Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis)* Communities in the Northern & Yorke Region 2008-2016

Update for *Natural Resources Northern & Yorke*

December 2016

by
Dr Anne Jensen
Environmental Consultant

Natural Resources Northern and Yorke
Government of South Australia

River Red Gum Die-Back Monitoring Program 2008-2016
***Natural Resources** Northern & Yorke*
Anne E Jensen Environmental Consultant ABN 34 930 978 273

Photographs by Anne Jensen
Cover photo: Most streams were flowing strongly during the 2016 survey, including a first sight of Rocky River flowing over the ford on Combe Road, upstream of Laura (September 2016)

Contents

Executive Summary

The ninth red gum monitoring survey since 2008 found significant improvement in condition and reduced die-back in red gum communities of the Northern and Yorke region, but also found continuing critical recruitment failure due to lack of germination, as reported since 2012.

Water availability in 2016 was even better than 2015, with most streams flowing strongly and a cool wet spring promoting healthy canopy growth in mature red gums. Healthy seed crops are being produced annually, but this is not translating into successful germination. Adequate soil moisture was available to sustain any germination from seed fall in summer 2015-16. However, there was still no mass germination of seedlings at any of 43 monitored locations across three catchments, and only a handful of new seedlings were found while traversing more than 900 km across the region.

The primary factor inhibiting successful germination is lack of bare, moist soil below mature trees for seeds to land on and germinate when they are shed from aerial seedbanks in late spring-early summer. There is intense competition from dense grassy weed cover emerging at the same time as seed fall. In watercourses and river beds, reduced rainfall and reduced flows since 1970 mean that reedbeds commence their summer growth earlier, covering potential red gum germination sites with dense growth. The increased flows of 2015 and 2016 may have reduced the effect of this competition, but any surviving red gum seedlings in watercourses may take 2-4 years to become visible above the reedbeds.

In spite of improved canopy condition, red gum die-back is still present across the region, with stressed trees needing up to five years of good water availability for recovery and return to healthy production. The primary cause of die-back in mature river red gums is reduced water availability, due to water extraction, storage in dams and declining regional rainfall. The monitoring results indicate that reduced access to water sources can be a very localised problem, with the level of stress across a community of red gums varying widely among individual trees. Local variations occur due to uneven access to water sources from fractured rock aquifers, and varying transmissivity and storage capacity of soils.

Conditions in 2016 were better than 2014 and 2015, with a cool wet spring and large areal extent of flows sustained into early September[1]. Flows were observed in many watercourses for the third time over all surveys, but the extent and duration of flows was not captured in sufficient detail in available water monitoring data. Rainfall patterns showed above average monthly rainfall in the first half of the year in 2014 and 2015, with the pattern repeated and extended into late winter-spring in 2016. Rainfall volumes in September 2016 were 2-3 times the average in upper catchment locations, leading to extensive flooding in October 2016.

As reported in 2014, the existing flow monitoring stations are very limited, and these are insufficient to document the flow events which have occurred. The need remains to upgrade the monitoring network to obtain a minimum data set for Broughton, Wakefield and Willochra catchments for future management, and proposals presented in 2014 to upgrade the water monitoring network should be listed as a priority if funding becomes available. The flows in 2014, 2015 and 2016 demonstrated the potential value of a program of citizen science, as recommended in 2014, to encourage individuals to report information on flow events, to supplement data from the limited official monitoring sites. Local data could allow tracking of individual flow events, with timing, extent and duration.

[1] Data were collected 15-19 September 2016, prior to significant flood flows which occurred in all 3 catchments just 3 weeks after the survey was completed, with potential damage to any small saplings in the watercourses, scouring of river beds and disruption to habitats occurring after the survey

Levels of insect attack were generally mild in 2016, compared to severe insect attacks in 2012 and 2013. The exception was in locations around Clare and the Skillogalee Valley which suffered severe lerp infestation, including major decimation of canopies for a second consecutive year on Spring Gully Road near the Clare Caravan Park. These locations had almost total epicormic growth, as trees began to re-build canopies following severe insect attack. Similar attacks and symptoms were reported from Horrocks Pass near Wilmington, leading to community concern and media attention.

Post-2014 bushfire epicormic recovery growth on a site on Rocky River near Wirrabara had failed and some fire-affected branches had fallen. However, good seasonal conditions had generated improved canopy condition through natural growth and fire-affected mature trees are likely to make a strong recovery, subject to water availability.

The overall prospect for the long-term survival of red gum communities through recruitment has not improved. Without active intervention to promote germination and to protect minimum water sources for red gums, the Northern & Yorke region is in danger of losing its distinctive red gum landscapes in the next 30-50 years. Actions to save river red gums fit best within sustainable management of the wider landscapes. A wider project has been recommended previously with the aim of sustaining a minimum 20% native component of mixed trees, shrubs and understory in regional landscapes, including red gums in appropriate habitats and the introduction of native shrub and understory habitat to support insect-eating birds and thus help to control outbreaks of lerp.

Urgent intervention is needed to facilitate germination and survival of red gum seedlings, as this is not happening via natural processes. This requires preparation of suitable seed beds by clearing weeds and creating bare soil to coincide with maximum seed rain (Nov-Dec), or by broadcasting seed onto prepared beds to coincide with useful rainfall events (>10 mm). Seed falling from trees needs to land on bare moist soil to germinate, and seedlings need to be protected from stock grazing until at least 1 m high (for sheep) or 1.2 m high (for cattle).

Concerted action is needed to save red gum communities, to obtain better water data, to engage community members in a program of citizen science to record flow events and red gum germination, for example via Facebook pages for each river catchment. Community members can also be encouraged to take an active part in the 20% revegetation project. The benefits of these actions will not only include improved health of red gum communities, but also sustainable management of landscapes, maintenance of a full range of environmental services (including insect control) and increased biodiversity. Successful implementation of 20% coverage with native vegetation across regional landscapes will also contribute to adaptation to predicted drier and hotter conditions and less available water due to climate change.

Figure 1

Rocky River flowing strongly over Thredgolds Crossing near Crystal Brook (site BR007A)

Background

An investigation into die back in river red gum (*Eucalyptus camaldulensis)* populations in the Northern & Yorke region was commenced in August 2008. Concerns about the decline of river red gum health dated from 2005, when the river red gums lining the Booleroo Whim Creek north-east of Melrose deteriorated alarmingly into a state of severe stress.

The initial assessment in 2008 found that local data were lacking on the status of water sources, changes in tree health and changes in secondary impacts, and this information was needed to provide feedback on the effects of management actions. Therefore, the monitoring program was established to gather important local data to monitor changes in tree condition over time and to understand the possible causes of die-back in the region. The four target catchments were Broughton, Mambray Coast, Wakefield and Willochra catchments (Figure 2, Appendix 1) and eight surveys of over 60 sites were completed from March 2009 to September 2015. The initial surveys covered each of the four seasons, and then spring was selected as the most relevant time for annual surveys to detect any red gum seedlings.

In addition to seven new sites added in 2013 to link red gum die-back monitoring under the *Four Catchments* project, a further three sites were added in 2014. Eight new sites were added in 2015, and four previous sites were suspended (Appendix 2). The data from all surveys and all sites are incorporated into the graphs presented in this report.

Brief for 2016 Monitoring Survey

A further monitoring survey was contracted to evaluate conditions in September 2016 at a revised list of 43 sites, to provide an assessment of ongoing trends in condition of red gum communities. Mambray Coast was not included in this survey.

The monitoring tasks included:

- Visit 18 ongoing monitoring sites in 3 catchments (Broughton 10, Wakefield 4, Willochra 4), recording data as per the monitoring guidelines
- Visit 17 new sites established in 2013-15 under the Four Catchments and Riparian Vegetation Projects (Broughton 3, Wakefield 8, Willochra 7), record data
- Analysis of data and comparison to previous monitoring surveys
- Update of catchment monitoring manuals and guidelines
- Update report on monitoring results for NY NRM Board
- Update recommendations for future monitoring activities
- Provide e-copy of report, updated manuals, photopoints and data sheets to Project Officer.

In addition, three community engagement workshops will be conducted in May 2017 facilitate citizen science activities as recommended in this report.

Methodology

The methodology and results have been described in previous reports (Jensen *et al.* 2008a, Jensen 2010, 2011, 2012, 2013, 2014a, 2015). The rapid assessment scoring system for site condition was continued as per previous surveys at the revised list of 35 sites, using health rankings for each parameter to generate scores to measure the risk of decline and the chance of recovery for each site (Appendix 3; Jensen *et al*. 2008a, Jensen 2014a). Low scores (0-7) indicate a high risk of decline and low chance of recovery, while high scores (15-21) indicate sites with low risk of decline and high chance of recovery, ie sites in good condition.

At 22 special monitoring sites with 5 target trees, additional parameters were scored to assess the stage and crop volume of the phenological cycle (buds, flowers, fruits, leaves), to assess canopy condition, and to evaluate the extent of epicormic growth (Appendix 3).

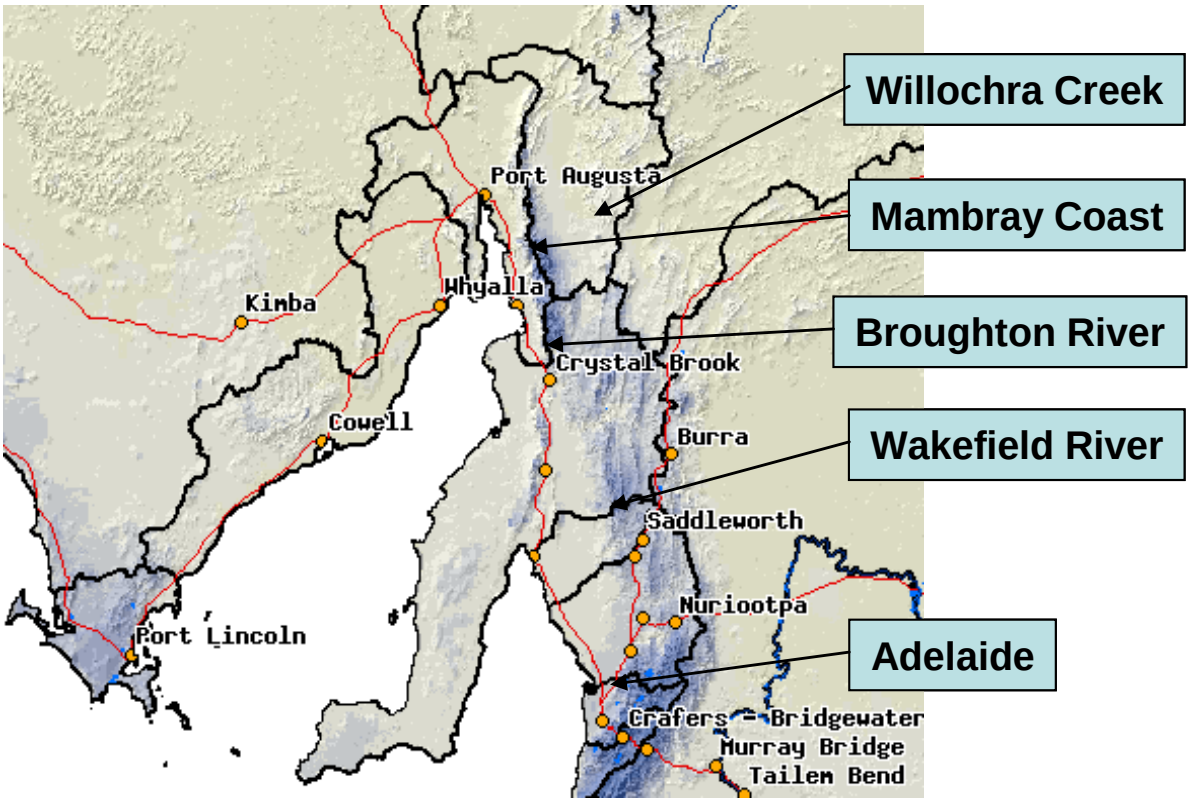


Figure 2 Location of monitored catchments. Base map: Rural Water Maps http://adl.brs.gov.au/water2010/mapserv/

Figure 3 Broughton River flowing at Lower Broughton Road, September 2016

Factors Influencing Growth and Health of Red Gums

As reported previously, water availability for river red gum regeneration and maintenance has reduced significantly since 1970, due to regional decline in rainfall and increased water abstraction for agricultural and domestic use (eg Jensen 2013). Rainfall and temperature anomalies for South Australia highlight the decrease in rainfall and increase in temperature which in combination are reducing water availability (Figures 5 & 6).

