substantial native vegetation between MS10 and MS14, between MS25 and MS23 and the southern Lot boundary, between MS9 and MS11 and upstream of MS13. Remnant native vegetation occurs in the roadside vegetation MS19 and MS20 however the channel bed and banks are being invaded by weeds and erosion is an issue. MS20 represents the downstream end of the revegetation zone and finishes at MS21. From this point north to the top of the sub-catchment, the remnant vegetation is restricted to parkland cleared with some Freshwater paperbark (*Melaleuca rhaphiophylla*) and Modong (*M. preissiana*) over pasture. The weed Redshank (*Persicaria maculosa*) fills the channel floors.
Weeds	Dominant weeds in the small wetland relics remaining include Pennyroyal (*Mentha pulegium*), Fleabane (*Conyza spp.*), Curly and swamp dock (*Rumex crispus* and *R. conglomeratus*) as well as Loosestrife (*Lythrum hyssopifolia*) which is toxic to stock. Kikuyu (*Pennisetum clandestinum*) and Flat weeds (*Hypochaeris* sp) occur throughout. Blackberry nightshade (*Solanum nigrum*) occurs throughout the riparian zone and adjoining floodway.
Bank stability and erosion	Drains are generally shallow with sufficient perennial vegetation to hold the swale shape however some channels lack the perennial component and are being cut out and contributing significant mobile sediment from MS23 to MS24.
Special features, other comments	There was no flowing water or pools in these assessed Sections at the time of survey. The farmers participate in Red Card for Red Fox and contract a professional shooter and trapper intermittently for feral pig control.
Native wildlife	Red-tailed black cockatoo, Western Ringtail possum, Brushtail possum and Brush-tailed phascogale have all been seen in this sub-catchment.

Key management Priorities for Sections MS8 to MS25

Generalised management suggestions are:

- Liaise with adjoining landholders about the potential to improve the long term survival of the persisting remnant vegetation through selective weed management and revegetation, although likely changes to land ownership may restrict on-ground projects in the medium term.
- Black wattle and Sydney golden wattle occur in the roadsides nearby and need to be monitored for in the waterways.
- Coordinate fox, feral cat and feral pig control activities at a catchment wide scale.

- Assist with the development of a whole of farm plan that includes fencing for paddock creation around waterways, allows for shelterbelts and explore site specific effluent management solutions to slow the rate of discharge and improve sediment and nutrient trapping.

Key management actions for Sections MS8 to MS25

Issue	Issue Management Action/Advice
Terrestrial Invasive species	Prioritise the eradication of Loosestrife, Redshank, Sydney golden wattle and African feather grass and African lovegrass before their populations' increase, particularly for plants that are toxic to stock. Support regular feral animal control and eradication of low frequency declared and highly invasive weed species.
Fencing and loss of native vegetation	Preventing stock access to the last few remaining pockets of remnant vegetation through which the waterways pass, and across the property should be a priority as there is limited variation in vegetation in age classes throughout (PP69). There is minimal internal fencing in Lot J and the current landholder is keen for support to develop appropriate paddock scales and management systems. Consider seeking a grant to assist with the development of a demonstration site that includes shelterbelts, fencing, revegetation, site specific effluent management solutions (see below) and paddocks of 29Ha each (PP70).
Water Quality	Consider exploring site specific effluent management solutions in Lot J (PP48, PP49) (particularly in an area where there was historically a sedge land) that would slow flow and trap manure further up the catchment. Consider re-aligning waterways around pivots rather than through and explore site specific sediment trapping and nutrient stripping options (PP2 and PP4). Investigate installing coarse sediment traps close to the laneways on large waterways (PP1, PP6, PP7 and PP8). Encourage the use of fast-growing perennials across channel floors where revegetation is not supported, to reduce sediment mobilisation.
Revegetation projects	Liaise with landholders to improve revegetation success and increase fence network to protect waterways and remnant vegetation, particularly if plantation landuses revert back to broadacre or intensive farming. Encourage fence re-alignments to protect wetland pockets and re-establish native vegetation particularly close to the southern boundaries to reduce mobile sediment intrusion into high quality remnant vegetation (PP4). Encourage the use of fast-growing perennials across channel floors where revegetation using native species is not supported, to reduce sediment mobilisation.

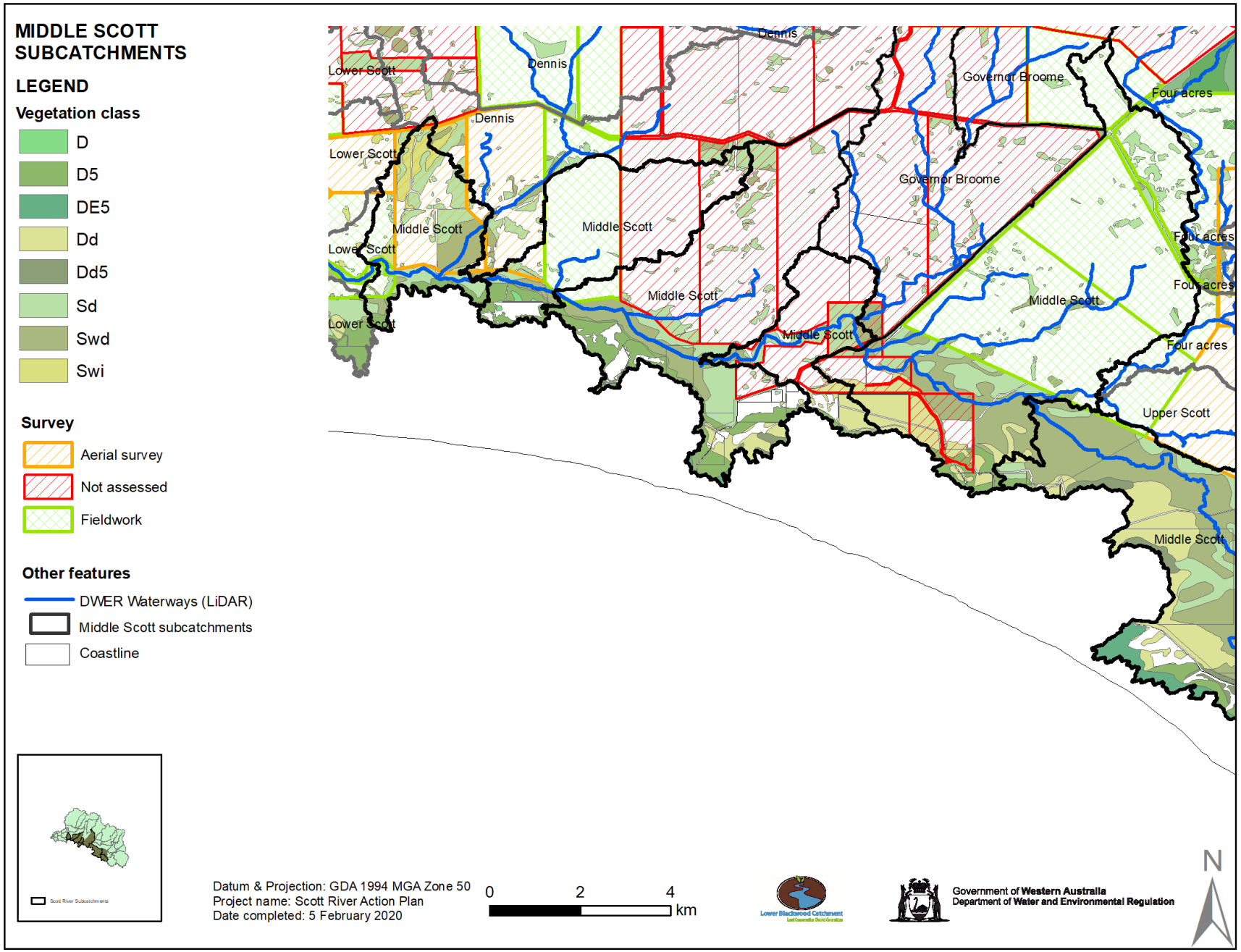
Sample photos from Sections MS8 to MS25

Plate 10: Unprotected and unstable waterway.

Plate 11: Revegetating a riparian zone.

Plate 12: Modified waterway.

Plate 13: New drain through recently harvested blue gums and weed assemblage (Approx. 300m upstream of main Scott River channel).


MIDDLE SCOTT SUBCATCHMENTS
LEGEND
Vegetation class
D
D5
DE5
Dd
Dd5
Sd
Swd
Swi
Survey
Aerial survey
Not assessed
Fieldwork
Other features
DWER Waterways (LiDAR)
Middle Scott subcatchments
Coastline
Lower Scott
Dennis
Governor Broome
Four acres
Middle Scott
Upper Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020
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Government of Western Australia
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MIDDLE SCOTT SUBCATCHMENT

LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

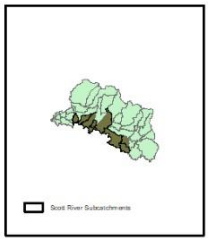
- Dam/Soak
- Blue gums

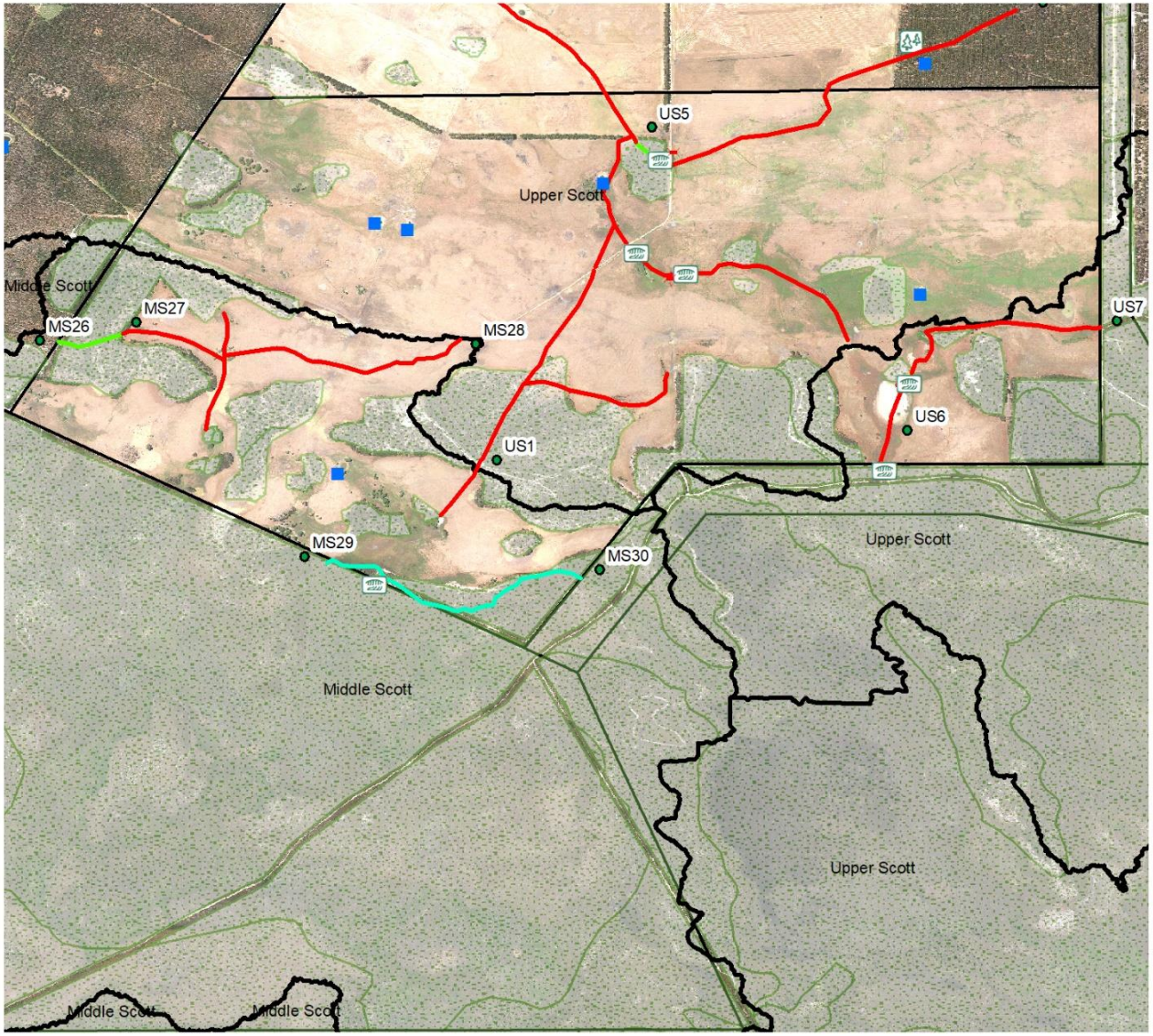
Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
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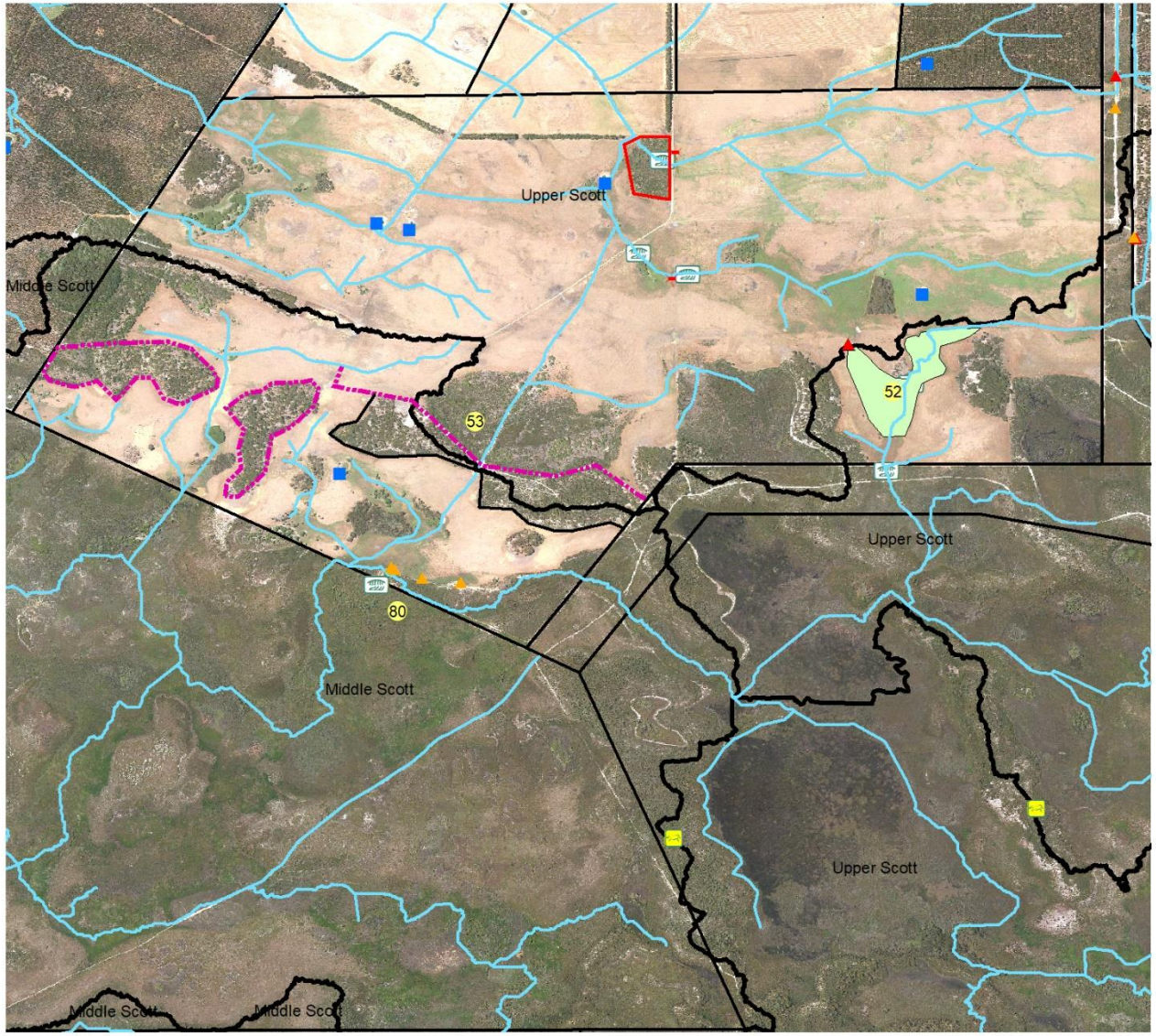
MIDDLE SCOTT SUBCATCHMENT



LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Potential revegetation nodes
- Erosion
- Feral animals

Fencing

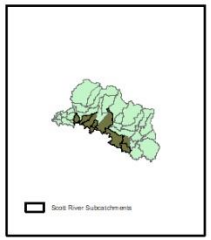
- Existing fence
- Fence maintenance required
- Potential fence

Infrastructure

- Dam/Soak
- Crossing
- Weir

Other features

- DWER Waterways (v9)
- Subcatchment boundaries (v9)
- Cadastre



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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Department of Water and Environmental Regulation

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MIDDLE SCOTT SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Previous revegetation grant
- Feral animals
- Erosion

Fencing

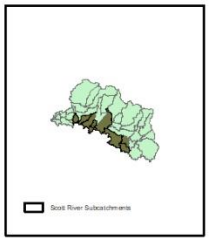
- Existing fence
- Potential fence
- Previous grant

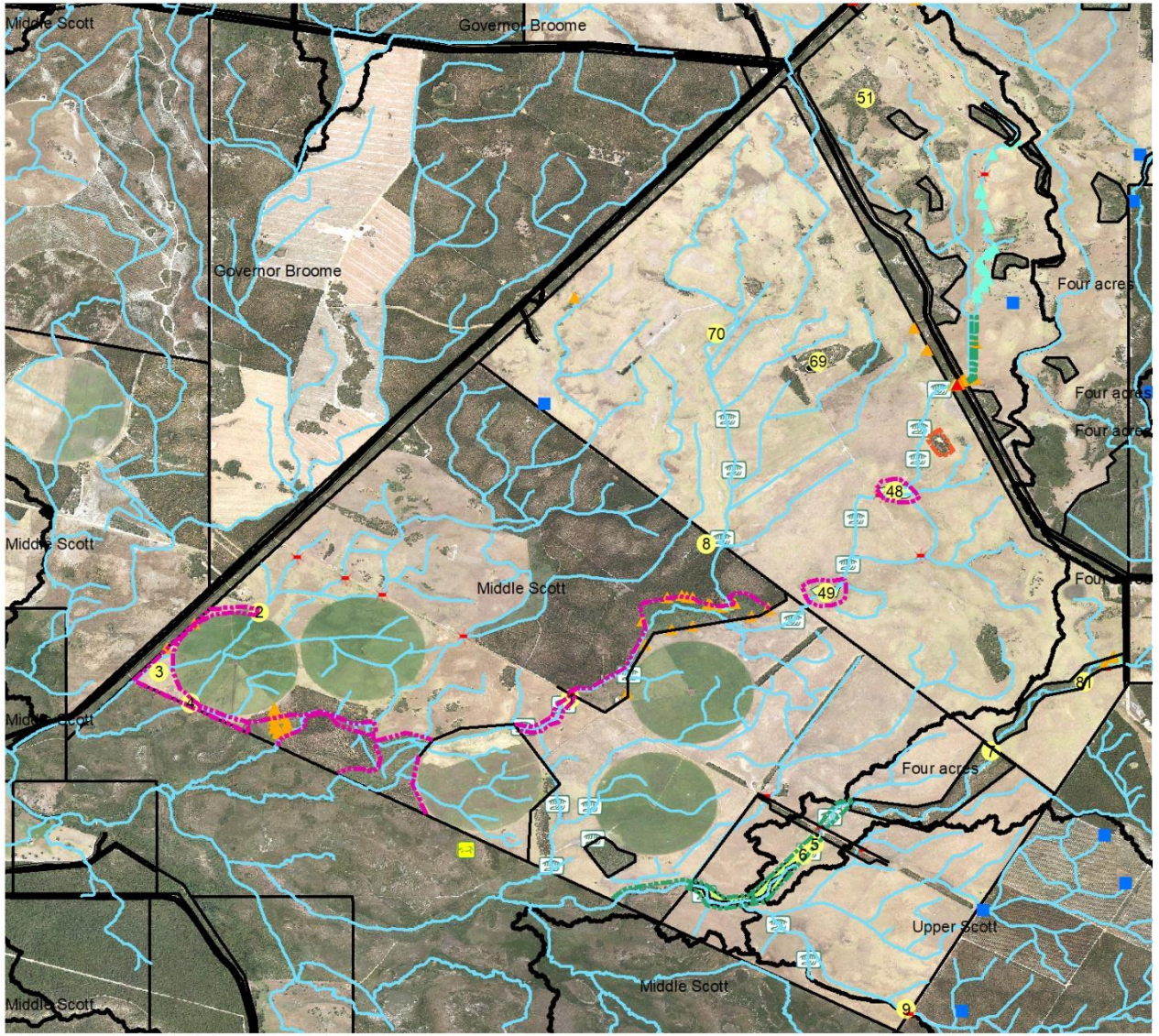
Infrastructure

- Dam/Soak
- Crossing

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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N

7.4 Dennis

This sub-catchment extends from DN1 to DN19. This tributary was assessed using a combination of aerial photograph interpretation and fieldwork.

