MOLONGLO CATCHMENT STRATEGY

2015-2030

November 2015

Molonglo Catchment Strategy 2015

This document is a living document, to be reviewed regularly. The Molonglo Catchment Group Inc. welcomes feedback on this Molonglo Catchment Strategy.

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If you would like to receive more information regarding the catchment planning process or the Molonglo Catchment Group, please visit our website at www.molonglocatchment.org.au or contact the Catchment Coordinator.

Front Cover: Molonglo Valley, Carwoola - view over part of the Carwoola rural residential area to Kowen Forest and 'Woodlands', prior to the building of Defence Headquarters.

ISBN[W1]

This document was produced by the Molonglo Catchment Group Inc. May, 2005 and revised in 2015.

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Helping Communities Helping Australia
An Australian Government Initiative

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FOREWORD

In introducing the first version of the Molonglo Catchment Strategy in 2005, Lynton Bond, President of the Molonglo Catchment Group until 2014, described the Strategy as part of our contribution to the challenge of finding better ways to manage the natural resources of New South Wales and the Australian Capital Territory. He drew attention to the need for balanced, cooperative cross-border natural resource management.

Unlike the previous Strategy, which covered the 20 years 2004-2024, the current version adopts a 15-year timeframe. This is partly to more acutely focus our responsibilities to the next generation and partly to align with the approach of existing regional planning frameworks. We acknowledge it would be irresponsible of us not to consider the unprecedented swings and extremes in weather patterns - for example, as we plan for increasing population pressures on the environment and resources of the Molonglo catchment. However, we also recognise that the nature and unpredictability of those swings and their potential effect on the catchment make it impossible to fully understand apparent shifts or irreversible changes.

In addition, the 2015-2030 Strategy provides a model of communication and engagement. The Strategy recognises that the Molonglo Catchment Group's capacity to support a viable and resilient Landcare network relies on increasing social capital through inclusivity. In so doing, the aspirational goals and long-term strategic outcomes place our member groups in alignment with the regional, national and Indigenous Natural Resource Management streams of the Australian Government's National Landcare Program.

In terms of our responsibilities to the next generation, both the focus of the Strategy and its timeframe are consistent with the recently-released United Nations publication, *Transforming our world: the 2030 Agenda for Sustainable Development*. The most relevant development goals listed in the agenda are about making places in which we live inclusive, safe, resilient and sustainable; taking urgent action to combat climate change and its impacts; and the sustainable use of terrestrial ecosystems; the sustainable management of forests; combating desertification; halting and reversing land degradation and the loss of biodiversity.

The resilience thinking of the Strategy leads to a more holistic understanding of how the Molonglo catchment works and how we can influence it for better or for worse. The strategy does not undertake any analysis of the possible extent or duration of predicted climate change: rather, its focus is on people and communities in a Landcare context. However, those who appreciate that the Australian climate has always been harsh and unforgiving will also appreciate that any potential for extremes or fluctuations poses the greatest risk at times such as now, when governments are reviewing their priorities in a quest for efficiency, and domestic and international markets have become more competitive. Thus, more than ever, we need to ensure that resilience, the ability to respond adaptably to an uncertain future, is a feature of all of our planning processes.

Borrowing further the words of my predecessor I also commend the Molonglo Catchment Strategy to you and encourage you, your group or organisation to consider how you may participate in its implementation. To investigate your potential involvement, you are welcome to contact the Molonglo Catchment Group or visit our website (www.molonglocatchment.org.au). Together, we can improve the way we manage the natural resources that are so vital for the future of our catchment.

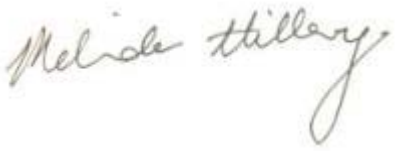
President, Molonglo Catchment Group

INTRODUCTION AND ACKNOWLEDGEMENTS

This Strategy is by its nature both a document with sweeping wide scope, and in other places, one which mines down deeply into fine detail. We would like to invite you as reader to collaborate with us in this project. Let us know where our sweeping overview has missed important details, or where in mining down a particular vein we have missed another important aspect. This document represents what the Molonglo Catchment Group has learnt over the past ten years…we certainly don't expect to stop learning now!

This document began with the Molonglo Catchment Strategy 2004-2024, prepared by the Catchment Coordinator at the time, Damian Wall. In every sense a living document, it has grown and changed over the years and will continue to do so into the future.

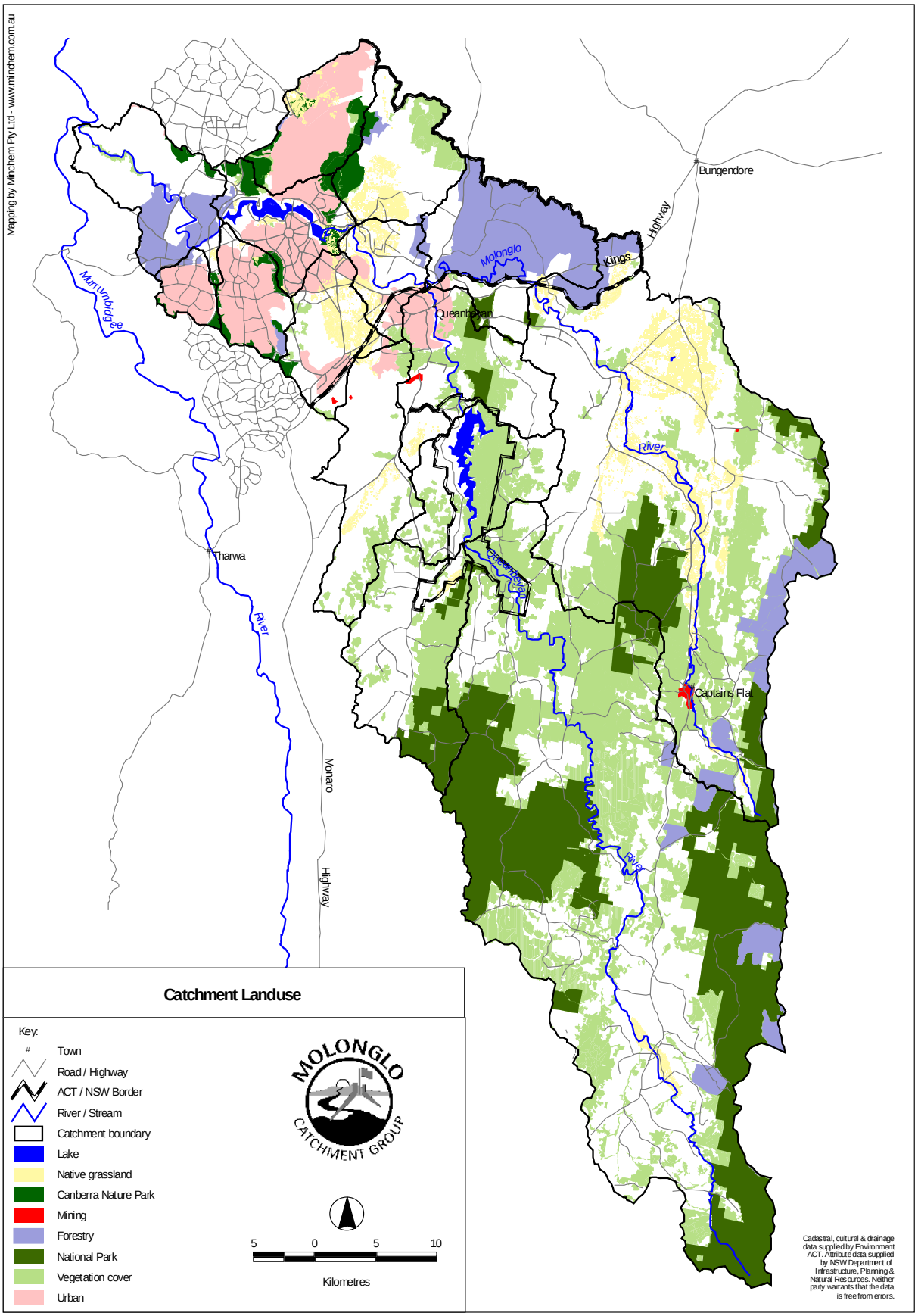
As the immediate author of the document I would like to thank the staff and committee members of the Molonglo Catchment Group who drove the creation of the central strategy. They have become "authors by extension" both by giving direct feedback on the document, and by being my work colleagues and mentors over the past two years. Past President Lynton Bond has been a constant source of corporate and catchment knowledge and a sounding board for ideas. President Karen Williams provided intellectual rigour and encouragement to the review process and helped write some of the sections which endeavour to bring in some indigenous perspectives. I am also very grateful to Coordinators Anna See, Bernie Bugden, and Waterwatch Coordinators Dr Stephen Skinner and Deb Kellock for their cheerful willingness to come to my aid on multiple occasions. Other committee members have been deep sources of knowledge on the corporate history of NRM in the Molonglo catchment, on good governance, methods of monitoring and best practice models. Key discussions with a number of Molonglo catchment stakeholders were pivotal in helping shape the direction of the strategy and I would like to acknowledge this assistance here. Volunteers in the MCG Office Ellen Eckhardt and Nikita Sharma provided invaluable support. Finally I am completely indebted to Martin Butterfield for his assistance in generating population statistics for a "catchment" which pays no respect to state or census collection boundaries!



Melinda Hillery

Molonglo Catchment Officer

November, 2015.


Mapping by Minchem Pty Ltd - www.minchem.com.au
Bungendore
Highway
Molonglo
Kings
Queanbeyan
Murrumbidgee
River
Tharwa
Captains Flat
Monaro
Highway
Catchment Landuse
Key:
Town
Road / Highway
ACT / NSW Border
River / Stream
Catchment boundary
Lake
Native grassland
Canberra Nature Park
Mining
Forestry
National Park
Vegetation cover
Urban
MOLONGLO CATCHMENT GROUP
5 0 5 10
Kilometres
Cadastral, cultural & drainage data supplied by Environment ACT. Attribute data supplied by NSW Department of Infrastructure, Planning & Natural Resources. Neither party warrants that the data is free from errors.

EXECUTIVE SUMMARY

Looking to the future, the Molonglo Catchment Strategy (MCS) 2015 (Figure 21 p88) has the following vision:

"A healthy and sustainable environment treasured by the entire catchment community"

The program represents an aspirational view of what the Molonglo Catchment Group (MCG) would like to achieve or influence others to achieve during the next 15 years. A Monitoring, Evaluation, Reporting and Improvement (MERI) process is described for feeding back results into planning and implementation.

The revised MCS 2015 uses the 'resilience' approach. That approach is also used in the *South East Catchment Action Plan* (South East Local Land Services, 2014) and influences Natural Resource Management (NRM) in the ACT. Resilience analysis describes the dynamics of a system and identifies potential factors that might drive the catchment between alternative system states (Resilience Alliance, 2010). From this a model of change is developed, describing how 'resilient' the system is to external shock, and how system governance operates in response. A final step in resilience analysis is to act on the assessment via the development of a strategy.

The identification of an alternative states model of the Molonglo catchment was used as a visioning exercise at the MCG committee workshop in May 2013, identifying not only where we have come from but also where we want to be (see Figure 8 p45).

Six key thresholds were identified where, since 1800, the Molonglo catchment has moved from one state into another (see Table 2 p44). There is some evidence however that key ecological functions of the original indigenous-managed system remain, despite degradation, and that a long-term view may see the system as 'resilient', to the 'shock' of non-indigenous migration, particularly if European governance systems are able to incorporate enough indigenous knowledge. Alternatively climate change may prove to be the 'shock' that pushes the Molonglo catchment irreversibly into a different state. Key drivers in the foreseeable future were identified as: climate change; population increase and then stabilization; improvements in house and development design; the need to live as much as we can within the means of our own catchment (food, water, resources); the need to continue to manage 'pest' species; increasing bushfire pressures; the development of new economic models that put a greater value on natural assets; acknowledging ecosystem services; and aiming to achieve sustainability.

Community views, obtained from a 2012 stakeholder survey, resulted in biodiversity and river restoration becoming higher priorities in 2012 compared with 2005, whilst other priorities remained similar. These priorities are reflected in the proposed projects for the MCS 2015.

The MCG has undertaken an impressive amount of community engagement since the MCS 2004-24 with at least 7,500 people participating in at least 61 MCS events, 33 on-ground projects, producing 30 written products and assisting over 73 community groups between July 2009 and 2013. The Waterwatch program monitored 25 sites in 2006, expanding to 64 sites by 2013. The MCG continues to make significant impacts through on-ground projects addressing native vegetation regeneration, weeds, feral animals, erosion and land-management change.

Where data is available, our review of the MCS 2004-24 targets indicates that resource conditions have been relatively stable for threatened biodiversity assets in the catchment, with some deterioration in water

quality at the lower end of the catchment in recent years, and on-going soil erosion leading to heightened turbidity in more developed reaches within the catchment. Lower Jerrabomberra Creek, lower Sullivans Creek, Yarralumla Creek and the Molonglo River from the confluence with Queanbeyan River downstream through Lake Burley Griffin and below Scrivener Dam all have water quality in the moderate to poor range in 2014. Water quality in the Queanbeyan River (including lower Queanbeyan) is very good considering the degree of urbanisation. This suggests that retention of significant bushland may have played an important role in retaining highly functional ecological processes. Data is patchy for Sullivans Creek but the excellent turbidity results suggest that the urban wetlands in this catchment are having a positive effect, although phosphorus levels and dissolved oxygen remain very concerning in the lower section.

Projects are developed at a landscape scale (subcatchments within the Molonglo catchment) and target one or more of the long-term outcomes. They are ideally linked to a Waterwatch and a Vegwatch (or other vegetation and/or fauna monitoring) site. Existing and potential projects are identified in the Strategy in response to a subcatchment priority, and linked spatially to address overall catchment connectivity.

LAYOUT OF THE STRATEGY

PART 1. SETTING THE SCENE

This part describes the purpose of the MCS 2015 and the approach that has been taken.

PART 2. RESILIENCE OF THE MOLONGLO CATCHMENT

A resilience model is given for the Molonglo catchment including a description of the catchment; the dynamics of the catchment (models of change and alternative system states); identifying interactions at different scales; and the evolution of planning and governance in the Molonglo.

PART 3. REVIEW OF THE MCS 2004-24

Reviews the targets and indicators as set out under the MCS 2004-24 using available data. This was an asset management approach, considering resource condition and community targets for land, water, biodiversity and community assets.

PART 4. THE MOLONGLO CATCHMENT STRATEGY 2015

This part details the MCS 2015 and the next five year program for the MCG. It lists foundational activities (research, partnerships and resources) and immediate activities (advocacy, action and education) that have been prioritised from the 2012 community survey, and MCG committee and stakeholder input. Using program logic these are then connected to intermediate outcomes, longer term outcomes and aspirational goals under the Molonglo catchment vision.

The MCS 2015's program consists of five long-term goals, and current and future projects are mapped out against these. Targeted measures are given in parentheses:

- protection of and improvement of soil health (phosphorus, turbidity, EC and pH);
- increased adoption of best practice NRM (MCG Member Survey, % of MCG projects adopting a cultural protocol);
- increased extent, connectivity and condition of native vegetation managed for culture and biodiversity (vegetation and fauna surveys, number of new habitat patches, number of new links);
- improved river health (% dissolved oxygen and macroinvertebrate surveys, area of restored riparian vegetation);
- viable and resilient communities (Regional Well-Being Survey).

The Strategy represents an aspirational view of what the MCG would like to see achieved in the next fifteen years. It provides direction for investment and collaboration, flagging areas that the MCG's past funding sources are unlikely to provide and where new approaches may need to be identified.

A process for Monitoring, Evaluation, Reporting and Improvement (MERI) against the MCS 2015 is outlined.

ACKNOWLEDGING THE ABORIGINAL TRADITIONAL CUSTODIANS OF THIS CATCHMENT REGION

There are presently four Representative Aboriginal Organisations (RAOs) registered under the ACT Heritage Act 2004: Buru Ngunawal Aboriginal Corporation; Little Gudgenby River Tribal Council; King Brown Tribal Group; and the Ngarigu Currawong Clan. The MCG seeks to work collaboratively and respectfully with all of these groups, and others, in achieving our Strategy aims.

MCG acknowledges the Ngun(n)awal people who are recognised as traditional custodians and carers of the land and waters of the region in and around the Molonglo catchment. We respect their continuing culture and recognise the contribution they make to life in the catchment.

To the reader - for clarification.

The word 'Ngunawal' (meaning 'we, the people')

The spelling of the word 'Ngunawal' (and in more recent usage, 'Ngunnawal') - in describing the particular language group of the acknowledged traditional custodians of the area in and around the Molonglo catchment, while contentious, has become symbolically important in local Aboriginal culture and politics. The word, spelt either 'Ngunawal' or 'Ngunnawal', raises the connection of identification and history.

In the current context, some family groups of the local Aboriginal community identify with the historical, single 'n' spelling of Ngunawal, while other groups united under the spelling of the word using double 'n' during the 1990's and more recently. The ACT Government has previously used the spelling Ngun(n)awal to acknowledge this but has subsequently adopted the double 'n' spelling, Ngunnawal. That spelling evidently came from a sign that was placed by the Yass Shire Council as the name of a park on a hill at Bowning, in recognition of the Aboriginal community of the area who were said to have died out due to smallpox in the mid-1800s (Jackson-Nakano, 2001). Today, as the politics changes and more is understood about the Aboriginal history of the local region, while there still remains a broad identification with the single and the double 'n' Ngun(n)awal, this strategy document uses the single 'n' spelling specific to the group to which we refer. Other people identify with the name Ngambri (Kamberri/Canberra) - a group not officially recognised as an RAO at the time of writing.

Native Title and the Molonglo catchment

In respectfully acknowledging the Ngun(n)awal people as the traditional custodians we distinguish them from the other local RAOs. Our distinction between traditional custodians and RAOs differentiates groups that have passed a rigorous Native Title Claimant registration test, from those that have not.

According to the Native Title Act 1993[1] a Native Title Claimant must meet all 12 conditions of the registration test before their application can be included in the Register of Native Title Claims. As long as the application remains registered the claimant group has certain procedural rights within the area that is

[1] (Sections 190A to 190C Native Title Act 1993) www.nntt.gov.au/nativetitleclaims/Pages/Registration-Testing.aspx

the focus of their claim, including the right to negotiate in a consultative process. Groups that have not qualified for that right must apply to negotiate.

A claimant group may differentiate themselves for verification purposes as descendants of particular, named ancestors, or using a family tree or genealogical chart that can be used to show which of the people in the family tree are living and which people have children.

Representing the only registered Native Title claimant of the region incorporating the Molonglo catchment, Wally Bell, Chair of the Buru Ngunawal Aboriginal Corporation, explains the interrelationship of Ngunawal ancestors, genealogy and territory in Section 3.2 history and people p10. Because Mr Bell's group is the only registered claimant group, and to promote a consistent cultural background and territorial context, MCG has limited the discussion of the Aboriginal cultural landscape in this strategy to the Ngun(n)awal interpretation.

Comparisons between competing, alternative perspectives of the Aboriginal cultural landscape would be valuable. However, the scale and complexity of that task extends beyond the scope and purpose of this Strategy document. MCG intends, as development of our capacity permits, to extend our discussion of the Aboriginal cultural landscape to include alternative (sometimes competing) interpretations of the Molonglo catchment by other local Aboriginal groups. We hope that future collaboration will provide further opportunities to continue exploring the cultural significance of the natural environment to Aboriginal people in our region, especially in relation to the priorities and issues of natural resource management.