The key data need for sustainable natural resources management is monitoring of surface water resources and the closely-linked groundwater resources. This includes data on the seasonality, duration and extent of inundation from flows, run-off from catchments, and the relationship to rainfall in the catchments.

A report for the NY Lower North Group in 2014 found that the Northern & Yorke region has limited historical collection of water data and monitoring of seasonal conditions related to flows (Jensen 2014b). The number of active streamflow monitoring stations is insufficient to provide adequate coverage of key catchments, with no stations in the lower reaches of the Broughton and Wakefield catchments, and no upstream or mid-stream stations in the Willochra catchment.

This lack of data makes it very difficult to monitor the extent and duration of individual flow events which might produce germination events in river red gums, or replenish shallow fractured rock aquifers which could supply a water source for existing trees. In particular, good seasonal flows to the lower end of the Broughton and Wakefield Rivers in September 2014 and September 2015 were not detected by the current monitoring network. Peak flows in winter and early spring were recorded in 2014 in the upper reaches of the Broughton and Wakefield Rivers, but not in 2015. A late peak in October 2015 appeared in the Broughton record at Mooroola. Flows in the Willochra Creek reached the site of the now closed monitoring station at Pinda Bridge in September 2015. The Rocky River station at Wirrabara was closed in 2010 and missed all recent flows.

Available data on water sources and flows in 2016 are summarised in the following section.

Figure 4 Crystal Brook was flowing strongly in Beetaloo Valley (BR006, left) and through the Crystal Brook golf course (BR012, top right), but it was only a trickle at the Frith Road ford (BR013), 8 km west of the town, where all mature red gums are dead or severely stressed. Crystal Brook very rarely reaches the junction with the Broughton River.

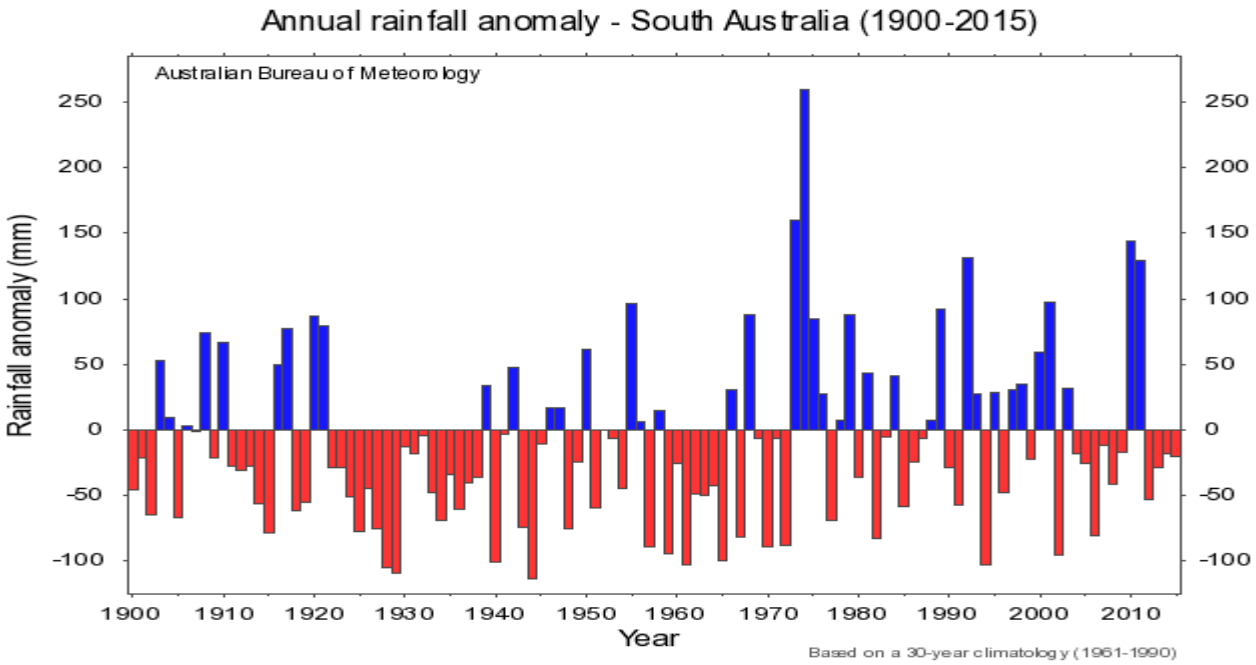


Figure 5 The rainfall anomaly suggests that current levels of water abstraction are unsustainable in the long term, since development has been undertaken during a period of above average rainfall since 1970, and future predictions are for reduced winter rainfall and increased summer rainfall

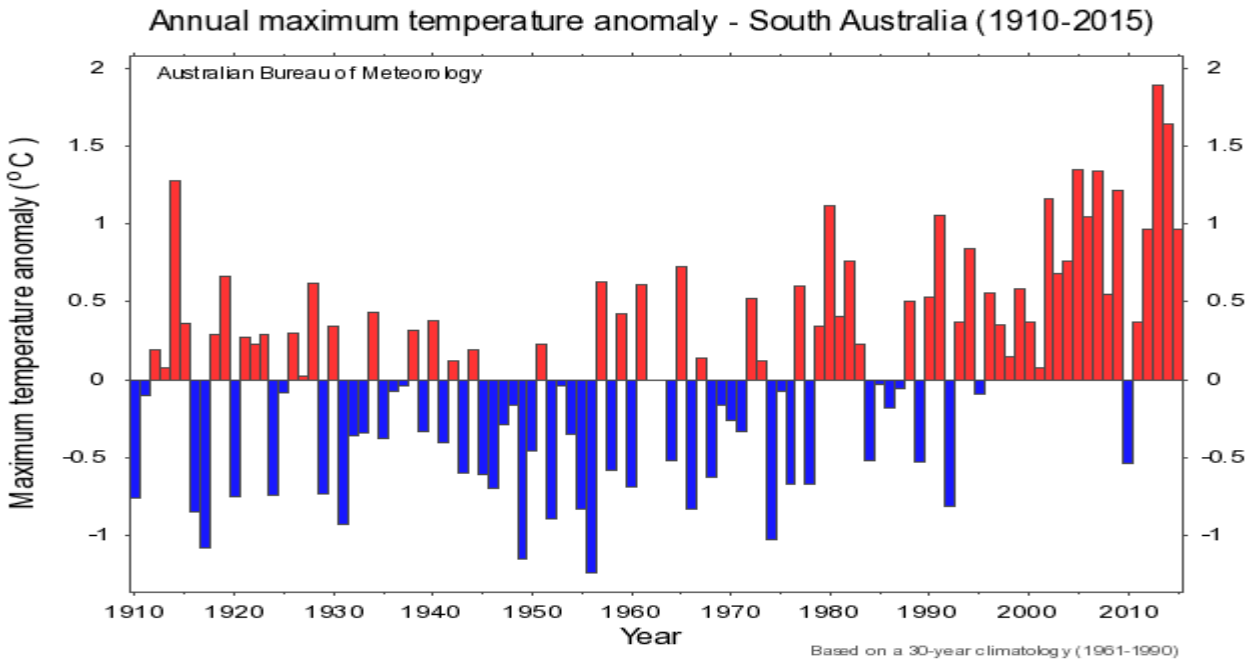


Figure 6 Maximum temperatures in South Australia have risen very significantly since the 1980s, with higher rates of evaporation reducing water availability

Rainfall Data

Rainfall patterns showed above average monthly rainfall in the first half of the year in 2014 and 2015 but little rain in the second half of the year (Figures 7-9). The pattern of early rainfall was repeated in 2016 but then extended into the 'normal' pattern of rain in late winter-spring. Rainfall volumes in September 2016 were exceptional, at 2-3 times the average in upper catchment locations. This led to extensive flooding in October 2016 which may have affected habitat condition and red gum health (either negatively or positively) after the survey was completed.

Predictions of future impacts of climate change in the mid-North region include a shift to more peak summer rainfall events, fewer spring rainfall events and more extreme events (Jensen 2010). This would appear to be the emerging pattern in rainfall for 2014-2016.

A 1% decline in rainfall translates to 3% decline in run-off in a semi-arid catchment, so the predicted future decline in rainfall due to climate change would also result in a significant decline in run-off, leading to an associated decline in water availability for red gums (Jensen 2015).

Flows Data

Conditions up to mid-September in 2016 were better than 2014 and 2015, with stronger flows sustained over a large areal extent into early September[2]. Flows were observed in many watercourses for the third time in all surveys, but the extent and duration of flows was not accurately captured in available water monitoring data (Figures 10-11, 13).

Sites observed with flowing water in 2016 included Willochra Creek at Melrose and sites further downstream (Figure 23); WL001C, WL006A, WL006, WL009). Spring Creek had medium flows at Pilliga Road (Figure 12; WL011A) but flows had not reached Coonatto Road (WL011). Wild Dog Creek was flowing at Murraytown (WL003) but stopped abruptly at Wild Dog Creek Station upstream of Melrose. In the Broughton catchment, the Rocky River was flowing strongly over Combe Road ford upstream of Laura (cover photo; BR008) and at Thredgold Crossing (Figure 1; BR007A). Crystal Brook was flowing strongly from below Beetaloo Reservoir through the town but did not reach the Broughton River prior to the larger floods in October (Figure 4). The Lower Broughton was flowing again at Cockys Crossing (BR014), Butler Bridge (BR015) and Lower Broughton Road (Figure 3; BR016). Along the Wakefield River, small to medium flows were observed from upstream sites near Mintaro all along the river to Bowmans (WK010), and flows reached Port Wakefield late on 16 September 2016.

The monitoring stations for the Wakefield River near Rhynie and the Broughton River at Mooroola give the longest data sets for stream flows in these catchments (Figures 10, 11; Jensen 2014b). However, there are no records of the extent or duration of flows in the upper catchment of Willochra Creek or the lower reaches of the Broughton and Wakefield Rivers. The records for 2015 do not indicate any significant flows to the end of September 2015, in spite of the flows observed reaching the lower Broughton and Wakefield catchments. A flash flood in November 2015 and the flows which generated large floods in October 2016 are clearly seen in all catchments.

The surprising absence of flows recorded by the primary monitoring stations for 2015 up to September means that flow volumes at Rhynie and Mooroola cannot be used reliably as indicators of the likelihood of flows in the lower reaches. This reinforces the need for more monitoring stations spread across catchments for more accurate assessment of the extent, duration and frequency of annual flows. It also reinforces the potentially high value of engaging the local riparian community in a citizen science project to record local flows.