Description for Sections DN1 to DN19

Feature	Comments
Landuse	South of Governor Broome Road, the dominant landuses are dryland grazing and irrigated dairy with the portion of one Lot, retaining a considerable parcel of remnant vegetation. There is a parcel of tree crop also within the lower sub-catchment. The tributary splits into two branches in Lot N and again in Lot JJ. The north-eastern tributary arising in Lot JJ passes through a fenced and revegetated Section prior to passing into tree farms north of Governor Broome Road. The north-westerly tributary that originates 200 m south of Governor Broome Road within Lot JJ, splits immediately north of that road (DN04). The north westerly tributary passes into plantation while the north-easterly portion drains an intensive irrigated dairy. There are small wetland and bushland remnants in amongst the tree plantations and pivots. North of the dairy is a mosaic of plantations with some wetland remnant vegetation surrounding the headwaters of this tributary.
Land tenure	The sub-catchment south of Governor Broome Road covers three land parcels that are held in Freehold (Lot H, N and JJ). North of Governor Broome Road, the area assessed were within five Freehold properties (Lots O, P, Q, R and S.
Fencing	Fencing appears to be limited in the well vegetated Lot immediately upstream of the confluence of this tributary with Scott River and is also limited within the plantation land north of Governor Broome Road. Plantations that have not had stock for many years generally remain unfenced apart from their boundaries, as they are not required for management. The waterways through the mix of dryland grazing and dairy with the fencing setback generally being around 6 m from the channel banks. The channel is eroding so increased setbacks are required. There is support for upgrading and realigning the fencing along the waterways as the current fencing requires maintenance.
Crossings	There are numerous narrow crossings to facilitate pivot movement in Lot P. Some of these impede flow in peak flow conditions.
Stock watering	There is extensive direct stock contact south of Governor Broome Road. There are opportunities to support off-line watering points and exclusion of stock to reduce nutrient contamination, pugging and localised bank slumping.

Feature	Comments
Remnant vegetation	Five vegetation communities within this sub-catchment have less than 22% of their original extent protected in conservation estate.

Condition for Sections DN1 to DN19

Feature	Comments
Vegetation	The lower reaches of this tributary appear to flow through high quality remnant vegetation (DN1 to DN2) based on aerial photography interpretation. Upstream of DN2 to DN 3 and DN5, there is evidence of grazing and it is considered likely that the riparian vegetation is losing its integrity with higher proportions of weed infestation. Between DN2 and DN5 (within Lot T), the vegetation is principally single rows with occasional stands of Freshwater paperbark (*Melaleuca rhaphiophylla*) over a Kikuyu (*Pennisetum clandestinum*) dominated assemblage and Redshank (*Persicaria maculosa*). Isolated Pale rush (*Juncus pallidus*) and Black bristle rush (*Chorizandra enodis*) persist with Balga (*Xanthorrhoea preissii*), Swamp peppermint (*Taxandria linearifolia*) and *Lepidosperma scabrum* on the margins. This vegetation community occurs in the small remnants for 1 km either side of Governor Broome Road. Patches of WA Peppermint (*Agonis flexuosa*) woodland over parkland cleared occur on higher Sections. The understorey is dominated by weeds occurs on the verges with Kikuyu (*Pennisetum clandestinum*), Clover (*Trifolium*), Pennyroyal (*Mentha pulegium*), Blackberry nightshade (*Solanum nigrum*), Redshank (*Persicaria*) and Dock (*Rumex brownii*) occurring along the channel length. Within the plantation (D9 to D10), there is a small patch of persistent Marri (*Corymbia calophylla*) over Modong (*Melaleuca preissiana*), *Astartea scoparia*, *Leptocarpus scariosus*, Bare twig rush (*Baumea juncea*) and Sheath twig rush (*B. vaginalis*) as well as stands of Scott River Cedar (*Taxandria juniperina*). Isolated Holly-leaved banksia (*Banksia ilicifolia*) occur north-east of DN9. East of Scott River Road (DN15 to DN14) the riparian vegetation community provides 100% cover over a stable channel with few weeds. Modong (*Melaleuca preissiana*) with occasional Freshwater paperbark (*Melaleuca rhaphiophylla*) occur over a shallow channel at the western end. *Astartea scoparia* persist in small numbers with infrequent *Juncus pauciflorus*, *J pallidus* and *Baumea juncea*. Native *Hydrocotyle* persists in small areas. East of this community, the overstorey varies to one dominated by *Astartea scoparia*, *Melaleuca preissiana* and *Taxandria linearifolia* with *Leptocarpus scariosus* and *Alternanthera nodiflora* dominating the understorey. The central part of the channel has *Persicaria*. A Pink and green kangaroo paw (*Anigozanthos flavidus* variant?), Grass trees (*Xanthorrhoea preissii*), *Bossiaea linophylla*, *Lomandra* spp. and *Banksia littoralis* occur regularly beneath extensive Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Bullich (*Eucalyptus megacarpa*). The channel is wide and stable. There is evidence of previous fire.

Feature	Comments
	The remnant vegetation around the headwaters west of Scott River Road is characterised by infrequent *Melaleuca rhaphiophylla*, *Taxandria linearifolia* and *Astartea scoparia* communities over linear Pale rush (*Juncus pallidus*) with interspersed weeds. The overstorey is restricted to small Sections of the waterway (first 100 m). The Pale rush community varies in with from 5 m to 10 m either side of the main channel (DN15, DN18 and DN19). The eastern channel (DN6 to DN11, DN 12 and DN13) ranges from a single row of Freshwater paperbark (*Melaleuca rhaphiophylla*) and Swamp peppermint (*Taxandria linearifolia*) alongside an excavated channel over relic *Astartea scoparia,* Sheath twig rush (*Baumea vaginalis*), *Empodisma gracillimum* and *Anarthria prolifera.* The sedges intermittently prevail over a chaotic weed assemblage. This linear vegetation community extends into a broader remnant with fewer native understorey species. *Juncus pallidus, J. kraussii* and *J. subsecundus* occur infrequently.
Weeds	The waterways pass through paddock and pivots. Kikuyu (*Pennisetum clandestinum*), Fleabane (*Conyza* spp), Pennyroyal (*Mentha pulegium*) and Curly dock (*Rumex crispus*) are widespread while isolated Spear (Scotch) thistle (*Cirsium vulgare*) are present. *Juncus microcephalus*, Fat hen (*Chenopodium album*) and Redshank (*Persicaria maculosa*) are widespread. Pennyroyal and *Persicaria* dominate the channel floor with infrequent *Leptocarpus scariosus* and Pale rush (*Juncus pallidus*) persisting. Some juvenile jarrah, Blackbutt (*Eucalyptus patens*) and Fleabane occur on the margins along with infrequent Shark tooth wattle. Isolated Stinkweed (*Dittrichia graveolens*) occur in the property and along laneways. Fleabane is also common along the laneways through the property. Common weeds in the plantation timber zones include Couch (*Cynodon dactylon*), Pennyroyal (*Mentha pulegium*), Water couch (*Paspalum distichum*), Blackberry nightshade (*Solanum nigrum*) and Docks (*Rumex* spp) are widespread. There are homogenous patches of *Persicaria*. Fleabane (*Conyza*), Bushy starwort (*Symphyotrichum subulatum*) and *Juncus microcephalus* are also present. Storksbill (*Erodium cicutarium*), Jersey cudweed (*Helichrysum luteoalbum*), Kikuyu (*Pennisetum clandestinum*) occur. Yorkshire fog (*Holcus lanatus*), Wild oats (*Avena fatua*), Spear (Scotch thistle) (*Cirsium vulgare*). The relative dominance of each species is variable.
Bank stability and erosion	The headwaters of the north-westerly tributary DN19 downstream to Scott River Road have been excavated to form a network of drainage channels. The main channels have flat bases between 1.5 – 3 m wide and the banks are 0.5 m. The majority of the excavated soil is white-grey sand although laterite clusters occur in Sections. There are Sections where the channel is more of a V-shape with 2 m banks and a narrow, 1 m wide channel floor.

Feature	Comments
	The channel dimensions increase in the areas lacking remnant vegetation cover and show evidence of historic interference with the channel shape. The channel expands up to 8 m wide and 3 m deep and is degraded with many undercut trees with exposed roots. The waterway varies from natural landform to excavated channel. There is a considerable fall across the property with the channel being wide and flat at the north-western entry point and becoming increasingly incised to the junction with Governor Broome Road. At one point the waterway is 2 m deep and 5 m wide with the floor being 2 m wide. The changes to sediment load in the channel floor downstream of this location has resulted in the channel becoming wider and shallower (< 1 m deep and 4 m wide).
Special features, other comments	There are considerable quantities of manure collected and where possible much is re-spread onto paddocks. There is interest to develop a commercial arrangement with another business to export the manure from site for other purposes such as use in the landscaping industry. The current effluent treatment system is a weeping wall however there have been breaches with only half of the effluent getting into the solids trap and half not. The overflow goes straight into the waterways. One difficulty managing the property is the low-lying undulating nature of the landscape that results in ponding up to 600 mm deep on occasions when rainfall exceeds 50 mm in one day. The tree crop is planted as close as practicable to the margins of the waterway through the property. There is limited scope for revegetation with the current management systems for the western tributary. Options exist for reducing weed infestations and increasing understorey diversity in the eastern tributary. Blue gum residue is burnt in-situ with considerable effort to avoid fire escape into the riparian zones and wetlands.
Invasive terrestrial fauna	Feral pigs pass through the waterways periodically and destroy fences. They tend to be an issue as water dries up elsewhere in the reserves and adjoining properties. Feral cats are a significant issue with up to 48 shot in one day. There is evidence of rabbits and feral pigs within Lots O, P, U and R. Rabbits are poisoned at the establishment phase in plantations only.

Key management Priorities for Sections DN01 to DN19

Generalised management suggestions are:

- Encourage landholders to improve the long-term survival potential of persisting remnant vegetation through additional fencing, selective weed management and where necessary supplementary revegetation.
- Maintain annual contact with landholders to determine if landuses are proposed to change i.e. following plantation harvesting and lease expiration reverting back to stock systems.

- Liaise with land owners to determine future leasing arrangements and therefore provide opportunities to develop collaborative projects. This possibility should be monitored as the lease arrangements for Lot O expires in December 2020.

Key management actions for Sections DN01 – DN19

Issue	Issue Management Action/Advice
Terrestrial Invasive species	Regularly review weeds within plantation as new weed incursions may arise from various contractors working in these areas. Eradicate small populations of Stinkwort (*Dittrichia graveolens*), Loosestrife (*Lythrum hysoppifolia*), Redshank (*Persicaria maculosa*) and African lovegrass (*Ehrharta calycina*) to prevent greater management issues in the future. Coordinate fox, feral cat and feral pig control activities at a catchment wide scale across different landuses. Ensure a collaborative timing approach to fox, feral pig and feral cat control activities between managers of different landuses by encouraging collaboration with the Lower Blackwood Vertebrate Pest Management Group (LBVPMG), targeting feral pigs in the most part.
Fencing and loss of native vegetation	Encourage fencing and revegetation of the riparian zone between DN2 and DN3 initially connecting the remnants then potentially extending to the head of the waterway. Encourage fencing revision and replacement to facilitate revegetation between DN4 and DN8, and DN11, DN12 and DN13. Consider more intensive revegetation in some areas of the property within Lot R outside of the pivot system. In areas without pivots tall species are acceptable and could include Blackbutt (*Eucalyptus patens*), Freshwater paperbark (*Melaleuca rhaphiophylla*), however lower taxa such as rushes and sedges will be necessary in the waterways to avoid interference with pivot operations (PP38). Liaise with the landholder/land manager to determine appropriate shelterbelts in Lot R. Upgrade the fence on the south eastern portion of Lot O that had been breached by cattle and there were fresh droppings along the waterway. Negotiate with the landowners of Lot O to achieve waterway protection if funding for fencing becomes available (PP24 and PP28). Encourage long term protection of high-quality remnant vegetation within Lot R and potentially use it as a monitoring site for comparative soil and vegetation moisture content for fire risk (PP35).
Water Quality	Improve effluent management as a key priority with upgrades needed for the weeping wall and extractive processes being preferred if feasible (PP39). Revegetate waterways through the irrigated dairy and grazing lands to assist in water quality improvement.

Issue	Issue Management Action/Advice
Bed and bank stabilisation	Upgrade the fencing to prevent stock access and increase perennial vegetation cover to help reduce bank slumping and localised erosion. Review waterway management (PP32) to slow flow and reduce channel incision through the blue gum plantation, particularly if the landuse reverts back to agriculture at the end of lease in 2020.

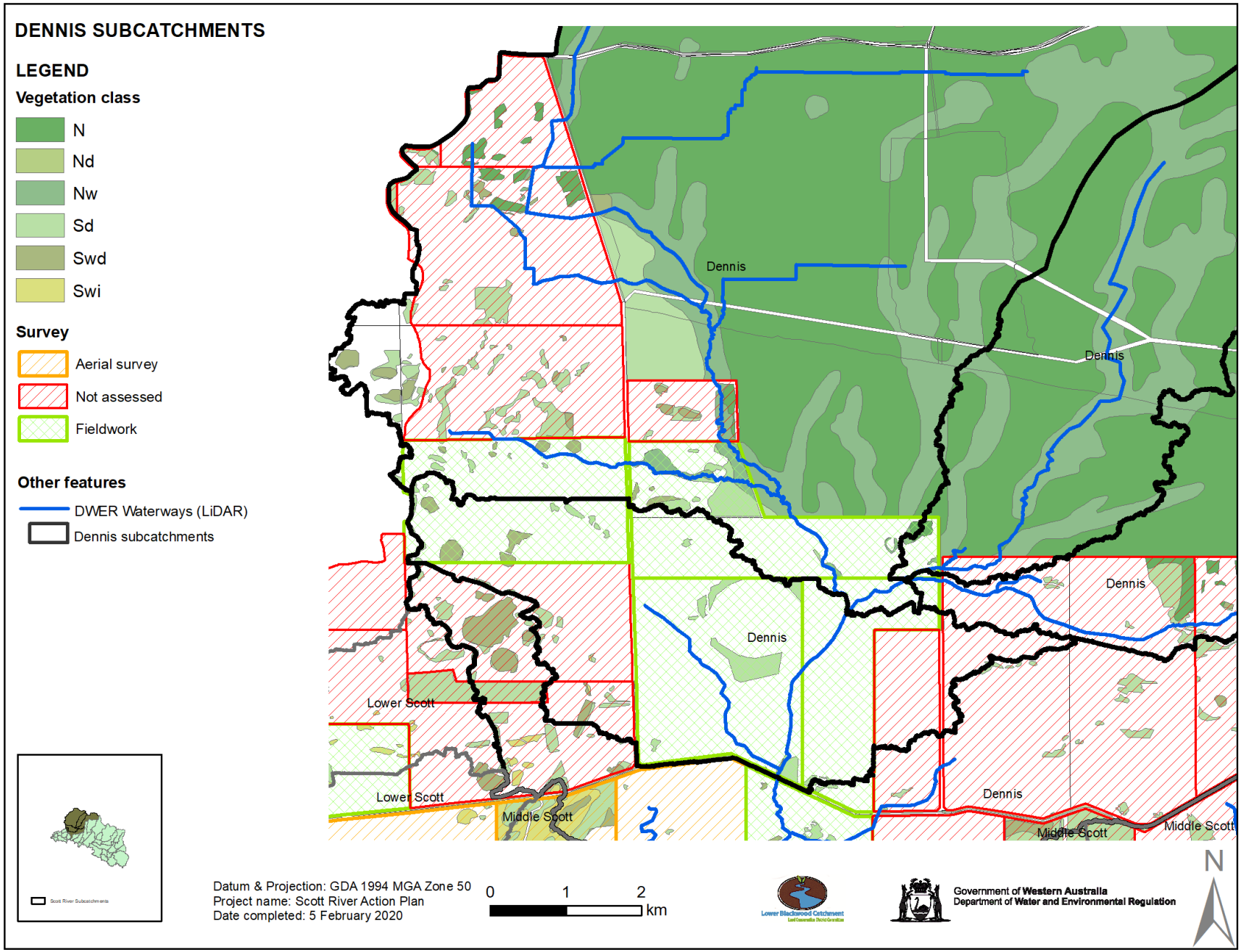
Sample photos from Sections DN01 – DN19

Plate 14: Drainage lines with a mix of Pale rush (Juncus pallidus) and Redshank (Persicaria maculosa) through blue gum plantation.

Plate 15: Representative waterway / drain.

Plate 16: Ponding of nutrient laden water on a property boundary between dairy and tree farm.

Plate 17: Excellent remnant vegetation persisting in pockets within tree farms.