PART 1. SETTING THE SCENE

1. PURPOSE OF THE MCS 2015

1.1 PURPOSE OF THE CATCHMENT STRATEGY

The revised MCS for 2015-2030 provides long-term direction for community investment decisions to ensure improved natural resource outcomes. The MCS:

- describes our current understanding of the Molonglo catchment;
- assesses what we have done well and not so well in the past;
- sets broad goals for 15 years and a detailed plan for the next 5 years;
- identifies indicators and baseline data for monitoring and evaluation of progress.

The MCS 2015 aims to assist and guide the planning and action of:

- private landholders, who own 35% of the land in the catchment;
- government, which manages the other 65% of land in the catchment on behalf of the community;
- local and State government agencies with responsibility for natural resource management;
- community groups and non-government organisations protecting and restoring the environment; and
- business and industry groups investing and operating within the catchment.

1.2 THE ROLE OF THE MOLONGLO CATCHMENT GROUP

The MCG was formed in 2003 with the principal objective of developing the Molonglo Catchment Strategy and a secondary objective, and subsequent role, in coordination and integration of the network of Landcare and Park Care groups in the Molonglo catchment[2], appropriate to the level of support (resources) available.

Our role is to help these groups promote and undertake environmental protection and enhancement within the catchment. The MCG has been supported by the ACT and Australian Governments' environmental programs in this role.

The MCS 2015 should not be interpreted to imply that the group intends to take on a larger action/implementation role than in the past. While this may be appropriate where no other group or agency is active or has a role, the MCG does not seek to duplicate services that are currently available, but rather to assist with coordination, collaboration and to add value to those services.

1.3 PLANNING FOR AN UNCERTAIN FUTURE

The MCG recognizes that there is community debate about the nature of climate change: whether it is bad, can be planned for, or that it exists. Substantial scientific evidence, public concern and the implications of

[2] With the exception of groups in Weston and Woden which have an historic connection with Southern ACT Catchment (see Southern ACT Catchment Group's role in Woden and Weston Creek).

not acting determined that MCS 2015 include climate change as a factor when addressing the resilience of the Molonglo catchment.

2. RESILIENCE APPROACH TO THE MCS 2015

2.1 A HOLISTIC MODEL RATHER THAN ASSET BASED APPROACH

In the MCS 2015 the MCG has moved away from the MCS 2004-24 asset management approach where land, water, biodiversity and community assets were accounted for separately. This is in line with the development of thinking behind the *South East Catchment Action Plan* (South East Local Land Services, 2014) and the *Murrumbidgee Catchment Action Plan* (CAP) 2013 (Murrumbidgee Catchment Management Authority, 2013) and currently in the natural resource management of the ACT.

The aim of the 2015 strategy is to utilise a more holistic understanding of how all these assets work together in a landscape and how we can influence that landscape for better or for worse.

Traditional 'command-and-control' management systems assume a static model of the environment, and address individual problems without considering feedbacks and interactions. By contrast, a holistic approach takes natural resource management as neither an ecological nor a social issue. This approach analyses the factors influencing the whole socio-ecological system at different scales in space and time, and assumes continuous change. It also acknowledges the level of uncertainty in our knowledge, understanding, and of future conditions (Resilience Alliance, 2010).

2.2 STEPS WITHIN RESILIENCE ANALYSIS

Resilience analysis has been used to think holistically about landscapes in the MCS 2015, following that of the Murrumbidgee CAP 2013. A full description of this can be found in *Assessing Resilience in Socio-Ecological Systems: Workbook for Practitioners v2* (Resilience Alliance, 2010) and is briefly paraphrased here.

Resilience analysis constructs a conceptual model to describe a place of interest, in our case the Molonglo catchment. It identifies multiple alternative states of the catchment, and potential factors that might drive the catchment between alternative system states.

"**Resilience** is fundamentally a system property. It refers to the magnitude of change or disturbance that a system can experience without shifting into an alternate state that has different structural and functional properties, and supplies different bundles of the ecosystem services that benefit people. Classic examples of shifts between alternate states include transitions from coral reefs to algae-covered rocks, from grasslands to shrub-dominated landscapes, and from clear to cloudy water in freshwater lakes. Associated with each of these shifts are changes in the supply of ecosystem services, for example fish production, grazing potential, and tourism and recreation opportunities." (Resilience Alliance, 2010)

The analysis is holistic because it focuses on how key components contribute to the dynamics of the whole system rather than a detailed understanding of the parts of the system. Though the Workbook doesn't specifically address it, resilience should be viewed as a value-neutral property in that it can work either to protect a healthy system from moving into a less desirable state, or to hold a dysfunctional state back from healthy change.

The Workbook for Practitioners v2 suggests the following steps:

1. Describing the system: resilience of what, to what, key issues, scales above and below
2. Describing the dynamics – a model of change, multiple system states, thresholds and transitions
3. Identifying interactions – cross-scale, cascading change, general resilience
4. System Governance – adaptive governance and institutions, social networks
5. Acting on the assessment – synthesizing findings, resilience based stewardship, initiating transformation.

Part 2 of the MCS 2015 undertakes the first four of these steps, whilst the fifth step, acting on the assessment is addressed in Part 4. Part 3 reviews progress against the goals of the MCS 2004-24 and provides a brief snapshot of the state of the catchment in 2014-15.

PART 2. RESILIENCE OF THE MOLONGLO CATCHMENT

3. DESCRIPTION OF SCOPE AND HUMAN ELEMENTS

3.1 AREA AND SCOPE

The Molonglo catchment comprises approximately 212,000 ha within the Murrumbidgee catchment in SE NSW and includes all the land that drains into the Molonglo River and Lake Burley Griffin, including the Queanbeyan River and all their tributaries (see map on p vi).

As a whole the catchment can be defined as the aggregation of nine subcatchments by similarities in land use and hydrogeology: Upper Molonglo, above confluence with Queanbeyan River; Reedy Creek; Queanbeyan River; Burra Creek; Jerrabomberra Creek; Woolshed Creek; Lake Burley Griffin and Molonglo (Fyshwick) reach; Sullivans Creek; and the Lower Molonglo below Scrivener Dam, including Yarralumla and Weston Creeks. See Southern ACT Catchment Group below.

The Molonglo catchment encompasses all of the Queanbeyan City Council area, parts of Palerang Council and Cooma-Monaro Council and also part of the ACT. Included within the boundary is the entire city of Queanbeyan and a portion of the central suburbs of Canberra.

The physical scale for this strategy is the Molonglo catchment itself. In order to utilise an holistic assessment the impact of dynamics must be analysed at both the scales above and below. The scale above (the Upper Murrumbidgee catchment) refers to how changes in the Molonglo catchment as a whole will in turn influence what the landscapes of the Upper Murrumbidgee come to look like in time, both directly and through their interconnected water cycles.

The scale below (individual properties/enterprises operating within the Molonglo catchment) addresses how the sustainability or otherwise of individual properties/enterprises operating within the Molonglo catchment affects what the entire catchment comes to look like over time. When one enterprise type becomes unsustainable in many places it is replaced or evolves into another enterprise type (e.g. the subdivision and transformation of sheep stations into suburbs and rural residential areas).

We have also been explicit in the MCS 2015 about scale in time. In order to understand how state changes take place in the Molonglo catchment we have focused on the period of history for which we have the best current information (1800s to the current day) looking at changes that have taken place over decades at a time whilst observing the yearly changes in decisions taken by various property/enterprise managers which contribute to these broader trends. When addressing larger time scales for the Molonglo catchment we must consider the longer time frames of colonisation, human and evolutionary history and climate change (see history and people below).

SOUTHERN ACT CATCHMENT GROUP'S ROLE IN WODEN AND WESTON CREEK

The Molonglo Catchment Group was formed in 2003 as a network of Landcare and Park Care groups in the Molonglo catchment and is one of three groups operating in the ACT. Another of the three catchment groups is the Southern ACT Catchment Group (SACTCG) which was formed in 2002. The SACTCG represents

all active environmental groups in the southern areas of the ACT: Woden, Weston Creek, Tuggeranong and Tharwa. The oldest of the three groups is the Ginninderra Catchment Group, formed in 1996 and overseeing the Ginninderra Creek catchment including the major urban areas of Belconnen and Gunghalin in the ACT.

The MCS 2015 includes Woden and Weston Creek in the description and monitoring of the Molonglo catchment. However the MCG recognises the primary role of SACTCG in supporting member groups in that area.

In some ways the relationship between the two catchment groups and their networks of smaller environmental groups is similar yet different to the interrelationship reflected in traditional notions of territory and country held by different Aboriginal family groups of the region. These notions defined the earliest forms of systems management governing the natural resources of our region.

Traditional Aboriginal territory boundaries, like our Landcare and Park Care catchment boundaries, are both social and ecological. They are defined by different levels of relationship between people and the places they make connection with, in their environment.

3.2 HISTORY AND PEOPLE

The MCS 2015 is a living document about an evolving Landcare practice that helps us understand the Molonglo catchment's capacity for resilience. The MCS 2015 also defines our identity and sense of place in the landscape. For the environment and for the people living and working in the Molonglo catchment, change has occurred. This may be the result of choice or accident, sometimes quickly and sometimes very gradually.

The present-day Landcare practice uses an inclusive approach. That approach suggests that the history and the people of the Molonglo catchment cannot be understood without recognising the momentous and at times catastrophic social and ecological changes brought about by British colonisation, in terms of land and water management, recognition of traditional rights and interests, and native title. The effects of those changes are now, in the main, acknowledged. A key indication is the recognition of native title in the High Court case of Mabo in 1992. Another indicator is *Bringing them home, t*he *Stolen Children* report of 1997 by the Australian Human Rights and Equal Opportunity Commission. The displacement of Aboriginal people through the processes of colonisation and the forcible removal of children from their parents is well documented in the *Stolen Children* report and was, by a small but important gesture, acknowledged in 2008 by our then Prime Minister, Kevin Rudd, saying "Sorry", on behalf of the nation.

The basis of Native Title is the traditional occupation of, or connection with, the land by Aboriginal people. The basis for the Ngunawal claim, shared with us by Wally Bell, Chair of the Buru Ngunawal Aboriginal Corporation, illustrates how that relationship works in the catchment context.

Tribal boundaries in Australia have been reconstructed largely on the basis of surviving linguistic evidence and are only approximate. Tribal boundaries probably varied over time and social interaction across boundaries appears to have been common.

The Ngunawal people have instigated several native title applications in relation to claims over our traditional land. To date we have had four determinations made on these claims. Of those four only one has been registered and unfortunately due to lack of financial assistance has been discontinued. A new application is being organised as of 2015.

The local traditional Aboriginal people, the Ngunawal, have occupied the area in the vicinity of the present town of Yass which was central to the tribal boundaries of the Ngunawal clan. The tribal boundaries encompassed the area from Goulburn to the north, Gundagai to the west, Cooma to the south and Braidwood to the East. This also includes the entire territory of the Australian Capital Territory on which the national capital, Canberra, is situated. Descendants of Aboriginal families are known to have been on official and unofficial reserves from the mid-1880s until the 1960s, and still occupy their Country in the surrounding region of Yass and Canberra to this day.

Much has been written, in ignorance, about Aboriginal people in general and about the Ngunawal people in particular. Every author writes with their own prejudices and cultural beliefs; and the assumption based on the cultural prejudices of the authors, that Bobby Hamilton was Queen Nellie's "first husband" and that Nellie used his name is wrong. The fact is that Bobby Hamilton used Queen Nellie's name and Bobby was not the "first" man that Queen Nellie bore children to. Wrong also is the claim that Queen Nellie was the last of the Ngunawal Aborigines.

Nellie had taken the name of Hamilton from white landowner Hamilton-Hume. Hamilton-Hume's wife was childless and Nellie bore him a daughter called Lucy. Whilst this may not have been acknowledged at the time, by the Hamilton-Hume family, Jenny McDougal-Hume, the niece of Hamilton-Hume, acknowledges this fact in her book about her family called Beyond the Borders.

[Wally's father, the late] *Don Bell* [1935-2008], *Ngunawal Elder, traces his lines back through his father, James "Eppy" Carroll, to his grandmother, Lucy, then to his great-grandmother, Queen Nellie. Queen Nellie Hamilton was not the last of the Ngunawals. Don Bell is the proud great-grandson of Queen Nellie Hamilton and Don Bell wants the truth told.*

In terms of resilience, perhaps we have passed the point of no return in the changing of lands and waters, taken under the mistaken application of the doctrine of Terra Nullius. However, the resolve for reparation, and the willingness to help restore and regenerate the land and its waters that were unfairly taken, will serve to strengthen the capacity to work with the Traditional Custodians and carers of the Molonglo catchment.

MCG also recognises that there are four Representative Aboriginal Organisations (RAOs) with interests in and associations to the region in and around the Molonglo catchment. We welcome opportunities to work collaboratively with all of these groups in achieving our Strategy aims.

Extending across the ACT-NSW border, the Molonglo catchment takes in the land and waters of the Ngun(n)awal people, who are the acknowledged Aboriginal Traditional Custodians, the initial carers of the tablelands of the region within and around the Molonglo catchment, and recognised under Native Title Act 1993.

Traditionally, Ngun(n)awal territory extends across the southern tablelands and is bounded by other traditional lands and language groups. These include: the Ngarigu/Ngarigo people in the highlands to the

southeast of the Catchment - stretching from the highlands to the south coast; the Yuin people on the coast in the east of Canberra; the Wiradjuri people on the slopes and plains to the west of Yass; and the Gundungurra people immediately to the north. Interpretation of territory and Country within the Molonglo catchment varies with differing individual and family group perspectives, and after following correct protocols, is inclusive of all of those groups.

The Ngunawal maintain that when the first colonial settlers arrived in their territory Ngun(n)awal clans lived in an area roughly bounded by the present-day towns of Braidwood, Goulburn, Boorowa, Harden, Gundagai and Cooma (refer to www.ngunawal.com.au and www.thunderstone.net.au). That perspective corroborates, generally, the often-cited description of Ngun(n)awal territory provided by N B Tindale (Tindale, 1974) as "Queanbeyan to Yass, Tumut to Boorowa, and east to beyond Goulburn; On highlands west of the Shoalhaven River".

The Ngunnawal have adopted Tindale's definition adding, in agreement with the Ngunawal, that seven Ngun(n)awal clans lived at specific places within that area. "The Maloongoola lived in the Molonglo area, the Biyaligee, in the area of Pialligo, the Namitch or Namwitch lived in the area we know as Namadgi, the Cumbeyan lived in the Queanbeyan area, the Kanberri lived in the Belconnen area, the Toogoranoongh lived in Tuggeranong and the Woolobaloah lived in the Yass area" (ACT Natural Resource Management Council, 2010).

Because Aboriginal history is a living history, it is about ancient and historical times understood in the present-day context as presented in the MCS 2015 document. The incorporation of indigenous land management and views of the changing landscape into Landcare practices relies on understanding a certain amount of environmental history to make sense of varying perspectives of traditional Ngun(n)awal boundaries.

The woodlands typical of the Ngun(n)awal landscape at the time of colonial settlement first appeared around 350,000 years ago (Lindenmayer, et al., 2005). New species of tree dwelling mammals evolved to inhabit the more open vegetation. As the climate became warmer and drier the increase in fires, particularly after people arrived, resulted in the eucalypts and wattles expanding to form their own woodland communities.

Typically, fire played a role in the development of the open vegetation patterns of this region. However, in the Monaro area south of present-day Cooma, fire played a lesser role than in other parts of Australia.

Intensive permanent occupation by people in the lowlands of Ngun(n)awal territory began about 4,000-5,000 years before the present day (Johnson, 2008). Other sites of occupation are dated at about 10,000-12,000 years ago near Goulburn, 3,600-4,000 years ago in Namadgi National Park, and about 10,500-11,000 and 19,000 years ago near Pigeon House Mountain in the coastal hinterland (Johnson, 2008). The earliest known occupation begins at around 21,000 years ago in the southern highlands closer to the Snowy Mountains (Flood, et al., 1987; Flood, 2003) recently revised to 25,000 years ago, with sites showing the most intense and longest occupation dates, so far, between about 300 and about 4,400 years ago (Argue, 1985).

During the time that people are first known to have been travelling across Ngun(n)awal territory the climate went through wild swings between warm and cool, and wet and dry, extending from the peak of

the last glacial period (17,000-19,000 years ago) to about 6,000 years ago. Glaciers covered about 19-32 square kilometres of the Mount Kosciuszko area. Snowlines dropped by at least 1,000 metres and temperatures were up to 10 degrees lower (Kershaw, 1995). The rivers of the regions in and around Ngun(n)awal territory were either not particularly active or had dried up, except on the inland plains to the west of the southern tablelands that received the runoff of melting snows from the Alpine region.

The melting of ice sheets of the Snowy Mountains, about 15,000 years ago and onwards, produced rapid environmental change and significant reversals in climate patterns. This period marked the beginnings of organic sedimentation and of peat lands in areas that had previously been frozen and under ice. It also resulted in changes to vegetation in the landscape immediately surrounding the mountains (Kershaw, 1995).

Being on the edge of that landscape the vegetation changes affected Ngun(n)awal territory both directly and indirectly. Rising temperatures encouraged a change from woodland to forest with grasses being the dominant understorey. In the last 3,000-4,000 years, change has been largely due to lower rainfall and has included a reduction in the amount of tree cover, slower river flows and subsequently lower lake levels or even the drying up of lakes and peat lands (Kershaw, 1995).

However, as rising seas inundated the coastline, forests immediately inland expanded. The use of fire in the coastal areas allowed people to create and maintain open habitats for favoured plant and animal resources in expanding forests. At the same time the moist influence of the encroaching sea, including rain-bearing winds, advanced further inland into places that had previously been arid and sandy (Hallam, 1987). The southern tablelands of Ngun(n)awal territory became a reliable naturally resourced meeting place, between the moist coastal environment and the dry inland.

Aboriginal people camped on the ridges of the present Kowen Forest area surrounding the junction of the Molonglo and Queanbeyan Rivers for up to 1,000 years before the present day (Kuskie, 1989; Bulbeck & Boot, 1990). Other known camps and meeting places of comparable age and scale have been documented at other major junctions and crossings of the Molonglo River: at Black Mountain, Pialligo and where the Molonglo meets the Murrumbidgee at Uriarra crossing. Major creek or river junctions ensured that there was a plentiful supply of food and water on flood plains, while the slopes of the surrounding hills and ridges supplied shelter. The higher ranges acted as watersheds separating river catchments while providing access between valleys and plains throughout the region.

Aboriginal people guided the colonial explorers who entered Ngun(n)awal territory, in the 1820s, looking to confirm the Murrumbidgee River as a source of water on which to rely for the watering of stock and, ultimately, for the expansion of the colony. Arriving from the north, the junction of the Molonglo and Queanbeyan Rivers was a major landmark for, most notably Throsby and Currie, followed closely by other explorers, squatters and more permanent pastoralists.

Between 1840 and 1870 a sequence of low stock prices and drought led to overstocking of grazing lands, while floods in 1852, 1872 and 1874 probably changed the landscape forever (Lea-Scarlett, 1968; Starr, et al., 1999). Many waterways, which had once been chains of ponds, became deeply incised channels with sand and gravel beds. By 1880 all available land on the plains between present-day Canberra and

Queanbeyan had been taken up. Many of the early holdings were sold, while remaining estates increased in size by merging adjoining blocks of land.