[2] Note that data for the survey were collected 15-19 September, prior to the significant flood flows which occurred in all 3 catchments just 3 weeks after the survey was completed

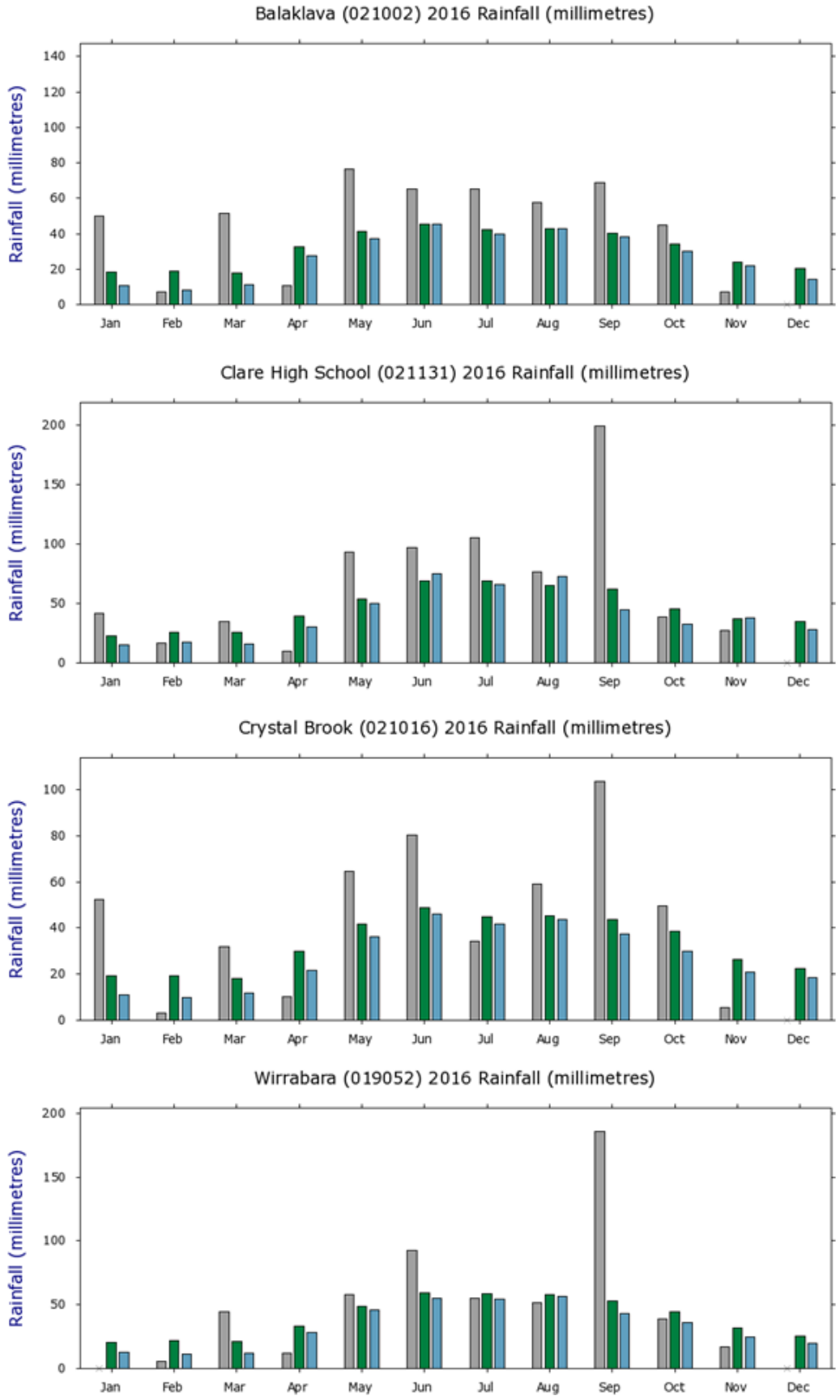


Figure 7 Monthly rainfall pattern January to November 2016 for regional stations, showing above average rainfall in first half of year, and extreme peak rainfall in September 2016 which produced flooding (Source: Bureau of Meteorology)

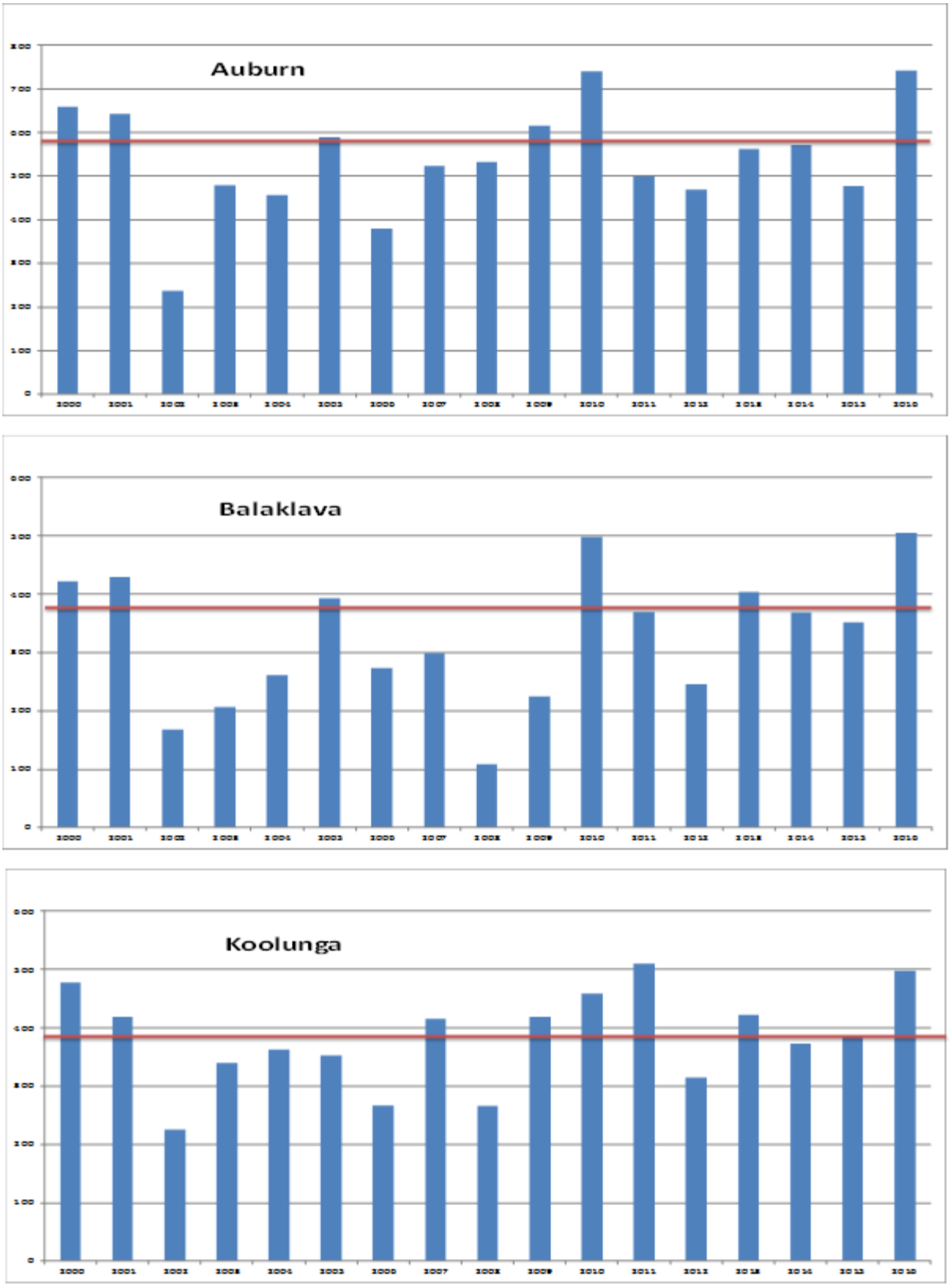
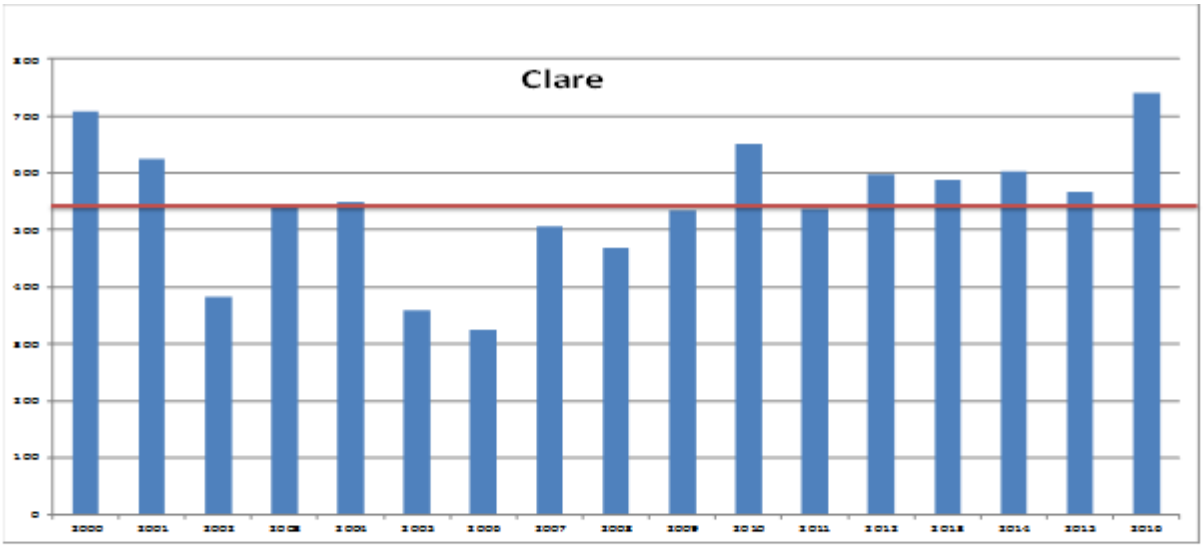
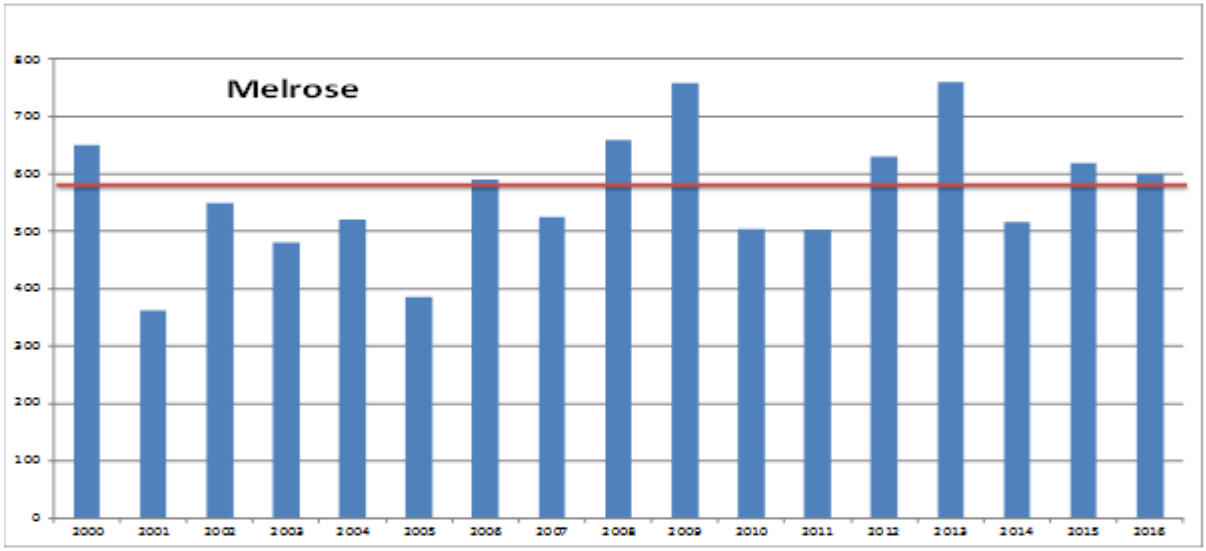


Figure 8 Average annual rainfall 2000-2016 for Auburn, Balaklava and Koolunga, with long term average volume shown by red line. Note that 2016 volume is to 30 November, including rainfall which led to heavy flooding after the survey
(Source: Bureau of Meteorology)