DENNIS SUBCATCHMENTS
LEGEND
Vegetation class
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Swd
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Survey
Aerial survey
Not assessed
Fieldwork
Other features
DWER Waterways (LiDAR)
Dennis subcatchments
Dennis
Dennis
Dennis
Dennis
Dennis
Lower Scott
Lower Scott
Middle Scott
Middle Scott
Middle Scott
Datum & Projection: GDA 1994 MGA Zone 50
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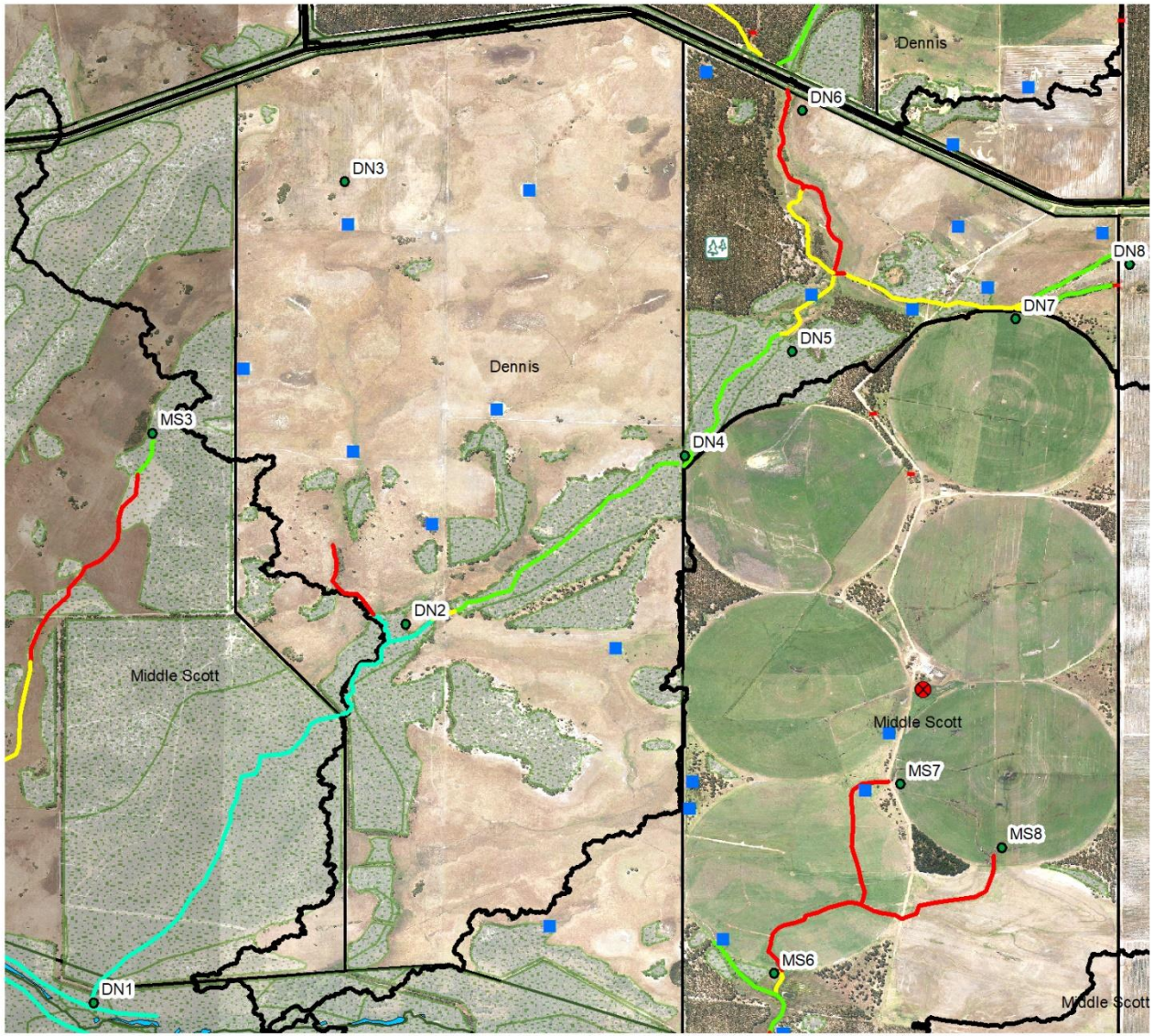
DENNIS SUBCATCHMENT



LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

- Effluent treatment
- Dam/Soak
- Crossing
- Blue gums

Other features

- River pools
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

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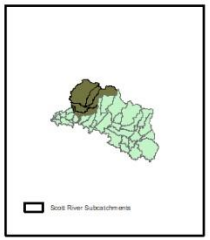

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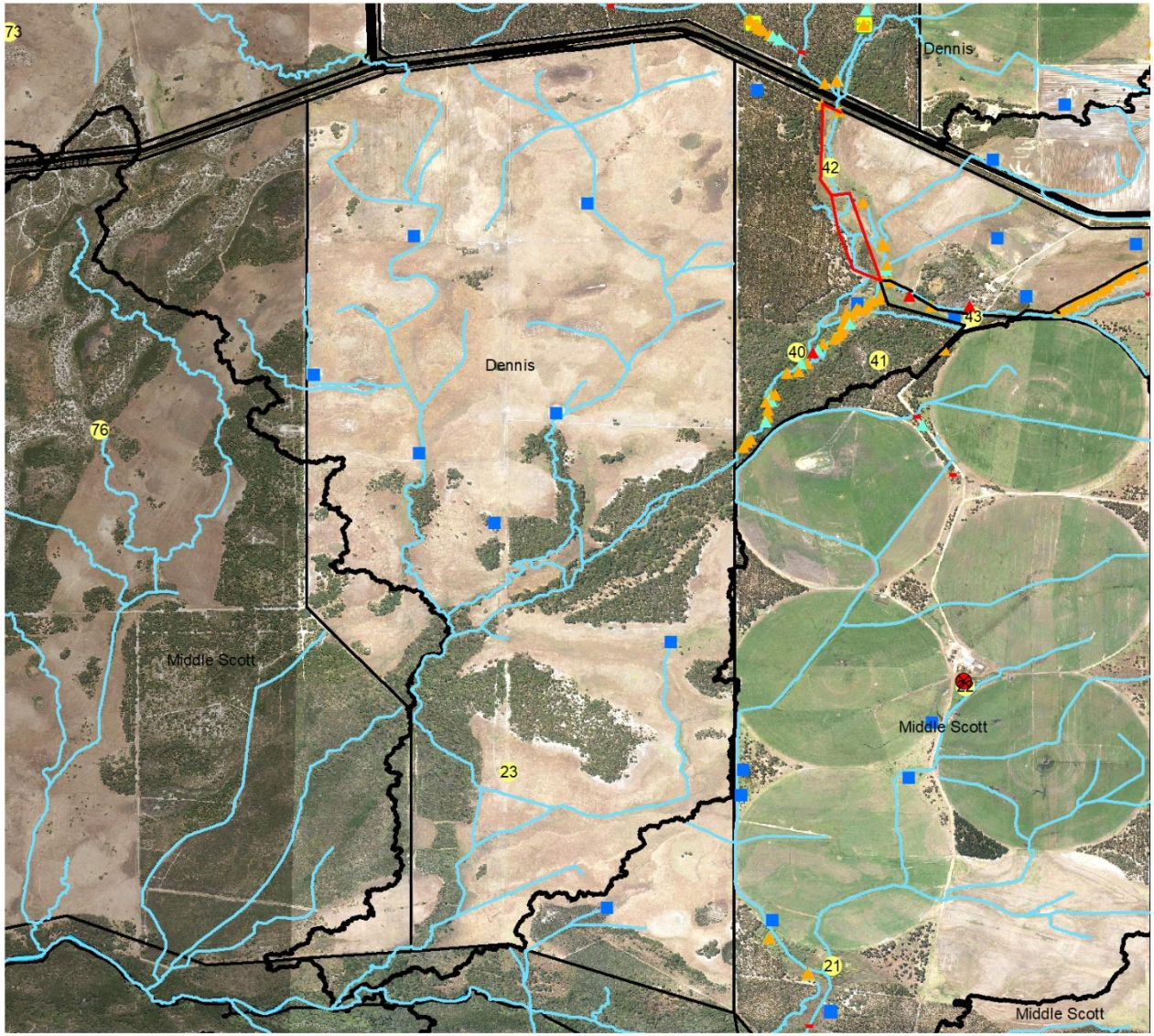
DENNIS SUBCATCHMENT



LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral animals

Fencing

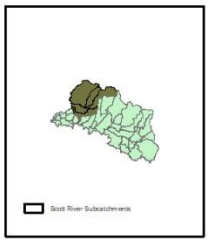
- Existing fence
- Fence maintenance required

Infrastructure

- Dam/Soak
- Crossing
- Effluent treatment

Other features

- DWER Waterways (v9)
- Subcatchment boundaries (v9)
- Cadastre



Datum & Projection: GDA 1994 MGA Zone 50
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DENNIS SUBCATCHMENT

LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

- Effluent treatment
- Dam/Soak
- Crossing
- Blue gums

Other features

- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

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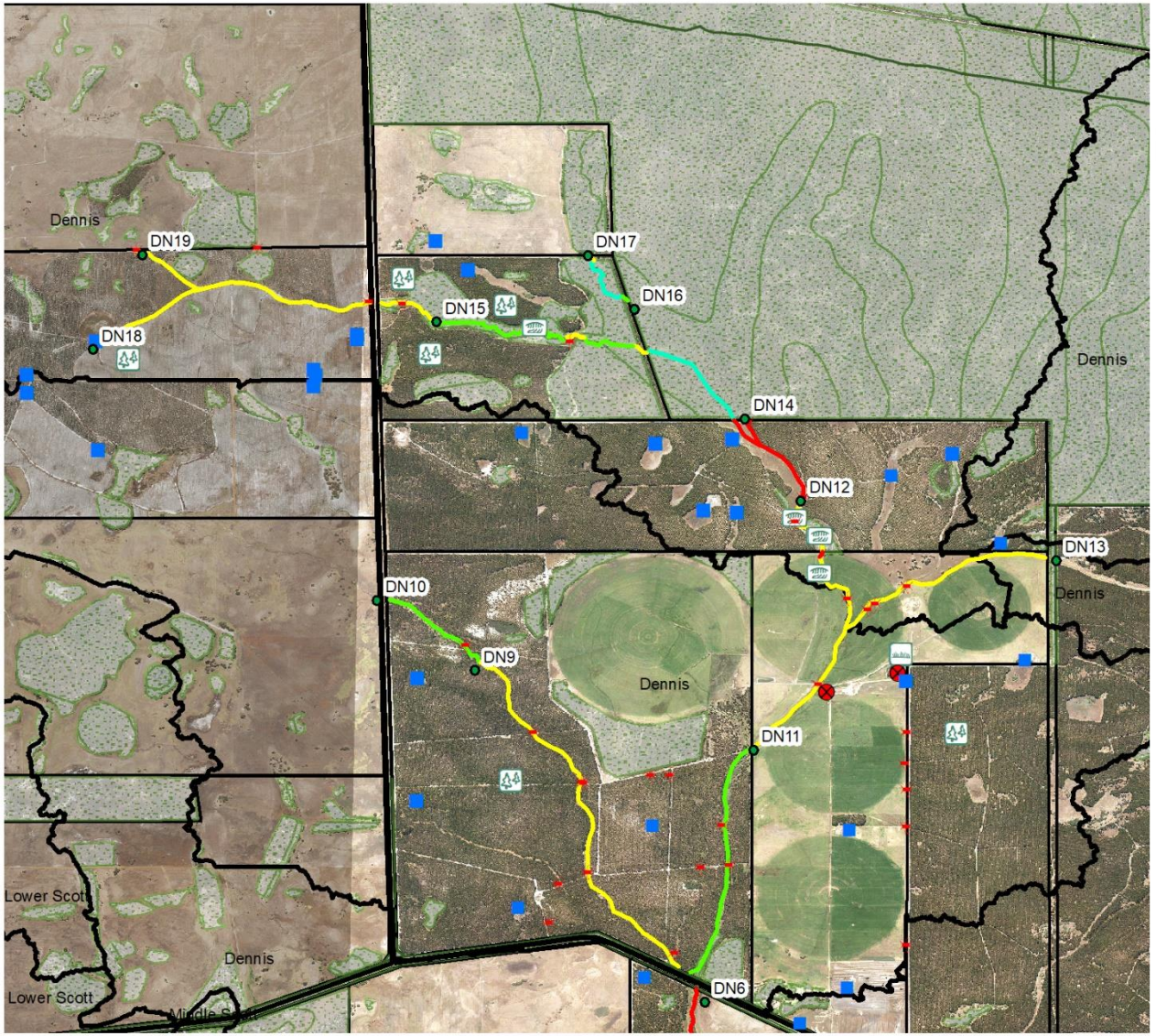

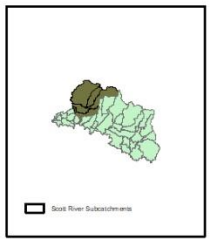

Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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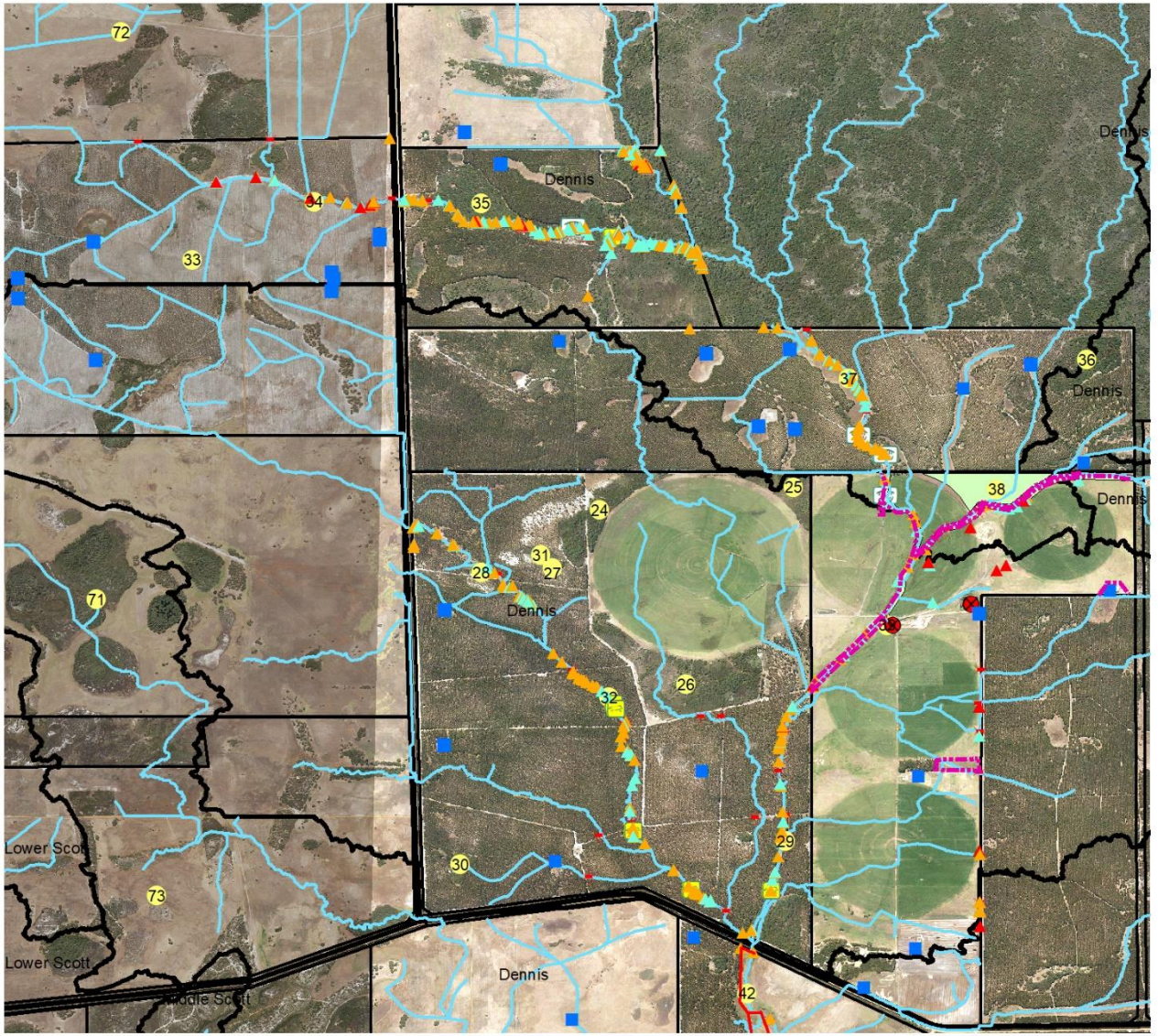


LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral animals
- Potential revegetation nodes
- Erosion

Fencing

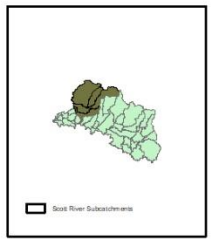
- Existing fence
- Fence maintenance required
- Potential fence

Infrastructure

- Dam/Soak
- Crossing
- Effluent treatment

Other features

- DWER Waterways (v9)
- Subcatchment boundaries (v9)
- Cadastre



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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7.5 Governor Broome

Two parcels of land within the Governor Broome sub-catchment were selected for fieldwork.

Description for Sections GB1 to GB9

Feature	Comments
Landuse	The two parcels are predominantly dryland grazing with one small remnant bushland area in the north-east corner of Lot V.
Land tenure	The fieldwork assessment sites were Freehold land and within Lots V and W.
Fencing	There is no fencing designed to manage stock access across the waterways.
Crossings	Low gravel bunds over culverts and level sills are the dominant form of crossings where needed. The waterways generally have a very low profile and can be crossed readily.
Stock watering	There are no permanent pools along the waterways within this property.
Remnant vegetation	Four of the five vegetation complexes within this sub-catchment are poorly represented in the conservation estate. They have less than 22% of their original extent protected.

Condition for Sections GB1 to GB9

Feature	Comments
Vegetation	The small bushland remnant in the north-east corner is in excellent condition with no weeds. The waterway and vegetation condition are rated A. The area was burnt two years. Characteristic species include an overstorey of Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*), *Acacia browniana, Astartea scoparia*, *Allocasuarina fraseriana* with Swamp peppermint (*Taxandria linearifolia*), *Lepidosperma spp.* and Balga (*Xanthorrhoea preissii*) on the waterway margins. A large population of Cats paw (*Anigozanthos humilis*) is present. There is no relic native vegetation on any other portions of the waterways aside from the bushland remnant described above. The western waterway passes alongside a short shelterbelt of Tasmanian blue gum (*Eucalyptus globulus*).
Weeds	The waterway passes through paddock with assorted pasture species widespread. The significant environmental weeds Sydney golden wattle (*Acacia longifolia)* and Wavy gladiolus (*Gladiolus undulatus*) spreading along Milyeannup Coast Road and into remnant bushland.
Bank stability and erosion	The waterways generally have a very low profile with localised erosion in sandy Sections.

Feature	Comments
Special features, other comments	Feral pigs occur in the reserve adjacent to these properties and anecdotal evidence suggests that the populations move from Milyeannup Coast Road west to Scott River Road.

Key Management Priorities for Sections GB1 to GB9

Generalised management suggestions are:

- Support feral animal control, particularly feral pig management to improve the long-term potential for the survival of the persisting remnant vegetation.

Key management actions for Sections GB1 to GB9

Issue	Issue Management Action/Advice
Weeds	Monitor and eradicate significant environmental weeds such as Sydney golden wattle (*Acacia longifolia*) and Stinkwort (*Dittrichia graveolens*) before their populations establish further through adjoining plantations and bushland remnants.
Fencing and loss of native vegetation	Liaise with the landholder to develop an overall farm plan that increases use of fencing and shelterbelts alongside waterways. Encourage planting of Blackbutt (*Eucalyptus patens*), Bullich (*Eucalyptus megacarpa*) and WA Peppermint (*Agonis flexuosa*) within shelterbelts.

Sample photos from Sections GB1 – GB9

Plate 18: Drainage lines with a mix of perennial and annual grasses.

Plate 19: Very good bushland remnant in the north-east corner of the assessed lot.