Aboriginal camping, local and regional corroborees still occurred in and around large rural properties or local towns such as Queanbeyan into the 1860s, albeit intermittently and generally in association with annual government blanket distributions. By that time Aboriginal people were hugely displaced and their presence and numbers in town was greatly reduced. They had largely become a local curiosity. In 1897, for instance, the local Queanbeyan newspaper reported that the last 'tribal' Aborigine had died in Queanbeyan Hospital (Gillespie, 1984; Williams, 1997)

However, present-day oral evidence indicates that Aboriginal people were still 'camping in the bush' in the last decades of the 1800s and the earliest decades of the 1900s. Some of those camps were at the Duntroon' estate, in the Oaks Estate paddocks, within the Queanbeyan town limits and as far back from the town as the base of Mount Jerrabomberra. There were also newspaper reports that "surviving remnants of the old Aboriginal order" were still living in the Yass region (where the Aboriginal missions were located) into the second decade of the 1900s (Queanbeyan Age 27/9/1912). Aboriginal people would also visit Queanbeyan into the 1950s following the boxing tents through the region (the late Ngunawal Elder Don Bell *pers. comm.*).

Five Aboriginal people died in Queanbeyan Hospital in the late 1800s and early 1900s: Jimmy Clements, Queen Nellie Hamilton, Bobby Hamilton, Nina Lowe and William Lowe. Significantly, each of these people were recognised as local identities through their association with prominent colonial townspeople (especially the doctors who treated them in hospital), their presence at major official events or their own significant achievements (Gale, 1927; Lea-Scarlett, 1968; Gillespie, 1984; Cross, 1985; Gillespie, 1992; Jackson-Nakano, 2001). At the time, they stood out in the social history of the region to the extent that their passing was perceived by their contemporaries to represent the passing of an era and the end of traditional Aboriginal life.

The turn of the 20th century brought further change with the beginning of the breakup of many of the large rural properties of the region, due largely to the death of their owners and the financial burden imposed by death duties (Starr, et al., 1999). In addition, federation had prompted a search for a site for a federal capital, resulting in the selection of the Yass/Canberra district. The Seat of Government Acceptance Act confirmed an area of about 900 square miles, determined to be sufficient to supply water for the expected population.

In 1911, following the proclamation of the Territory for the Seat of Government, the Aboriginal Protection Board forced Aboriginal people living in the territory to move to the Edgerton mission station at Yass and, later, the Hollywood mission (Australian Human Rights Commission, 1997), further encouraging the perception that traditional Aboriginal life had come to an end. There were another 1,714 people living on farms, with 1,762 horses and 224,764 sheep grazing in the Yass/Canberra district. At that time, Queanbeyan had a population of 1,273 people and, as a long-established regional centre, played an important role in the growth of the new capital (Starr, et al., 1999).

The NSW Government Surveyor, Charles Scrivener, selected the Canberra site and wrote: "The Capital would properly lie in an amphitheatre of hills with an outlook towards the north and north-east, well

sheltered from both southerly and westerly winds". He also indicated that the flood plain of the Molonglo River could form an ornamental lake in the centre of the city site. After an international design competition, in 1913 the Government appointed Walter Burley Griffin as Federal Capital Director of Design and Construction to implement his winning design (see www.naa.gov.au/collection/fact-sheets/fs95.aspx).

The First World War interrupted the growth of the capital, but Parliament opened there in 1927, signalling the real beginning of Canberra's growth. The city grew slowly through the Depression, the Second World War, and post-war shortages. The decision to move the central offices of all departments to the capital in 1954 saw the setting up of the National Capital Development Commission to oversee the planning, development and construction of Canberra. The population then was about 30,000.

The growth of Canberra became rapid with new town centres being developed. Subsequent rural residential development has resulted in a dispersal of population in all directions from Canberra (Starr, et al., 1999). Since the 1980s Canberra's population has continued to expand, with even greater growth in Queanbeyan and the surrounding area.

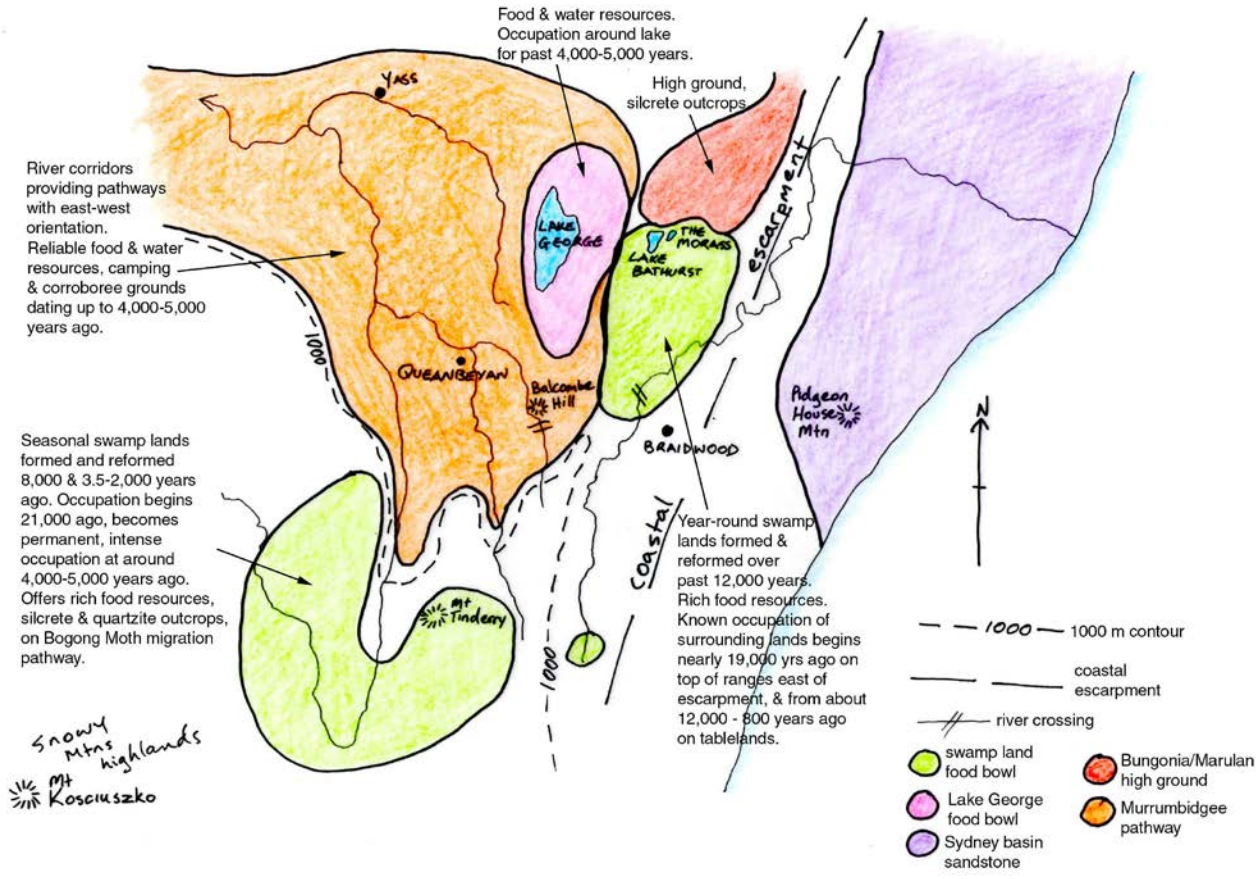


Figure 1 A spatial narrative of Ngunawal territory - a mind-map of social, cultural and environmental interactions that contribute to the origins of pathways and frontiers of the Ngunawal socio-cultural landscape. Reproduced from (Williams, 2011)

Villages, townships and, ultimately, cities have spread across the Molonglo-Queanbeyan and Murrumbidgee flood plains, initially orientated by individual mountains, networks of valleys, ridges and ranges, the most reliable river crossings and by thoroughfares that criss-crossed the open forests and grass

lands between the pastoral properties lining the creek and river corridors. In January 2003, ferocious fires inflicted loss of life, personal hardship and community cost on the rural and urban areas of the ACT. Following the fires, the ACT Government released a document, *Shaping our Territory* (Non-Urban Study Steering Committee, 2003), addressing the recovery and rebuilding processes in terms of the 'bush capital', considering recreational opportunities and aesthetics, and the need to more effectively manage bushfire risk. That discussion paper led to a firmer direction for urban expansion, which is now occurring within the Lower Molonglo Valley, west of Canberra City.

ABORIGINAL CULTURAL HERITAGE VALUES

Documentation of Aboriginal land use in the Molonglo catchment and broader region continues to slowly expand and a significant amount of information is available from historical sources (Galvin, 2008; Gammage, 2011). Figure 1 shows one representation of how Ngunawal social, cultural and environmental interactions past and present create a "lived in our own time" (Don Bell pers. comm. to Karen Williams) socio-ecological landscape for Ngunawal people. It also illustrates how the major cultural, travel and food production places in the landscape are associated with environmental features like the Murrumbidgee, Molonglo, and Shoalhaven river corridors, and the Lake George Basin (Williams, 2011).

3.3 POPULATION

The calculation of population figures for the Molonglo catchment is not a trivial exercise due to the fact that catchment boundaries do not neatly fit statistical boundaries. Further the ACT/NSW border dissects

Table 1 Population and population density for the Molonglo catchment 2011 Census. Note that the area in which this population occurs is around 50% more than the area of the Molonglo catchment due to the statistical boundaries falling outside the catchment, however all of the areas in which this is the case are sparsely populated for example much of the 485 square kilometres of the SA2 unit Molonglo fall outside the catchment but there are currently only 29 people there; the Molonglo part of this unit however houses the new Molonglo development and thus was included as population is likely to grow significantly here. (For more information see Appendix 2. Population in the Molonglo Catchment).

Unit	sq km	pop'n	density persons/sq km
Burra (Palerang - NSW)	99.0	716	7.23
Captains Flat	715.4	741	1.04
Carwoola	84.4	1,432	16.97
Hoskinstown	257.8	341	1.32
Jerangle	760.9	223	0.29
Primrose Valley	244.5	277	1.13
Queanbeyan Total	172.4	37,174	215.63
Total (NSW)	**2334.4**	**40904**	**17.52**
8102801= SA2 Molonglo	485.3	487	1.00
8102701 =SA2 ACT South West	59.9	29	0.48
Total (ACT SA1 units)	**545.2**	**516**	**0.95**
Fyshwick - Pialligo - Hume	221.6	1,505	6.79
North Canberra	37.7	48,032	1274.06

Unit	sq km	pop'n	density persons/sq km
South Canberra	34.6	24,154	698.09
Weston Creek	15.8	22,751	1439.94
Woden	28.6	32,960	1152.45
Total (ACT SA3 units)	**338.3**	**129,402**	**382.51**
Grand Total	**3217.9**	**170822.0**	**53.08**

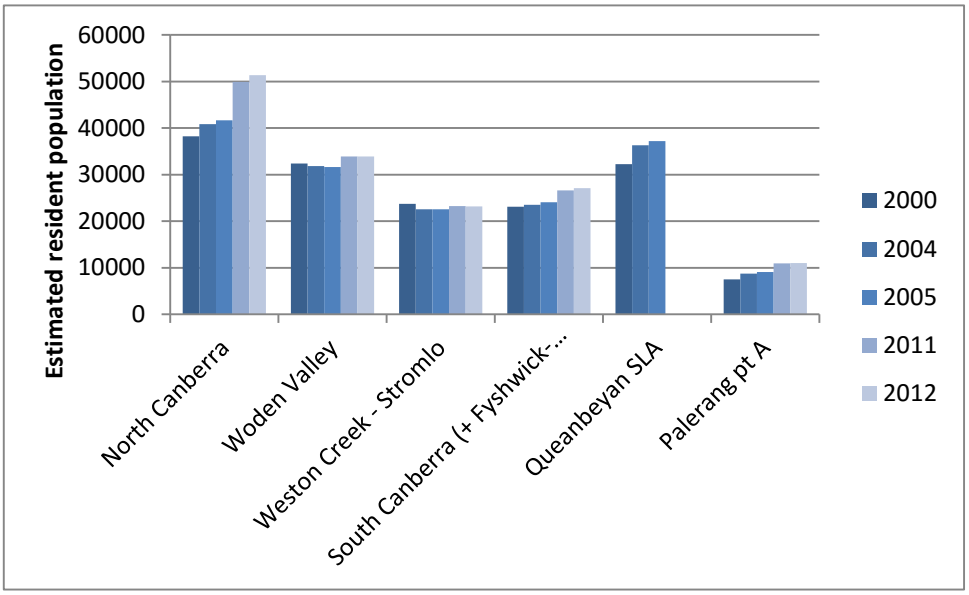


Figure 2 Estimated resident population trends across the Molonglo catchment (see Appendix 2. Population in the Molonglo Catchment)[3].

the catchment, and there was a major change in the statistical boundaries in 2012. In *Appendix 2. Population in the Molonglo Catchment* Martin Butterfield details how the approximate population was calculated. The estimated resident population of the catchment was approximately 170,822 in the 2011 Census according to this method of estimation (see Table 1).

Population across most of the parts of the catchment is growing (Figure 2), particularly in North Canberra, Queanbeyan and Palerang Part A. By contrast, the MCS 2004-24 looked at population data from 1997-2002 and noted little change within ACT parts of the catchment.

Growth in the NSW areas, then as now, is most likely due to increasing overall population of the region as well as an increase in the popularity of the rural residential lifestyle and the larger lifestyle house blocks in the Jerrabomberra area.

[3] Data for 2000-2005 are for Statistical Subdivisions in the ACT and Statistical Local Areas in NSW; data for 2011-2012 are for Statistical Areas Level 3 in the ACT and Statistical Areas Level 2 in NSW.

Aboriginal people comprise 2.6% of the Queanbeyan population (unchanged since 2005) which is similar to the NSW average of 2.5% (an increase from 1.7% in 2005), but lower than the surrounding Capital Region of 3.0% (ABS: National Regional Profile).

3.4 ECONOMY

EMPLOYMENT

The economy of the catchment is diverse and relatively prosperous. Figure 3 presents the Industry of Occupation for the catchment as recorded in the 2011 Census. Employment is dominated by the Public Administration and Safety sector, which is a reflection of employment in the urban centres, Canberra and Queanbeyan. There is also a healthy small business sector at least partly associated with Government and Defence. The profile is similar in the regional NSW part of the catchment with the exception of a significantly higher proportion of people being employed in Construction and Agriculture, Forestry and Fisheries in rural areas, than in the catchment as a whole.

AGRICULTURE

Agriculture or land for farming represents approximately 35% of the catchment's land use pattern. Traditional industry including sheep and cattle grazing are the predominant enterprises in agricultural areas. All have experienced extremely harsh climatic extremes in the past decade and enterprises are also facing serious challenges relating to farm size and an ageing farm population.

Land values are high in the catchment, being influenced by the proximity to urban centres. The additional value attached by the market to land located close to major population centres impacts on the ability of farming businesses to expand through land purchase, and may tend to intensify any agricultural expansion towards the south east of the catchment and beyond.

In a complementary reaction to the increasing land values and tendency to smaller property sizes, agricultural viability becomes increasingly dependent on high value, often more intensive, enterprises. Cottage industries such as vineyards (e.g. Pialligo, Mount Majura), olives, alpacas and truffles appear and disappear.

FORESTRY

Territory and Municipal Services ACT is responsible for the management of about 7,500 ha of commercial pine plantation on public land in the ACT (see www.tams.act.gov.au/parks-conservation/trees_and_forests). Prior to 2003, ACT Forests managed 26,000 ha of land, including about 16,000 ha of pine plantation. The remaining 10,000 ha consisted of areas of native vegetation including nature reserves, special purpose reserves, other conservation areas, watercourses, road reserves, travelling stock reserves and general utility areas.

In January 2003 approximately 10,500 ha of the pine plantation estate, mostly outside the Molonglo catchment, was destroyed during the Canberra bushfires. Following the fires, the burnt plantations were cleared and some areas replanted with pine trees, particularly where the soil stabilisation and water quality

protection was a priority. The previous plantation boundaries were re-defined in some places, which resulted in conversion from plantation to native vegetation, particularly in steep areas where environmental buffers were increased.

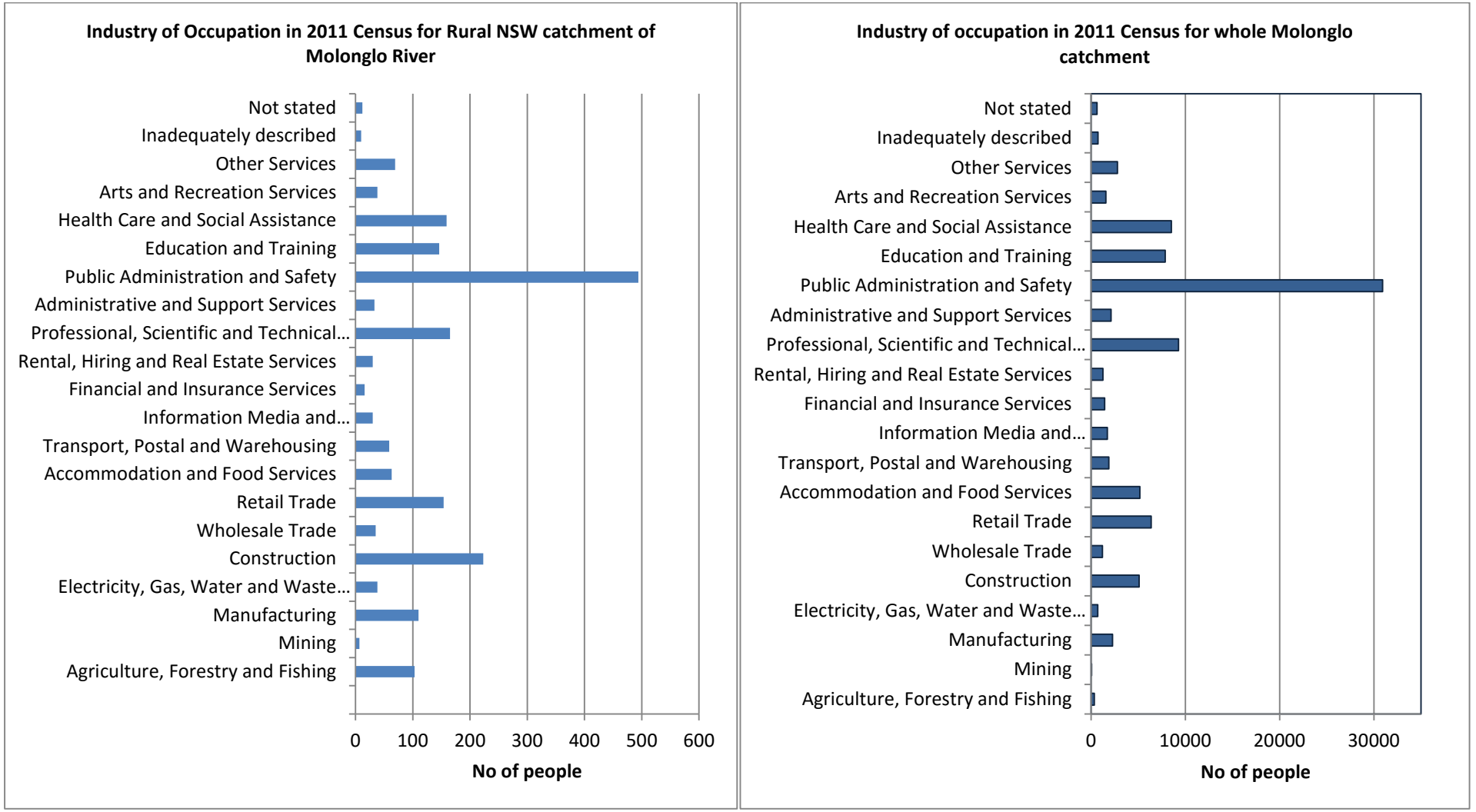


Figure 3 Industry of Occupation in 2011 Census for the whole Molonglo catchment compared with just the rural NSW part.