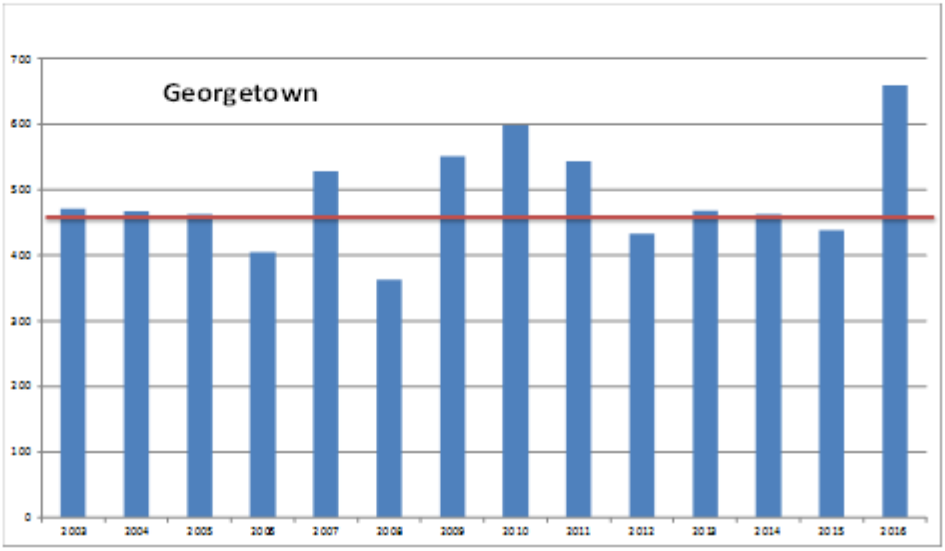


Figure 9 Average annual rainfall for Clare, Melrose (2000-2016) and Georgetown (2003-2016), with long term average volume shown by red line. Note that 2016 volume is to 30 November, including rainfall which led to heavy flooding after the survey
(Source: Bureau of Meteorology)

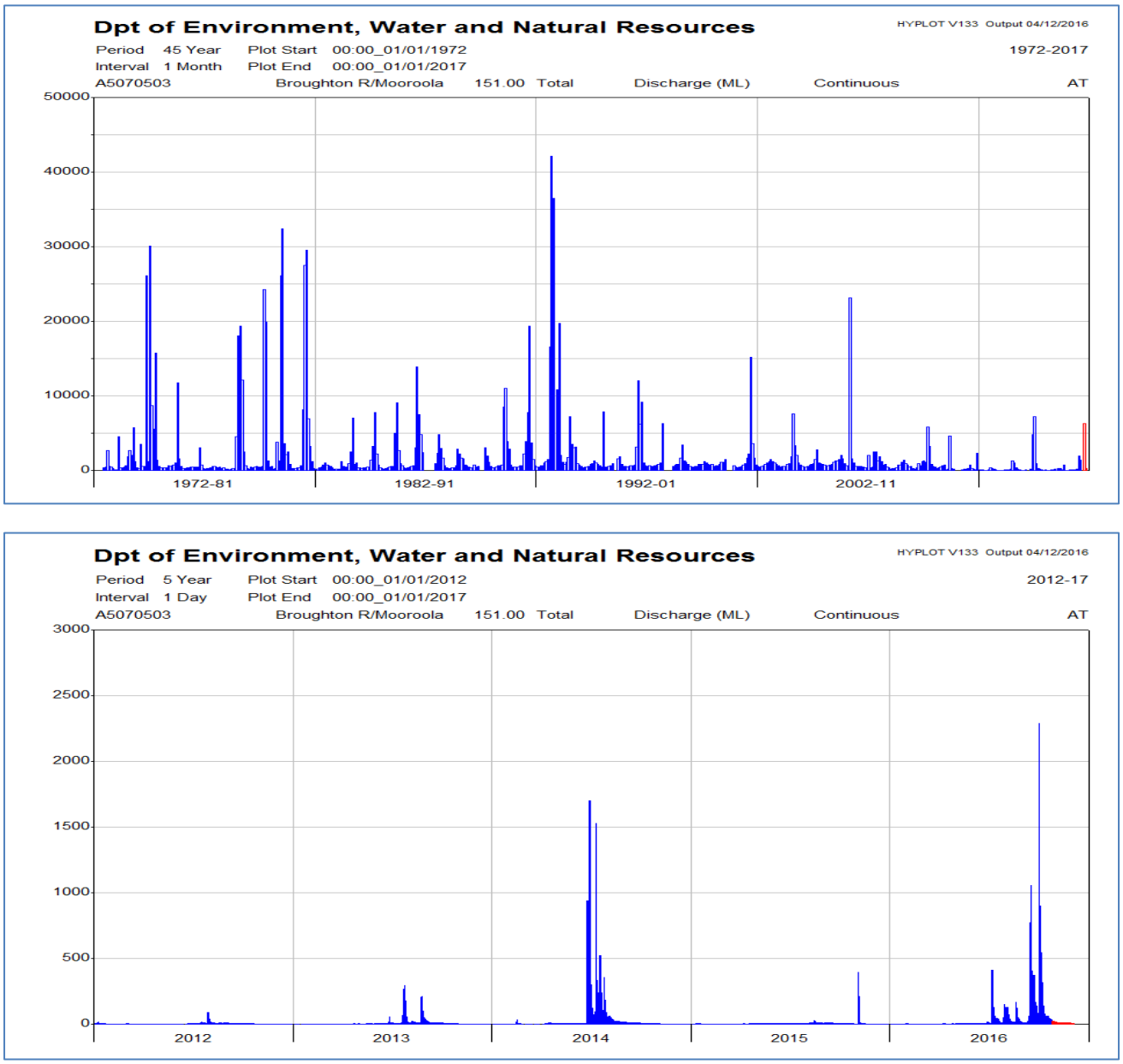


Figure 10 Stream flow data from the monitoring station on the Broughton River at Mooroola, showing monthly data from 1972-2016, and daily data from 2012-2016 with no significant flow peak recorded showing flows observed in the September 2015 red gum survey. (Source: DEWNR WaterConnect database)

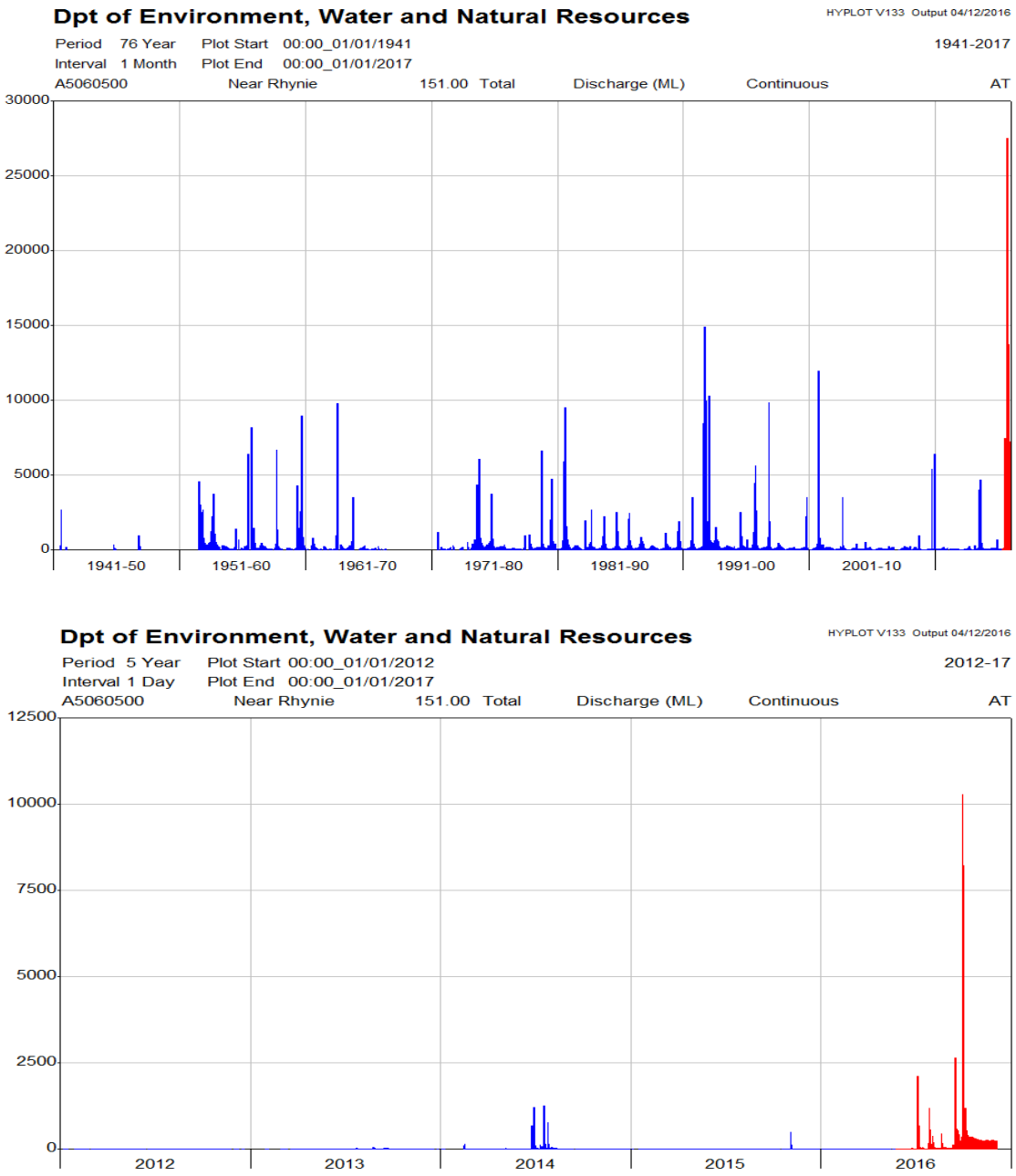


Figure 11 Stream flow data from the monitoring station on the Wakefield River near Rhynie, showing monthly data from 1941-2016, and daily data from 2012-2016, with no significant flow peak recorded showing flows observed in the September 2015 red gum survey. (Source: DEWNR WaterConnect database)

Figure 2 Spring Creek flowing at Pilliga Road in September 2016 (monitoring site WL011A)

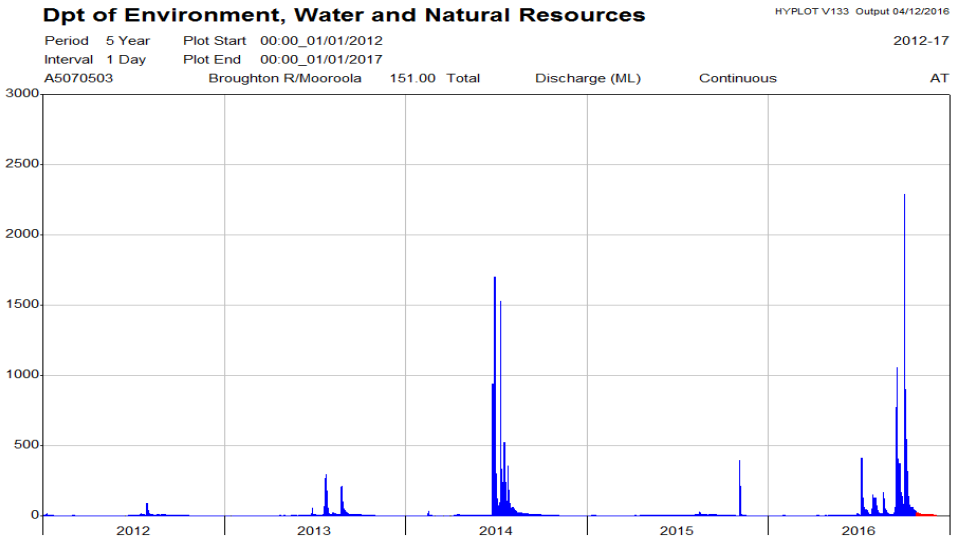


Figure 13 Flow records at Thredgolds Crossing on the Rocky River show the volume and velocity of flows in September 2016 (Source: DEWNR WaterConnect database)

Site Condition Results

Previous Condition

From the initial stressed condition of 2008, red gum communities in the Northern & Yorke region partially recovered at most sites in 2010 and 2011, following two years of average or above average rainfall (Jensen 2010, 2011). However, most trees still exhibited a significant level of stress and site condition deteriorated again in 2012, coupled with heavy insect attack on recovering epicormic growth (Jensen 2012). Recovery in 2013 was again compromised by significant insect attack, although it did not trigger new epicormic growth (Jensen 2013). Levels of insect attack in 2014 were insignificant, and canopy condition improved as epicormic growth converted to normal tip growth (Jensen 2014a). With stream flows in 2014, 2015 and 2016, and mostly average or above rainfall in 2014 and 2016, condition of mature trees has continued to improve, with only isolated instances of insect attack.