GOVERNOR BROOME SUBCATCHMENT

LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

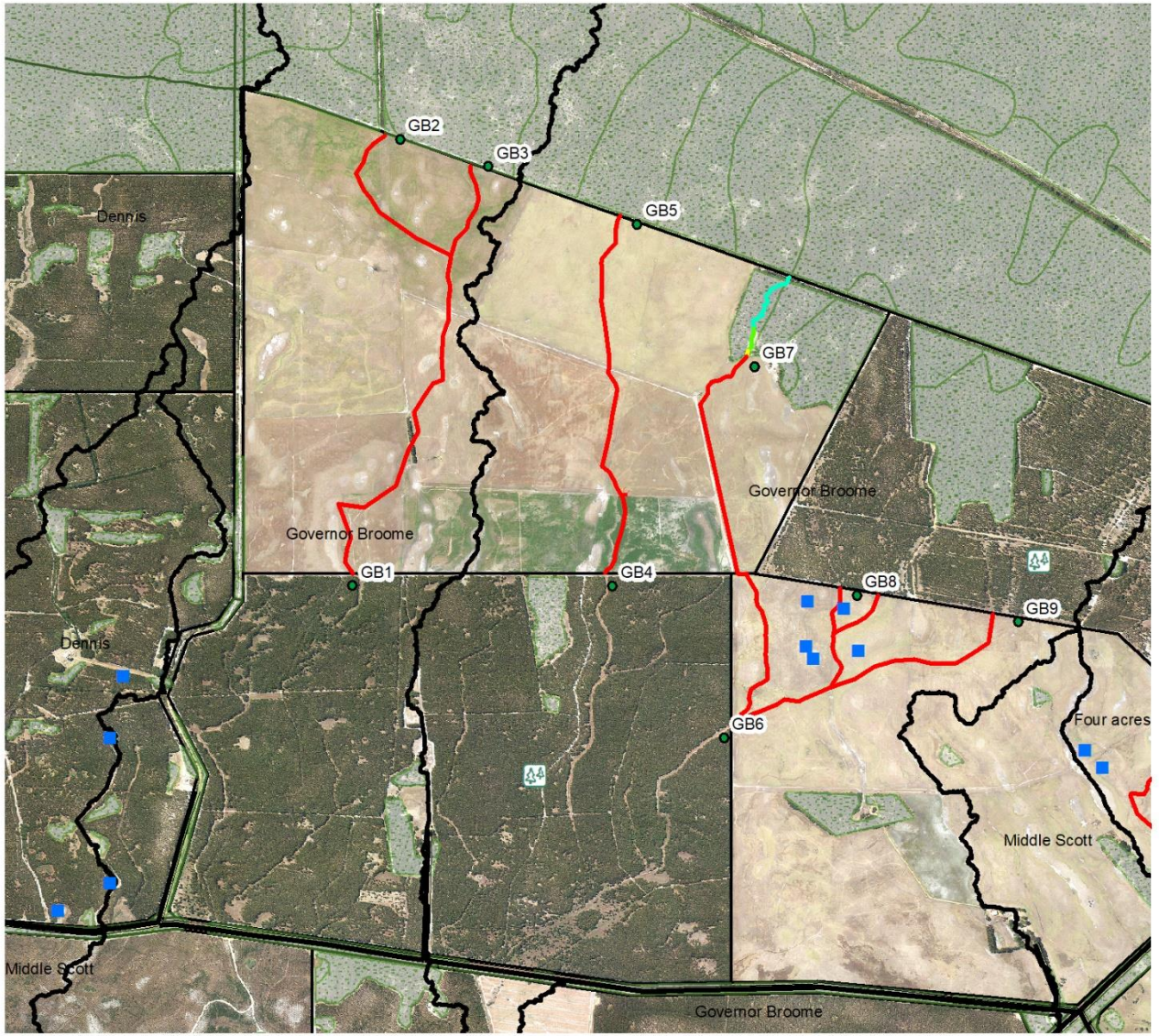
- Dam/Soak
- Blue gums

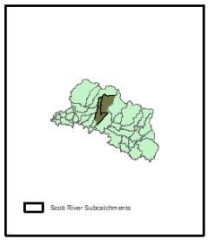
Other features

- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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GOVERNOR BROOME SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral_animals

Fencing

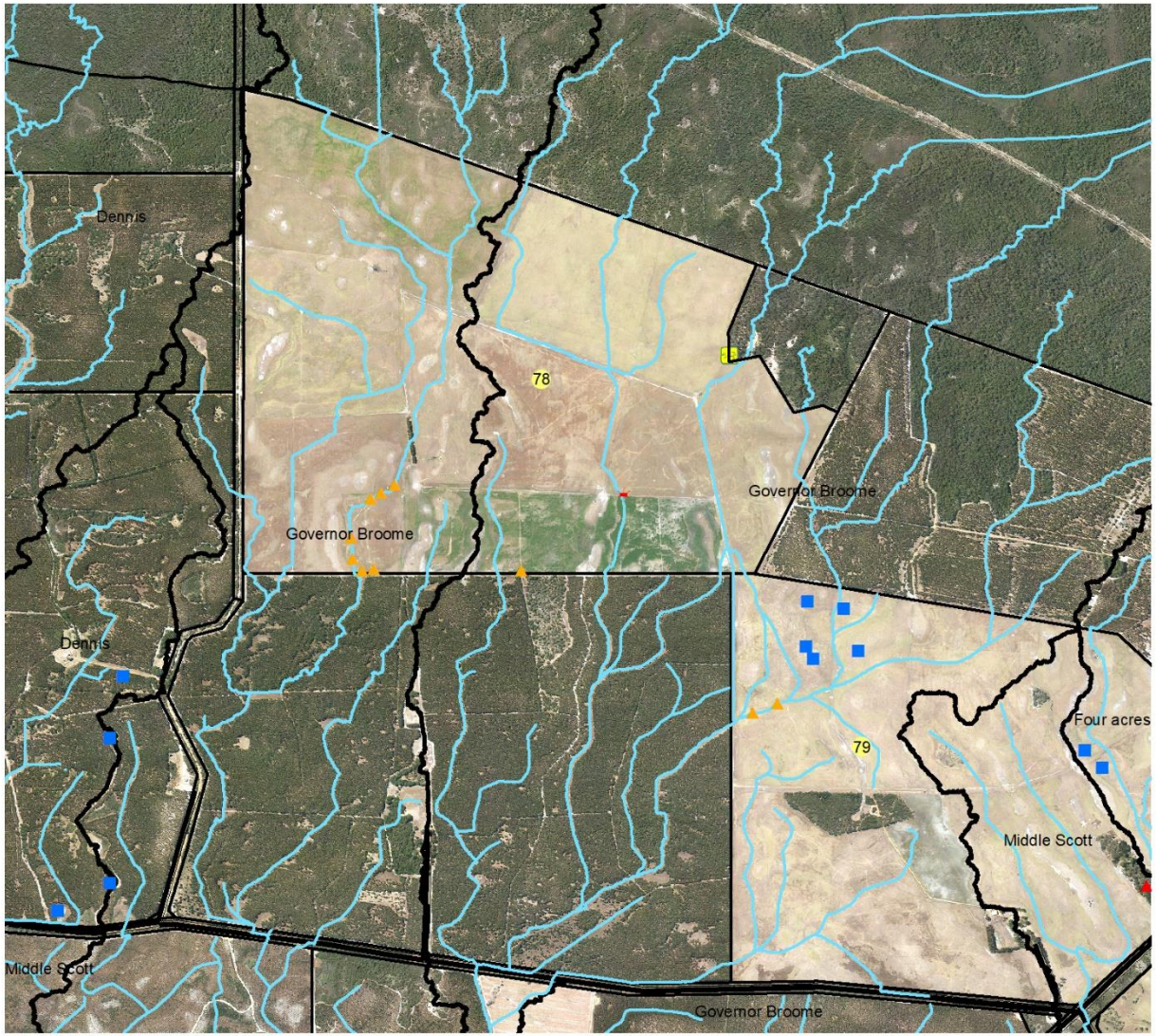
- Existing fence

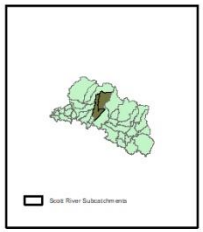
Infrastructure

- Dam/Soak
- Crossing

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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7.6 Four Acre (Part 1)

The Four Acre sub-catchments extend north and south of Four Acre Road. This sub-catchment has been divided into three components to facilitate ease of descriptions based on the type and extent of survey undertaken. The first of these covers the downstream reaches of the waterways within two properties. The first portion was assessed with fieldwork (FA1 to FA3) and the second through aerial photograph interpretation (FA1 to FA2, FA3 to FA4 and FA5).

Description for Sections FA01 and FA05

Feature	Comments
Landuse	The landuses within the assessed properties include dryland grazing and some remnant vegetation zones.
Land tenure	The sites assessed are within Freehold land and include part of Lot J and the portion of Lot GG south of Four Acre Road.
Fencing	Waterway fencing is limited to the south-western corner, west of Tom Brittain Road, where both sides are fenced and the natural regeneration processes are resulting in a very good quality riparian zone (Lot J).
Crossings	There is a gravel road with multiple culverts providing for water movement beneath Tom Brittain Road.
Stock watering	It appears that stock have access to the entire waterway in Lot GG. Horses were present at the time of survey.
Remnant vegetation	Five of the eleven vegetation communities within these sub-catchments have less than 30% represented in the conservation estate.

Condition for Sections FA1 to FA5

Feature	Comments
Vegetation	The fence is generally set well back from the remnant vegetation, with extensive areas of remnant sedges between FA1 and FA3. The dominant overstorey is Freshwater paperbark (*Melaleuca rhaphiophylla*) and dense stands of Swamp peppermint (*Taxandria linearifolia*) occur within this riparian zone. A diverse and healthy understorey comprising Pithy sword sedge (*Lepidosperma longitudinale*), *Anarthria scabra*, Bare twig rush (*Baumea juncea*), Sheath twig rush (*Baumea vaginalis*) and Bracken fern (*Pteridium esculentum*) occur on the margins of the woodland. There is no remnant vegetation persisting between FA01 and FA02. Between FA3, FA4 and FA5, the vegetation condition appears to be moderate to poor with limited natural regeneration. Patchy stands of Freshwater paperbark (*Melaleuca*

Feature	Comments
	rhaphiophylla) and clumps of Swamp peppermint (*Taxandria linearifolia*) persist over pasture species such as Kikuyu (*Pennisetum clandestinum*). Tussocks of Pale rush (*Juncus pallidus*), Shore rush (*Juncus kraussii*) and *Juncus usitatus* persist.
Weeds	The density of weeds varies depending upon canopy cover with the greatest weed proliferation where the canopy is open. Isolated weeds persist in dense shade, typically Blackberry nightshade (*Solanum nigrum*). Redshank (*Persicaria maculosa*) and Pennyroyal (*Mentha pulegium*) occur in small patches. Diverse pasture weed dominate between FA2, FA3, FA4 and FA5 and along the fencelines in FA1 to FA3.
Bank stability and erosion	Woody debris is accumulated up to 500 mm above the channel floor, indicating the peak flow height. As result of high flows, there are areas of mobile sediment. The main channel supports an extensive groundcover of *Alternanthera nodiflora* with occasional rushes. There are washouts and scours where the debris has diverted peak flows into parts of the floodplain dominated by annual pasture weeds. Feral pigs are exacerbating the instability of the channel bed by wallowing in the persisting small pools.
Special features, other comments	There is an opportunity to enhance this remnant to provide a seed store to encourage natural regeneration downstream. Removal of small populations of weeds may also be beneficial if resources allow. Tiger snakes occur in the remnant vegetation. Emus are considered a pest by some landholders. Black beetles are one cause of bank destabilising and perennial vegetation loss when they graze on the rhizomes.
Feral animals	There is evidence that feral pigs pass through periodically and signs of European rabbit, fox and feral cat activity in the waterway.

Key management priorities for Sections FA1 – FA5

Generalised management suggestions are:

- Continue to liaise with landholders to encourage vegetation protection and enhancement.
- Work with managers of tree farms to determine the feasibility of constructing a wetland/enhancing existing locations for nutrient stripping and water quality improvement.

Key management actions for Sections FA1 to FA5

Issue	Issue Management Action/Advice
Terrestrial Invasive species	Provide support for weed control in the riparian zones to encourage natural regeneration and reduce weed infestation downstream.

Issue	Issue Management Action/Advice
	Provide support for feral pig, foxes and rabbit control to ensure a collaborative approach to the timing of effort.
Fencing and loss of native vegetation	Select species for revegetation that have been shown to work in these environments such as Blackbutt (*Eucalyptus patens*), Flooded gum (*Eucalyptus rudis*) and Bullich (*Eucalyptus megacarpa*). Continue to encourage remnant vegetation protection through additional fencing. Check current fencing and replace where required.
Water Quality	Consider planting the buffer along the west side of Tom Brittain Road to increase nutrient uptake and sediment/manure trapping.
Bed and bank stabilisation	Determine appropriate measures to manage peak flows upstream. Use rock spillways as in-line sediment traps and crossing points, to enable sediment excavation if necessary, from a localised point.
Feral animal control	Provide support for feral pig, foxes and rabbit control to ensure a collaborative approach to the timing of effort.

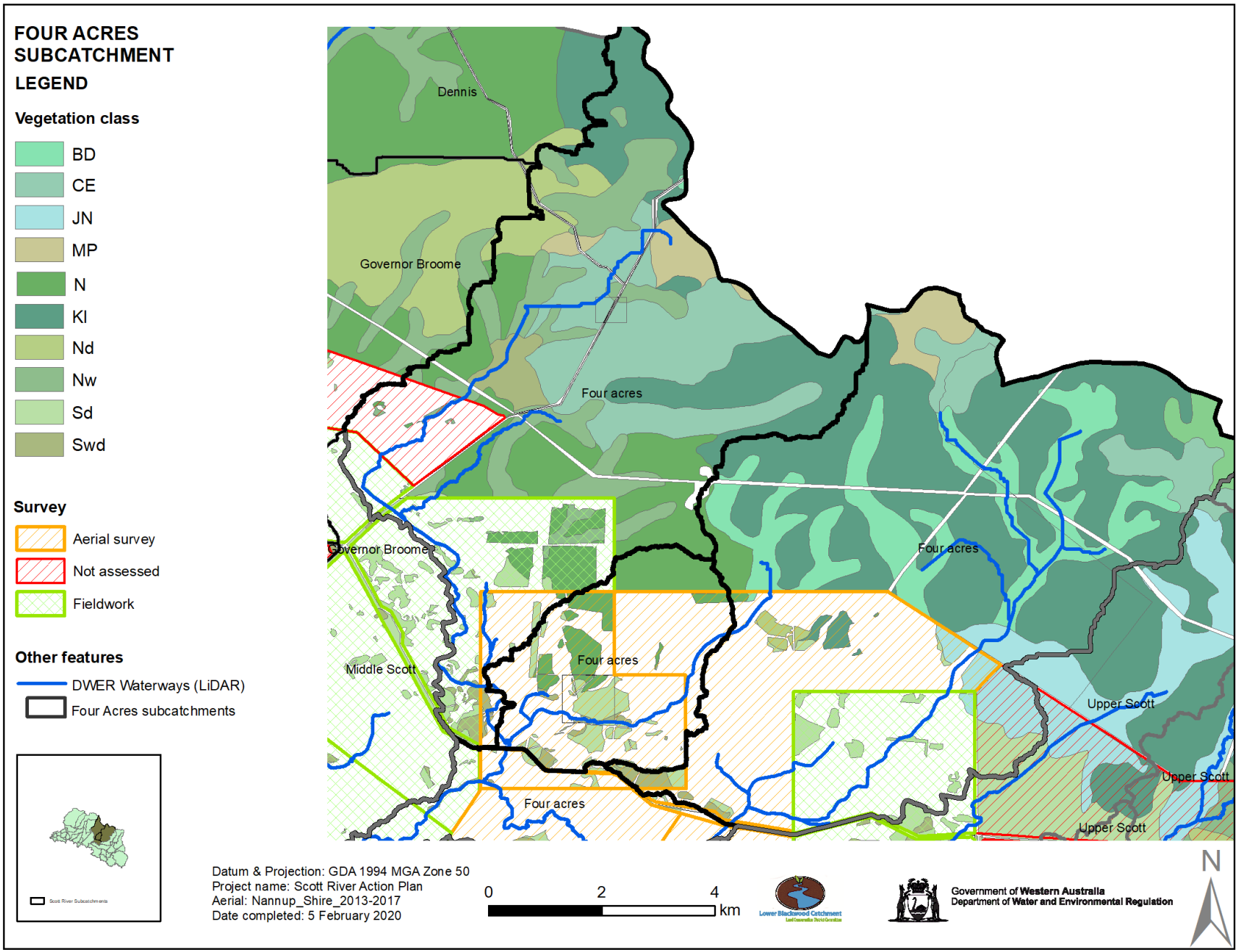
Key management actions for Sections FA1 to FA5

Issue	Management Action/Advice
Weeds	Target Stinkwort (*Dittrichia graveolens*), Redshank (*Persicaria maculosa*), Bushy starwort (*Symphyotrichum subulatum*), Curly and swamp dock (*Rumex crispus* and *R. brownii*) and Sydney golden wattle (*Acacia longifolia*) before their populations establish further. Continue to use cattle grazing to control Blackberry nightshade (*Solanum nigrum*) in paddocks.
Fencing/loss of native vegetation	Continue to offer support for fencing and revegetation of waterways and remnant vegetation should landholders become interested.
Water quality	Consider investigations to revegetate wide shallow portions of the floodplain to increase nutrient uptake by rushes and sedges.
Bank and bed stabilisation	Encourage landholders to protect any perennial vegetation (native or weeds) where they are dis-interested in fencing and revegetation to maintain channel stability and avoid issues arising from annual plant cover. Minimise stock interference with channel beds and banks to reduce active management requirements. Work with landholders to design and implement appropriate water sensitive design where an excavated channel is highly unstable and is impacting detrimentally on good quality remnant vegetation downstream.

Please note: ‘encourage’ and ‘support’ can mean to provide financial support, education or technical advice, depending on the resources available.

Sample photo from Sections FA1 to FA5

Plate 20: Drainage lines with a mix of perennial and annual grasses.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LEGEND
Vegetation class
BD
CE
JN
MP
N
Kl
Nd
Nw
Sd
Swd
Survey
Aerial survey
Not assessed
Fieldwork
Other features
DWER Waterways (LiDAR)
Four Acres subcatchments
Dennis
Governor Broome
Four acres
Governor Broome
Four acres
Middle Scott
Four acres
Upper Scott
Upper Scott
Four acres
Upper Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
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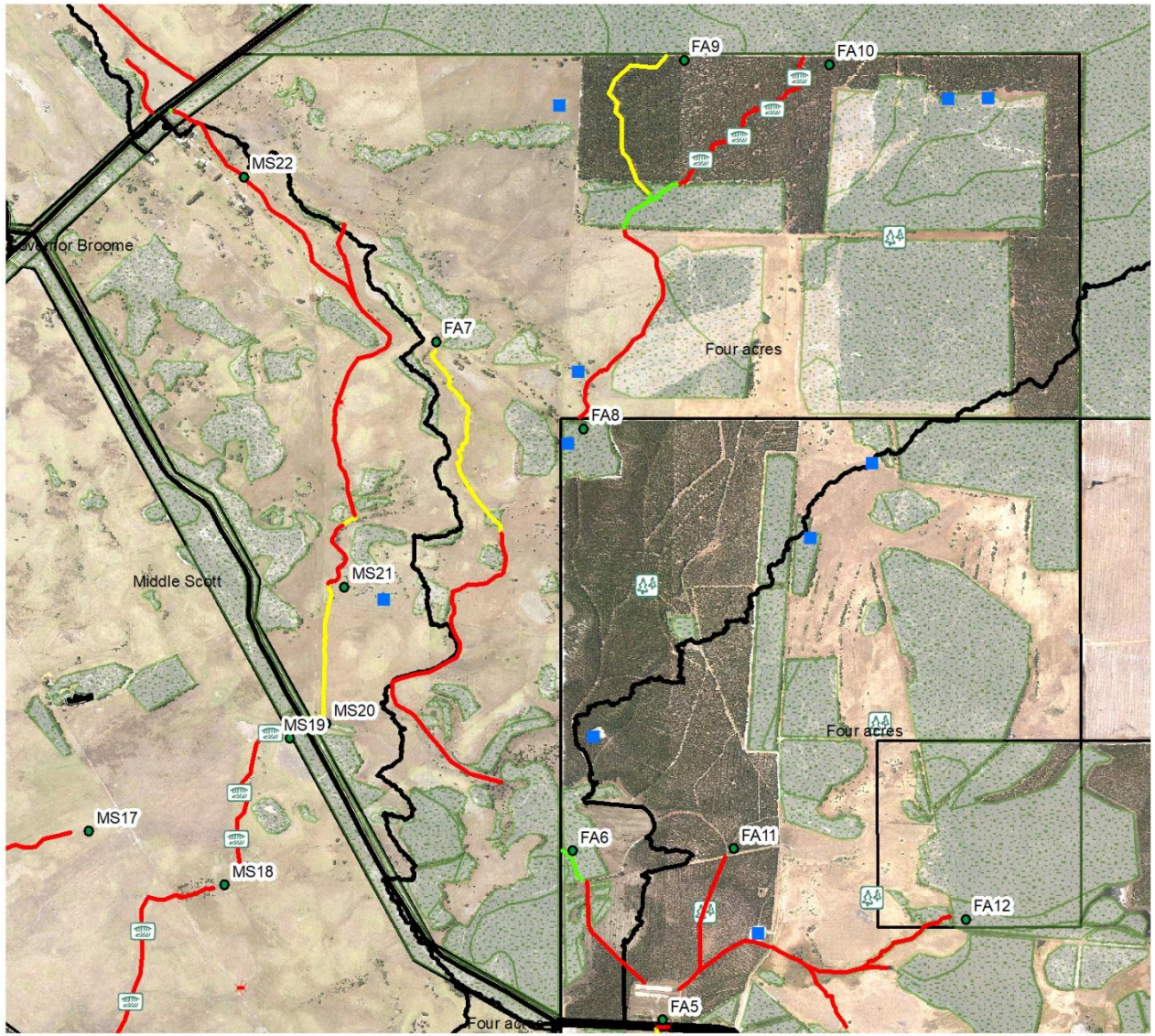


LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

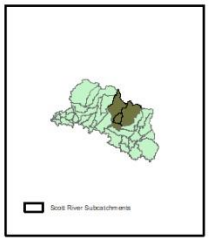
- Dam/Soak
- Blue gums
- Crossing

Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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FOUR ACRES SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Feral_animals
- Erosion

Fencing

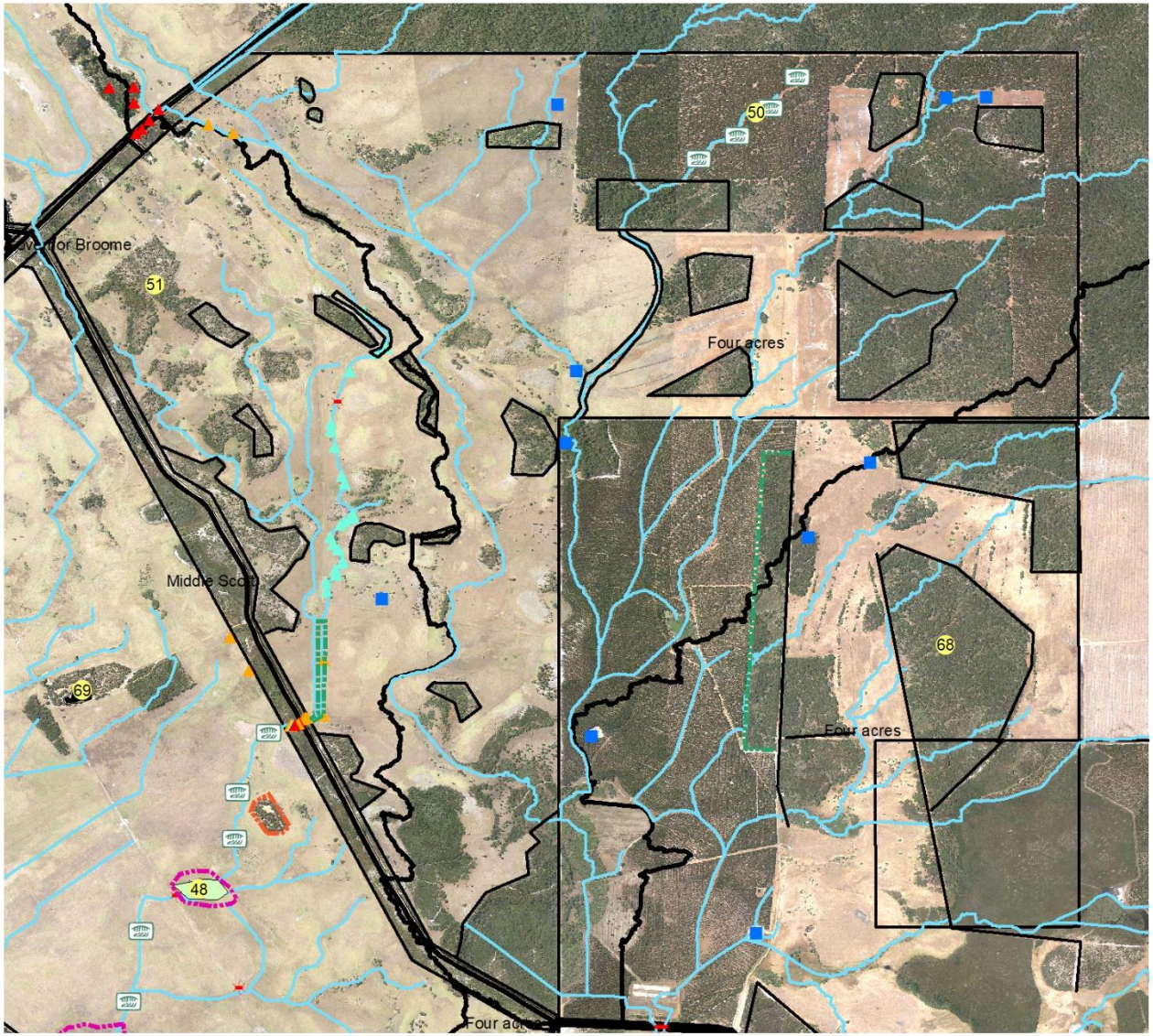
- Existing fence
- Previous grant
- Potential fence

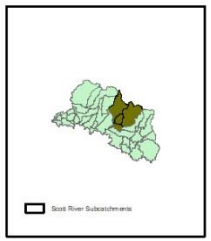
Infrastructure

- Dam/Soak
- Crossing

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
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Date completed: 5 February 2020

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7.7 Four Acres (Part 2)

The waterways within five properties in the Four Acre sub-catchment were assessed entirely through aerial photograph interpretation and looking at the waterways from the roadside. The sub-catchments extend either side of Four Acre Road.

Description for Sections FA06 through to FA21

Feature	Comments
Landuse	The landuses within the assessed properties include dryland grazing, plantation timber and some remnant vegetation zones.
Land tenure	The sites assessed all occurred within Freehold land and includes parts or all of Lots Y, Z, AA, BB and the portion of Lot CC south of Four Acre Road. A small tributary passes through the south-east corner of Lot CC (North of Four Acre Road).
Fencing	Based on aerial photograph interpretation, it appears that there is no fencing throughout the plantation landuse. Some remnant wetlands appear to be fenced in Lot Z.
Crossings	It appears that there is an extensive network of laneways, beneath which there must be culverts allowing for water movement.
Remnant vegetation	Five of the eleven vegetation communities within these sub-catchments have less than 30% represented in the conservation estate.

Condition for Sections FA06 to FA21

Feature	Comments
Vegetation	The majority of the riparian zones appear to be degraded and lack remnant vegetation cover where they pass through plantations. Some Sections appear to be channelised and modified. It is expected that these riparian zones lack significant populations of native plants. Remnant riparian vegetation appears to occur in the vicinity of FA08. Upstream of FA12 there appears to be an extensive wetland system in extremely good condition. There appears to be a good quality riparian zone between FA14 and FA15. There is a small wetland remnant immediately downstream of FA17 that retains some relic native species including Pale rush (*Juncus pallidus*).
Weeds	Roadside assessment suggests that Kikuyu (*Pennisetum clandestinum*), Docks (*Rumex crispus* and *R. brownii*), Bushy starwort (*Symphyotrichum subulatum*) and Fleabane (*Conyza bonariensis*) occur within the waterways.

Feature	Comments
Bank stability and erosion	Aerial photograph interpretation suggests that a significant portion of the riparian zone is highly unstable with mobile sediment plumes throughout Lot AA and BB south of Four Acre Road (except through a high quality wetland). The channel bed in Lot DD also appears unstable as it is clearly visible in the aerial photographs.
Special features, other comments	There is an opportunity to encourage remnant vegetation protection and enhancement. Continued intermittent liaison with landholders to enable on-site visits for potential grant applications to support important biodiversity should be considered.
Feral animals	Protecting the substantial wetland upstream of FA12 from feral pig activity should be considered a priority if the landholder wishes to seek support.

Key management priorities for Sections FA06 – FA21

Generalised management suggestions are:

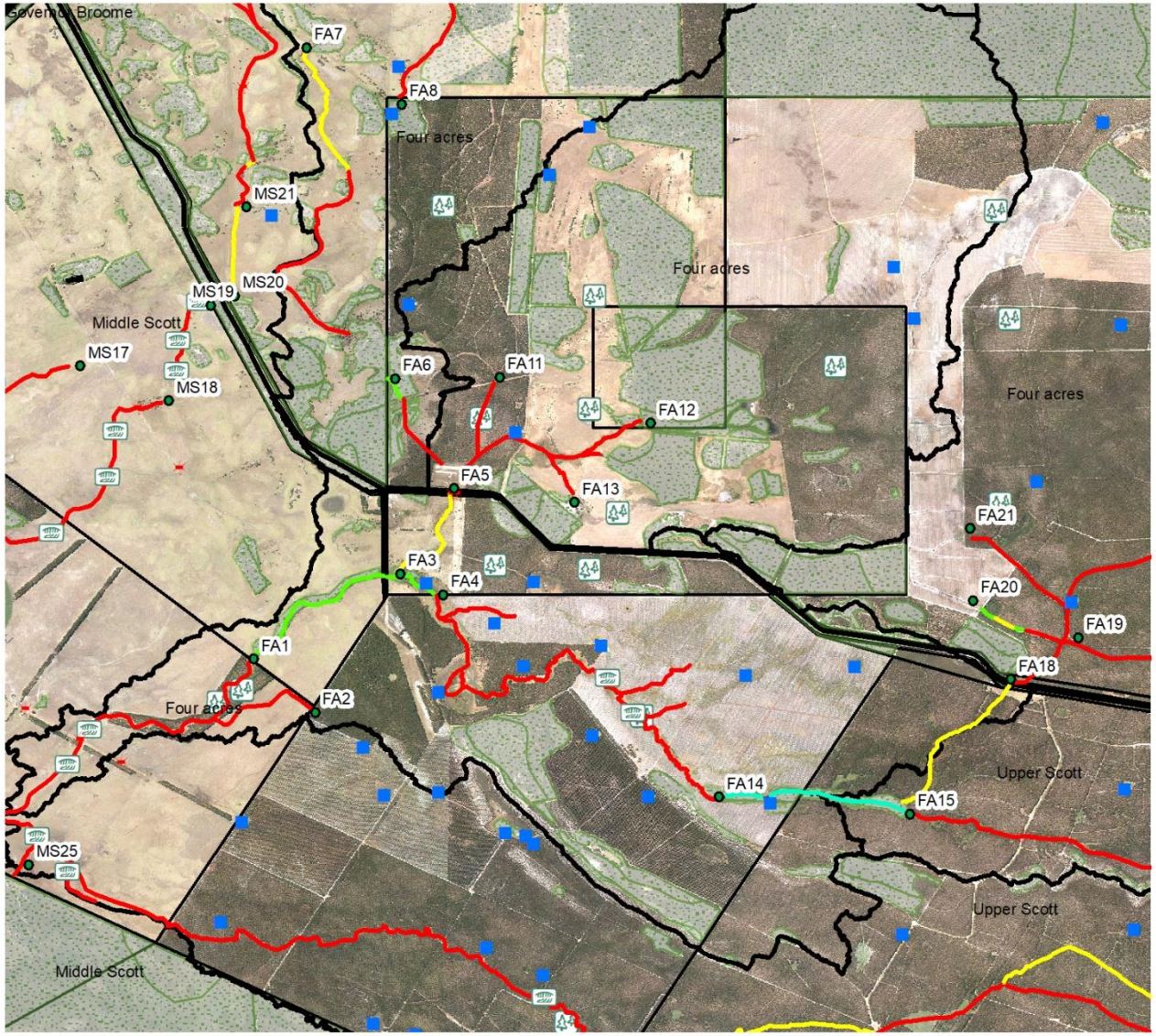
- Encourage open communication lines with landholders to determine any future support options for land management, particularly associated with invasive species management and the potential for site specific effluent management and nutrient export options as well as wetland enhancement to improve water quality.

Key management actions for Sections FA06 to FA21

Issue	Issue Management Action/Advice
Weeds	Target Declared or serious environmental weeds within the high-quality remnants or their margins. Encourage weed control in Lot CC (south of Four Acre Road) through the plantation. Monitor within plantations for weed populations to ensure any new incursions are managed prior to the weed populations becoming established and spreading from these point sources. Encourage 'Clean on Entry' approaches to machinery moving around the sub-catchments.
Fencing and loss of native vegetation	Seek supporting funds for additional fencing to protect remnant vegetation and wetlands, potentially within Lot CC (south of Four Acre Road).
Water Quality	Seek the opportunity to monitor water quality within Lots AA and BB.
Bed and bank stabilisation	Encourage protection of perennial vegetation within the waterways, native or not, to armour the bed and banks of the waterway and reduce mobile sediment movement through the landscape.
Feral animal control	Provide support for feral pig, foxes and rabbit control to ensure a collaborative approach to the timing of effort.

Please note: 'encourage' and 'support' can mean to provide financial support, education or technical advice, depending on the resources available.

FOUR ACRES SUBCATCHMENT



LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

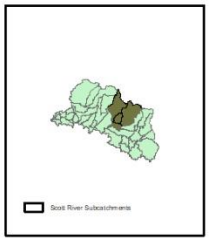
- Dam/Soak
- Blue gums
- Crossing

Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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FOUR ACRES SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Erosion

Fencing

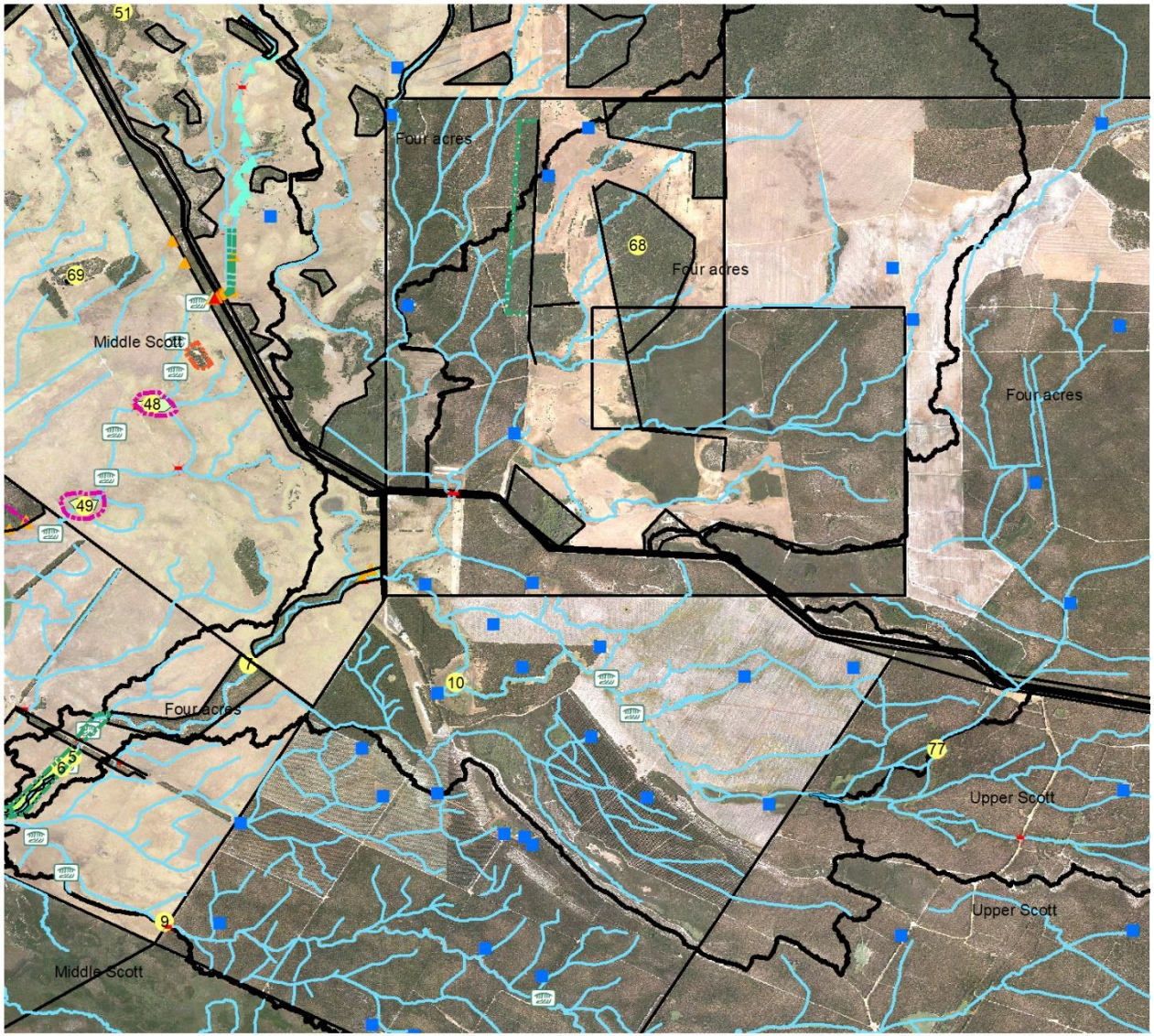
- Existing fence
- Previous grant
- Potential fence

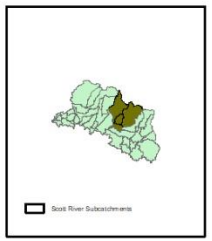
Infrastructure

- Dam/Soak
- Crossing

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre
- Previous revegetation grant





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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7.8 Four Acres (Part 3)

The waterways within one property in the Four Acre sub-catchment were assessed through a combination of aerial photograph interpretation and fieldwork.

Description for Sections FA22 and FA29

Feature	Comments
Landuse	The landuses within the assessed properties include irrigated grazing and a dairy and plantation timber with small areas of remnant vegetation.
Land tenure	The sites assessed all occurred within Freehold land (Lot EE).
Fencing	The laneways are fenced and provide some protection for waterways around the pivot system. One small wetland remnant was fenced in 2019. Fencing is minimal in the plantation portions.
Crossings	There are a number of culverts providing for water movement between extensive networks of laneways.
Stock watering	Stock have unrestricted access to most of the waterways in Lot EE.
Remnant vegetation	Five of the eleven vegetation communities within these sub-catchments have less than 30% represented in the conservation estate.

Condition for Sections FA22 to FA29

Feature	Comments
Vegetation	The small wetland downstream of FA26 and between FA24 and FA25 includes patches of very good dense sedgeland including Sheath twig rush (*Baumea vaginalis*), Bare twig rush (*Baumea juncea*) and *Juncus sp.* beneath Tasmanian blue gums (*Eucalyptus globulus*), with Dodder and occasional *Taxandria linearifolia* and *Astartea scoparia*. Persistent native understorey plants in the margins of the floodplain include Yellow flag (*Patersonia umbrosa*), *Johnsonia* sp. with *Beaufortia squarrosa*. Swamp peppermint (*Taxandria linearifolia*) and *Astartea scoparia* cover open to closed tall sedgeland with Pale rush (*Juncus pallidus*) and pasture weeds are also present. Patchy Pithy sword sedge (*Lepidosperma longitudinale*) persists along with occasional relic Hakea, *Callistemon glauca* and *Beaufortia sparsa*.
Weeds	The waterways pass through paddock and pivots. Kikuyu (*Pennisetum clandestinum*), Fleabane (Conyza spp), Pennyroyal (*Mentha pulegium*) and Curly dock (*Rumex crispus*) are widespread, while isolated Scotch thistle (*Cirsium vulgare*) are present. *Juncus*

Feature	Comments
	microcephalus, *Isolepis prolifera,* Fat hen (*Chenopodium album*) and Redshank (*Persicaria maculosa*) dominate the channel bed and banks. Blackberry nightshade (*Solanum nigrum*) occurs intermittently as does Jersey cudweed (*Helichrysum luteoalbum*).
Bank stability and erosion	The drains are artificial and re-directed around many pivots. At the upstream end of the waterway, the channel is poorly defined in part. Where the channel adjoins laneways, the channels are double fenced. Cattle pugging has destabilised the riparian wetland remnants throughout the property.
Special features, other comments	Black swans visit the farm consistently in April each year and stay for about one month. Bronzewing pigeons and wrens are present. There is interest in improving primary wastewater treatment throughout the property.
Feral animals	Anecdotal evidence suggests that the community is concerned about a perceived lack of regular feral animal control in the plantations. Feral pigs pass around the perimeter of the property periodically.