The forests to the east of Canberra and lying within the Molonglo catchment (approx. 5,500ha) were unburned and the pine plantation continues to be managed for timber production. Management of the former ACT Forests lands is now carried out by the Parks and Conservation Service foresters within Territory and Municipal Services (TAMS). The management of pine plantations aims to generate sufficient income from timber sales to offset land management costs while ensuring the maintenance of long-term social and environmental benefits (see www.tams.act.gov.au/parks-conservation/trees_and_forests/management_of_the_commercial_pine_plantation_estate).

There are extensive areas of both state and private forests to the east and south of the NSW portion of the Molonglo catchment (see map on p vi).

URBAN MIGRATION

People from the city continue to move to rural sub-catchments for permanent 'life stylers', weekenders and retirement. The attraction of the catchment will rise as Canberra and Queanbeyan land values increase and as services improve. At the growth rates experienced between 1997 and 2002 the population could increase by over 25,000 people in the next 20 years, significantly changing current population densities in the catchment.

The Southern section of the NSW portion of the Sydney to Canberra Corridor has been projected to grow from 61,400 in 2008 to 87,500 in 2031 (NSW Department of Planning, 2008). This will have a significant effect on the availability of land for agriculture and other issues such as water security and availability in the Canberra region.

Migration to current rural areas will change the character of communities, bringing in people with who often have little experience of managing rural land, but with high expectations of their rural lifestyle. Growth of smaller lots will make biodiversity and waterway protection more complex and present a new challenge to Landcare and other local environmental groups. Land use planning decisions by local government may pose significant challenges for catchment health. Increased residential and visitor populations in the catchment has the potential to increase the rate of environmental damage. One observation from Palerang Council is that there is a relatively high turnover rate of properties, with landholders remaining in the shire for an average of around seven years. This presents challenges in maintaining a satisfactory awareness of environmental issues. On the other hand, rural residential landholders have undertaken substantial tree planting, weeding and erosion control work so that some areas have seen an improvement in environmental management under rural residential subdivision.

There is uncertainty about whether the trend of urban migration will continue in the light of predictions of an aging population and increasing oil prices. Even if the trend continues, the emphasis may shift from rural residential developments to rural village developments.

COMPETITION FOR WATER

Consumption of water for Canberra and Queanbeyan has decreased from a maximum of 66.56GL in 2006 to a fairly steady 50.6 GL for 2014 (see Figure 4).

This is a major change from the situation reported in the MCS 2004-24 which foresaw continuing growth in consumption and increasing conflict between different uses for water. The result is in large part due to a successful program of demand management (Office of the Commissioner for Sustainability and the Environment, 2011).

In addition Icon Water is undertaking a number of large projects to increase the storage capacity for the ACT and Queanbeyan water supply. An enlargement of the Cotter Dam was completed in 2013 increasing the dam's capacity to 78 GL, nearly 20 times its previous size. The Murrumbidgee to Googong water transfer has also been completed. This will allow for the transfer of up to a maximum of 100 megalitres of water per day from the Murrumbidgee River through a 12 km pipeline to Burra Creek in NSW. From here the water travels 13 km downstream to the Googong reservoir, part of the Molonglo catchment (see https://www.iconwater.com.au/Water-and-Sewerage-System/ACT-Water-Supply-Map.aspx).

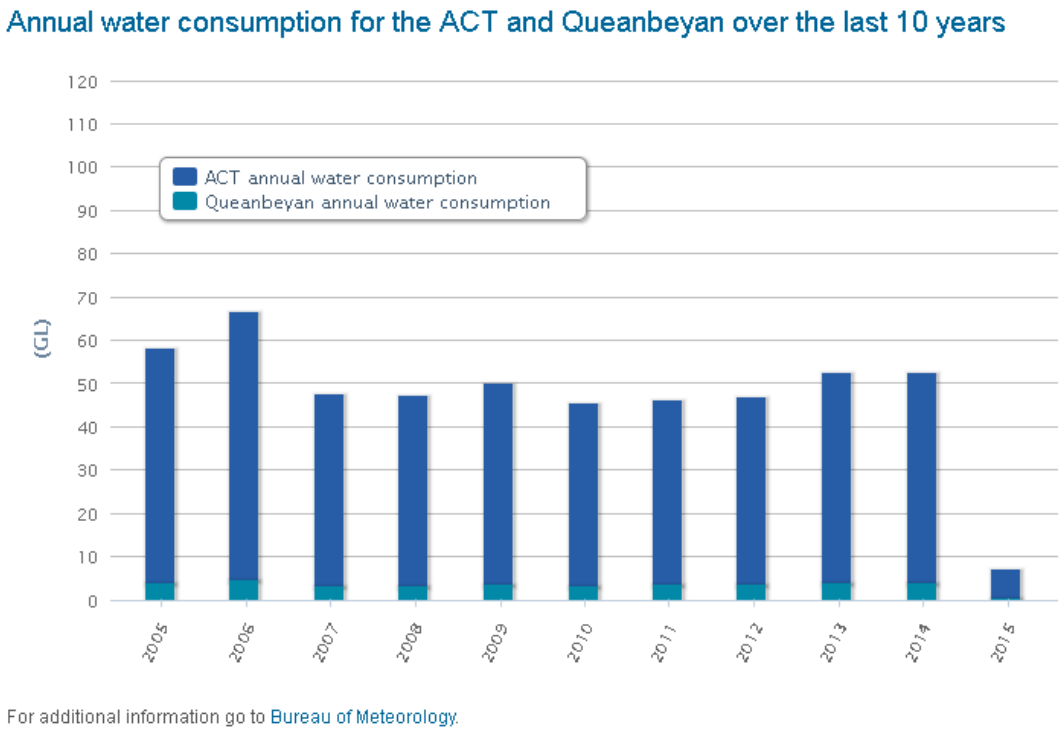


Figure 4 Annual water consumption https://www.iconwater.com.au/Water-and-Sewerage-System/Dams/Water-Storage-Levels.aspx The National Water Accounts are another useful data source.

In 2006 the ACT Government released the *Environmental Flow Guidelines* (Office of the Commissioner for Sustainability and the Environment, 2011) to provide a framework on volumes and timing of environmental flows in the ACT, and abstraction limits. From 2008 to 2010 these environmental flow targets have largely been met for the Murrumbidgee River but not always for Bendora, Googong and Cotter Dams.

The need for environmental flows has set an upper limit on extraction for economic uses, and reduced summer flows will increase pressure on winter use of flows. As mentioned above, the 2015 targets for a 12% reduction in baseline consumption will be easily met, however the targeted reduction of 25% from

baseline consumption in 2023 will be challenging unless further demand management programs are implemented (Office of the Commissioner for Sustainability and the Environment, 2011).

There will be increased debate within the region, as a whole, between different water users over the balance needed for private utilisation, flows for the environment, recreation, and public water supply. Groundwater flows will receive increasing attention, particularly the impact of extraction for stock and domestic supply.

4. DESCRIPTION OF NON-HUMAN ELEMENTS

4.1 GEOLOGY

Much of the ACT is underlain by rocks formed from sediments deposited some 460 million years ago when the region was under the sea. These sediments have become sandstone, limestone, siltstone and shales — rocks that are part of the Palaeozoic Lachlan Fold Belt that stretches from central NSW to Victoria.

Silurian rocks are well represented in the catchment, with many of the major peaks including Mt Majura, Red Hill and Mt Ainslie showing Silurian volcanism towards the top of the formation. Granitic intrusions are also well represented in the upper reaches of the catchment as too are deep alluvial deposits found on the Carwoola Flats, Dairy Flats and much of the Bungendore Plain. Many smaller alluvial deposits occur in minor drainage lines and on lower hill slopes and there are some accumulations of Aeolian sands on Dairy Flat to the east of Lake Burley Griffin (Jenkins, 2000).

There are no mineral-bearing rocks of economic significance in the ACT half of the catchment. However deposits of gold and base metals have been mined extensively over the border along the Molonglo River. Gold was found at 'Foxlow' Station in the 1870s, but it was not until 1882 that serious mining activity commenced at Captains Flat. The gold was heavily associated with silver and lead, and in 1885 silver smelting facilities were erected. By 1893, the main mineral extracted was copper and at this time Captains Flat was booming and there were as many as 2,000 people on the field. There were a number of attempts to recommence mining, but little happened until the 1930s, when Captains Flat developed into a silver, lead and zinc mining centre of national importance. Mining ceased in Captains Flat in 1963.

A number of quarries in the catchment provide materials such as crushed granite, crushed dacite/ basalt (bluestone), gravel and sand for building in the ACT and NSW.

4.2 CLIMATE

The region is characterised by summers with maximum daily temperatures ranging from 18 to 42°C, and very cold winters with daily minimum temperatures below freezing. Long-term records indicate evenly distributed rainfall throughout the year, however the first decade of this century experienced some extremely dry conditions, well below the 595mm average annual rainfall (see Figure 5).

Most recently, since 2010, there has been above average rainfall years, resulting in healthy flows in the Molonglo and Queanbeyan rivers, improved riparian and aquatic habitat, increased ground-cover and re-generation of native plant species. This has recharged groundwater sources, improved water quality and

provided weather induced opportunities for successful riparian restoration. On the other hand, certain weeds have also increased, possibly along with kangaroos and rabbits.

Both locally and nationally there has also been an increasing warming trend with Australia's climate warming by 0.9 ^{o}C since 1910 (Bureau of Meteorology and CSIRO, 2014). 2013 was Australia's warmest year on record, being 1.2^{o}C above the 1961-1990 average of 21.8^{o}C and 0.17^{o}C above the previous warmest year in 2005. Seven of the ten warmest years on record have occurred since 1998 (Bureau of Meteorology and CSIRO, 2014). The long-term warming trend for Australia is illustrated in Figure 6, which shows the departures from the 1961 to 1990 average temperature for Australia. 2012/13 was also the hottest summer on record for Australian sea-surface temperatures.

For the future, Adapt NSW now has specific climate modelling available for the South East and Tablelands, including a Climate Change Snapshot (climatechange.environment.nsw.gov.au).

4.3 LANDSCAPES

The landscapes of the catchment reflect geological events, the long-term effects of weather and climate, and the influences of human settlement. The three broad landscape types are:

1. Uplands (areas at altitudes above 800 metres): The uplands lie mainly on erosion-resistant, ancient, sedimentary rocks and granites. Most of the south western corner of the catchment is in this category.
2. Rolling or undulating country (usually 600–900 metres): These areas are formed across moderately weathered rocks, and account for most of the eastern half of the catchment. The country is crossed by minor streams such as Woolshed and Jerrabomberra Creeks.
3. Plains (550-650 metres): These areas occur along many of the streams in the Upper Molonglo Sub-catchment, the lower Molonglo at its junction with the Murrumbidgee River and surrounding the upper reaches of Jerrabomberra Creek. They surround isolated hills and ridges of erosion-resistant rock, such as Black Mountain and Mount Ainslie, which are evidence of greater elevations and a more-pronounced topography in times past.

4.4 WATERWAYS

The catchment lies within the upper Murrumbidgee River catchment, in the Murray-Darling Basin. The Molonglo River flows through the catchment from the south east, and its tributary, the Queanbeyan River, from the south west. Other tributaries which are important watercourses are Jerrabomberra, Reedy, Woolshed, Ballinafad, Sherlock, Tinderry, Primrose Valley, Chimney, Urialla and Burra creeks. Urban creeks including Yarralumla Creek and Sullivans Creek discharge to the Molonglo below Scrivener Dam and into Lake Burley Griffin respectively.

When the ACT was gazetted, the borders were planned so that the Territory would incorporate sufficient area for an adequate water catchment for the new city that was to arise on the plains. The new Territory was granted rights to the NSW catchment of the Queanbeyan and Molonglo Rivers for the purposes of water supply. These rights have been exercised by the construction of Googong Dam (Commissioner for the Environment ACT, 2000).

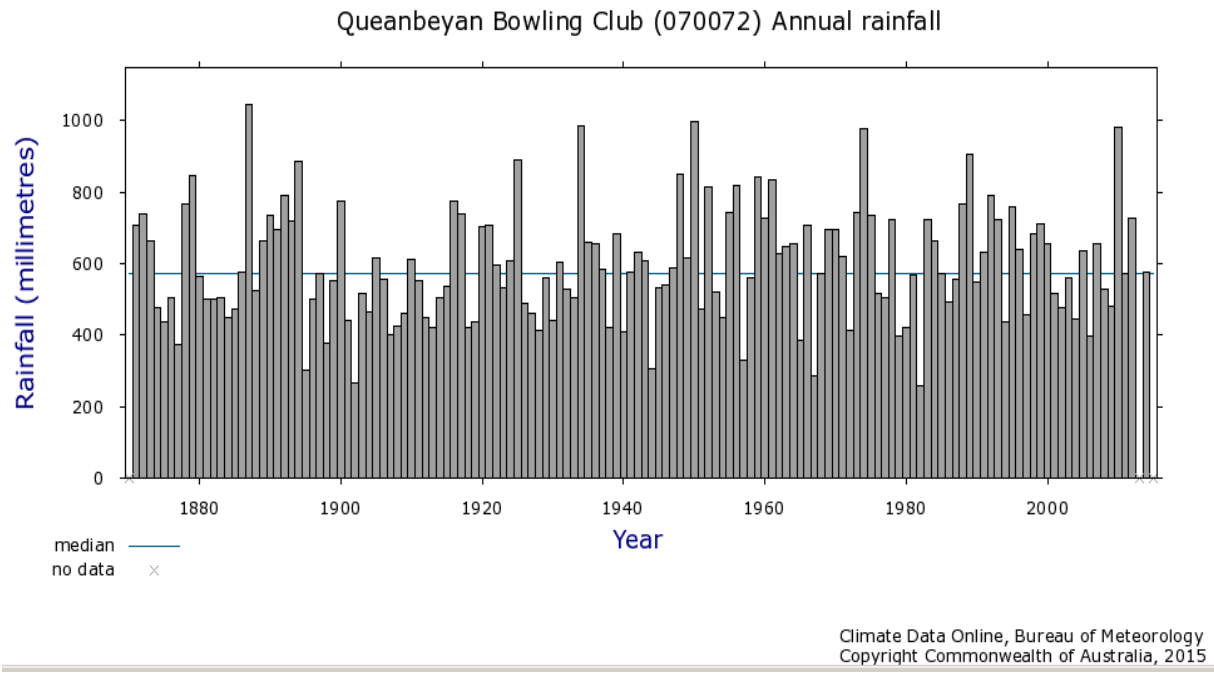


Figure 5 Annual rainfall for Queanbeyan 1871- 2014. Missing Nov 2013 so no 2013 total.

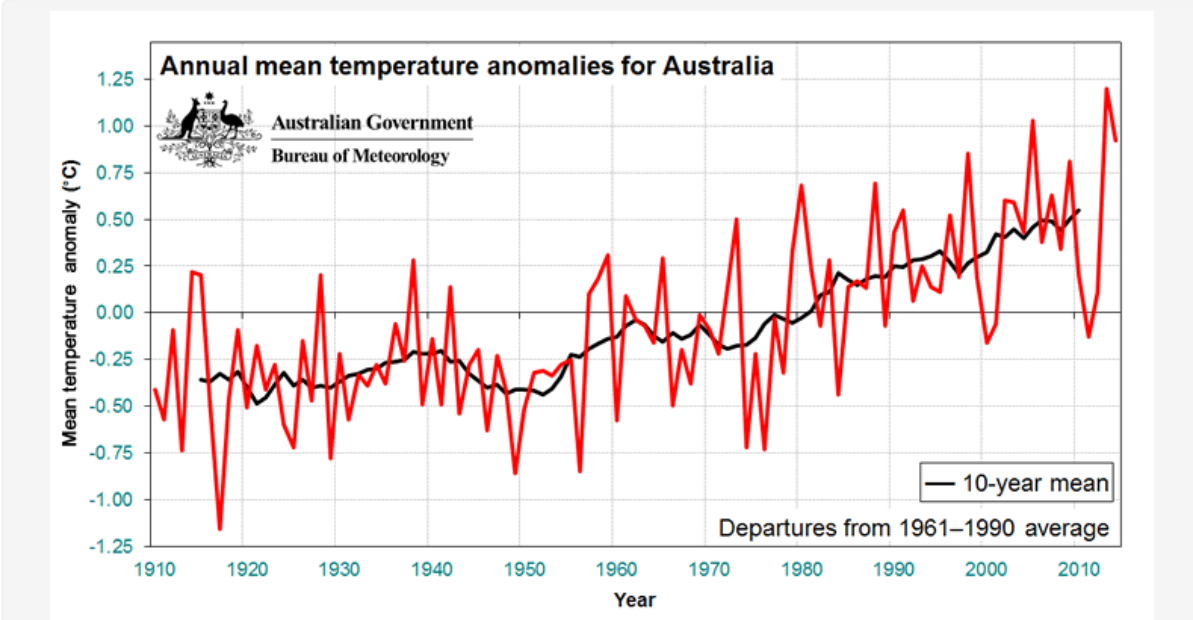


Figure 6 Annual mean temperature anomalies (from 1961-90 average) in Australia from 1910 to 2014 illustrating a warming trend.

4.5 GROUNDWATER

There has been progress in the assessment of groundwater sources since the MCS 2004-24. A 2008 data assessment report stated that groundwater data has not historically been measured systematically and did not provide a comprehensive picture of the impacts of groundwater use (reported by the Office of the Commissioner for Sustainability and the Environment (2011)). Since that time the ACT Government has been aiming to improve groundwater monitoring.

In 2009 the National Water Commission began the *ACT Aquifer Storage and Recovery Feasibility Study* and demonstrated that the yields from ACT groundwater sources are relatively low (typically 0.1 to 24 L/s with the majority of bores yielding between 1.5 and 2.45 L/s) being from fractured rock aquifers. Fourteen dedicated monitoring bores are maintained and additional information is supplied from another 6 monitoring sites by users. In 2010 three additional monitoring bores were proposed for construction in Weston, Wanniassa and Kambah in recognition of the pressure from current levels of abstraction. The amount of monitoring in an area is proportional to the risk posed to the groundwater by abstraction, contamination or land use change (Office of the Commissioner for Sustainability and the Environment, 2011). However it is difficult to find the results of this monitoring published in any comprehensive manner.

The *ACT State of the Environment Report 2011* does report that groundwater extraction by licensed users remains less than the sustainable yield as determined by the licensing framework. This does not take into account unlicensed use, and must be viewed in a context of increased demand for groundwater extraction particularly during drought.

A new study looking at the hydrogeology of the ACT and South East NSW is due to be released by the ACT government and South East Local Land Services respectively in the near future and will provide an important new data source. The study will integrate mapped groundwater, surface water, geology, soils and land use information at a landscape level, and will provide suggestions for management options.

The importance of comprehensive groundwater data cannot be overstated. Risk of overuse of water resources is possible due to an incomplete understanding of the dynamics of the total water resource in the catchment. Changes to groundwater levels in the catchment not only have the potential to impact upon land use, but they can also reflect changes in land use, such as conversion of forest to agriculture, changing the proportion of perennial vegetation in a groundwater catchment or changing the amount of water used for irrigation or urban/peri urban consumption.

4.6 LAKES AND WETLANDS

LAKE BURLEY GRIFFIN

Lake Burley Griffin is an integral part of Canberra's design and is a vital element in the plan for the nation's capital. The lake consists of the waters of the Molonglo River between Scrivener Dam and the Sylvia Curly Bridge on the Monaro Highway.

Named after Walter Burley Griffin, winner of the design competition for the National Capital in 1912, the lake is a key element in Griffin's Plan for the city. The heart of Griffin's plan was a central artificial lake and

a 'Parliamentary Triangle', in which the most important national buildings were to be placed. Griffin's original plan was modified to become a lake controlled by Scrivener Dam. The scheme has created valuable wetland habitats upstream of the lake.