Bushfire Impacts

A major bushfire affected some monitoring sites in February 2014. One fire-affected site was visited on this survey, on Rocky River upstream of Wirrabara (Figure 14). The development of epicormic growth had failed, and some fire-affected branches had fallen. It had been already observed in September 2014 and September 2015 that initially vigorous epicormic growth had slowed and was not developing into new canopy growth. In place of the epicormic response, healthy natural growth in 2016 is driving recovery of fire-affected trees.

Current Condition

Seasonal conditions in 2016 were above average, with a cool wet spring and widespread seasonal flows in streams and rivers for the third year in a row. Results for tree condition in 2016 indicate significant recovery in mature trees compared to previous years, with negligible insect attack. However, individual trees with severe stress still only have limited recovery and will require continued good water availability for recovery. Trees subject to localised severe insect attack had been stripped of foliage and were diverting physiological resources into epicormic growth to replace lost leaves, so will require 2-3 years to reach seed production.

Condition scores for the new sites added in 2013, 2014 and 2015 have been added to the main database and included in pivot tables to generate trends in various parameters over the full period of surveys. Condition scores for the Mambray Coast catchments have been included in the condition assessments.

Canopy Condition

Canopy condition significantly improved in Broughton, Wakefield and Willochra, reflecting the cool wet spring and widespread stream flows (Figure 16). The newer sites, monitored since 2013-15, started in better condition and have lower risk-of-decline scores and higher chance-of-recovery scores than the original sample sites (Figures 17-18). The primary factor contributing to improved condition is the minimal extent of epicormic growth, compared to the high levels of epicormic growth in 2011 and 2012.

Insect Attack

The only significant epicormic growth in 2016 occurred at sites with heavy insect attack, in the Clare and Skillogalee valleys. The sites suffering insect attack had mostly weeds and introduced species in the understory. It was also noted that the Clare region had average or above rainfall from 2009-2016, while all other sites which did not have significant insect infestation had some drier years in 2010-2015 (Figure 15).

Figure 14 Large fire-affected branch has broken off and epicormic post-fire growth has failed on Rocky River upstream of Wirrabara, but general canopy condition has improved in 2016 following above average rainfall (monitoring site BR009A)

Figure 15 Devastating insect attack on red gums on Spring Gully Road, Clare (monitoring site BR024)

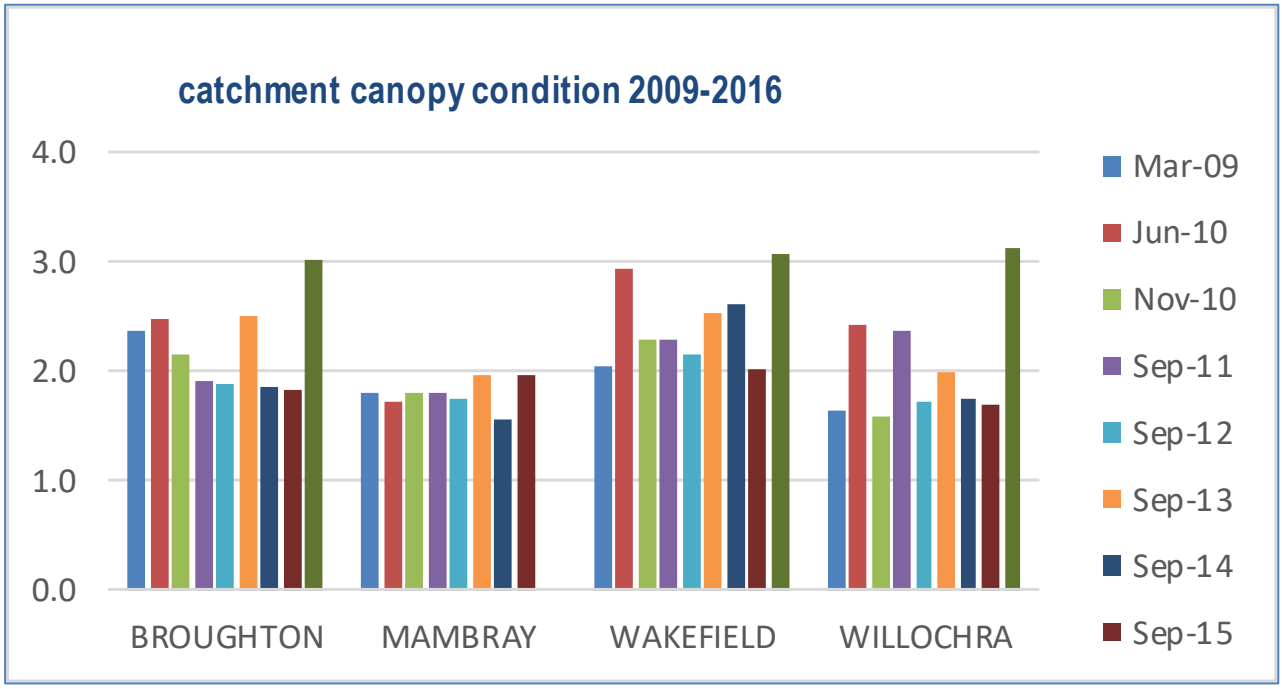


Figure 16 **Highly variable patterns of change in canopy condition in each catchment from 2009 to 2016, showing significant responses to higher rainfall in the year previous, as seen in 2011, 2013 and 2016. While the scores in 2016 have all improved compared to 2008, there have been multiple years with lower condition scores in between.**

Seasonal Phenological Cycles

Phenological data for the newer sites since 2013 have been included in the overall catchment scores in Figure 19 but not data for Mambray Coast catchments, which were not surveyed in 2016. Data since 2011 are for the spring season, so flowering is rarely recorded in 2011-2016. High volumes of mature buds recorded in spring indicate that dense flowering is likely to occur in summer.

The phenological data for 2015 were dominated by mature bud crops as well as mature closed fruit, indicating significant numbers of trees carrying dual crops, with seed ready for release in summer 2015-16 and a further crop of seed developing for summer 2016-17 (Jensen 2015). Trees in Willochra catchment also had open mature fruit in 2015, indicating that some seed had already been shed. All catchments had trees with dual crops, indicating healthy phenological cycles, and healthy seed sources were available in summer 2015-16. However, no germinating seedlings were found in the September 2016 survey.

The phenological data for 2016 are dominated by mature buds, indicating a strong flowering for summer 2016-17, with seeds to be shed in summer 2017-18. The dual crops continued in 2016, as an indicator of improving health and productivity.

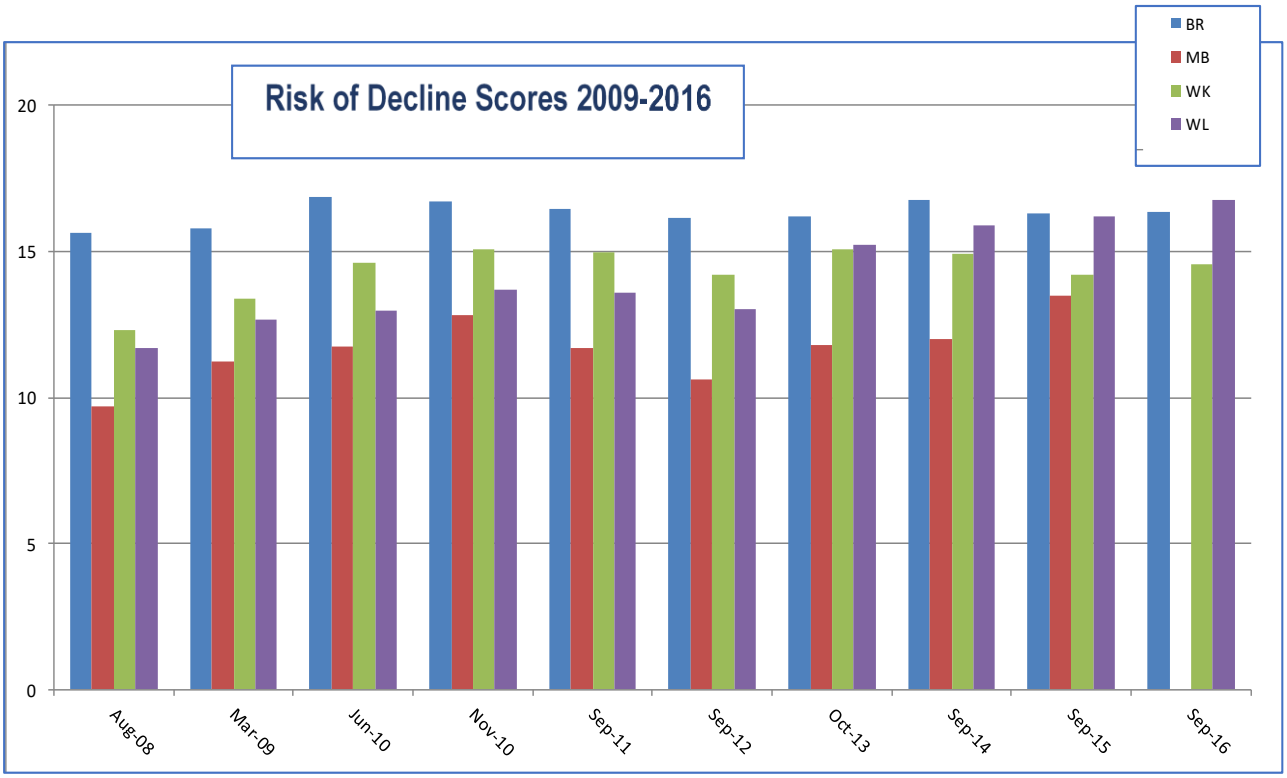


Figure 17 Comparison of Risk-of-Decline Scores for individual Catchments (2008-2016), showing the highest risk of decline in Mambray Coast catchments (*not surveyed in 2016*), stable risk of decline in Broughton catchment, and steady improvement in risk of decline scores in Wakefield and Willochra catchments