Key management priorities for Sections FA22 – FA29

Generalised management suggestions are:

- Enhance and protect remnant vegetation (dryland and wetland) persisting in the property to provide a seed store for downstream Sections.
- Exclude stock from remnant vegetation and undertake weed control within fenced areas to encourage natural regeneration processes.
- Encourage the land managers to regularly liase with the LBVPMG
- Review wastewater management throughout and invest in physical and biological nutrient removal from within the property boundaries.
- Protect wildlife that visits regularly through wetland enhancement and protection from nutrient influx.

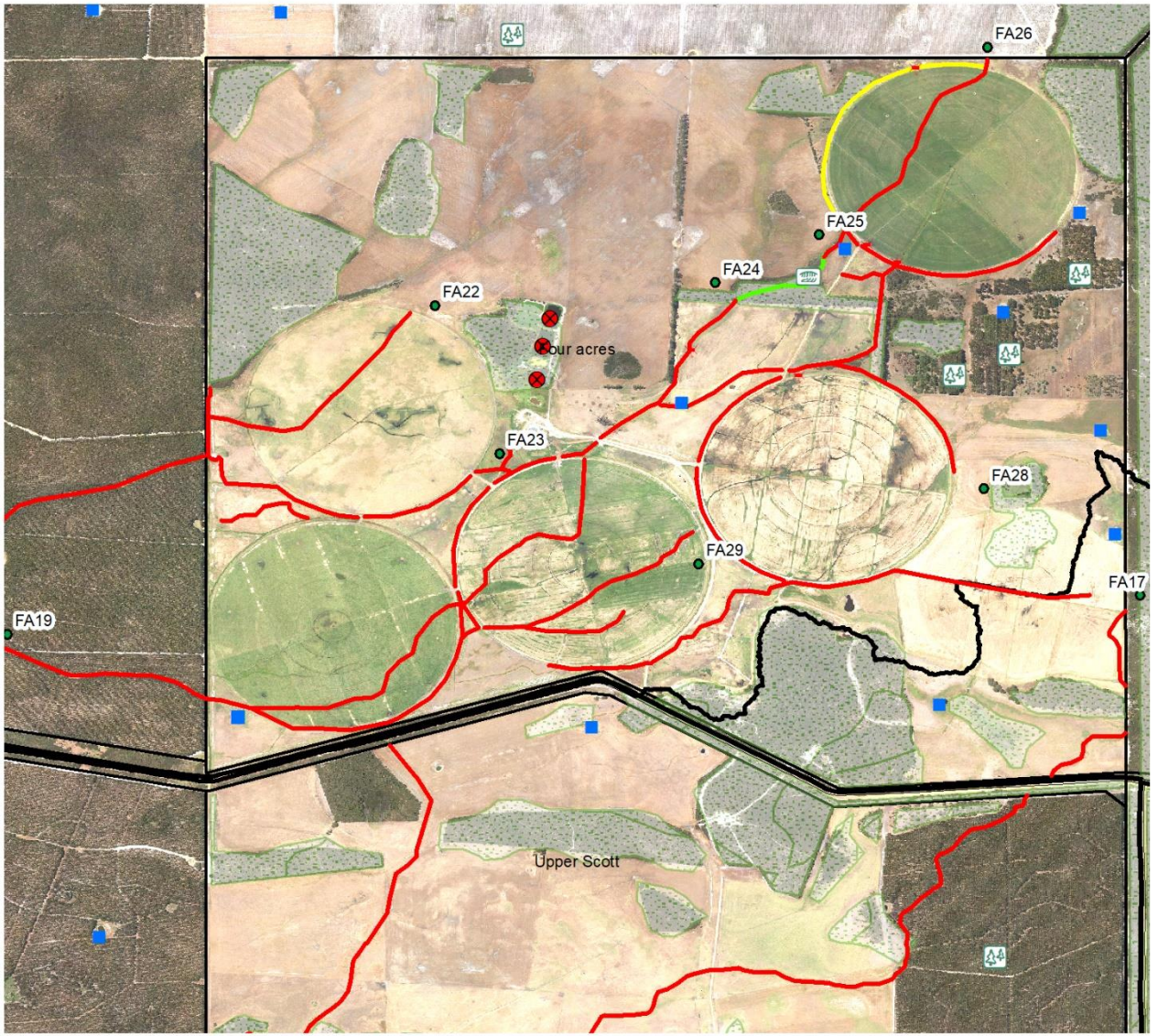
Key management actions for Sections FA22 to FA29

Issue	Issue Management Action/Advice
Weeds	Continue to replace populations of Redshank with emergent rushes and sedges to improve habitat values in channels around pivots. Target Spear thistle, Stinkwort, Bushy starwort and Docks to improve farm performance and reduce competition for establishing native plants.
Fencing and loss of native vegetation	Complete the fencing around persistent remnant vegetation within the entire property to improve stock management capacity and avoid permanent loss.

Issue	Issue Management Action/Advice
	Seek supporting funds for additional fencing to protect remnant vegetation and wetlands, potentially within Lot EE (south of Four Acre Road).
Water Quality	Investigate options to improve primary and secondary wastewater treatment within the property by utilising space between laneways and pivots for site specific nutrient export options.
Bed and bank stabilisation	Maintain perennial vegetation cover, preferably native, to prevent bank collapse and mobilisation of sediment.
Feral animal control	Support feral pig, foxes and rabbit control activities to ensure a collaborative approach to the timing of effort. DBCA does not monitor emu populations. Collect anecdotal evidence on whether emu populations are congregating in some properties more than others as a result of disturbance or other factors.

Please note: 'encourage' and 'support' can mean to provide financial support, education or technical advice, depending on the resources available.

FOUR ACRES SUBCATCHMENT



LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

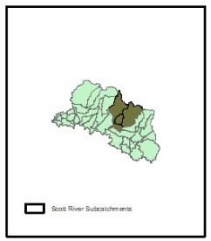
- Dam/Soak
- Blue gums
- Crossing
- Effluent treatment

Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

Note 1: Priority remnants have less than 30% of their former extent protected in conservation estate and are in private property. There are visible errors with the remnant vegetation extent as shown in these maps.

Note2: The codes with catchment initials and a number enable cross-referencing with the text.



Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

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FOUR ACRES SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

- Potential projects
- Potential revegetation nodes

Fencing

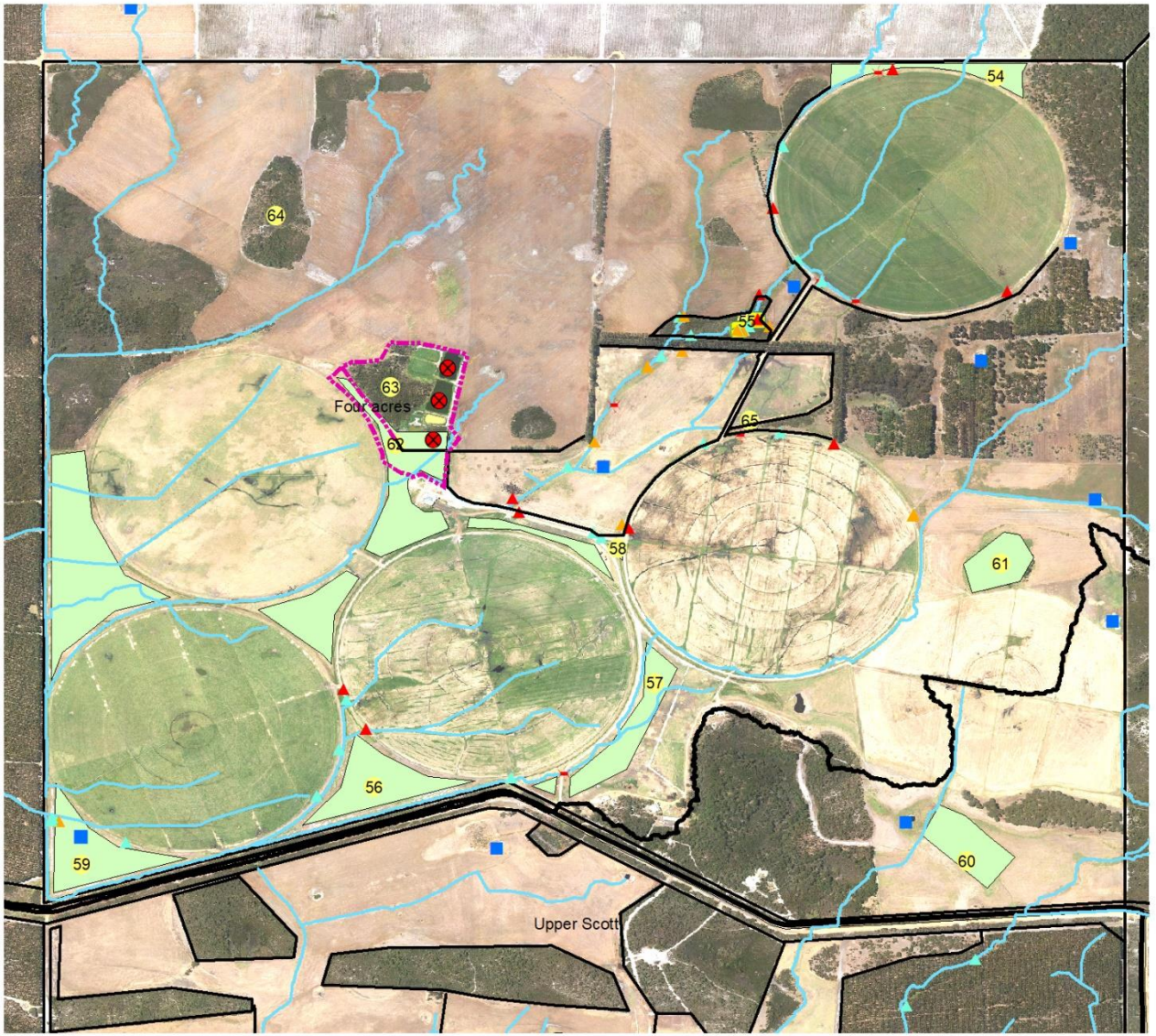
- Existing fence
- Potential fence

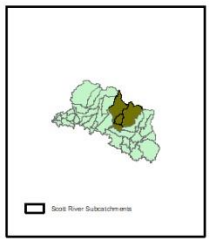
Infrastructure

- Dam/Soak
- Crossing
- Effluent treatment

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.25 0.5 km

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7.9 Upper Scott

Two properties were selected for assessment within the Upper Scott River sub-catchment.

Description for Sections US01 to US08

Feature	Comments
Landuse	The landuse is dryland grazing with some remnant vegetation persisting.
Land tenure	The site assessment is entirely within Freehold land (Lot FF).
Fencing	The paddock arrangement results in fences crossing many waterways and there is limited protection for waterways and wetlands. Fences provide some protection for some hilltop remnant vegetation.
Crossings	Culverts are used within the laneway system and the majority of waterways can be crossed with care as they are wide and shallow.
Stock watering	Stock generally have unrestricted access to most of the waterways through the property.
Remnant vegetation	Six of the 12 vegetation complexes are inadequately protected in conservation reserves with less than 26% of their extent in conservation estate.

Condition for Sections US01 to US08

Feature	Comments
Vegetation	Where the channel passes through agricultural land, there is no relic native vegetation. There is one wetland remnant located in the centre north of the Lot (US5) that retains a dominant overstorey of Freshwater paperbark (*Melaleuca rhaphiophylla*) and dense stands of Swamp peppermint (*Taxandria linearifolia*). A diverse and healthy understorey comprising Pithy sword sedge (*Lepidosperma longitudinale*), *Anarthria scabra*, Bare twig rush (*Baumea juncea*), Sheath twig rush (*Baumea vaginalis*) and Bracken fern (*Pteridium esculentum*) occur on the margins of the woodland. *Alternanthera nodiflora* is present in some channel beds. Other wetland remnants within the property include *Astartea scoparia,* Wonnich (*Callistachyus lanceolata*) and some Scott River Cedar (*Taxandria juniperina*). These remnants are well away from the targeted waterways. WA peppermint, small Jarrah (*Eucalyptus marginata*) and WA Christmas tree (*Nuytsia floribunda*) occur on the sandy hills. There are also small pockets of Freshwater paperbark (*Melaleuca rhaphiophylla*) that line the edge of seasonal pools with Balga (*Xanthorrhoea preissii*) on the margins. The understorey includes a diverse range of introduced grasses but particularly Kikuyu (*Pennisetum clandestinum*), Yorkshire fog (*Holcus lanatus*) with patchy Sheath twig rush

Feature	Comments
	(*Baumea vaginalis*), *Muehlenbeckia*, Spreading sword sedge (*Lepidosperma effusum*) and Native wisteria (*Hardenbergia comptoniana*).
Weeds	Blackberry nightshade occurs throughout the blue gum plantations and on the margins of firebreaks. Dock (*Rumex crispus*) and Redshank (*Persicaria maculosa*) have increased in density in recent years, changing the flow dynamics of the main channels. A weevil had been targeting the Dock but the biological control has proven less effective over the years.
Bank stability and erosion	All waterways on the property are artificial channels with the only natural formation on the southern boundary and Scott River.
Special features, other comments	There is interest in identifying a market for fox pelts to encourage coordinated fox shoots through the area. The firebreak installed by DBCA is eroding and impacting on channel bed stability and boundary fences are being undermined.
Invasive terrestrial fauna management	Pigs are widespread in the neighbouring river, wetlands and conservation reserves. The farmers have a perception that there is a significant drop in juvenile emus and chicks and have an opinion that feral pigs are eating the eggs or young birds. This also applies to swans and plovers. The pigs live in Gingilup Swamp throughout the summer and then move into the farming properties as it floods in winter.

Key management priorities for Sections US01 – US08

Generalised management suggestions are:

- Liaise with neighbours and the LBVPMG to encourage invasive species control.
- Consider expanding fencing program for remnants and wetland portions of the property to facilitate stock mustering and management.

Key management actions for Sections US01 – US08

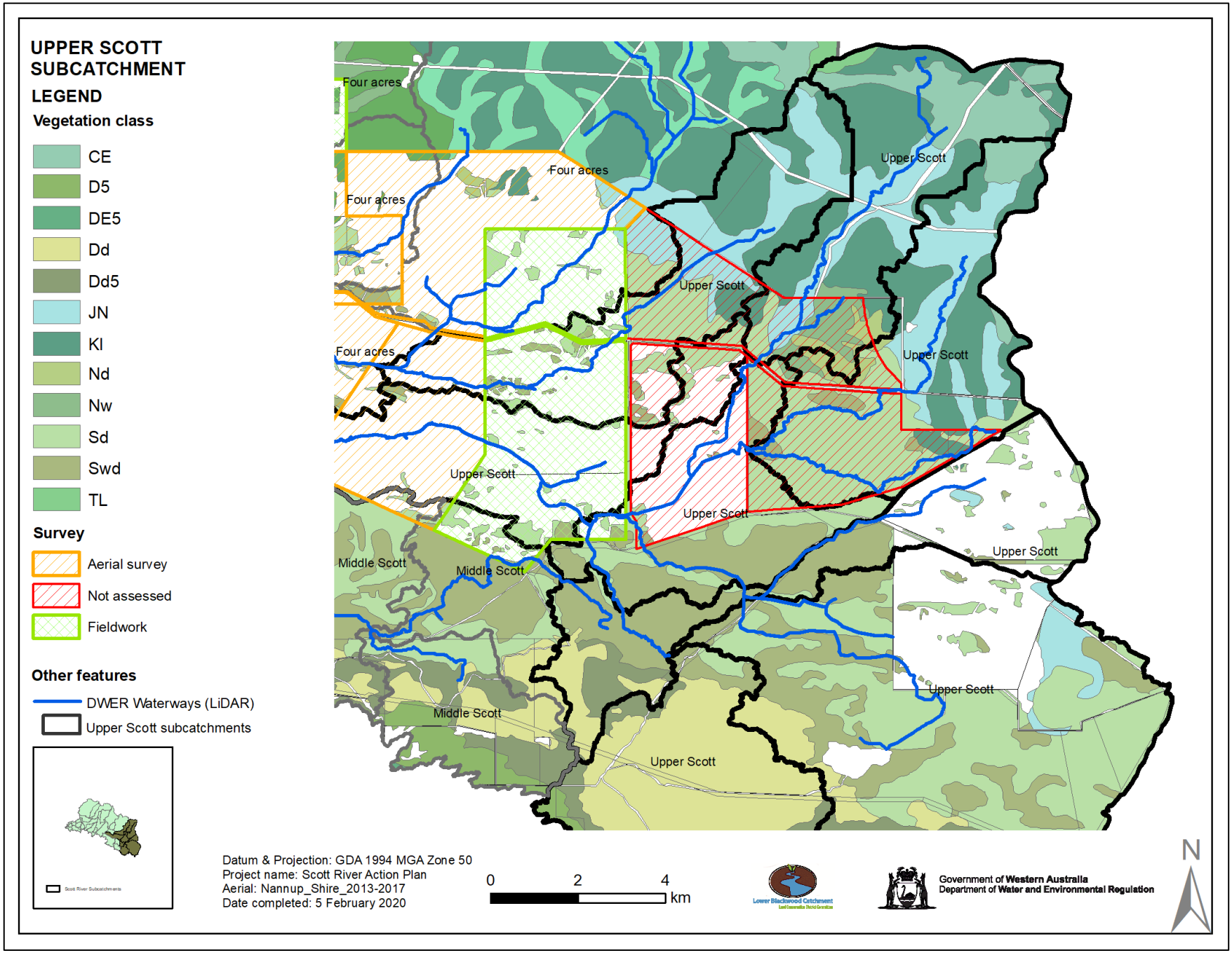
Issue	Issue Management Action/Advice
Weeds	Monitor new weed incursions in property and treat prior to populations expanding.
Fencing and loss of native vegetation	Review boundary alignment along southern edge to determine more manageable alignments in consultation with DBCA, to reduce replacement and vegetation clearing issues if possible. Consider extending the fencing program to include all significant remnant and hilltop vegetation within the property.

Issue	Issue Management Action/Advice
Bed and bank stabilisation	Review drainage construction, weirs and waterways to determine if alternative management systems are appropriate. Consider revegetation of the wetland in the south-east corner to reduce sediment movement into high conservation value vegetation.