Different sections of Lake Burley Griffin have different uses appropriate to their special physical characteristics, their foreshores and their water quality. As an important freshwater ecosystem, the lake and its margins are a significant wildlife refuge and bird habitat. The Jerrabomberra Wetlands, at the eastern end of Lake Burley Griffin, provide a valuable habitat for many species of waterbirds. Westlake and West Basin are the main areas for sailing, sailboarding and swimming. There are many areas around the lake where public recreation has priority, such as Commonwealth, Kings and Grevillea Parks, Lennox Gardens and Commonwealth Place to name a few. The water area covers 664 ha and the distance around the shoreline is 40.5 kilometres. It is managed and maintained by the National Capital Authority on behalf of the Commonwealth of Australia.

JERRABOMBERRA WETLANDS

The Jerrabomberra Wetlands are an artificially formed area of wetlands at the head of Lake Burley Griffin. The wetlands are one of the most valuable wetland habitats in the ACT, increasing the biological diversity of Lake Burley Griffin and Canberra City. It provides a series of wetland habitats which support a rich and diverse bird fauna, including most of the wetland species occurring in southern Australia. Many terrestrial birds occur there as well as platypus, water rats and other wildlife including invertebrates, amphibians, reptiles and fish.

Sections of the wetlands are used as a stopover for migratory waders, including Latham's Snipe which is the subject of protection agreements between Australia, Japan and China. The agreements encourage the signatory nations to protect the habitats of species listed as well as to conserve the bird species themselves. The wetlands provide the only extensive area of riverine flood plains with existing palaeochannels in the ACT.

GOOGONG DAM

The Googong Dam was constructed in the late 1970s for the Queanbeyan and Canberra water supply. It is located five kilometres upstream of Queanbeyan City and holds approximately 125 GL of water. The Commonwealth Government owns the dam and it is operated and managed by Icon Water. The ACT Government manages the dam foreshores.

Flow diversions caused by Googong Dam have significantly altered the river corridor. Consequently, management of the Queanbeyan River must take account of the effect of flows released from Googong Dam, which include: differences in water temperatures; willow invasions in areas near the Dam wall and loss of upstream spawning grounds. The Murrumbidgee to Googong water transfer pipeline, completed in 2012, will also change flow conditions above the dam in future.

Catchment management in the Queanbeyan River catchment in NSW, apart from the Googong Dam foreshores, is the responsibility of relevant NSW Government agencies. Through the activities of these agencies and the laws under which they operate, NSW has mechanisms in place which can be used to meet

its obligation under the Seat of Government Acceptance Act 1909 to prevent the pollution of the Queanbeyan and Molonglo rivers throughout their whole course above the ACT (Commissioner for the Environment ACT, 2000).

4.7 TERRESTRIAL RESOURCES

LAND USE

The catchment has been significantly cleared for pasture, agriculture and urban development. Sheep and beef cattle grazing dominate the remaining large pastoral areas of the Upper Molonglo sub-catchment and the rural areas of the lower Molonglo in the ACT. The fertile alluvium on the river flats east of Lake Burley Griffin supports an established turf farm. Areas of remnant grasslands and woodlands exist in most sub-catchments and there are good in-stream habitat values in the upper reaches of the Molonglo and Queanbeyan rivers.

Some of the creeks in the Kowen, Jerrabomberra, Lower Queanbeyan and Woolshed sub-catchments maintain some of the 'chain of ponds' characteristics, while the Jerrabomberra Wetlands are listed as important JAMBA and CAMBA sites. Many of the associated wetlands contain rare vegetation communities and both major lakes are used for recreational pursuits, including fishing, yachting and rowing.

Territory and Municipal Services of the ACT reports in 2012 that it manages 11,393 ha of forests and 146,382 ha of reserves (Territory and Municipal Services Directorate, 2012). This includes:

- 34 Canberra nature parks (13 307ha)
- seven town parks,
- 22 district parks and
- 5,350 ha of urban open space

The Lower Queanbeyan, Molonglo River at Fyshwick to Lake Burley Griffin, Sullivans Creek and increasingly, Lower Molonglo sub-catchments (including Weston and Woden) are heavily urbanised with almost an 80-85% built environment.

In addition to all the land utility changes there is evidence that one of the most significant changes since 1800 has been the change to Aboriginal fire management practices in the landscape. Gammage (2011) describes the large difference between the vegetation patterns found by the early surveyors of the district and those parts of the ACT and surrounding region that are now regenerating in the absence of regular fire management. Black Mountain for example "was open lower down, a little thicker higher up. The summit was clear, 'a very high Hill from the Top of which we had an extensive View all around'" according to either FB Hoddle (1832) or CT Smith (1820) quoted in various sources within Gammage (2011).

SOIL

The catchment falls within the area covered by the Canberra and Michelago 1:100,000 soil landscape surveys. Generally speaking, the dominant soil materials on crests and gentle hill slopes in the catchment are lithosols and shallow red podzolics, with bleached sodic yellow podzolics in lower lying areas (Jenkins,

2000).

Steeper slopes are also largely lithosols soils with rocky outcrops and extensive surface stone. Broad crests and gentle side slopes, such as those in much of the mixed grazing areas of the catchment carry a mix of lithosol and red podzolic soils which display fine sandy loam topsoils to a depth of around 5 to 10cm, grading to a clay loam to light clay subsoil (Jenkins, 2000).

Soil depth is commonly in the range of 40 to 60cm before grading to weathered shale bedrock with the exception of terrace and alluvial flats which display light grey coloured silty loam topsoil to a depth of 30 to 50cm sharply overlying a yellowish coloured clay loam to light clay subsoil. Discontinuous layers of gravel are also a feature of these soils, reflecting their formation in a depositional environment. Total soil depth of the yellow podzolics is variable, but generally doesn't exceed 1 to 1.5m (Jenkins, 2000).

Most soils in the catchment are very low in the nutrient elements phosphorous and nitrogen and also vary in pH and salt levels. Many subsoils are relatively sodic and display a relatively high content of magnesium relative to calcium. This can create problems in the effective functioning of septic systems / adsorption trenches in some areas.

There is evidence of significant compaction, soil erosion and de-carbonisation since the arrival of European farming methods. The explorer Captain Mark Currie RN writing in 1823 states "all the country around Lake George….is very rotten, making the riding bad." And in other parts of Australia early writers described soil that was "naturally soft" and "dug like ashes" quoted in (Gammage, 2011). This apparently changed within decades of hooved stock arriving and a number of writers noted the point. Here is the New South Wales Government Botanist in 1891:

"There is no gainsaying the fact that ever since pastoral settlement took place there has been a gradual decrease of many valuable salicious and other plants from the central plains of this continent, partly through the constant trampling of the animals hoofs, which has also made the surface soils so hard that seeds with difficulty germinate."

The result was soils that did not hold water as well, and rapid erosion causing rivers to become turbid, erode deeply in some places and silt up in others. Charles Strutt in 1850 described the Murrumbidgee prior to the changes which were particularly bad in the floods of the 1870s as "clear water" at Gundagai and many other places. It often ran dry, apart from great deep holes along its length. Today the 1850 river bed is meters up today's bank (Gammage, 2011).

4.8 BIODIVERSITY

The Environment Protection and Biodiversity Conservation Act 1999 (C'wealth EPBC Act) online database search tool helps to determine whether matters of national environmental significance or other matters protected by the EPBC Act are likely to occur in an area. A search of the database in 2013 revealed a total of 2 Threatened ecological communities, 39 Threatened species, 13 terrestrial and wetland species covered by EPBC migratory provisions and 13 species covered by EPBC marine provisions.

The Threatened Species Conservation Act 1995 (NSW) (TSC Act), the Fisheries Management Act 1994 (NSW) and the Nature Conservation Act 1980 (ACT) also specify ecological communities and species of

environmental significance within NSW and the ACT which may not have the same status nationally. Other key sources of information for native flora and fauna distributions includes the ACTmapi website, the Canberra Nature Map website, the Atlas of NSW Wildlife, Canberra Birds website and the Atlas of Living Australia.

NATIVE VEGETATION

The Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands along with the *Atlas of NSW Wildlife* remains a key source of fine-scale resolution information on vegetation communities, endangered ecological communities and the distribution of threatened species in this region (but see also other on-line tools listed in section above). The *Planning Framework* identifies important species and ecological communities at the regional scale and accesses databases which cross jurisdictional boundaries. Important regional issues for the conservation of natural ecosystems are also identified (Fallding, 2002). The planning framework provides an excellent record of important species and threatened species information for each of the landscape units that cover the Molonglo catchment (see Appendix 3: Threatened and important species and endangered ecological communities) in the context of using planning law in both NSW and the ACT to help protect these declining communities.

For some time four vegetation communities in the Molonglo catchment have been identified as endangered ecological communities: Natural Temperate Grassland, Alpine Fens and Bogs, Yellow Box / Red Gum Grassy Woodland (ACT only), White Box – Yellow Box - Blakely's Red Gum Woodland (NSW only). NSW declared the Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions endangered in 2011. *A Vision Splendid of the Grassy Plains Extended: ACT Lowland Native Grassland Conservation Strategy* was released in 2005 as an Action Plan to protect this ecosystem in the ACT (ACT Government, 2005). *Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy* 2004 is the parallel Action Plan for endangered woodlands in the ACT.

Remaining grassland areas in the catchment occur in moderate to good condition and a further 500 ha of low botanical significance is also found, providing buffers or protecting grassland habitat for threatened species. Most of the sites occur as small urban remnants and roadsides, but several large (over 100 ha) sites still remain, of which the majority is Commonwealth land within the ACT, mainly managed by Department of Defence.

NATIVE FAUNA

The *Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* (Fallding, 2002) consolidates information on threatened ecological communities and species (with the exception of freshwater aquatic species – fish and crustaceans) for each of the landscape units the framework recognises. Appendix 3: Threatened and important species and endangered ecological communities presents the information for those landscape units in the Molonglo catchment (see also on-line tools listed in 4.8 Biodiversity).

NATURAL HABITATS AND ECOLOGICAL PROCESSES

BIRDS

The majority of native birds in the catchment are insectivorous or nectarivorous, typically occurring in woodlands with an intact grassy understorey. Pasture habitat with scattered remnant trees can also provide a foraging resource for woodland birds on an occasional or transitory basis from their core habitat areas (larger woodland remnants in the catchment). Of particular note are the endangered and vulnerable species listed under the EPBC Act and the TSC Act (see Appendix 3: Threatened and important species and endangered ecological communities). Grassy woodland birds forage on occasion into open pasture areas or open woodlands but are not wholly reliant on these habitats for their life cycle requirements.

The Canberra Ornithologists Group produces an Annual Bird Report which provides indications of trends in bird abundance in the Canberra region, and ten years of data were analysed in 2010. For those species reported in more than 1% of surveys, 15 species showed some indication of decline, 25 species showed no overall change and 15 species showed an increasing trend. Species like the Hooded Robin and Diamond Firetail have declined to a point where their numbers were not sufficient to be considered in the analysis. One threatened species which is on the increase is the Superb Parrot (Office of the Commissioner for Sustainability and the Environment, 2011).

MAMMALS

The native mammals in the catchment similarly occur in grassy woodlands with an intact grassy understorey for shelter. The pasture habitat in the catchment in which there are areas with few scattered remnant trees, would also be expected to represent a limited foraging and breeding resource for mammals. As with native birds, mammals may forage on occasion into open pasture areas or open woodlands but would not be exclusively reliant on these habitats for their life cycle requirements. Species including the Eastern Grey Kangaroo, Swamp Wallaby, Brush tailed Possum, the Echidna and Common Wombat are perhaps more resilient and do occur in most areas of the catchment. Insectivorous bats may forage throughout the catchment on an occasional or transitory basis, with a number of roosts expected to occur in heavily wooded areas (Fallding, 2002).

There is historical evidence for significant numbers of small mammals in Canberra's urban nature reserves two decades ago; however recent surveys have not detected any. The Common Dunnart is still present at Mulligans Flat and Goorooyarroo nature reserves (Office of the Commissioner for Sustainability and the Environment, 2011).

AMPHIBIANS

Most frogs in rural areas of the catchment typically occur in woodlands or open woodlands with adequate groundcover for shelter (rocks, logs, dense grass) in the vicinity of watercourses or ponds for breeding. Urban areas surrounding stormwater drains and subsidiary watercourses are also important habitats for frogs. Ephemeral creek lines which represent the upper most watersheds of the catchment as well as large dams and lakes in the catchment would be expected to provide a seasonal breeding resource for native frogs.

ACT and Region Frogwatch recorded a favourable season for frogs in 2009 with ten species detected overall and the average number of species at a site also higher than previous years, possibly due to rain prior to the survey. In the ACT there are now estimated to be fewer than 100 Northern Corroboree Frogs remaining in the wild, although there is a successful captive breeding program in operation (Office of the Commissioner for Sustainability and the Environment, 2011).

The Green and Golden Bell Frog was once one of the most commonly encountered frogs in south eastern Australia however it has severely declined in range and abundance since the 1960s. In NSW it has disappeared from highland areas above 250m with the exception of a population along the Molonglo River below Captains Flat. No similar decline has been observed in Victoria where it is largely a coastal species. The frog has been introduced and is now common in the North Island of New Zealand, and New Caledonia and Vanuatu. It is listed as 'endangered' in New South Wales, and 'vulnerable' under the Commonwealth EPBC 1999 Act (Pyke & White, 2001).

The main reasons for the frog's decline are thought to be habitat loss and predation of tadpoles by the Plague Minnow *Gambusia* although these cannot be implicated in all of the cases of declining populations. The Green and Golden Bell Frog represents an intriguing case of a weedy and once widespread species that has become endangered, and yet paradoxically some of its strongest remaining populations in NSW are in highly modified habitat like the Homebush Bay site of the 2000 Sydney Olympics, a former brickworks, and the Molonglo River below the gold mine at Captains Flat, which has been affected by tailings pollution (Pyke & White, 2001).

REPTILES

Snake and lizard species listed as vulnerable and threatened under the EPBC Act and TSC Act have been previously recorded in the catchment in eucalypt woodlands, native grasslands and typically on stony hills where there is adequate shelter. The ACT is home to three reptile species listed as threatened under the Commonwealth EPBC Act (2011) – the Grassland Earless Dragon (endangered); the Striped Legless Lizard and the Pink-tailed Worm Lizard – all of whom are threatened by habitat loss and degradation (Office of the Commissioner for Sustainability and the Environment, 2011).

FISH

Recent studies of the Murrumbidgee, Molonglo and Queanbeyan Rivers have found that up to 96% numerically of the fish catch in these rivers are alien fish (Lintermans, 2002). Habitat destruction however remains the primary cause of native fish decline in the region. This includes the barriers to movement of fish created by dams, the changed flow and thermal regimes, reduction in access to floodplains, loss of instream habitat and decline in water quality. There are four endangered species listed for the region which include the Macquarie Perch, the Trout Cod, the Silver Perch and the Two-spined Blackfish (Lintermans, 2002). The Molonglo River contains an impoverished fish fauna, most likely due to the collapse of mine waste dumps into the river at Captains Flat between 1939 and 1945. Before this the river was known to have good populations of cod and perch (Lintermans, 2002). More recently a translocation of Macquarie Perch near Molonglo Gorge was undertaken in 2008/2009. Follow up monitoring has recorded a few adults but no recruitment (D Starrs *pers. comm.*). The Queanbeyan River, once known as the Fish River, also supported good native fish populations prior to the building of two weirs at Queanbeyan, and then the

Googong Dam 5km upstream in 1977. A 1980 translocation of Macquarie Perch to sites above the dam was thought to have failed until angler reports alerted researchers to their presence again in the 1990s. Following the 'Millennium' drought in 2001, the fish has not been reported (Lintermans, 2013).

5. THREATS TO THE MOLONGLO CATCHMENT

5.1 WATERWAYS

THREATS TO SURFACE WATER FLOWS

The data available for streamflow for much of the Molonglo catchment is surprisingly recent and patchy. For example Molonglo River has been monitored at Koboda since 2006, Burra Creek since 1999 and the longest time series data set is for Queanbeyan River since 1990 (Beavis, 2011). As most of these data sets largely cover a period of drought it is difficult to draw conclusions about any longer term reduction in flow. Longer term data is available for the Murrumbidgee River in the ACT.

There is however substantial evidence that we are approaching or have passed the sustainable harvest rate for surface water stored in small farm dams. For Molonglo River it was calculated in 2010 that surface water diversion to small farm dams in the Molonglo River catchment is 70% of sustainable yield not including any licences to extract water from creeks or rainwater captured in tanks etc. (Keyzer, 2010). A second study (Beavis, 2011) mapped dam storage as a per cent of maximum harvestable right (10% of annual runoff) for West Palerang local government area and showed that for the rural residential areas around the Molonglo River (Carwoola) and Burra Creek (Burra) the values were mostly 100% of harvestable right and above 250% in some places. The problem is exacerbated by the large number of shallow small dams that lose significant amounts of water to evaporation.

Groundwater supply is likely to interact with surface water and in some systems may determine the base-flow of some rivers and streams in ways we still do not understand. Groundwater monitoring is improving in the ACT but for the NSW rural sections of the Molonglo catchment is almost non-existent; a study compiling data for the hydrogeology of this region is currently being undertaken by the South East Local Land Services. Work on the similar fractured rock aquifers in the ACT suggests that these are low yielding aquifers, and users in the Molonglo catchment appear to be well below sustainable yield for now (Keyzer, 2010), although demand is increasing (Office of the Commissioner for Sustainability and the Environment, 2011).

The biggest factor likely to cause an impact on surface water flows is climate change. Average minimum temperature is predicted to increase in Western Palerang by 0.8 degrees by 2030 which will result in predicted increases in evaporation of 3% or more (Wild River, 2012)(see also NARCLiM data on the Adapt NSW website). Just how this will affect rainfall is less certain although the best estimate models predict a drying trend across west Palerang with the river 'flats' (and best farmland) experiencing the greatest drying. Climate change will also lead to greater extremes in weather – more frequent floods and droughts (Wild River, 2012).

THREATS TO SURFACE WATER QUALITY

Surface water resources are stressed throughout the ACT, with elevated levels of phosphorous and nitrogen in most streams (Environment and Sustainable Development Directorate, 2013a). Extensive clearing of native riparian vegetation has resulted in streambank erosion and sedimentation problems in waterways producing siltation and nutrient enrichment. Blue-green algal blooms are increasing in frequency in the catchment and in the region as a whole. These are attributed to several factors, including agricultural and urban runoff, sewage discharges and some forest operations (Starr, et al., 1999). Unrestricted stock access to watercourses is also of concern in some parts of the catchment.

Densely urbanised sub-catchments generate high levels of nutrients and toxins from stormwater systems. Studies within the ACT have indicated that sources of nutrients include disturbed soils in areas undergoing urban development, and organic material derived from established urban areas (Middelmann, 1998). In addition, there has been increasing attention to the salt load of wastewater discharges from the Lower Molonglo Water Quality Control Centre (LMWQCC). Treated effluent from the LMWQCC is discharged to the Molonglo River just above its confluence with the Murrumbidgee River. There are few small sewerage treatment plants outside metropolitan Canberra and as a result, the LMWQCC treats nearly 100% of Canberra's sewage (Office of the Commissioner for Sustainability and the Environment, 2011).

Queanbeyan City Council Sewerage Scheme serves all the developed areas of the city area and consists of a gravity reticulation system and the sewage treatment plant at Oaks Estate (in the ACT). The treatment plant has been progressively upgraded since the 1930s. The effluent is discharged to the maturation ponds before release to the Molonglo River under Environment ACT licence conditions (Queanbeyan City Council, 2003). Queanbeyan Council has committed to a six year phased project to upgrade the facility with planning and consultation beginning in 2014 (Queanbeyan City Council Media Release 29 May 2014).