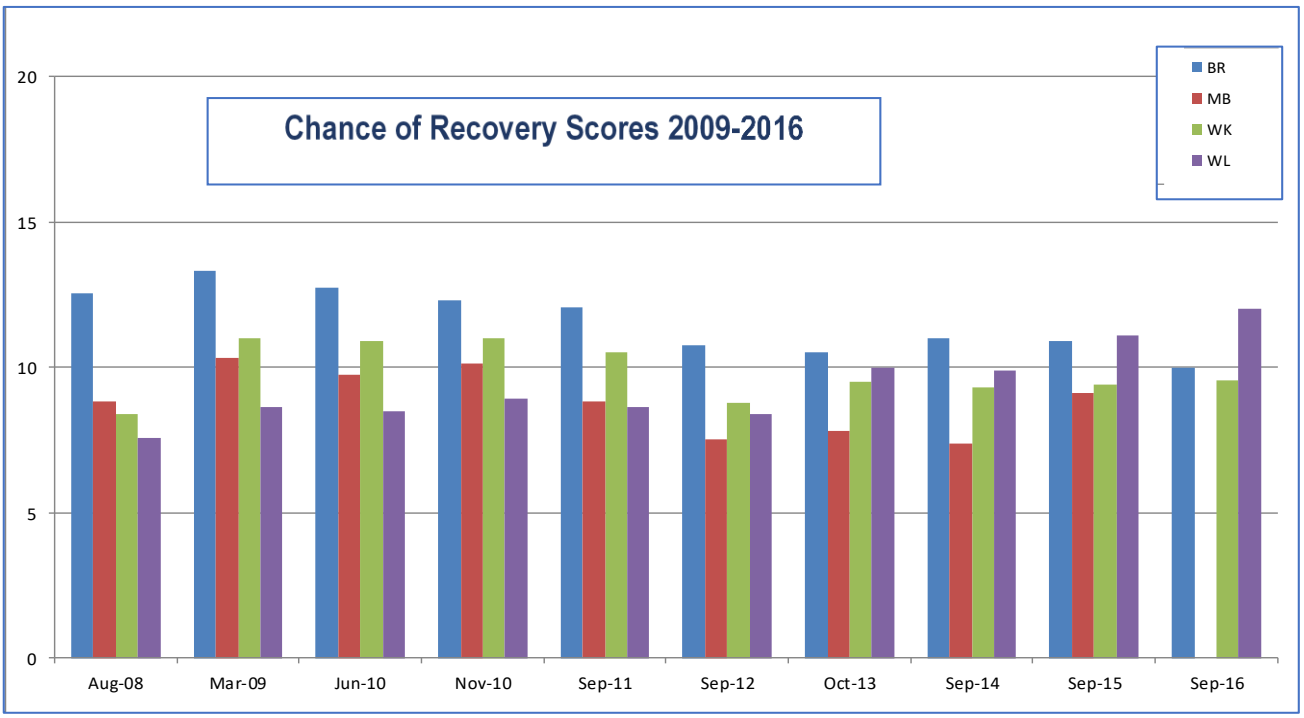


Figure 18 Comparison of Chance-of-Recovery Scores for individual Catchments (2008-2016), with variable responses to climatic conditions and general decline over time due to lack of regeneration in Broughton, Mambray and Wakefield. Willochra shows some improvement owing to improved riparian condition, but also lacks regeneration.

Figure 19 Phenological cycles for 2016 were dominated by mature buds, with many trees also carrying dual crops, as indicated by closed mature fruit ready to release seed

Critical Lack of Regeneration

The issue of regeneration continues to be of urgent concern, with no change in 2015. No effective regeneration of red gum seedlings has been found at any monitoring sites on any surveys since 2008. This represents a critical recruitment failure, with the long term survival of red gum communities threatened if they fail to replace themselves.

Sampling sites were deliberately placed near existing regeneration (already well-established in 2008), including the Rocky River between Wirrabara and Laura, Broughton River near Merriton, and isolated patches of regeneration on the Hutt River north of Clare, Horrocks Creek, Nectar Brook and Crystal Brook. However, only two new seedlings were found anywhere across the region in 2015, this time at a sample site on Willochra Creek (WL006a). Just a handful of seedlings has been found over eight surveys, mostly on roadsides or in vineyards, and few of them have survived slashing or poisoning. Five seedlings which emerged at a sample site in Armagh Creek near Clare continue to survive (BR023), but seedlings which grew in the adjacent vineyard were poisoned. No mass regeneration has been found at any site, although it would be expected at some suitable locations in any season with widespread stream flows and average rainfall.

As reported previously, seedlings need open space, preferably bare ground, control of competing weeds and pasture species, and control of grazing stock in order to survive. Regeneration within riparian zones is clearly being limited by competition from dense weeds and pasture species, and by grazing stock. In addition, reduced flows have had the effect of allowing annual regeneration of reedbeds to occur earlier, creating competition with red gum seedlings when seeds land in watercourses, with only a few seedlings surviving to sapling stage (Figure 20).

Figure 20 Single red gum seedling found by Willochra Creek downstream of Melrose (monitoring site WL006A)

Discussion

The 2016 survey found accelerated recovery and significantly improved canopy condition in river red gum communities across the Northern & Yorke region. However, under-lying significant die-back and stress remains, and further good seasons are need for stressed mature trees to recover fully.

Critical recruitment failure continues, which threatens the long-term survival of red gum communities in the region. No broad-scale regeneration has been found since 2008, either at monitoring sites or in observing the landscape generally across more than 900 km of travel in the four catchments.

Seasonal stream flows were more widespread and of longer duration in 2016 than seen in any previous survey, and cool wet conditions in spring promoted healthy canopy growth and there was a significant improvement in canopy condition in 2016.

The pattern in risk-of-decline and chance-of-recovery is very variable over 2009-2016. For risk-of-decline scores, Broughton has been relatively stable, Willochra catchment has shown a steady improvement, and Wakefield and Mambray have varied up and down in scores. Seasonal variation in scores appears to reflect regional rainfall variation. The improving scores for Willochra have coincided with a period when rainfall at Melrose has been average or higher since 2009. Other catchments had drier years in the period 2010-2015.

Chance-of-recovery scores declined in Broughton, improved in Willochra (due to improved riparian habitat) and varied up and down in Wakefield and Mambray. These scores will not improve above current values until significant red gum regeneration occurs.

Long-term Lack of Regeneration

There are now extreme concerns about the lack of regeneration across the region. No natural examples of mass germination have been found, in spite of good potential for regeneration from rainfall during the past three years and phenological results demonstrating the availability of significant volumes of seed (Jensen 2014, 2015). Only a handful of seedlings (<10) were observed on Willochra Creek on this survey (Figure 20; WL006A) The very few examples of individual seedlings germinating are insignificant and will have no effect on the long-term survival of red gum communities at a landscape scale.

Active intervention is required to facilitate significant regeneration in the region (Jensen 2012, 2013, 2014a, 2015). Mass germination and survival of red gum seedlings require adequate water availability until the seedlings have established a root system, bare moist soil for initial germination, seeds falling from the trees, no weeds competing with the seedlings for moisture, and no grazing for up to two years until the growth tips are above grazing level for stock. Action required would include preparation of suitable bare soil seed beds, weed control, addition of seed if no available seed sources, and control of grazing until growing tips of seedlings reach 1-1.2 m. Watering will be required during the first two summers if natural water sources are not available.

Lack of Monitoring of Water Sources

Lack of local rainfall data and flow data is an ongoing issue. Seasonal flows occurred in the catchments in 2015, lasting for up to three months, with many sites still flowing in early September. However, measured flow data from five stations in the Broughton and two stations in the Wakefield, all in the upper catchment, did not capture September 2015 flows, only a flash flood in November 2015. The high flows in 2016 were recorded at currently active stations in the upper catchment, but there are no records of flows to the lower catchments.

The two flow stations in the Willochra catchment are both at the extreme downstream end of the catchment, and did not capture data on flows in the upper catchment. It is critical to measure flows at Melrose to obtain useful flow data for the Willochra system. Flows in 2015 and 2016 reached the former monitoring station at Pinda Bridge, now discontinued and no longer recording flows.

Recommendations that additional monitoring stations be installed and some closed stations be re-activated, made to the NY Lower North Group and the Board of *Natural Resources Northern & Yorke* in 2014, remain relevant (Figures 21 & 22; Jensen 2014b). These recommendations, at a relatively small cost of

$32,000, would provide a minimum regional flow database. Priority should be given to seeking this funding to install the recommended telemetry to monitor key flow events in the main watercourses.

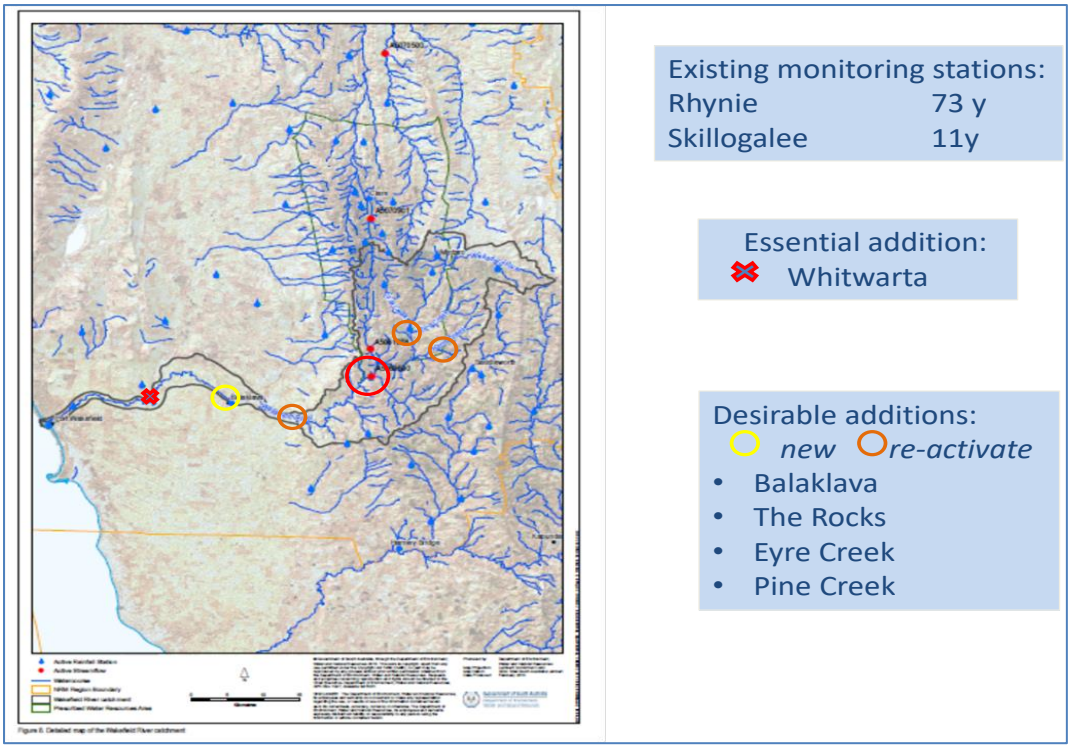


Figure 21 Recommended additional water monitoring sites for the Wakefield River catchment

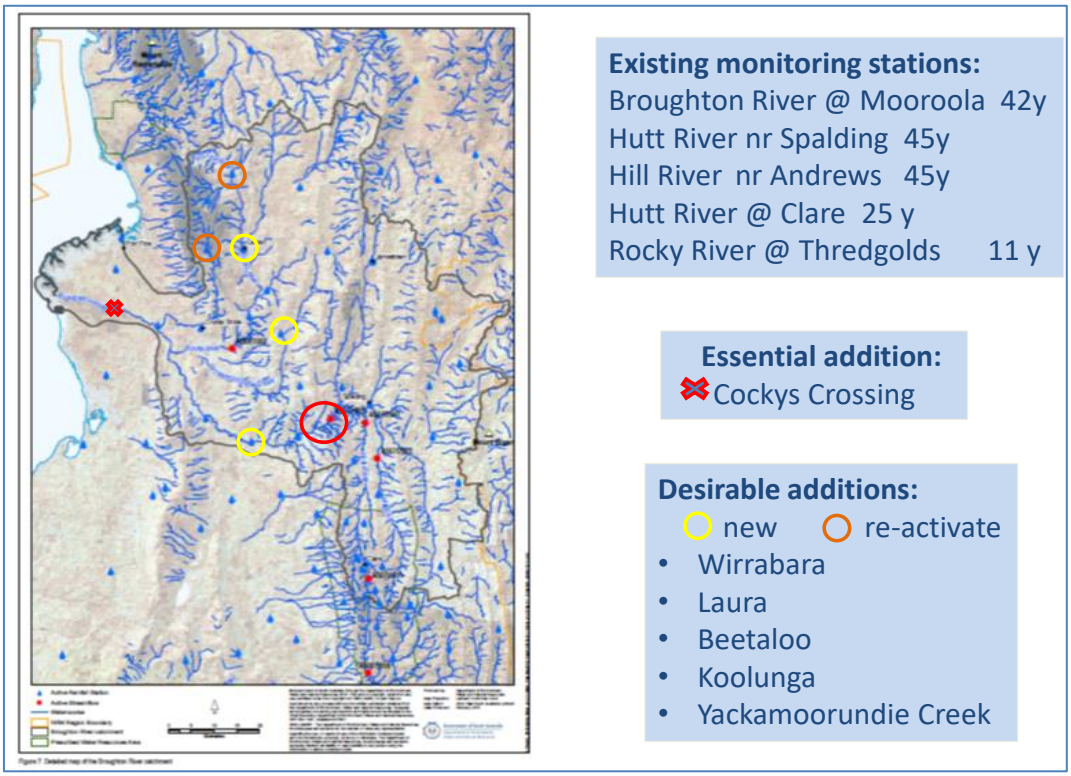


Figure 22 Recommended additional water monitoring sites for the Broughton River catchment

Recommendations for Data Projects using Citizen Science

Citizen science projects should be developed to monitor local flows and any regeneration events, as recommended to the NY Lower North Group and the Board of *Natural Resources Northern & Yorke* in 2014 (Jensen 2014b, 2015). Landholders and community members should be encouraged to record local river flows, levels, duration and timing.