Sample photos from Sections US01 to US08

Plate 21: Standard drainage design

Plate 22: Firebreak


UPPER SCOTT SUBCATCHMENT
LEGEND
Vegetation class
CE
D5
DE5
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Dd5
JN
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Nd
Nw
Sd
Swd
TL
Survey
Aerial survey
Not assessed
Fieldwork
Other features
DWER Waterways (LiDAR)
Upper Scott subcatchments
Four acres
Four acres
Four acres
Four acres
Upper Scott
Upper Scott
Upper Scott
Upper Scott
Upper Scott
Upper Scott
Upper Scott
Middle Scott
Middle Scott
Middle Scott
Upper Scott
Upper Scott
Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Aerial: Nannup_Shire_2013-2017
Date completed: 5 February 2020
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Government of Western Australia
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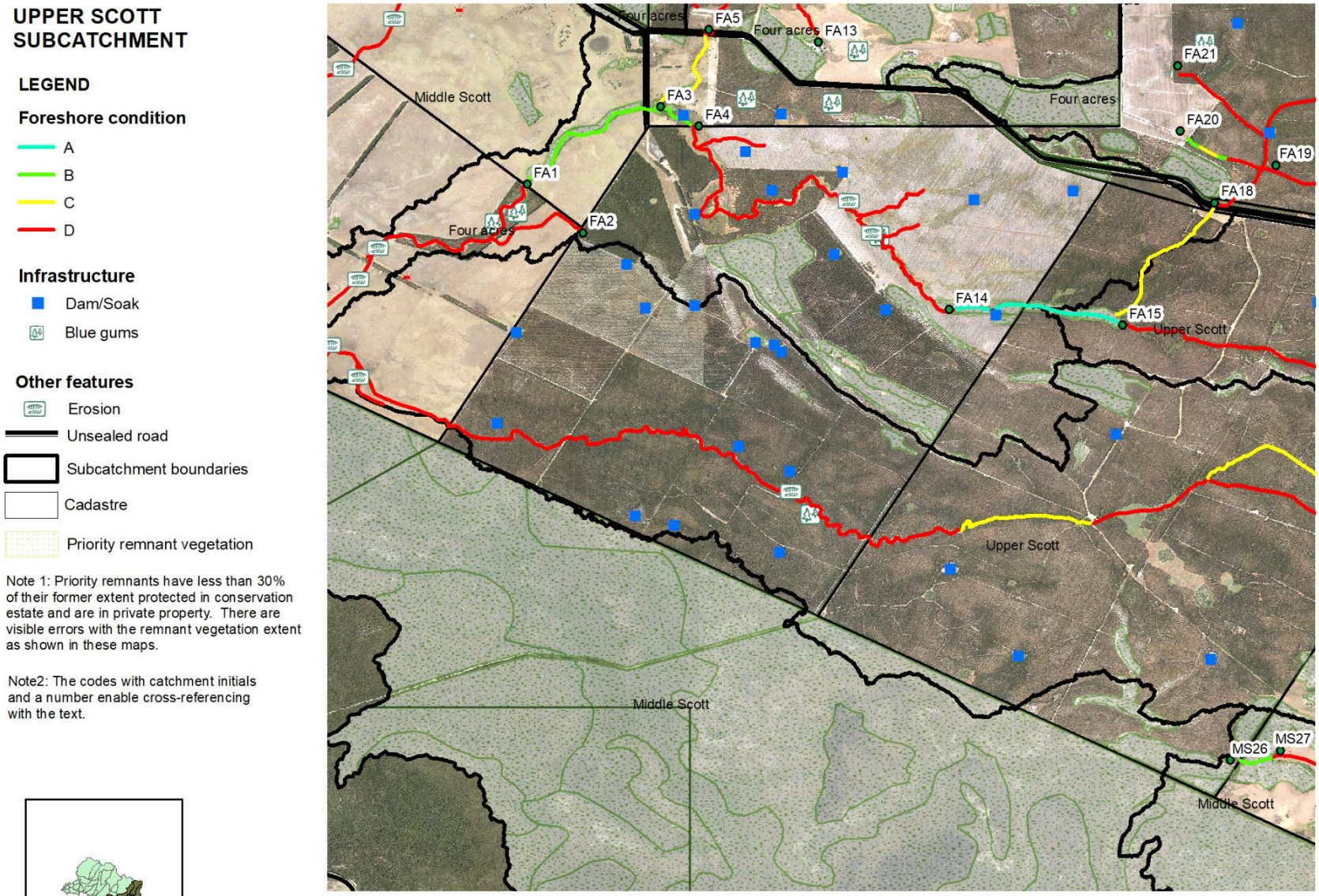

LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

- Dam/Soak
- Blue gums

Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

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Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

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UPPER SCOTT SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Potential projects

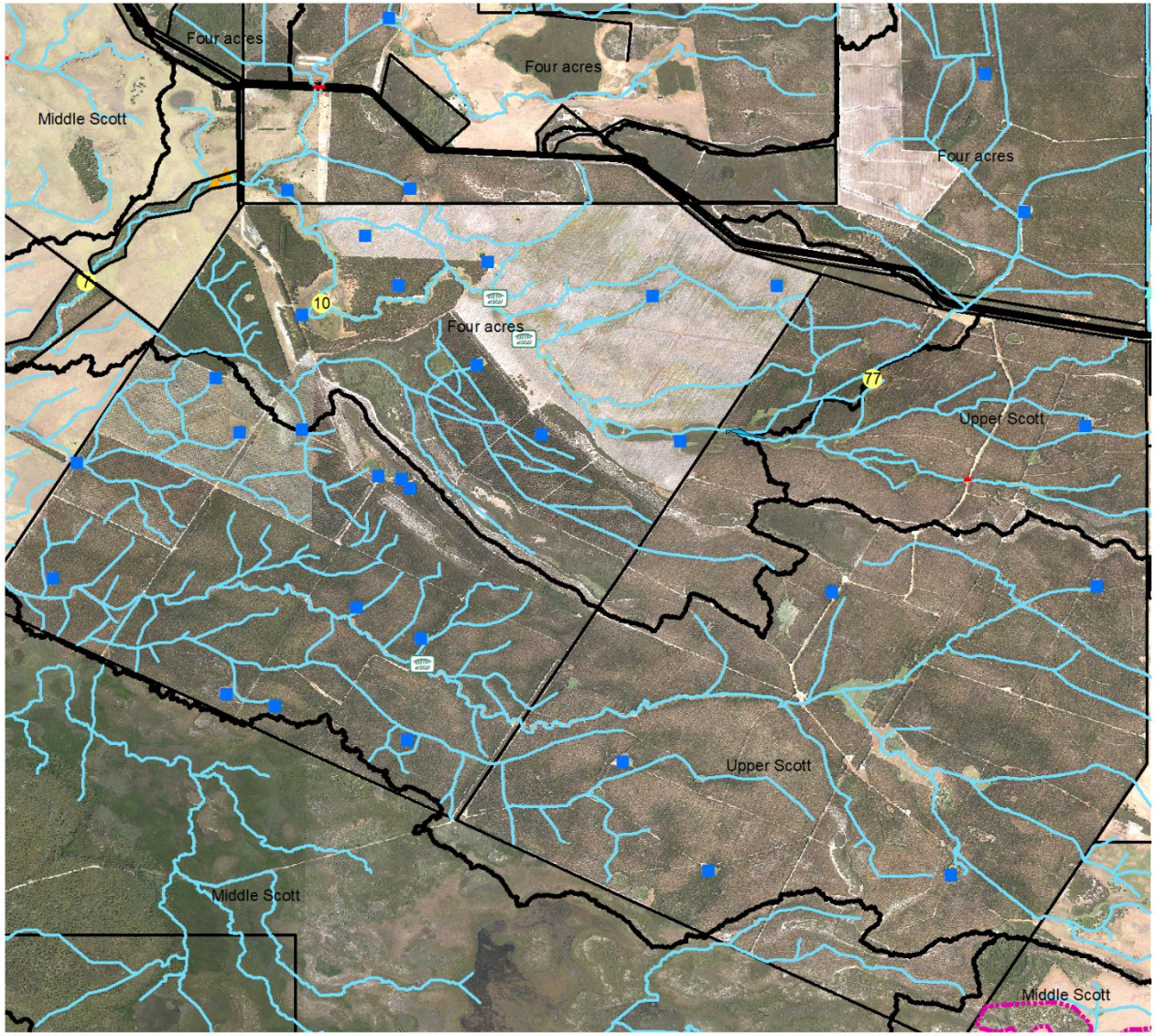
- Potential projects

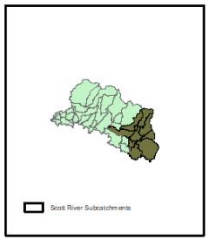
Infrastructure

- Dam/Soak
- Crossing

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre
- Erosion





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

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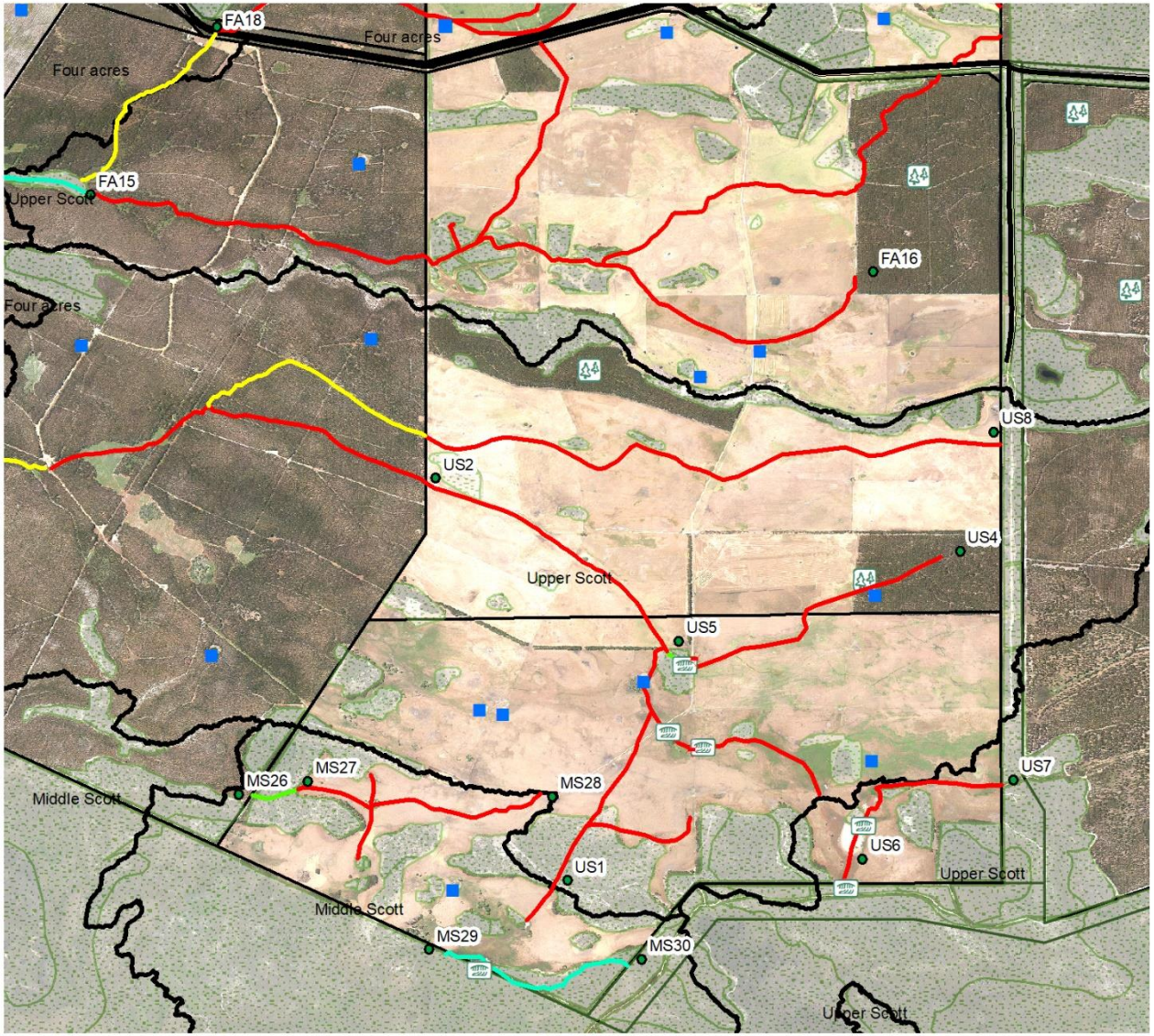
UPPER SCOTT SUBCATCHMENT



LEGEND

Foreshore condition

- A
- B
- C
- D

Infrastructure

- Dam/Soak
- Blue gums

Other features

- Erosion
- Unsealed road
- Subcatchment boundaries
- Cadastre
- Priority remnant vegetation

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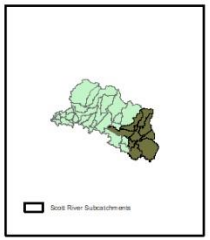

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Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.5 1 km

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UPPER SCOTT SUBCATCHMENT

LEGEND

Priority weeds

- 1
- 2
- 3

Fencing

- Existing fence

Potential projects

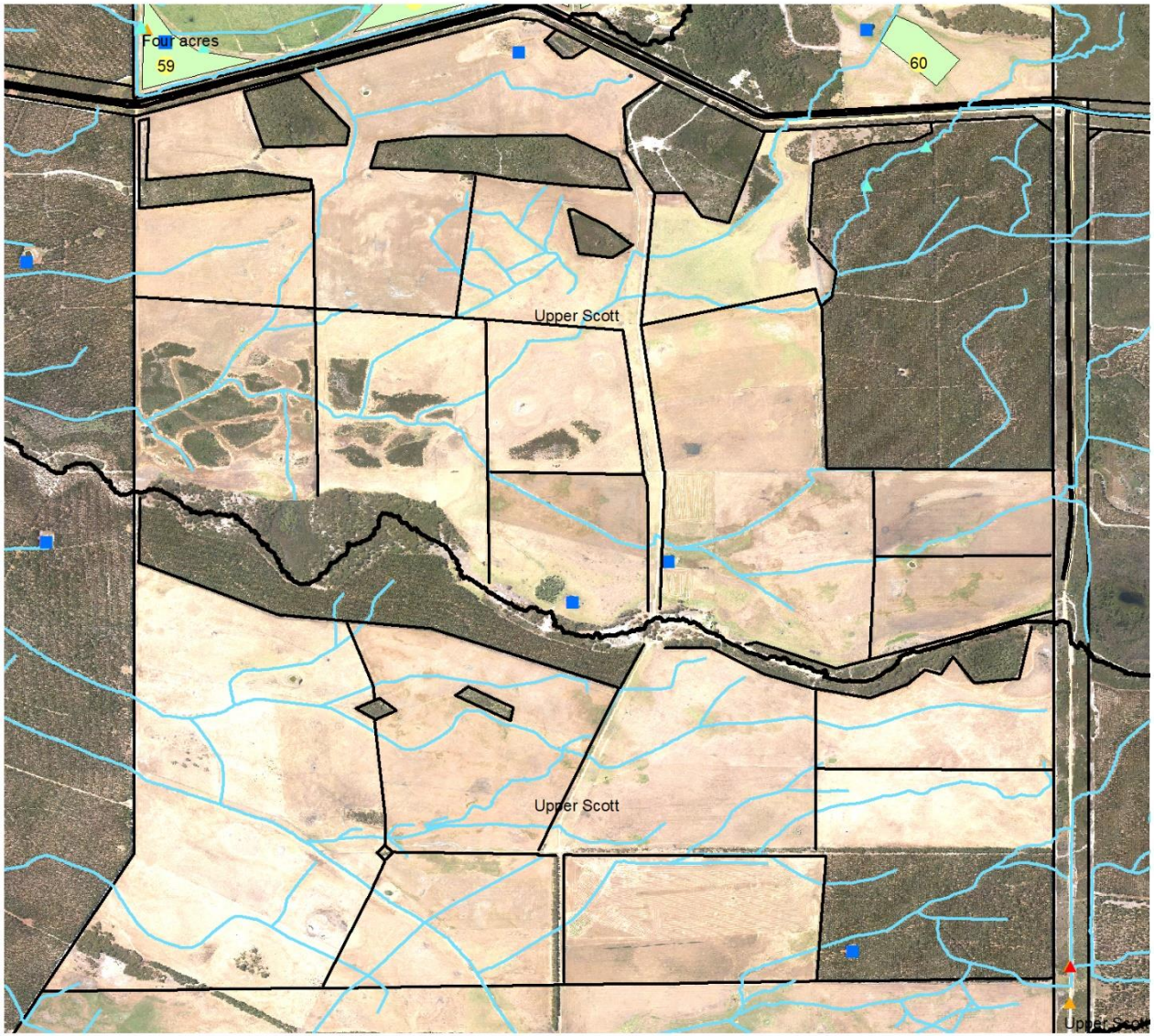
- Potential projects
- Potential revegetation nodes

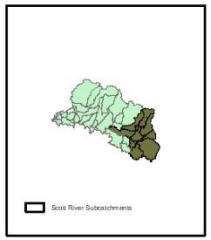
Infrastructure

- Dam/Soak

Other features

- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

0 0.4 0.8 km

Government of Western Australia
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UPPER SCOTT SUBCATCHMENT

LEGEND

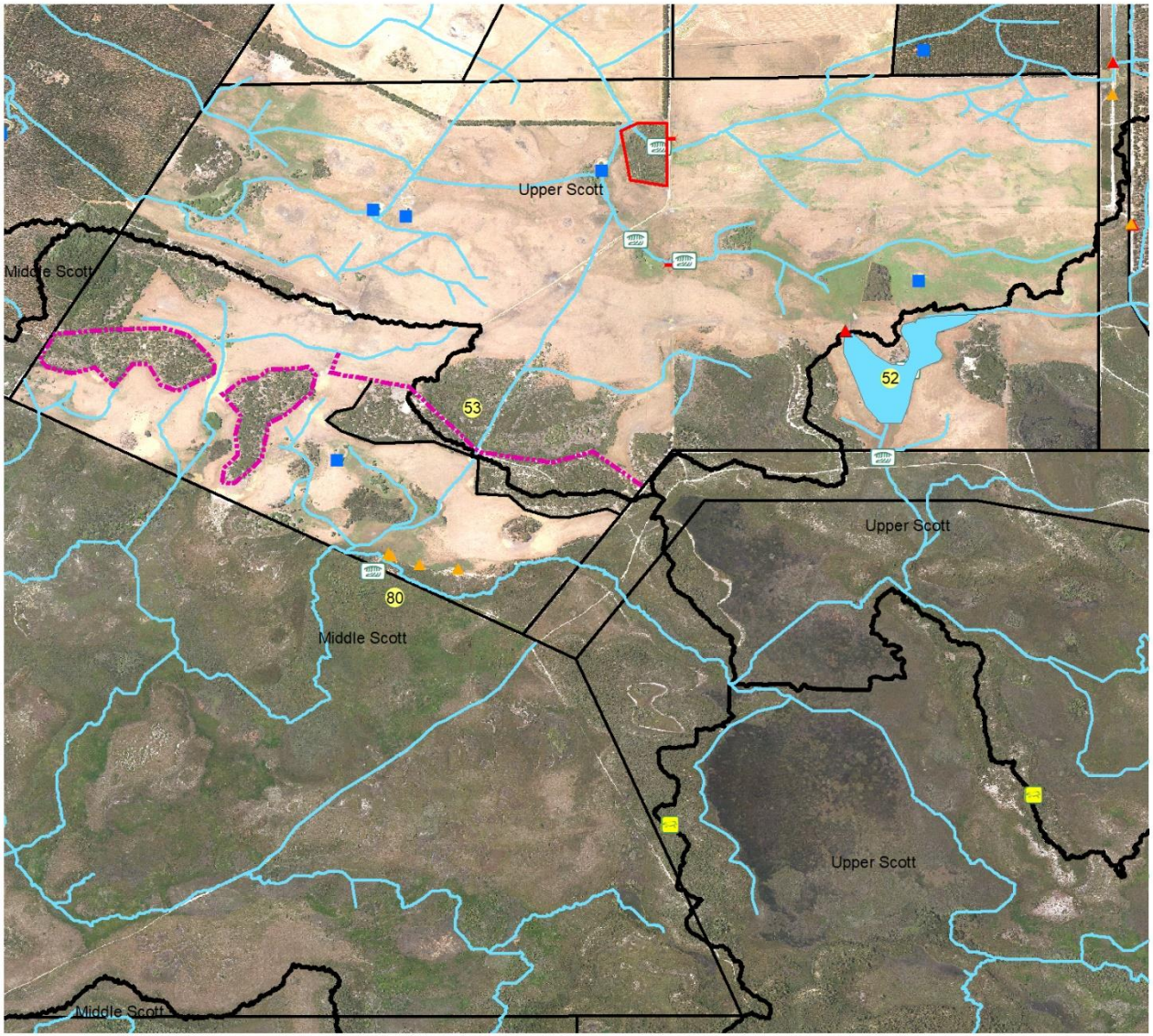
Priority weeds
- 1
- 2
- 3

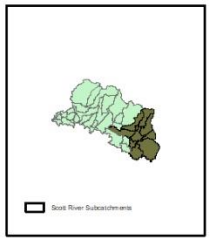
Potential projects
- Feral_animals
- Potential projects_Summary
- Potential revegetation nodes

Fencing
- Existing fence
- Fence maintenance required
- Potential fence

Infrastructure
- Dam/Soak
- Weir

Other features
- Erosion
- DWER Waterways (v9)
- Unsealed roads
- Subcatchment boundaries (v9)
- Cadastre





Datum & Projection: GDA 1994 MGA Zone 50
Project name: Scott River Action Plan
Date completed: 5 February 2020

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APPENDIX B

Flora and Fauna

Table 23: EPCB Act Threatened and priority flora species present within the Catchment (source DBCA's; 5th December 2018). Refer to conservation codes at the beginning of the document.