There is some evidence that waste water disposal may be of concern in rural residential areas of the Molonglo catchment also. The *Water Quality Snapshot for Western Palerang* assessed water pollution risk from various sources (sewage treatment sites, landfills, erosion gullies, roads etc.) and found that the cumulative pollution risk in the rural residential areas was almost as high as the densely settled towns, but spread over a much wider area (Holloway, et al., 2012).

Water quality in the Molonglo River is also partly degraded by leachate discharging from the disused Captain’s Flat mine site as a result of the collapse of waste dumps. On-going rehabilitation work at the site is designed to control further leachate being discharged to the river.

THREATS TO BIODIVERSITY

A biological assessment of river health in the Upper Murrumbidgee catchment has been undertaken since 1997 using the Australian River Assessment System (AUSRIVAS) method. This method compares the number of observed macroinvertebrate taxa with the number expected by comparison with a nearby reference stream (identified to Family level except for worms and mites which are identified to Class). Results show that stream ecology varies in different parts of the Upper Murrumbidgee catchment, but

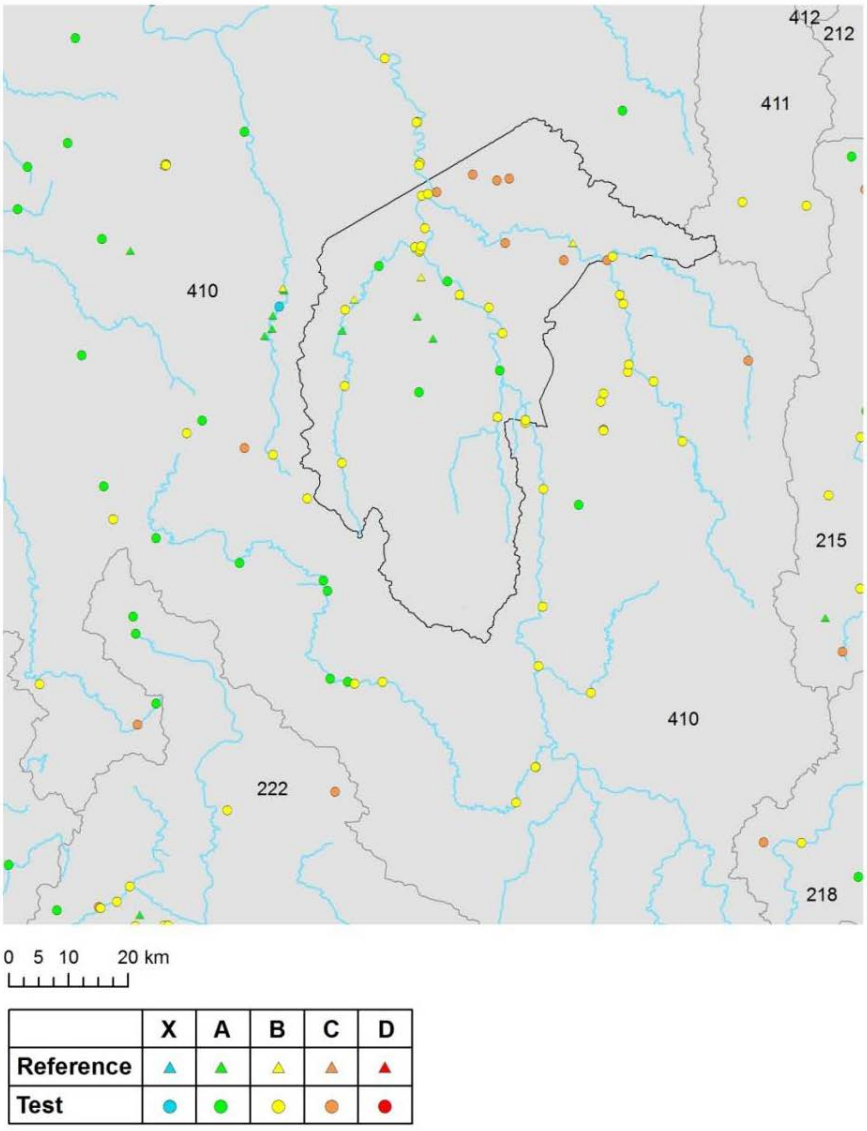


Figure 7 Macroinvertebrate diversity site assessments showing AUSRIVAS Observed: Expected ratios for river sites sampled in 2003-2010. Green indicates macroinvertebrate biodiversity similar to a reference condition sit, yellow significantly impaired, and orange indicates severely impaired (Office of the Commissioner for Sustainability and the Environment, 2011).

Band	Condition	Taxa interpretations
X	More Biologically Diverse than Reference	More families found than expected - Potential biodiversity "hotspot" - Loss of pollution tolerant taxa
A	Similar to Reference	Expected number of families
B	Significantly Impaired	Fewer families than expected - Potential impact on aquatic condition or riparian zone (habitat) resulting in a loss of families
C	Severely Impaired	Many fewer families than expected - Loss of families from substantial degradation of the aquatic condition and riparian habitat
D	Extremely Impaired	Few of the expected families - pollution tolerant families remain

many streams are degraded in terms of the AUSRIVAS criteria (see Figure 7). The Molonglo catchment, being the most urbanised of these streams has macroinvertebrate assemblage that is significantly to severely impaired, even in the NSW (upstream) portion of the catchment.

The Molonglo River is perhaps the most striking with severely impaired assemblages occurring high in the catchment. This is likely to be due to the long-term impact of the Captains Flat mine mentioned in the section above, as well as extensive native vegetation clearing and elevated nitrogen and phosphorus levels as described above. The Queanbeyan River has assemblages that are significantly impaired compared with other streams in the region, but on the whole better than the Molonglo River. Again the impairment is likely to be due to clearing of native vegetation and run-off from rural lands, particularly along Burra Creek (see also Water Asset p63).

In the ACT the distribution and condition of riparian vegetation on the Molonglo River has been assessed in a 2011 report by (Peden, et al., 2011). This report found that the Molonglo River had been substantially modified since European settlement and there is little native vegetation in the most degraded areas.

Activities including removal of streamside vegetation; unrestricted stock access to rivers; bed and bank erosion; obstruction to fish passage; and woody weed invasion (particularly willows and blackberry) have seen degradation of stream condition becoming relatively widespread throughout the catchment. A counter to this however is the great progress made in recent years on willow control and removal – to the extent that the Queanbeyan River below Googong is almost willow free and much work is also being done on the Molonglo River via the Molonglo River Rescue Action Plan.

Over the past 10 years Canberra's lakes have been closed increasingly often due to faecal contamination or potentially toxic blue-green algae in the water. In most cases the high to extreme alerts occurred in the summer months, when more people are using the waterways (Office of the Commissioner for Sustainability and the Environment, 2011). The Molonglo River also receives treated effluent from ACT wastewater from the Lower Molonglo Water Quality Control Centre, and from the Queanbeyan Sewage Treatment Plant. Effluent has increased from the latter from an average of 8.71 ML/day in 2007 to 9.22 ML/day in 2010.

5.2 TERRESTRIAL RESOURCES

IMPACTS OF HUMAN ACTIVITIES ON THE LANDSCAPE

The Molonglo River catchment area has suffered extensive land degradation, initiated during the early periods of European settlement in the 1820s, with many of the degradation processes continuing to be active under the present regime of land use. Extensive clearing, heavy grazing, inappropriate burning, droughts and rabbits all contributed to the creation of conditions which have led to extensive loss of soil from hill slopes and the development of gullies in drainage lines (Wasson, et al., 1989). As early as 1915, just after inauguration as the site of the national capital, the slopes of Mt Stromlo were planted with *Pinus radiata* to slow erosion being caused by rabbits (Forster & O'Meara, 1978).

The poor condition of the Molonglo catchment was a concern to planners in Canberra in the 1960s, prior to and following the construction and filling of Lake Burley Griffin completed in 1964. Land degradation in the catchment was perceived as a significant threat to water quality and longevity of the storage (Department of Land and Water Conservation, 2000).

In order to remediate the active erosion occurring in the catchment of the new lake, the Lake Burley Griffin Catchment Protection Scheme was initiated. The Commonwealth provided significant annual funding and the NSW government provided planning and supervision of works, with landholders making in-kind contributions such as fencing, tree planting and pasture improvement (Department of Land and Water Conservation 2000). A program of soil conservation measures was initiated in the ACT (targeting the field firing range, Kowen forest and Jerrabomberra Creek) and this was extended into the NSW part of the catchment, notably around Burra Creek. Similarly, an erosion management program was implemented during the construction of Googong Dam in the 1970s (Forster & O'Meara, 1978; Department of Land and Water Conservation, 2000).

In the late 1980s erosion processes in the Molonglo catchment were measured from accumulated farm dam sediments. The research showed that gully erosion at the time was the dominant source of sediment being exported from small catchments to the Molonglo system, while well-grassed hill slopes were a relatively minor contributor of sediment. Gullied catchments were shown to yield 50 times the volume of sediment from catchments in a natural condition; the latter measured at 3t/km^2/yr (Wallbrink & Fogarty, 1989).

Pastured hill slopes yielded four times the natural rate and heavily grazed pasture yielded twenty times the natural rate. Dairy Station Creek, which drains to the Molonglo River, was one of the most degraded sub-catchments of the Molonglo River, with a ratio of gully length to catchment area of 16.9 m/ha. This was five times greater than other sub-catchments on the Molonglo River upstream of Lake Burley Griffin, with an estimated annual average sediment yield of 476 tonnes (Wallbrink & Fogarty, 1989).

Erosion risk has also been mapped more recently for the ACT (Office of the Commissioner for Sustainability and the Environment, 2011) with only low risk for the urban area, however it would likely be high further south of the ACT in NSW. This information will be much improved following the release of the Act Hydrogeological Framework Project and the parallel South East Local Land Services project.

In April 2012 the Commissioner for Sustainability and the Environment released the report of his inquiry into "the State of the Watercourses and Catchments for Lake Burley Griffin." This found that the key water quality issues of Lake Burley Griffin (from 1978 to 2010, summarised in Lake Burley Griffin Taskforce (2012)) were:

- *"Low dissolved oxygen levels caused by the decomposition of organic matter in urban stormwater flowing into the lake;*
- *Blue-green algae blooms caused by the release of phosphorus from sediments, when dissolved oxygen is low with a poor mixing of the water column, especially during dry periods; and*
- *the loss of submerged and fringing water plants caused by increasingly turbid Lake water which contributes to low dissolved oxygen levels.*

The Commissioner also found that the main sources of faecal pollution in the Lake were urban run-off, wildlife, re-growth of bacteria already in the Lake and possible leakages from sewer pipes…

…Similarly rural catchments were not of themselves a significant source of nutrients or turbidity in the Lake. However the condition of these catchments needs to continue to be improved as during periods of high rainfall they continue to contribute to water quality issues in the Lake."

This finding points to the success of the Lake Burley Griffin Catchment Protection Scheme and the importance of this sort of work alongside the application of water sensitive design and urban catchment protection.

Today another significant threat is the intensification of pressure through greater numbers and demand for a rural lifestyle adjacent to the major urban centres of Canberra and Queanbeyan. This issue is difficult to manage in locations where demand is greatest, and emphasises the need for good planning. Increasing density following sub-division in traditional farming areas can also detract from landscape values and catchment health. Any further deterioration of the quality of rivers and streams adversely affects a range of water-based recreational activities. The change from Aboriginal landscape fire management to our current technologies for fencing, feed and fuel management and harvest is also likely to have been very significant for landscape health (Gammage, 2011).

SALINITY

Some saline scalding has developed on foot slope areas in the catchment. The Dairy Station Creek catchment was targeted for extensive soil conservation works under the Lake Burley Griffin Catchment Protection Scheme mentioned previously. Works to combat the effects of salinity constructed during 1989 to 1990, included farm dams, diversion banks, gully filling, saline scald reclamation and revegetation by direct seeding. Landholders have also carried out extensive tree plantings, and fenced out areas of remnant woodland. Piezometers were installed on some salinized sites to monitor movements in the shallow groundwater system.

In 2015 there is still limited information available on the extent of soil salinity, the storage of soil carbon and the overall condition of soils in the ACT (Office of the Commissioner for Sustainability and the Environment, 2011). Again this will be much improved with the release of the ACT and South East Local Land Services' respective projects on hydrogeological mapping.

PEST PLANTS AND ANIMALS

Pest plants have reduced agricultural land productivity in parts of the catchment and impacted upon biodiversity values. European settlement has introduced many pests, including weeds such as Serrated Tussock, Paterson's curse and St John's Wort. Other weeds including Blackberry, Willow, African Lovegrass and Chilean Needlegrass are particularly widespread. Animal pests (especially foxes, rabbits, wild dogs, pigs and feral cats) have thrived on both public and private land. Foxes (and some native fauna), that are predators of rabbits, lambs, calves and other small farm animals reach high densities in rural areas of the catchment. Carp, redfin and plague minnow are widespread in many of the waterways in the catchment. Rural residential developments, with their ubiquitous farm dams and mix of grassy and woodland habitat encourage Eastern Grey Kangaroos to become overabundant.

THREATS TO SOIL

Degradation at both the local and regional level is undermining the values of our soil asset. Soil degradation issues broadly include those affecting soil chemistry (soil chemical fertility), soil structure and soil loss. More specifically, the following key issues are considered to be a priority in the catchment:

- Soil erosion by water;
- soil structure decline including soil sodicity and waterlogging;
- soil acidity; and
- soil fertility decline.

There is an increasing need for the catchment community to develop a clear understanding of the trends and threats associated with soil degradation and establish actions and targets as appropriate. Improved data is needed on the actual condition of soil and the regional significance of each degradation issue (to be addressed by the ACT Hydrogeological Framework Project and South East Local Land Services equivalent). Understanding the influences on good soil management and encouraging best management practices is required for the catchment, to be able to plan and invest in this area more strategically. It is estimated that there is 416 km of gully erosion in the catchment ranging from minor (<1.5m deep) to very severe (>6m deep) (Molonglo Catchment Group, 2005).

5.3 BIODIVERSITY

THREATS TO NATIVE VEGETATION

There are two major groups of threats to remnant vegetation in the catchment, those affecting the extent or quantity, and those that have an impact on quality. The greatest loss to the catchment's native vegetation is attributed to land clearing. Over half of the catchment has been cleared, mostly as a result of human activity, including settlement, agriculture and forestry.

The removal of understorey and mid-storey species through feral animals, stock grazing, fire prevention practices, pesticide drift and draining of wetlands are common threatening process to native vegetation. These processes often lead to the decline of trees and taller shrubs due to the absence of regrowth, an increase in 'dieback', mistletoe and the absence of habitat for fauna species that prey on insects (which

have a detrimental impact on the remaining vegetation). In some areas however, clearing has resulted in the regeneration of a monoculture understorey of *Kunzea* which does little for local biodiversity.

Inappropriate management can also lead to losses in the *extent* of native vegetation. In the rural areas of the catchment, much of the remnant vegetation has been confined to roadsides which are under pressure from upgrades to the road system as rural residential development increases (especially around the vicinity of the major urban centres of Canberra and Queanbeyan).

Loss and fragmentation of natural temperate grassland has been continuous from the time of earliest settlement of the region, and has increased in the last century, particularly due to the establishment of the city of Canberra, and associated with the development of areas for domestic, civic and industrial use and for infrastructure such as roads, utilities, lakes and other recreation areas. The focus of much of this development has been in the valleys and low-lying areas where natural temperate grassland habitat occurred (Commissioner for the Environment ACT, 2000). Urban development has been a major factor leading to an estimated 95% loss of natural temperate grassland in the ACT, and to severe fragmentation of the remaining 5% (Office of the Commissioner for the Environment 1995).

In 2004, the ACT Government released two Conservation Strategies, one for ACT Lowland Woodland and the other for ACT Lowland Native Grassland. These strategies are intended to fulfil a number of roles, including:

- action plans for threatened species and ecological communities listed under the *Nature Conservation Act 1980 (ACT)*;
- a multi-species ecological community strategy for native grassland and woodland conservation;
- a source document on native grassland and woodland for ACT and Commonwealth Government agencies with responsibilities for nature conservation and land management; and
- a source document for community and other stakeholders with an interest in native grassland and woodland conservation (ACT Government, 2004; ACT Government, 2005).

In 2013 the *ACT Nature Conservation Strategy* was released (ACT Government, 2013) which looks at ways to restore key landscapes and enhance connectivity in the ACT and across the border into neighbouring NSW. In 2007 *Ribbons of Life: ACT Aquatic Species and Riparian Zone Conservation Strategy* was released to guide the management and reparation of degraded riparian zones and their associated flora and fauna (ACT Government, 2007).

In parallel with this Molonglo Catchment Group has also become a partner in the Kosciuszko to Coast (K2C) target area of the Great Eastern Ranges project. K2C is offering landholders in the region help to build a connected landscape with a range of management options that may include advice as well as funding. The K2C project complements existing catchment management goals. K2C combines a broad team of existing community groups and government agencies with experience in working with landholders to solve environmental and land management issues. K2C is the primary contact point for those people interested in being involved.

THREATS TO NATIVE FAUNA

Habitat destruction is the principal threat to fauna in the catchment. It results from a wide range of activities, including land clearing and cultivation, grazing of stock on roadsides and wetlands, establishment and intensification of rural sub-divisions and impacts of public utilities. Other threats include degradation of waterways, weeds and predation by feral animals. The main threats to native fish populations come from habitat degradation and competition from introduced species including redfin and carp. Changed water flow regimes and water quality also affect populations and emphasise the need to sustain environmental flows (Office of the Commissioner for Sustainability and the Environment, 2011).

6. RESILIENCE MODEL OF CHANGE IN THE MOLONGLO CATCHMENT

After describing the Molonglo catchment, the next step is to focus on the dynamics of the system and what we know about how it responds to external shocks. We have chosen to begin that analysis from 1800 to the current day because it is a 'familiar' history in a system of written records. This history does involve a dialogue with concepts of land management that cross both cultural (Aboriginal and different immigrant cultures) and cross-disciplinary boundaries.

At the outset of this dialogue it is important to state the respect that we give to the Aboriginal people of this region, past and present. In particular we recognise the deep, practical, nuanced and spiritual understanding that Aboriginal peoples had for the Australian socio-ecological landscape, and the evidence of country being managed with skill and detailed knowledge that we are only now coming to appreciate. We recognise that in many ways immigrants to this country appropriated that knowledge both consciously and unconsciously, such that our current land uses, roads and cities often reflect resource rich areas cultivated in the past, important pathways through the landscape and key meeting places.

In moving to a resilience approach to the Molonglo Catchment Strategy it is also our hope that we can come up with new methods of planning and practice that incorporate this rich and deep understanding of the Australian socio-ecological landscape, in which we do not appropriate this understanding and culture, but are transformed by it. The way forward is to create new knowledge through the dialogue between these "living histories" and our own multiple Western European traditions of knowledge (also incorporating the "lived histories" of different immigrant groups to the region) and to place this as central to our knowledge and practice of catchment management (Williams, 2011).

This process raises important questions about the nature of "knowing" things and being able to communicate ideas, and how this can happen across cultural and disciplinary boundaries. We adopt a practice of being empathetic, self-critical and reflective managers and look to the development of methods to approach these questions within recent critical thought (Williams, 2011).