It is recommended that a Facebook page be developed for each catchment and linked to the *Natural Resources Northern & Yorke* website, for community members to add photos of flow events, red gum flowering and other items of interest. Residents already post photos on Facebook of these events (C Fisher pers comm 2016), so they should be encouraged to provide this form of data to *Natural Resources Northern & Yorke.*

Proposal for Landscape Scale Revegetation

The issue of river red gum health and lack of regeneration is part of a wider problem, the general lack of native vegetation across regional landscapes. It has been recommended previously that actions to maintain river red gum health and promote red gum regeneration be incorporated into a broader approach to sustainable landscapes, linking to projects aiming to increase regional biodiversity (Jensen 2014b, 2015).

Briefly, the proposal is to aim for a target of 20% native vegetation (alongside 80% agricultural uses) in regional landscapes, to be achieved in 10 years, including:

- water reserves, road reserves, public reserves, rocky hilltops
- one side of 5-chain roads (allow width for farm machinery to pass)
- riparian zones along watercourses, including red gums
- fencelines & driveways, including red gums with native understory shrubs and groundcover
- develop corridors of bushes only, or mix trees and bushes
- develop ‘golden corridors’ of acacias and sennas, particularly along tourist routes
- involvement of community groups, local government, landholders, conservation volunteers in active regeneration projects.

Figure 23 **Willochra Creek flowing downstream from Ken Walters Road, north of Melrose, September 2016**

Conclusions

The condition of river red gum communities across the Northern & Yorke region continues to give cause for concern, with no significant regeneration since 2008. Canopy condition has improved 2013-2016, with minimal epicormic growth, particularly with a significant positive response in 2016. However, the long term chance of recovery for red gum communities remains low as long as there is no mass regeneration.

The primary cause of die-back in mature trees continues to be reduced water availability, due to the combined effects of water extraction from catchments, regional decline in rainfall over the past 30 years and the impacts of severe drought conditions from 2000 to 2010. Seasonal flows in 2014, 2015 and 2016 in many streams supported improved canopy condition at most sites. The level of insect attack in 2014 and 2015 was minimal, so this was not inhibiting canopy growth or affecting condition. The exception was localized sites in the Clare and Skillogalee valleys that suffered sustained severe lerp attack which decimated foliage.

The lack of any germination events is attributed primarily to weed competition in riparian zones, and competition with reeds in watercourses. Good fruit crops have been present in the last three seasons, so sufficient seed is present in the landscape and there have been rainfall events and stream flows which potentially could have provided adequate soil moisture to support germination. There have not been any instances found in any survey of germination which has been grazed off by stock, and only a very few isolated seedlings have been found on road and stream edges. Since 2009, the largest numbers of new seedlings were found in small numbers in localized modified environments with bare soil, eg in a vineyard near Armagh Creek in Clare, and along the Anama Lane diversion following road construction.

Strong seasonal flows occurred in 2016 at many locations, with water still flowing to the lower Broughton in early September 2016 (Figure 26), followed by major flooding in October 2016 after the survey. However, as noted in 2014 and 2015, the lack of water monitoring stations means that these events were not recorded in sufficient detail in the water data network, and it is recommended that additional monitoring be implemented, along with a program of citizen science to capture the knowledge of local community members.

In addition to action to stimulate regeneration, a general solution is recommended, by including river red gums in a broadscale revegetation target of 20% native vegetation, using a mixture of trees, bushes and groundcover and targeting roadsides, council reserves, fencelines and riparian zones. Red gums should be included in all appropriate locations, especially riparian sites, and understory species to encourage small birds.

Funding could be sought for a package of actions for management of sustainable landscapes, incorporating the 20:80 landscapes vision proposal, together with the proposals for improved water data instrumentation, leading to improvement of regional red gum recruitment and health.

A low-cost option to generate community engagement in citizen science would be the establishment of Facebook pages for each catchment, with community members encouraged to post photos and records of any flow events, water levels, frogs, extent of reedbeds, red gum regeneration, or other relevant natural resources information.

A program could be developed to train community members to undertake action to promote red gum regeneration. This would include advice on site selection, preparation of suitable bare soil seed beds, weed control, addition of seed if no available seed sources, and control of grazing until growing tips of seedlings reach 1-1.2 m. Provision for watering will be required during the first two summers if natural water sources are not available. Options include fencing off around individual mature trees, fencing corners out of paddocks with mature trees or protecting suitable riparian strips, with action to provide bare soil, weed control and grazing control measures. Support for landholders to undertake these actions to facilitate red gum regeneration could be incorporated into the landscape revegetation project.

These or similar actions are essential to ensure the Northern & Yorke region does not lose its distinctive red gum landscapes in the next 30-50 years.

References

Favier, D., Scholz, G., van Laarhoven, J. and Bradley, J. (2004). *A River Management Plan for the Broughton Catchment*. SA Dept of Water, Land and Biodiversity Conservation: Adelaide.

Jensen, A.E. (2008). *The roles of seed banks and soil moisture in recruitment of semi-arid floodplain plants: the River Murray, Australia.* PhD thesis, University of Adelaide, Adelaide. http://digital.library.adelaide.edu.au/dspace/handle/2440/49169

Jensen, A. E. (2010). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. A report for the Northern & Yorke Natural Resources Management Board. December 2010. Crystal Brook, South Australia.

Jensen, A. E. (2011). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. An update for the Northern & Yorke Natural Resources Management Board. December 2011. Crystal Brook, South Australia.

Jensen, A. E. (2012). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. An update for the Northern & Yorke Natural Resources Management Board. December 2012. Crystal Brook, South Australia.

Jensen, A. E. (2013). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. An update for Natural Resources Northern & Yorke. December 2013. Clare, South Australia.

Jensen, A. E. (2014a). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. An update for Natural Resources Northern & Yorke. December 2014. Clare, South Australia.

Jensen, A. E. (2014b). Broughton and Wakefield Rivers Terminal Flows Scoping Study 2014. Report for Lower North Group, Natural Resources Northern & Yorke, Clare, South Australia.

Jensen, A. E. (2015). Monitoring of Die Back in River Red Gum (*Eucalyptus camaldulensis*) Communities in the Northern & Yorke Natural Resources Management Region. An update for Natural Resources Northern & Yorke. December 2015. Clare, South Australia.

Jensen, A., Newman, B., & Vasey, E. (2008a). Investigation into Die-back in River Red Gum (*Eucalyptus camaldulensis*) Populations in the Northern & Yorke Natural Resources Management Region. For the Northern & Yorke NRM Board, Crystal Brook, South Australia.

Jensen, A.E., Walker, K.F., & Paton, D.C. (2007). Using phenology to determine environmental watering regimes for the River Murray floodplain, South Australia. In *Australian Rivers: making a difference* (Eds A.L. Wilson, R.L. Dehaan, R.J. Watts, K.J. Page, K.H. Bowmer & A. Curtis). Proceedings of 5th Australian Conference on Stream Management, 175-180. Charles Sturt University, Albury, New South Wales.
http://www.csu.edu.au/research/ilws/publications/5asm%20proceedings.html

Jensen, A.E., Walker, K.F., & Paton, D.C. (2008b). Smart Environmental Watering: getting most benefit from scant flows for floodplain trees (River Murray, South Australia). In (Eds) Daniell, T., Lambert, M. & Leonard, M.*, Proceedings of Water Down Under 2008 Conference, 15-17 April, Adelaide*, 1426-1437. Engineers Australia, Melbourne, Australia.

Jensen, A.E., Walker, K.F., & Paton, D.C. (2008c). The role of seed banks in restoration of floodplain woodlands. *River Research & Applications*, Special Issue: Proceedings of Riverine Ecohydrology Conference 2006, Stirling Scotland, **24** (2008), 632-649.

Appendix 1 Monitoring Site Locations

NORTHERN & YORKE RIVER RED GUM MONITORING: BROUGHTON CATCHMENT					
Reach	Site No	grid (GPS waypoint)	Photos	Directions	Subject
Broughton Catchment: Crystal Brook upstream towards Brookman Park, Crystal Brook in Beetaloo Valley					
	BR001*	0242994 6314046 (8)	1	Crystal Brook Valley Road (upstream of town), north	healthy trees, regeneration
	BR004	0242057 6308189 (7)	1	Crystal Brook Valley Road, view along escarpment	stressed trees
	BR005	0241921 6317796	1	Tributary to Beetaloo Creek, at ford on Beetaloo	stressed tributary creek
	BR006	0241801 6318953	1	Tributary to Beetaloo Creek, at ford on Beetaloo	healthy tributary creek
Broughton Catchment: Rocky River upstream to Appila Springs (Crystal Brook to Gladstone, Laura, Wirrabara, Appila)					
	BR007a		1	Rocky River pool, Threadgolds Crossing	mature trees, no regeneration
	BR007	0252530 6316215	2	Rocky River floodplain (upstream & downstream)	mature trees, regeneration
	BR008*	0247542 6330696	3	Rocky River opposite Laura Golf Club, ford on side	reported fertilizer impact, stress
	BR009	0252968 6341333	2	Rocky River Creek (upstream & downstream), at ford	regeneration
	BR009a		1	Rocky River, upstream of Wirrabara	weed removal
	BR010	0260620 6341791	2	Appila Creek (upstream & downstream), at road	erosion impact, regeneration
	BR011	0264572 6345581	1	Appila Springs, looking south-west	stressed trees, healthy riparian
Broughton Catchment: Lower Broughton River downstream to Lower Broughton (Crystal Brook west to Lower Broughton)					
	BR012	0239300 6306776	1	Crystal Brook, entrance to Golf Club (under railway	stressed mature, no
	BR013*	0231301 630581 (91)	1	Crystal Brook, ford on Frith Road from floodway sign	stressed floodplain
	BR015	0238770 6306598	1	Butler Bridge, Old Broughton Road	lower reach, mild stress
	BR016	0774311 6310907	1	Broughton River floodplain, Lower Broughton Road	floodout zone, Cassytha vines
Broughton Catchment: Mid-Broughton River, upstream to Hutt River tributaries (Crystal Brook to Merriton, Red Hill, Koolunga, Yacka Spalding,					
	BR017	0235172 6297097	1	Broughton River at old Merriton Bridge on Highway 1	healthy trees, regeneration
	BR020*	0258314 6280119	1	Broughton River, White Cliff Corner Crossing, Yacka	regeneration
	BR021	0277335 6289633	1	Broughton River (old bridge on Spalding to Clare	limited regeneration
	BR022	0276650 6266317	2	Hutt River (Cornwall Rd at culvert)	regeneration, overgrazing
	BR023	0276645 6255238	2	Armagh Creek (St George Terrace at culvert)	weeds, gorse, regeneration
	BR024*	0279657 6249974	1	Hutt Creek (Spring Gully Road at culvert)	weeds, broom