Scientific name	Common name	Schedule
Adenanthos detmoldii	Scott River Jugflower	P4
Adenanthos x pamela		P4
Andersonia ferricola		P1
Andersonia sp. amabile		P3
Aotus carinata		P4
Astartea onycis	Clawed Astartea	P4
Banksia meisneri subsp. ascendens	Scott River Banksia	P4
Banksia nivea subsp. uliginosa		T
Banksia sessilis var. cordata		P4
Blennospora doliiformis		P3
Boronia anceps		P3
Boronia exilis		T
Caladenia abbreviata		P3
Calothamnus lateralis var. crassus		P3
Chordifex gracilior		P3
Chordifex jacksonii		P3
Chorizema carinatum		P3

Scientific name	Common name	Schedule
Cyathochaeta stipoides		P3
Dampiera heteroptera		P3
Darwinia ferricola		T
Drosera fimbriata	Manypeaks sundew	P4
Gastrolobium formosum		P3
Grevillea manglesioides subsp. ferricola		P3
Grevillea papilosa		P3
Isopogon formosus subsp. dasylepis		P3
Lambertia orbifolia subsp. Scott River Plains		T
Leucopogon alternifolius		P3
Leucopogon sp. Gingilup		P2
Leucopogon wheelerae		P3
Melaleuca incana subsp. Gingilup		P2
Stylidium leewinense		P4
Synaphea nexosa		P1
Synaphea otiostigma		P3
Verticordia lehmannii		P4
Verticordia plumosa var. vassensis		T
Conospermum quadripetalum		P2
Cyathochaeta teretifolia		P3
Hemigenia sp.Nillup		P2
Gonocarpus pusillus		P4
Hybanthus volubilus		P2
Lasiopetalum membranaceum		P3
Leptomeria deilsiana		X
Lepyrodia extensa		P2
Lepyrodia heleocharoides		P3
Loxocarya magna		P3
Melaleuca basicephala		P4
Myriophyllum trifidum		P4
Pericalymma megaphyllum		P1
Philydrella pygmaea ssp. minima		P1
Schoenus loliaceus		P2
Stylidium gleophyllum		P4
Stylidium sp.Scott River Plain		P1
Stylidium trudgeonii		P3

Scientific name	Common name	Schedule
Synaphea macrophylla		P1
Thysanotus formosus		P1
Tripterococus sp. brachylobus		P4

Table 24: EPBC Act (1999) Threatened and priority fauna that are known to forage (*) or may have suitable habitat within the Catchment (source DBCA's; 23rd May 2017). Refer to conservation codes at the beginning of the document.

Scientific name	Common name	WA Status	EPBC Status
Setonix brachyurus	Quokka	Vulnerable	Vulnerable
*Pseudocheirus occidentalis**	Western Ringtail Possum	Critically Endangered	Critically Endangered
*Calyptorhynchus baudinii**	Baudin's cockatoo	Endangered	Endangered
*Calyptorhynchus banksii naso**	Forest Red-tailed Black-Cockatoo	Vulnerable	Vulnerable
*Calyptorhynchus latirostris**	Carnaby's Cockatoo	Endangered	Endangered
Nannatherina balstoni	Balston's Pygmy Perch	Vulnerable	Vulnerable
Dasyurus geoffroi	Chuditch	Vulnerable	Vulnerable
Engaewa reducta	Dunsborough and Margaret River Burrowing Crayfish	Endangered	Critically Endangered
Westralunio carteri	Carter's Freshwater Mussel	Vulnerable	Vulnerable
Galaxiella munda	Western dwarf galaxias	Vulnerable	
Lepidogalaxias salamandroides	Salamanderfish	Endangered	
Pandion cristatus	Osprey	MI	MI
Galaxiella nigrostriata	Black-stripe minnow		Endangered
Lepidogalaxias salamandroides	Salamanderfish	Endangered	

Table 25: Fauna species not listed as Threatened likely to be found within the Catchment.

Scientific name	**Common name**
Galaxias occidentalis	western minnow
Cherax quinquecarinatus	gilgie
Cherax cainii	smooth marron
Cherax preissii	koonac
Nannoperca vittata	Western pygmy perch
Bostockia porosa	nightfish
Pseudogobius olorum	Swan River goby
Afurcagobius suppositus	blue-spot goby

Table 26: BCA List - Threatened and priority fauna that are known to forage (*) or may have suitable habitat within the Catchment.

Scientific name	Common name	Status
Elapognathus minor	Short-nosed snake	P2
Falco peregrinus	Peregrine falcon	OS - Specially protected
Hydromys chrysogaster	Rakali	P4
Tyto novaehollandiae novaehollandiae (southwest)	Masked owl	P3
Ninox connivens (southwest subpop.)	Barking owl	P3
Isoodon fusciventer	Quenda	P4
Macropus irma	Western brush wallaby	P4
Thinornis rubricollis	Hooded plover	P4
Phascogale tapoatafa wambenger	Brushed-tailed phascogale	CD
Austroassiminea letha	Cape Leeuwin snail	VU

Table 27: Common frogs found in the Catchment.

Common name	Scientific name	Key characteristics	Call type
Bleating Froglet	*Crinia pseudoinsignifera*	Belly with grey spots.	A warbly 'baaa…baaa…baaa'
Crawling Toadlet	*Pseudophryne guentheri*	Short arms and legs, crawls.	A short sharp grating rasp
Forest Toadlet	*Metacrinia nichollsi*	Walks, short legs, belly with colourful spots.	A short croak with a twang
Rattling or Clicking Froglet	*Crinia glauerti*	Belly lumpy with black and white patchwork.	A drawn-out rattle
Roseate Frog	*Geocrinia rosea*	Pink to red smooth belly.	- 'Tk...tk...tk...tk'
Slender Tree Frog	*Litoria adelaidensis*	Green or brown, dark side stripes.	A loud grating 'grrrk'
Sunset Frog	*Spicospina flammocaerulea*	Lumpy purple back with orange belly.	'Da duk...da duk' repeated frequently
Ticking Frog	*Geocrinia leai*	Dark back with smooth pale green belly.	- A 'tk...tk...tk'
Walpole Frog	*Geocrinia lutea*	Yellow belly, males with black throats.	A series of clicks
Quacking frog	*Crinia georgiana*	Variable back pattern all with distinctive red patch in groin	Sounds like duck quacking
Moaning frog	*Heleiporos eyreii*	Robust build with flanks behind front limbs distinctive yellow.	Long drawn out mournful moan
Motorbike frog	*Litoria moorei*	Most common frog up to 7.5 cm	Sounds like motorbike changing gears
Western Banjo frog	*Limnodynastes dorsalis*	Thin pale, yellow line running from nose to rump. Bright orange to red patches in groin.	Single explosive 'bonk'

RIPARIAN RESTORATION - CASE STUDY

CREEK RESTORATION PROJECT IN THE SCOTT RIVER CATCHMENT

Background & Project Planning:

In late winter and early spring of 2018, the implementation of a riparian revegetation project in the Scott River Catchment was undertaken. The project involved the planting of native trees, shrubs, sedges and rushes along two creeklines on the property. The primary goal was to increase native plant cover in order to enhance the biodiversity value and habitat for fauna of the degraded waterways whilst reducing the density and distribution of invasive plant species. Both creeklines were observed to be very degraded with only sporadic patches of remnant vegetation. Bank gradient was pronounced in one of the creek (up to 1.5m) and less in the other (0.5m). Weed cover was estimated at approximately 30% for the areas treated in the weeks prior to planting and as high as 100% in the lower lying areas sprayed in the days before implementation. Sedimentary accumulation was difficult but appears to be minimal along both creeklines.

Electric stock fencing around the perimeter of the two creekline planting sites was installed by the landholder and will serve to eliminate the threat of encroachment by cattle and minimise kangaroo access. Fenceline breaks with gates for vehicle and cattle crossings were installed.

Post planting an activity report and email incorporating recommendations for maintenance of the sites was forwarded to the LBLCDC representative. No provision for follow up was allocated to the contractor.

Site Preparation

Electric stock fencing was installed by the landholder to eliminate the threat of encroachment by cattle and minimise kangaroo access. Fenceline breaks with gates for vehicle and cattle crossings were also installed.

The landholder also undertook weed control once winter weeds had germinated across the site.

Planting

15,200 seedlings were planted along both creeklines during September and October 2018 with the budget allowing for the installation of 3040 tree guards – equating to one third of the tree and shrub species. To protect the revegetation area, the landholder installed fencing approximately 10 meters from the centre and either side of the creek.

Planting was undertaken with Pottiputkis and a small hand held auger depending on seedling pot size and species requirement. Sedges and rushes were concentrated along the edge of the waterway with shrub and tree species spread randomly in the more elevated areas of each creekline. Sedges and rushes were planted at a density of 2 plants per $1m^2$ and shrub and tree species were planted at a density of 1 plant per $3m^2$. The species list is provided in Figure 38.

Cape Life

Prosser Species Mix Breakdown (per area)

Species	Creekline 1 (1km)	Plants per area	Creek/Drain (520m)	Plants per area
Trees and Shrubs				
Agonis flexuosa	463	58	241	48
Anigozanthos flavidus (Green)	505	63	263	53
Astartea scoparia	589	74	307	61
Banksia littoralis	622	78	323	65
Beaufortia sparsa	253	32	131	26
Calothamnus lateralis	758	95	394	79
Corymbia calophylla	168	21	88	18
Melaleuca incana	168	21	88	18
Melaleuca lateritia	484	60	251	50
Melaleuca rhaphiophylla	1011	126	525	105
Taxandria linearifolia	716	89	372	74
Viminaria juncea	379	47	197	39
Sedges and Rushes				
Baumea articulata	253	32	131	26
Juncus pauciflorus	1474	184	766	153
Juncus subsecundus	1474	184	766	153
Lepidosperma effusum	316	39	164	33
Lepidosperma tetraquetrum	237	30	123	25
Meeboldina scariosa (now Leptocarpus scariosus)	132	16	68	14
Overall Total	**10000**	**1250**	**5200**	**1040**

Note - There is 176 extra trees and shrubs and 176 less sedges and rushes to what was quoted

yellow shading shows species to be guarded

Figure 38: Project species list. In yellow, the species chosen for tree guard protection were those deemed more susceptible to predation.

Figure 39: Planting in the Scott River. Site 1.

Figure 40: Planting in the Scott River. Site 2.

Monitoring & Evaluation

Project evaluation was not included in the contractor request for quote and therefore there were no transects or monitoring points established at the time of implementation. Without this information, it is difficult to get a true representation of survival rates and species distribution across both sites. To evaluate this project one year after the planting the contractor was commissioned by the LBCLC to establish a number of transects and their baseline data. The data captured in the transects does not necessarily reflect the seedlings that may have died since planting but weren't visible during the evaluation. Therefore, in support of the transect observations, a random survey of 50 guarded species was undertaken, adjacent to each transect, to give a survival percentage of those seedlings planted with the protection of tree guards.

Findings

General observations indicate that after 1 year the Viminaria juncea and Corymbia calophylla seedlings display the most growth amongst those species planted in the more elevated soil profile closest to the fenceline perimeter. Agonis flexuosa is also well represented amongst surviving seedlings but without the proliferation of growth shown by other species. In the soil profile between the middle of the buffer and the edge of the water (during planting), the Melaleuca species appear to have established more effectively than species such as Beaufortia sparsa, Banksia littoralis and Calothamnus lateralis which were poorly represented. Of these better surviving species, the most prolific growth was observed in the Melaleuca

incana, Melaeuca raphiophylla, Melaleuca lateritia and Taxandria linearifolia seedlings.

The sedges and rushes planted were also poorly represented throughout both creeklines. Due to the weed density, outside of the monitored transects, it was difficult to get a visual representation on the survival success of these seedlings.

Survival rate

Creekline 1 North: an average survival percentage of 54% with the highest record at 81% and the lowest at 31%. Of the 200 seedlings planted with tree guards and counted across 4 survey areas adjacent to each transect, the average survival rate in Creekline 1 North is recorded as 33% with only minor variation amongst most of the survey areas.

Creekline 2 South: Observations recorded in the 2 transects located along this waterway indicate an average survival percentage of 44% and an average species representation of 3.5 species – out of 18 planted. The survey of tree guarded seedlings indicates a survival percentage of 34% of those species planted with protection.

The weed burden and distribution observed during site evaluation in October 2019 was significant with a number of species exhibiting strong growth throughout both creeklines. The contractor's recommendation was not to undertake any weed control and/or slashing due to the growth height of weeds and their proximity to the planted native seedlings. It is recommended to wait for the weeds to die off and monitor the sites throughout summer and autumn, undertaking weed control once seasonal germination has occurred next year and before weed growth becomes restrictive. Infill planting would be of benefit during Winter 2020 if the opportunity were to become available providing a well-timed follow up weed control program could be administered. Continued visual assessment of the exclusion fencing would also be recommended to maintain its integrity.

Observations indicate that weed management and potential insect damage appear to be the main mitigating factors in the reduction in planting density, species diversity and seedling establishment. No significant predation by kangaroos was evident, however predation by rabbits could not be assessed as seedlings would have been partially or wholly consumed and were not visible during evaluation.

Recommendations for similar project sites

- Undertake at least two separate whole site weed control events prior to planting occurring. This will minimise weed competition with seedlings and prevent having to plant into dense grasses.
- Schedule in follow up weed treatments in Spring, Summer and Autumn following planting for at least two years after the planting date. Grass selective herbicides can be used to prevent off target damage and careful spot spraying of broadleaf species will ensure planted seedlings have the best opportunity to establish.
- Schedule seasonal site inspections to allow for assessment of weed burden, insect damage, seedling predation and exclusion fencing. Based on these inspections, remediation works can be implemented to ensure maximum seedling survival.
- If future monitoring is likely to be required, organise for monitoring plots to be established once the site is planted so that the information captured at this time can be used for comparison against data recorded in subsequent monitoring events.
- An assessment of the presence of local rabbit populations could be beneficial in determining the requirement of baiting prior to planting.
- Increase planting density of sedges/rushes and target specific areas for planting as opposed to planting along the entirety of each creekline.

Weed Control Methods

Table 28: Weed control methods

Weed	Control method
Apple of Sodom Solanum linnaenum A declared plant by the Department of Agriculture and Food under the categories P1 and P4 which prohibits movements and aims to prevent infestation from spreading beyond existing boundaries. The seed is spread by birds.	An erect perennial shrub with deeply lobed prickly leaves, and prickly stems and branches. It has a purple star shaped flowers often throughout the year and the fruits are bright yellow when mature. Introduced from South Africa, it is a serious problem in parts of the South West, especially in grazed paddocks and creek lines. Small plants may be grubbed out; however, all root fragments must be removed. Control but can be achieved by spraying the shrub until thoroughly wet with a mixture of 120 mL amitrole (250 g/L) in 10 L water. The area needs to be checked the next season for seedling regrowth (Moore, Wheeler 2008).
Cape tulip Moraea spp. A declared plant by the Department of Agriculture and Food under the categories P1 and P4 which prohibits movements and aims to prevent infestation spreading beyond existing boundaries.	Both one and two leaf Cape Tulips are toxic to stock and most deaths occur in hungry animals that have recently been introduced to the plant. There are several methods of control including cultivation 250 mm in June or July or spraying in June through to early September. Control normally takes several years and follow-up is essential cultivation to expose the corms a few weeks after spraying may improve control (Moore, Wheeler 2008).
Woody weeds* *only black wattle identified during the survey. Willow tree species (Salex sp.). WONS & a declared plant by DAFWA under the category P1 which prohibits movements and aims to prevent infestation spreading beyond existing boundaries. Sweet (Wavy) Pittosporum Pittosporum undulatum Black wattle (Acacia melanoxylon)	Woody weeds and deciduous species like Willows and Poplars can be controlled using stem injection or cut and paint with undiluted glyphosate. To stem inject, holes should be drilled around the trunk and spaced no more than 5 cm apart into the sapwood (just beyond the bark, but not into the heartwood) and herbicide injected immediately. The tree may take up to 3 months to die and can then be felled or left as habitat. To cut and paint, the tree should be felled with a chainsaw as close to the ground as possible and painted immediately with undiluted herbicide. All material must be removed and monitoring for suckers should continue for at least 2 years. Willow tree species (Salex sp.). – except Weeping Willow (S. babylonica), Pussy Willow (S. x calodendron) and Sterile Pussy Willow (S. x reichardtii), are considered WoNS and are declared plants in WA. There were several willow species on Bullant Road at the creek crossing however which species these were was not determined. It is recommended that the identity of the species be determined and dealt with accordingly. Sweet (Wavy) Pittosporum is a shade-tolerant shrub or small tree that produces fleshy orange fruits that are highly attractive to birds. It is highly invasive and out-competes native species forming dense thickets. It is killed by fire and can be controlled by hand weeding or cutting down large plants and applying 50% Glyphosate to the cut trunk (CCCG, 2009). Black Wattle (Acacia melanoxylon) is a native of eastern Australia and has been used in re-vegetation projects. It reproduces vigorously and has the potential to become a serious wetland weed from Augusta to Albany. It is recommended that they not be used in any re-vegetation works and removed from existing locations. Control methods include hand pulling of seedlings, drill and fill with 50% glyphosate and ring barking the older plants by spraying or painting the lower 60 cm of bark with a herbicide (Triclopyr/Picloram) and a penetrant (usually diesel).

Weed	Control method
Pennyroyal Mentha pulegium	A slightly succulent rhizomatous perennial that favours damp conditions such as along paddock drains and creek lines. Has a strong mint-like smell when crushed. Chemical control using high rates of glyphosate when actively growing is sometimes effective. Caution should be used when applying glyphosate near waterways. Spray when flows have stopped. Cultivation can be successful but relies on the establishment of a rapidly germinating, competitive crop or pasture and this can be difficult on land that is often waterlogged. Replanting the waterlogged areas with native trees and shrubs will shade out the herb.
Grasses Kikuyu (Pennisetum clandestinium),	These perennial-introduced grasses all spread from runners or rhizomes and are very invasive. Manual control (except large scale scalping) is not effective. A spray-burn-spray regime using glyphosate appears to work well. In areas where water levels recede (allowing herbicide and fire use) it is best to spray in late spring or early summer when the grass is actively growing and respray when new shoots emerge. Where native vegetation is present it is best to use a grass selective herbicide for example Fusilade®.
Useful references on weed control Southern Weeds and their control booklet (Moore and Wheeler, 2008). LBLCDC newsletters and brochures (contact LBLCDC for a copy)	