6.1 RESILIENCE OF MOLONGLO CATCHMENT SINCE 1800

Key events in the familiar history (1800s to current day) of the Molonglo catchment as identified by members of the Molonglo Catchment Group committee are listed in Table 2. The committee identified six key thresholds which they believe represent moments in the familiar history where the Molonglo catchment has moved from one state into a different one. These are indicated in Table 2 by dark lines and

bold print however a number of them are gradual changes which are difficult to pinpoint precisely in time. The thresholds were:

1. The disruption of Aboriginal landscape management, particularly fire management, beginning with the arrival of small pox and Europeans with their stock.
2. 1850s Gold rush in Australia which helped to offset precarious income from farming and brought higher European and Asian immigration
3. Crown Land Alienation Act 1861 and increasing numbers of fences, drainage channels, telegraph poles, trains and rabbits, along with the large floods of the 1870s.
4. Development of Canberra in at least two stages – 1913-1923 and 1960s, accompanied by the shift from the horse and train, to the car and truck for transport, and post-war migration and soldier settler farms.
5. Whitlam and Hawke Federal Government's investment in Heritage and Landcare respectively in response to growing environmental and heritage movements.
6. Recognition of climate change and the Global Financial Crisis

This timeline and the six thresholds are further illustrated in the progression of landscapes in Figure 8. Three key external shocks can be identified in this progression from 1800 to the present day. The first one was the arrival of Europeans which was caused by factors happening at larger scales in other parts of the world and as far as we know had no local pull factors. The second one was the international impact of World War I and II, which again was largely instigated by influences outside of Australia. The final shock is climate change. As we are still in the midst of that one it is difficult to judge our resilience to it.

Interestingly the other additional thresholds identified in Table 2 (and summarised above) appear to be re-adjustments of the local socio-ecological system of the Molonglo catchment to these shocks. They are evidence of the resilience of the system. The 1850s (1860s locally) gold rush was in part a lucky break due to the presence of gold in the area and the development of technology at this point in time so that greater volumes of material could be processed. It was a lucky break in that it saved a colony that was already suffering from the effects of applying European farming methods via compacting soil and the loss of regular Aboriginal fire management, and one whose success still hung very much in the balance in 1850. It was probably more than luck as desperate people turned to look for other ways of making an income in a country in which their usual land-management practices didn't seem to work reliably. The 1850s gold rush was the turning point at which immigrant people voted with their feet to indicate their confidence that the new colonies in Australia would be (in some measure) sustainable.

The Crown Land Alienation Act was associated with the increased immigration. The major floods of the 1870s and the severe erosion events that occurred from 1850 onwards suggest a system heading towards irreversible change. Since that time in the Molonglo catchment soils have lost moisture, carbon content (from inappropriate fire regimes) and become compacted. Waterways are more turbid and from time to time nutrient and salt polluted. Hydrogeological cycles have undergone vast changes so that some parts of

the landscape (e.g. rural residential areas) possibly retain more surface water than pre 1800 in farm dams[4] (though not as much soil moisture) whilst in others the water rushes straight through doing enormous damage on its way. All of these factors unchecked may have delivered the Molonglo catchment to an alternative state where a regular dependable supply of local food cannot support the local population of humans. It is unclear whether this is currently the case. From the 1900s onwards we have imported a significant amount of our food from outside the region, and our population numbers continue to grow. For the food that is grown here we also depend on external supplies of fertilisers and other nutrients. It seems fairly unlikely that we can support the current local population without this massive external subsidy at present, but less clear whether in future we could return to local sustainability.

There are some indications of the original system reasserting its resilience. Two hundred years is a relatively short period of evolutionary time, and this period could be regarded as still in the bounce-back phase from the shock of European colonisation. The increasing community participation firstly in conservation and then sustainable land management based on an understanding of managing key ecological functions suggests that the system may be responding in a positive manner. The re-recognition, particularly in recent years, of understanding Aboriginal land management practices (by some at least) as critical to managing Australian landscapes in a healthy and resilient state suggests that we may yet have the reassertion of some of the original key ecological processes, albeit in modified form. We are learning about the importance of ecological burning and indeed this may become critical to the management of fire risk apart from anything else in the near future. We are coming up with ways to try and return some of our waterways to the original chain of ponds features. We are seeking ways to recarbonize and rehydrate soils, and reconnect the biodiversity that has become so fragmented. In the move towards localisation we may yet find a way to feed ourselves without an external subsidy and connect better with the landscape in a more culturally and spiritually healthy way.

The biggest challenge that remains to this reassertion of the resilience of the pre 1800 socio-ecological system is climate change. Whilst some reapplication of pre 1800 land management practices will help us adjust to climate change (e.g. rehydration of landscapes, slowing down of water, recarbonizing soils) the use of fire as a tool will need to be finely honed. But all of the past understanding will need to be reviewed in light of rising temperatures and contributions to green-house gases from burning. On the other hand climate change has been a major factor in the rapid conversion of our socio-ecological systems to renewable energy sources – a conversion which is now well under way. It remains to be seen whether climate change will be the ultimate factor that does push us into irreversible change to ecosystem services and whether the alternative state in which we arrive is one in which ecosystem services are more or less resilient to other future shocks.

[4]Although these are often large shallow dams that lose much to evapotranspiration, surrounded by compacted eroded soils that have lost much of their ability to hold water (Beavis, 2011; Keyzer, 2010).

Table 2 Timeline story of key events and thresholds in the familiar history of the Molonglo catchment identified by the Molonglo Catchment Group committee in May 2013. Thresholds of significant disturbance which resulted in a transition to a new state for the catchment are indicated by the bold print.

Decade	Event
1790	Arrival of small pox; beginning of disruption to Ngunawal fire management
1800	
1810	
1820	**Arrival of Europeans & stock in district;**
1830	
1840	Arrival of rabbits; bottom fell out of overseas financial and wool markets;
1850	
1860	**Gold rush begins locally 1861-1881 around Bywong Hill; Crown Land Alienation Act 1861 (Robertson's Land Act); Fences erected;**
1870	**Severe rain and erosion events from 1850 – 1874 Flood in particular;**
1880	Railway to Bungendore 1885, Queanbeyan 1887; Captains Flat mine 1882
1890	Severe economic depression & recovery; early mechanisation of farms;
1900	Federation, planning the Capital; Gould League established; Federation drought
1910	**Building of Canberra commenced 1913**; Kingston Power Station begins generating 1915;
1920	Soldier settlers; pine plantations planted in ACT;
1930	Major rabbit plagues; Koala bounty ceases; Captain's Flat Mine collapse of tailings dam into Molonglo River– 1939 and 1942
1940	1945 National Trust formed in Australia;
1950	Myxomatosis released 1950; Soldier settlers; **1958 National Capital Development Commission;** shift from horse to car transport;
1960	Australian Wool Board and 'single desk' established, price dropped and Government stockpiled; 1967 referendum removing elements of the Constitution discriminating against Aboriginal people; Australian Conservation Foundation 1964; damming of the Molonglo to create Lake Burley Griffin 1963.
1970	Wallaby, possum and koala hunting ceases; rural residential development begins; introduction of (later defined) 'problem' willows starting at Tumut; 1979 Googong dam completed; contour banks begin to be used;
1980	**Franklin Dam campaign in Tasmania and 1983 Federal Election sparks national environmental action; 1989 Decade of Landcare begins; Greening Australia established 1982;**
1990	Aboriginal land councils established; 1995 Calicivirus escapes quarantine in Australia;
2000	**2003 Canberra bushfires; 2007-8 Global financial crisis;**
2010	
Undated	Each drought allows a new weed to take hold; Spread of willows & willow removal; bushfires; development of Canberra – some periods faster than others; local abattoirs; local mining – Stirling Park; electrification of sheds for shearing; plastic bags; increasing numbers of pets;

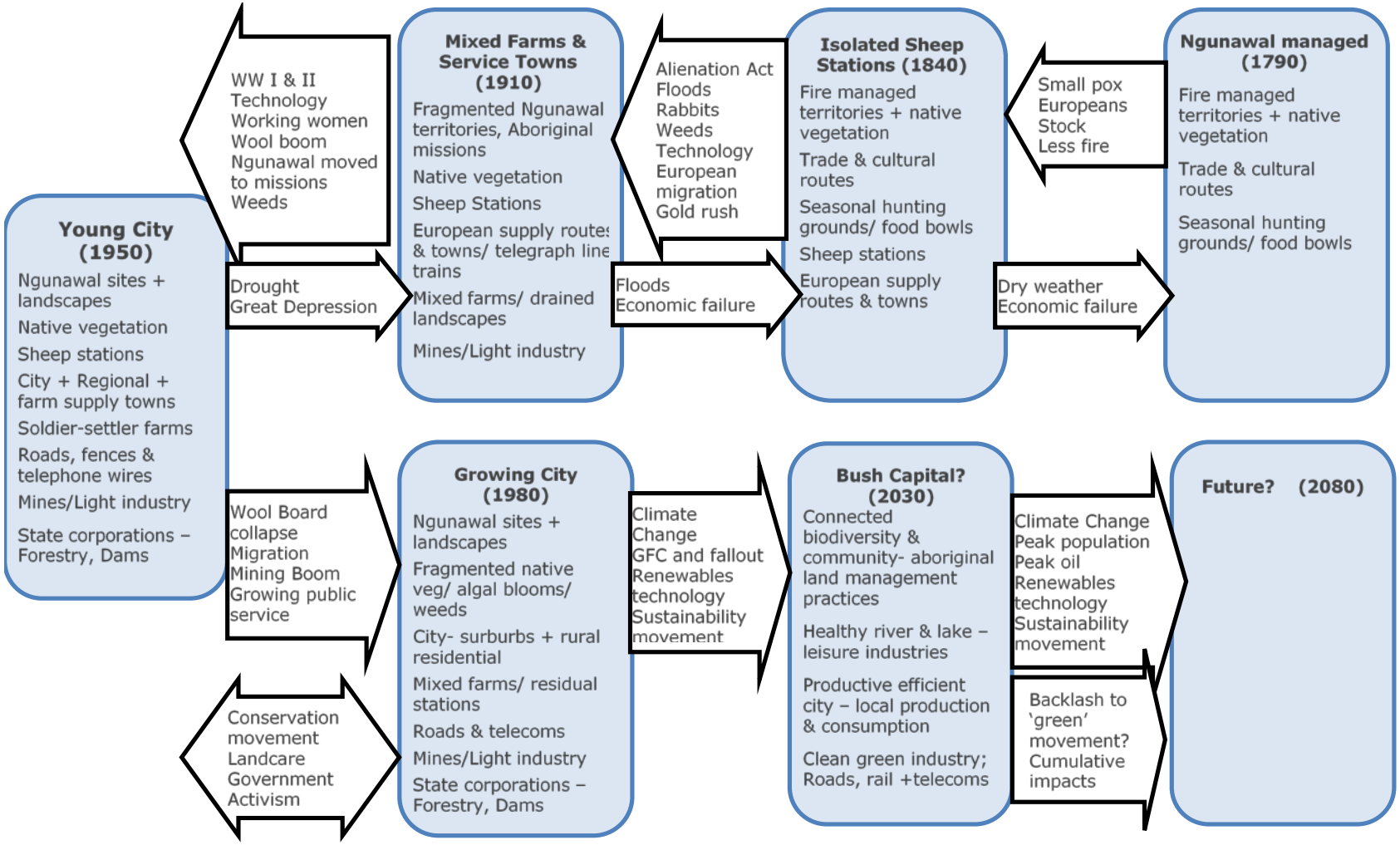


Figure 8 Starting top right: resilience models for the familiar history of the Molonglo catchment identifying key state changes. Each state of the catchment is described by the viable enterprise/management units that make up the landscape. Drivers to and from the state are indicated by the arrows.

6.2 MODEL OF CHANGE FOR THE MOLONGLO CATCHMENT 1800 UNTIL PRESENT

Many theories of change have tended to focus on what has been termed the "ABC" – attitude, behaviour and individual choice (Shove, 2009)) but researchers are suggesting we need a shift towards analysis of the broad environmental factors that influence what we do (Shove, 2009; O'Brien, 2012) or the cognitive biases that underlie our behaviour (Kahneman, 2011). Certainly when looking back in time models of environmental drivers that explain 'push' and 'pull' factors larger than individuals for particular changes have a long tradition of insight in the historical sciences.

If we look at the factors that led to the initial 'shock' of European immigration to the Molonglo catchment in the early 1800s we need to place this within the wider context of the Industrial Revolution going on in the Northern Hemisphere (see also Cross-scale interactions below). From the point of view of those coming to Australia the behaviour change for many was likely to have been driven by frustrations with the lack of resources and social status in their home countries. This may have been a direct driver if they chose to emigrate, or an indirect driver if they came here as convicts. Others no doubt saw the opportunity to enhance their resources and social status by coming to the latest frontier. There were no 'pull' factors in the sense that nothing in Australia at the time had changed to precipitate the immigration, rather this was a circumstance when 'push' factors explain all.

For large numbers of people to do this after 1850 the benefits had to be large enough to exceed the considerable costs of the journey, and be very apparent in the evidence of returning colonials. 'Pull' factors begin to play a role here as people observed that social status and wealth in the 'colony' did not seem to rely on status and wealth from 'home'.

On the other side of the frontier we know a little about the response to the 'shock' of European immigration among Aboriginal people (Reynolds, 1981; Gammage, 2011). It was a crisis of unforeseen proportions and the various reactions documented from first contact include curiosity, fear, appeasement, disruption, aggression; and assimilation, assertion of cultural identity, rejuvenation and reconciliation.

As discussed in the previous section there are signs of the original indigenous managed system asserting some resilience albeit in modified form. Current 'best practice' sustainable land management approaches appear to owe much to the pre-1800s indigenous land management practices for their inspiration and understanding. This could be an example of the 'adaptive cycle' as expressed in resilience theory (Resilience Alliance, 2010) whereby after a disturbance a system reorganises, grows, maintains itself and then collapses before reorganising again. Once again in taking this avenue, we must be mindful of not repeating the mistakes of the past in appropriating Aboriginal knowledge without an understanding of its socio-ecological context, and understanding that in bringing our own perspectives we must expect to be transformed. This approach results in the creation of a new shared knowledge rather than behaving as if traditional knowledge and practice is ours as land managers to use.

The post WW II immigration boom can be seen as a second wave in the same larger processes set off by the Industrial Revolution. It came about for a similar raft of 'push' factors in countries outside of Australia, with the addition of some 'pull' factors in the guise of Australian government policies that encouraged immigration from 'acceptable' countries.

Although climate change can also be seen at the larger scale as part of the ripple effect of the Industrial Revolution it has really only begun to influence people in the Molonglo catchment (in a conscious way) in recent times. It should come as no surprise that the range of reactions seem to mirror those of previous large external shocks: curiosity, fear, appeasement, disruption and aggression seem to dominate the response so far. It is to be hoped that in the future rejuvenation and reconstruction of adaptive cultures will become the dominant response.

7. CROSS-SCALE INTERACTIONS

The shock of European immigration in the 1800s into the Molonglo catchment was one in which there has been, at least temporarily, a scale change in the governance of landscapes. Bill Gammage (2011) makes a convincing thesis that indigenous land management practices were to some extent coordinated across Australia ("the biggest estate on earth") and codified through the law and cultural practice but flexible enough to respond to local conditions. However, it is likely that the immediate decision-makers were all relatively local, with some consultation made at a regional level. Today, the Australian political and governance system has moved quite a bit of that decision making up a level or two. Local Government is still the primary land use planner, but increasingly strategic planning involves State Governments and sometimes the Federal Government. Additionally, there is codified influence by international law and practice.

It has been the default position to assume that we have passed an irreversible threshold in the way that the socio-ecological system of the Molonglo catchment and other parts of Australia function. We have assumed that the original indigenous systems of land management were not resilient to the external migration shock, and that with each wave of disturbance: arrival of disease, stock, fences, loss of fire regimes, erosion, rabbits, weeds, roads and railways, imported fertilisers and food, large numbers of people, cities etc.; we have pushed the original system into something completely unrecognisable. Or, as suggested above, are there signs of the original system dynamics reasserting themselves?

HAVE WE GONE PAST A TIPPING POINT SINCE 1800?

How do we decide when we have changed a system irreversibly and when we are still in the same basic socio-ecological system, but perhaps a different state within it? Resilience theory suggests that we remain within the same system whilst it has the same structural and functional properties, and supplies the same bundle of ecosystem services to benefit people (Resilience Alliance, 2010)*. In the Molonglo Catchment we could argue that we have passed such a threshold because our local ecosystem no longer feeds us. But even that may bounce back in the future.*

Our conclusion is that the answer to this question is probably beyond the usefulness of the resilience model. Its value lies not in determining whether we have tipped over an edge of no return, but in conceptualising the range of alternative states and the factors at play in driving the system between them.

As far as interactions at scales above and below that of the Molonglo catchment the point has already been made that the key drivers of change within the Molonglo catchment appear to be European immigration and climate change, both of which can be seen as responses to the Industrial Revolution taking place at larger scales of space and time. Within the dynamics of particular threats to the Molonglo catchment detailed here (soil erosion, loss of biodiversity, weeds) we can see smaller adaptive cycles within the way that corporations, government institutions and family businesses respond.

8. GOVERNANCE IN THE MOLONGLO

The final step to understanding a socio-ecological system is to understand how the system governs itself, a key facet of resilience.

8.1 INDIGENOUS GOVERNANCE

"Who are the real people and what is the real culture?"

Ruth Bell, Ngunawal elder, was expressing her frustration with heritage policy and interpretation when she said that researchers hold out the snippets of the past as if it is the whole story, all the while ignoring the living history. (Williams, 2011)

Up until recently indigenous governance was not something that non-Aboriginal people thought we could ever know much about, except in snippets perhaps from a few early colonists' diaries or remaining Aboriginal people with knowledge. Fortunately, in recent times, research and collation of past records and current living experience is increasing.

In this section, at the risk of drawing on only a few sources, the Strategy attempts to give the time and space to expressing something of an indigenous (in this case Ngunawal) perspective via the development of a shared understanding with non-indigenous people. This is hopefully just the beginning of a rich conversation which will draw in many more perspectives.

Dr Karen Williams' thesis explains how, under appropriate protocols, non-Aboriginal people may gradually over time learn cultural information that is granted and appropriate depending on gender, age and experience. Her thesis describes how she does this in the context of a personal journey of interpreting landscape and the processes she undertakes to avoid cultural appropriation. She explains how the knowledge that she has come to hold is not that of the Ngunawal elders with whom she was privileged to work, but a new knowledge born of the creative tension at the boundaries between cultures and disciplines:

"Although I have presented a hybrid perspective of Ngunawal territory, that perspective will never be complete. Using a transdisciplinary approach to complement multiple ways of experiencing will only ever generate knowledge and perception that moves and changes. New knowledge of Ngunawal territory is shaped both by the sources from which it is constituted and by the nature of the existing knowledge into which it is being reflexively fed. Socially constituted knowledge (being generated from variable experience and perception) will never be final and absolute. I can never assume, even if I were Ngunawal, that being Ngunawal would open the way to essential and unchanging truths or to the all-knowing will of some Ngunawal power. My spatial narrative of Ngunawal territory may be comprehensive; however, the perspective and knowledge that is presented will only ever be one part of a more extensive storied line." (Williams, 2011, p. 337)

In this context (and in no way doing justice to detailed scholarship, rich stories and transformational development that leads to these insights), Williams is able to communicate her understanding of a Ngunawal view of interconnection between the mind, body and environment that has no parallel in Western dialogue and thinking.

"I struggle to understand the meanings behind what Don and Ruth are saying and the symbols they are showing me. How will I capture what they are saying? They are leading me and causing me to experience the bushland in a way that is familiar to me yet outside of my own experience. I have no reserve of culture to call on. The landscape is a stranger while also a comfort to me. …

…Ngunawal sense of place reflects the past as a reflexive, two-way interaction with the present. For example, the telling of a personal story in the present renews the meaning of an event or a place in the ancestral past. The past and present become different dimensions of the one experience of interactive space… There is no indelible line drawn between what is past and what is present, although there is a differentiation between 'old' history (traditional lifestyle and customs) and 'new' history (current and short-term socio-political events).