Table 1 Monitoring Sites in Broughton Catchment

NORTHERN & YORKE RIVER RED GUM MONITORING: MAMBRAY COAST CATCHMENT					
Reach	Site No	grid (GPS waypoint)	Photos	Directions	Subject
Mambray Coast Catchment: north to south tributaries					
	MB003*	0781010 6387247 (83)	1	Horrocks Creek ford (track off Horrocks Pass road, Nectar Brook Road)	mildly stressed creekline
	MB004	0780736 6384704 (84)	1	Tattiwa Creek (side view from track, Nectar Brook Road)	mildly stressed creekline
	MB005	0777252 6378587 (85)	1	Nectar Brook (view from track near homestead, Nectar Brook Road)	healthy creekline, regeneration
	MB006*	0778429 6364847 (86)	1	Mt Gullet Creek (side track at creek crossing east of Highway 1)	relatively healthy creekline
	MB007*	0779128 6361788 (87)	1	Mambray Creek at railway line (parking area east of Highway 1)	very stressed floodplain
	MB008	0775876 6360990 (134)	1	Mambray Creek downstream reach (Spencer Road west 3 km of Highway 1, gate at corner of Colin Mudge Road)	downstream floodout zone, stressed floodplain
	MB010*	0228158 6341893 (97)	1	Telowie Creek road crossing on Top Track, south of Telowie Gorge park entrance track	medium stress in creekline
	MB011	0228820 6338114 (96)	2	North End Well Creek, upstream and downstream from ford on Top Track	very stressed creekline
	MB012	0224147 6337748 (138)	1	Telowie Creek downstream reach, Noel Smith Road 1 km east of Highway 1 at ford	very stressed floodplain

*= special sites for intensive tree monitoring

Table 2 Monitoring Sites in Mambray Catchment

NORTHERN & YORKE RIVER RED GUM MONITORING: WAKEFIELD CATCHMENT					
Reach	Site No	grid (GPS waypoint)	Photos	Directions	Subject
Wakefield Catchment: Skillogalee Valley					
	WK001*	0280530 6243341 (117)	1	Upper Skillogalee Creek, from Upper Skilly Road	sheep grazing, no riparian zone
	WK002*	0281037 6237498 (119)	1	Upper Skillogalee Creek, from Upper Skilly Road	cattle grazing, contours
	WK003	0280871 6234706 (121)	1	Lower Skillogalee Creek, from Lower Skilly Road	regeneration, grazing
Wakefield Catchment: Lower Wakefield Valley					
	WK004	0280150 6223400 (122)	1	Wakefield River (junction of Nyowee & Rhynie to Balaklava Roads, from road)	healthy trees, permanent pool
	WK005	0266081 6218367 (123)	1	Wakefield River (Whitings Ford), from track south of ford	stressed trees
	WK006a		1	Wakefield River downstream of Balaklava	healthy trees, weeds
	WK006*	0258366 6221880 (124)	1	Wakefield River (Werocata Rd between Balaklava & Whitwarta, from north of ford)	stressed trees, recovery
	WK007	0256349 6223625 (125)	1	Wakefield River (from Rifle Range Road near Whitwarta cemetery)	stressed trees
	WK008*	0254544 622978 (126)	1	Wakefield River (old bridge at Whitwarta)	healthy trees
	WK009	0252484 6222363 (127)	1	Wakefield River (distant view to river from Angels Road)	stressed trees, possible salinity
	WK010	0247373 6217653 (129)	1	Wakefield River (upstream from old bridge north of Bowmans on Bowmans Beaufort Road)	stressed trees, weeds

* = special sites for intensive tree monitoring

Table 3 Monitoring Sites in Wakefield Catchment

NORTHERN & YORKE RIVER RED GUM MONITORING: WILLOCHRA CATCHMENT					
Reach	Site No	grid (GPS waypoint)	Photos	Directions	Subject
Willochra Catchment:	Melrose Loop -- Campbell Creek, Wild Dog Creek, Willochra Creek				
	WL001	0235631 6359500 (39)	1	Peach Tree Hill, Melrose – Pt Germein Road	mature trees, no regeneration
	WL001a*		1	Mt Remarkable Creek	native woodland, creek
	WL004	0241692 6355110 (46)	1	Wild Dog Creek	floodbank blocking flows
	WL005*	0241777 6356582 (47)	1	Wild Dog Creek	stressed mature, regeneration
	WL006a*		1	Willochra Creek	grazed riparian, mature trees
	WL006*	0238552 6367619 (51)	1	Willochra Creek	very stressed, 2007 recovery
Willochra Catchment:	Willochra Creek --Booleroo Whim Creek to Beautiful Valley Creek				
	WL008*	0250269 6369636 (53)	1	Booleroo Whim Creek (from south)	very stressed, 2007 recovery
	WL009*	0239908 6369771 (54)	1	Willochra Creek	medium stress in creekline
	WL011*	0239294 6379223 (58)	1	Spring Creek	stressed floodout zone
	WL012	0236025 6389275 (61)	1	Beautiful Valley Creek	stressed creekline

* = special sites for intensive tree monitoring

Table 4 Monitoring Sites in Willochra Catchment

Appendix 2 New Monitoring Site Locations 2013-2015

NORTHERN & YORKE RIVER RED GUM MONITORING						
Reach	Site No	grid (GPS waypoint)	No of Photos	Directions	Subject	Date
Broughton Catchment: Rocky River mid-valley, upstream of Crystal Brook						
	BR007a*		1	Thredgold Crossing	die-back, insects	201
Broughton Catchment: Rocky River upstream to Appila Springs (Crystal Brook to Gladstone, Laura, Wirrabara, Appila)						
	BR009a*		2	Wirrabara Creek (Pilmore)	removal of weeds	201
	BR011*		1	Appila Springs, looking south-west	stressed trees, no regeneration	201
	BR018a		1	Broughton River, Redhill, opposite hotel	regeneration, pool, Broughton willow	201
	BR019a		1	Broughton River, Koolunga – Hope Crossing	regeneration, reeds	201
Wakefield Catchment: Wakefield River Valley						
	WK003a*		1	Wakefield River, Mintaro (Riley Road Reserve)	planted trees, reserve, weeds	201
	WK003b*		2	Wakefield River, Mintaro (Hare Road)	remnant mature riparian trees	201
	WK003c		3	Wakefield River, Mintaro (Holm Park)	weeds, healthy trees	201
	WK004a*		1	Wakefield River, Auburn (Agostino)	weeds, healthy trees	201
	WK004b		2	Wakefield River Auburn (Vandeleur)	bare riparian zone, red gum planting	201
	WK004c		1	Wakefield River, Auburn (Taylors)	fenced riparian zone	201
	WK004d		1	Wakefield River, Auburn (river walk)	introduced species, mature red gums	201
	WK004e		2	Wakefield River, Auburn (Saddleworth bridge)	mature red gums, weeds	201
	WK004f		2	Wakefield River, Auburn (Undalya bridge)	reedbeds	201
	WK005a		3	Wakefield River, The Rocks (McInerny)	regeneration, reeds	201
	WK005b*		3	Wakefield River, Whiting Ford (Shepherd)	mature red gums, river bed	201
	WK006a*		1	Wakefield River, Balaklava (Fisher)	weeds, healthy trees	201
Willochra Catchment: Upper Willochra Valley						
	WL001a*		2	Mt Remarkable Creek, Melrose (NP)	conservation site, insects	201
	WL001b*		1	Campbell Creek, Melrose (Lello)	grazed riparian	201
	WL001c*		1	Melrose	weeds, riparian zone	201
	WL006a*		1	Willochra Creek, Melrose (McCallum)	grazed riparian	201
	WL011a*		1	Spring Creek, Pilliga Road	grazed mature woodland	201

* = special sites for intensive tree monitoring

Appendix 3 Field Guidelines for Scoring Site Condition

QUICK GUIDELINES FOR SCORING SHEET D

Chance Of Decline	5	4	3	2	1	0
Past Die-Back	0%	<25%	25-50%	50-75%	>75%	100%
Recovery	100%	>75%	50-75%	25-50%	<25%	0%
% Dead Trees	0%	<25%	25-50%	50-75%	>75%	100%
% Stag Ends	0%	<25%	25-50%	50-75%	>75%	100%

Chance Of Recovery	5	4	3	2	1	0
Regeneration	--	VH	H	M	L (few)	0
Multiple Ages	--	4	3	2	1	0
Riparian	--	--	H	M	L (few)	0
% Healthy Trees	100%	>75%	50-75%	25-50%	<25%	0%
% Epicormic Growth	0%	<25%	25-50%	50-75%	>75%	100%

QUICK GUIDELINES FOR SCORING CANOPY CONDITION ON SHEET F

Condition	Indicators	Score
Healthy	Intact without die-back or epicormic growth	4
Low Stress	<10% of canopy died back	3
Medium Stress	10-33% of canopy died back	2
High Stress	33-66% of canopy died back	1
Extreme Stress	>66% of canopy died back	0

DIE-BACK = branches or branchlets without full leaf cover, exposed bare branches (stag ends), dead branches

CONVERSION OF EPICORMIC SCORES ON SHEET F

% Epicormic Growth In Canopy	Score
100	0
80-90	1
60-70	2
40-50	3
20-30	4
0-10	5

Appendix 4 NY Press Release on Dieback in River Red Gum Communities

Managing dieback in river red gum communities

Jessica Henderson Communications Coordinator Natural Resources Northern and York
Email Jessica.Henderson@sa.gov.au www.naturalresources.sa.gov.au/northernandyorke

River red gums across the Northern and Yorke region have been noticeably under significant stress due to a combination of issues, leading to mounting concern from the community.

Lerp (psyllid insects) is not a new problem, having occurred for thousands of years, however the impact of the insects is compounded by other stresses such as lack of water, increased water salinity and bird damage.

Environmental consultant Dr Anne Jensen says the attacks were particularly bad across the region in 2012 and 2013 but have since been very localised, with Clare affected last year and Horrocks Pass and Port Germein Gorge being impacted this year.

“The attacks target stressed trees, which have higher levels of nutrients in their sap.
Climatic conditions this year have been ideal for insect breeding, with higher humidity in summer, and lower than average rainfall in the traditional rain-producing months.”

Dr Jensen said that the primary cause of dieback in red gums in the region is water stress and that in addition to dry conditions this year, there is underlying water stress from reducing regional rainfall over the past 35 years, as well as increasing extraction of water from catchments.

Another factor is the reduced number of bird predators on lerp, owing to the loss of shrub habitat from the landscape.

“Trees with sufficient resilience will survive, but severe lerp attack will set them back 3-4 years.
It takes this length of time for trees to recover, replace the lost leaves and start the cycle from buds to fruit and seed, which takes 2 years” Dr Jensen said.

Natural Resources Northern and Yorke Water Officer Jennifer Munro said a major issue for river red gums is the shortage of younger trees to replace the old trees as they die.

“The most useful action that can be undertaken by the community is to protect young seedlings and saplings from harm caused by grazing or machinery by using tree guards and controlled grazing methods.

Additionally, natural control of insect numbers can be achieved by increasing the number of native shrubs along watercourses, thereby increasing the number of insect-eating birds that use the shrubs for travelling and habitat.

The combination of these actions will help ensure that the tree communities will be sustained for the long term” Ms Munro said.

To get involved in the Four Rivers project which aims to protect and enhance existing native vegetation, contact the Clare Natural Resource Centre on 8841 3400.