In the interaction of personal and environmental space there is no separation of the perception of the land beneath a person's feet from what that person will see and feel in the distance of space or of time. No perceived separation of mind, body and environment. No absolute boundary drawn between the physical and the metaphorical - the everyday mundane, the traditional and ritualistic. Each is perceived as a different perspective of the one lived experience." (Williams, 2011, p. 133).

This lack of perceived separation between mind, body and environment is paralleled in the attempt to identify Ngunawal territorial boundaries. Williams develops the idea of 'permeable boundaries' and reflects on the evidence that different groups moved through particular parts of the landscape:

"In the local region this means that Ngunawal people identify with ecological and linguistic characteristics that vary from neighbouring Ngarigo, Walgalu, Wirradjuri, Gundungurra, Wodi and Yuin land and people. On the other hand, different groups or clans seemed to function at different levels as they moved separately about Ngunawal lands, but came together from time to time for various reasons and common interests. Flood (1980) discusses these points at length in the publication of her research of the local region. Further to this, Bluett (1954) distinguishes, on one level, between people of the southern tablelands and of the south coast. On another level, he mentions politically significant exchanges between leaders of groups of people from the Lake George, Braidwood, Yass and Canberra areas (Bluett 1954, pp4-5). On what appears to be yet another level, Bluett also refers to three groups that coexisted in Ngunawal territory as Tindale describes it. The three groups seem to coincide with the geographical meeting places I have focused on throughout my own narrative – the Yass, Lake George and Canberra/Queanbeyan areas." (Williams, 2011, p. 140).

Ultimately after experiencing both Ngunawal 'guided' and 'unguided' journeys through different parts of Ngunawal territory, researching the landscape context in terms of geological and environmental formations, and developing a storied line that explains her journey, Williams arrives at a series of illustrations of her perception of Ngunawal territory through maps and descriptions (see Figure 9).

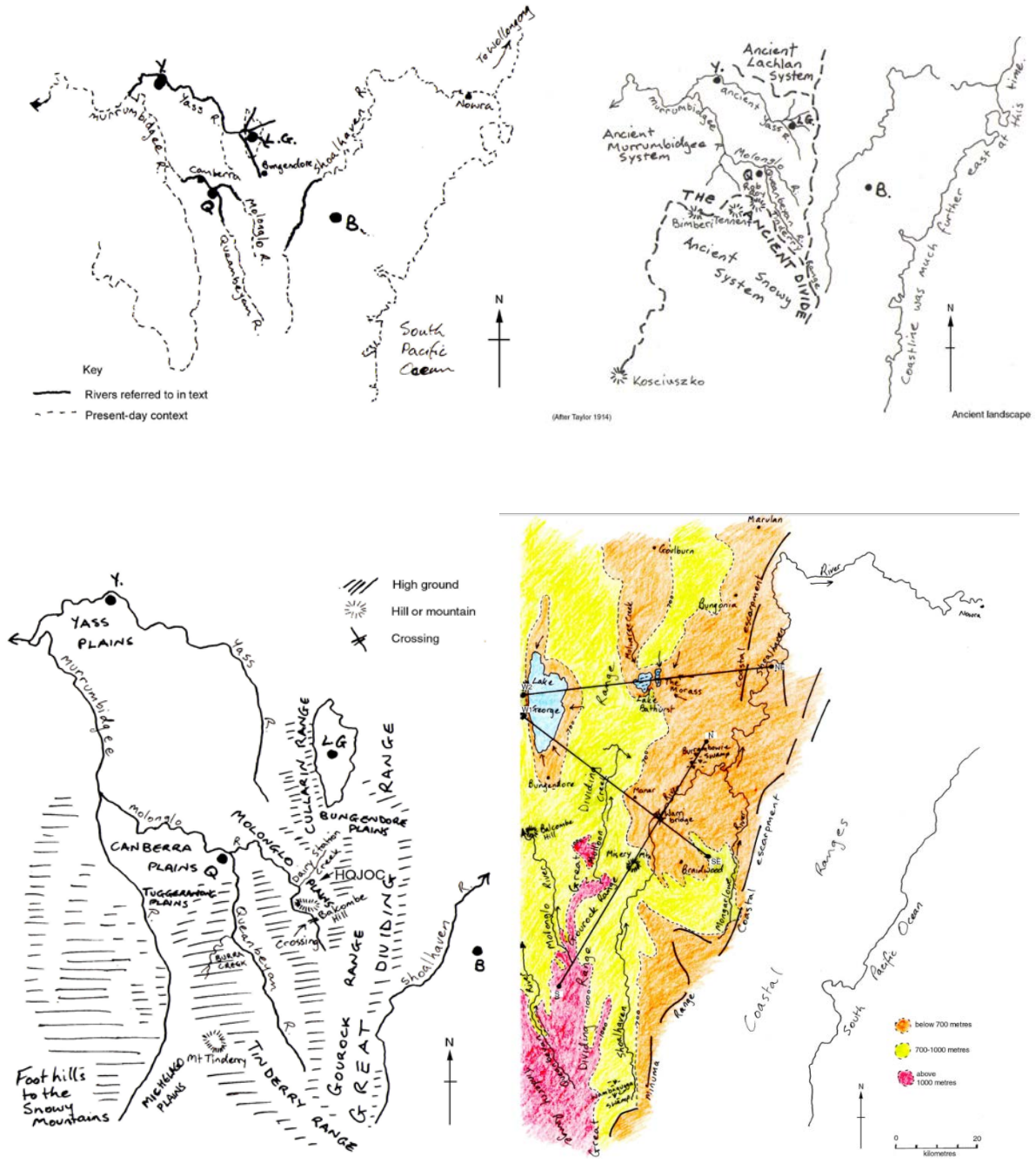


Figure 9 Maps taken from Karen Williams thesis that illustrate an evolution of her perception of Ngunawal territory from a) connected places (p254); to b) links between these connection to ancient Murrumbidgee pathways (p264); to c) important highland pathways and river crossing(p266)s; and d) topographic boundaries that outline the swampy resource-rich table-lands country that connected the coast to the inland plains and the alpine high country (Williams, 2011, p. 284) culminating in the integrated map shown in Figure 1.

The maps illustrate her progression from the identification of connected places in the Ngunawal landscape; to realising a linkage with the pathways of the ancient Murrumbidgee which flowed from east to west

rather than south to north; to relating these pathways to high grounds and river crossing which also came to feature prominently in early settler history (and can often still be seen today); to recognition of these sites as all being associated with a swampy tablelands landscape rich in resources that formed a key linkage between coastal areas, the inland western plains and the high alpine country. All of this information then forms the basis for the ultimate integrated map presented in Figure 1.

The inability of native title and the recognition of traditional owners in Australia to encapsulate, communicate or understand such a fluid and sophisticated embodiment of 'territory' may underlie the reasons why so many native title claims remain unresolved and so much division has resulted. When a Western European legal system attempts to set terms of reference for identifying native title without a language for these concepts, then it may end up perpetrating further wrongs in the divisions in which it produces amongst Aboriginal people. The socio-ecological dialogue approach that Williams presents suggests that there are other more productive ways to approach an understanding of indigenous territory.

A completely different approach to documenting Aboriginal landscape practice has been taken by Bill Gammage in his book *The Greatest Estate on Earth: How Aborigines made Australia* (2011). Gammage has made no attempt to develop a shared language or understanding with indigenous peoples of Australia but has simply collated much of the written and graphic information available at the time of early European exploration and settlement into one source. In this sense this resource is not as rich as the approach described by Williams above as it gives no insight into Aboriginal perceptions or motivations. However, the ability to draw together so much data over the whole of Australia brings to light patterns that would never have been identified in any other way. Often the observations come out of the pens of the early European explorers, surveyors and artists revealing things that the authors often did not themselves notice, nor have we noticed ourselves in two hundred years of studying them.

Gammage's main thesis is that the Australian landscape as observed in the early days of colonisation showed clear signs of a vast complex and detailed system of landscape management that could not have occurred without human intervention. He shows that similar patterns of vegetation, that were not along any ecological boundaries (like soils, aspect, topography etc.), re-occurred all over Australia in 1788 and suggests that Aboriginal people had a series of landscape 'templates' that they managed the landscape into, primarily through the use of fire. Each template was made up of a different set of ecological boundaries and had a different purpose. For example, a common 'template' combined open grassland with nearby woodland and water to promote a local abundance of kangaroos. The template was often organised so that in the right season it could be burnt driving kangaroos uphill away from shelter and into various topographic or dense vegetation 'traps' for easy hunting.

Local country, he argues, was intensively managed with many parts of the landscape being burnt every 3-4 years to promote nutritious grasses whilst other vegetation types were burnt less often, as required to maintain the required 'templates'. Fire-sensitive plants and animals were protected by protective 'cool' burns, as well as important campgrounds and waterholes. Other areas were managed in particular ways to promote cropping plants. An example is the yam daisy, once common to the Molonglo Catchment region. He describes the landscape as 'farming without fences'. The practice of this management was local but he suggests its principles must have been encoded in country-wide law and relationship to landscape, and he details evidence of how information and technology were passed quite rapidly from region to region.

Gammage makes reference to the Molonglo Catchment region a number of times throughout his book and also has a section dedicated to relaying Hoddle's 1832-5 travels in the Canberra region:

"In 1832-5 Robert Hoddle soon to survey Melbourne, surveyed between Yass and Michelago, including Canberra and Queanbeyan. 'Open plains' and 'fine open grassy forest' without undergrowth were easily most common, and commonly alternated…Kangaroo Grass and Blakely's Red Gum, Ribbon Gum or Apple Box dominated, with Yellow Box on lighter soils, and wattle or casuarina in places. Hoddle marked no dense forest, not even on hills thickly forested now, and only two 'scrubby' places, one on hills south of Lake George, one east of Jerrabomberra Creek towards Burra. Another scrub belt…bordered the northeast corner of the airport plain. Scrub undergrowth now typifies Australian Capital Territory bush."

Almost all watercourses were chains of ponds, including the Queanbeyan and the Molonglo with "large ponds holding fish, eel, platypus and yabbies", and grassland either side. A painting by Hoddle from 1832 shows the hills and ranges of the Ginninginderry Plains with only sparse grassy woodlands which are today densely forested. Some of the trees even appear to be in lines across the landscape. All this is offered as evidence that this too was a landscape managed by fire (Gammage 2011).

8.2 GOVERNANCE 1800 TO LATE 20TH CENTURY

ACT NSW CROSS-BORDER WATER SHARING ARRANGEMENTS

Under the *Seat of Governance Acceptance Act 1909 (Commonwealth)* the Commonwealth Government of Australia gained the land and water now comprising the Australian Capital Territory and paramount rights to certain waters of the Queanbeyan and Molonglo Rivers in New South Wales. The waters of the Queanbeyan catchment were developed through the construction of Googong Dam for paramount supply of water for the ACT. Control of the waters of Googong Dam is vested in the Territory Executive by the *Canberra Water Supply (Googong Dam Act 1974 (Commonwealth).* Supply of water to a place in NSW requires the prior agreement of the Commonwealth and NSW and comes under the 2006 *Memorandum of Understanding on Cross Border Water Resources* between the Australian Capital Territory, New South Wales and the Commonwealth of Australia.

GOVERNANCE OF THE MURRAY DARLING BASIN

The first conference on the Murray River system was held in 1863. The need for and development of a plan for managing the Murray Darling Basin was closely aligned with the federation of Australian states to form the Commonwealth of Australia. At the 1897 Federation Convention South Australian Premier Charles Kingston held out hope "*that the Federal Parliament will be trusted with Federal questions of the gravity involved in the use of the waters of the Murray."* Conflict between the colonies over water use preceded these developments.

The severe 'Federation' drought (started in 1895 and widespread in 1902) led to a conference in Corowa in 1902 eventually resulted in the River Murray Waters Agreement signed in 1915 by the governments of NSW, Victoria, South Australian and the Commonwealth. This was followed by the formation of the River Murray Commission in 1917. This body controlled all the subsequent development and works carried out on the Murray River to create a regulated river with numerous dams and weirs some dating back to the early 1900s.

Environmental impacts from increasing water extraction and a drought in 1968 led to the first benchmark study of salinity in 1970. A series of agreements ensued over the following decade:

1987: the first *Murray-Darling Basin Agreement* which established the Murray-Darling Basin Commission

1989: Salinity and Drainage strategy produced

1995: A cap on surface water extraction was introduced

2004: The *National Water Initiative* saw governments agree to a national approach to the way Australia manages, measures, plans for, prices and trades water

2004: The *Living Murray Initiative First Step* to recover 500 GL for the environment

2007 The *Water Act 2007* and the *Water Amendment Act 2008* implements key reforms and transfers the functions of the Murray-Darling Basin Commission to the Murray Darling Basin Authority.

2012: The Basin Plan becomes law.

(Source: www.mdba.gov.au/what-we-do/basin-plan/development/history)

The Basin Plan is significant to the management of the Molonglo catchment, not least because it has provided funding for the ACT Basin Priority Project announced in 2014 (see 21st Century below).

8.3 21ST CENTURY: INTEGRATED CATCHMENT PLANNING AND BEYOND

THE INITIATION OF INTEGRATED CATCHMENT PLANNING IN THE UPPER MURRUMBIDGEE

The *NSW Catchment Management Act* was gazetted in 1989. It established, amongst other things, the Murrumbidgee Catchment Management Committee (MCMC) which in turn established the Upper Murrumbidgee Catchment Coordinating Committee (UMCCC) in 1992

THe MCMC finally releasedthe *Murrumbidgee Catchment Action Plan* (MCAP) in 1998 as an overarching Action Plan. When the NSW Catchment Management Act was repealed in 2002, the UMCCC remained and became an incorporated association, whilst the MCMC became the Murrumbidgee Catchment Management Authority.

Source:
www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_committees?url=environ/cminq/sub98-e.pdf

THE FIRST CATCHMENT PLANS FOR THE MOLONGLO CATCHMENT

Catchment planning in the Molonglo catchment began by building a framework for wide stakeholder engagement and participation across the entire catchment. The groundwork for this was laid with SWAMP and the Molonglo planning framework, and achieved with the *Molonglo Catchment Strategy 2004-2024* (Molonglo Catchment Group, 2005).

In the late 1990s catchment management was instituted right across NSW, initially in a non-statutory arrangement. Following the NSW Government reforms of 2003, statutory catchment management authorities were established. By this time there had been two generations of catchment plans – the MCAP 1997 and the *Murrumbidgee Catchment Blueprint* (Murrumbidgee Catchment Management Board, 2003). This generation of catchment planning was characterised by an asset management approach to planning, and the formulation of targets and actions. In the ACT a natural resources management plan was developed and shared the same regional targets. The Molonglo Catchment Strategy 2005 built on this approach for sub-catchment planning, but also drew on some of the early thinking going into the draft versions for the next generation approach.

The next generation of planning documents took the asset management approach further. Each asset (land, water, biodiversity and community) was analysed for the issues that impact upon it using a state-pressure-response conceptual model. Systematic processes for monitoring, evaluating and reporting to measure progress towards achieving specified targets and adaptive management were introduced. These can be seen in both the *Murrumbidgee Catchment Action Plan 2008* (Murrumbidgee Catchment Management Authority, 2008) *and the Bush Capital Legacy: A Plan for Managing the Natural Resources of the ACT* (ACT Natural Resource Management Council, 2009).

THE MOLONGLO CATCHMENT STRATEGY 2004-2024

The MCS 2004-2024 laid out the following:

Goals/Visions were expressed as aspirations for 2024. The terms used in the goal statements were listed by stakeholder workshops, in light of desired future management of priority issues.

They were:

1. A healthy environment
2. Sustainable economic use of natural resources
3. Cohesive, innovative communities
4. Partnerships between community and government

Priorities/Issues identified the most valued assets (water, land, biodiversity and community, as with the draft (at the time) *Murrumbidgee CAP 2008* and the *ACT NRM Plan 2009*) and the most significant threats faced by each asset. They were based on workshops with stakeholders and review of current technical information about threats to assets.

Targets and *Actions* were obtained from:

- community inputs in workshops
- existing regional strategies
- discussions on appropriate targets for the MCS held with technical experts involved with the development of regional targets.

Performance Indicators were developed through:

- in-house discussion of measures that would best assess the progress of the MCS in reaching regional targets
- consideration of milestones for evaluating performance of the MCS implementation.

MURRUMBIDGEE CATCHMENT ACTION PLAN 2013

Following the adoption in 2011 of *NSW 2021* (the NSW Government State Plan) Catchment Management Authorities in NSW were required to upgrade their Catchment Management Strategies in line with *NSW 2021* priorities and feedback from catchment communities. This resulted in the Murrumbidgee CAP 2013 (Murrumbidgee Catchment Management Authority, 2013) which sets a regional strategic direction for NRM but does not describe detailed roles, actions and budgets for local on-ground activities as in previous CAPs.

The *MCAP 2013* identified a vision of "Healthy and Resilient Murrumbidgee Landscapes" and was supported by six catchment goals and six measureable outcomes. These goals and outcomes have been applied to each of ten unique Murrumbidgee landscapes with porous boundaries from east to west.

Across these landscapes seven themes were identified: riverine and wetland system, irrigation system, mixed farming system, grassland/woodland system, rangelands, community capacity and Aboriginal capacity. Each of these themes was analysed using a resilience framework for the drivers that might move a system from one possible state to that of a few alternatives via participatory workshops including a range of stakeholders. The understanding from these models was used to derive a set of Key Goals and Management Priorities and Actions for each landscape. The landscapes which are of relevance to the Molonglo catchment include the Monaro landscape, the Capital Landscape and the Tablelands Landscape.

SOUTH EAST CATCHMENT ACTION PLAN 2014

A major reform to the delivery of natural resource management in NSW was undertaken by the NSW Government in 2013. From January 2014, a new government body titled Local Land Services delivers functions previously provided by Catchment Management Authorities, Livestock Health & Pest Authorities, and agriculture advisory services of Agriculture NSW, part of the Department of Primary Industries.

These new statutory based organisations are semi-autonomous and governed by a board of locally elected and skills-based members. They are centred in each of eleven new regions with the boundaries recently determined. The NSW areas of the Molonglo catchment fall into the South East Local Land Services boundary, which extends from Wollongong, Wingecarribee, Upper Lachlan and Boorowa Shires in the north to Snowy River, Bombala and Bega Valley in the South and Yass Valley and the ACT border to the west.

In 2014 the *South East Catchment Action Plan* was released (South East Local Land Services, 2014). This drew on work done for the Murrumbidgee CAP 2013, the Southern Rivers CAP 2013, the Hawkesbury-Nepean CAP 2013 and the Lachlan (Kalare) CAP 2013. It comes under the NSW 2021 goals and targets. The vision for the South East region is "Sustainable communities, profitable industries, resilient landscapes." There are three pillars that groups similar activities under a common goal: People, Governance and Natural Resources.

Within this, five landscapes have been identified as distinct socio-ecological systems; the Molonglo catchment falls mostly into the Tablelands landscape, but the upper catchment falls into the Monaro landscape. Each pillar is applied to each landscape and within these pillars across all landscapes state and transition resilience models have been developed including those for social capital, Aboriginal community cultural landscape, grazing landscapes, soil condition, landscape habitat, grassy ecosystems, African lovegrass, water quality, quantity and movement, river reaches, and wetlands.

BUSH CAPITAL LEGACY ACT NRM PLAN 2009 AND NATURE CONSERVATION STRATEGY 2013

The ACT falls entirely within the Murrumbidgee catchment, however as a separate jurisdiction, the ACT has to deal with natural resource management within its own policy and planning framework.

To facilitate integrated cross border NRM, Bush Capital Legacy: Plan for Managing the Natural Resources of the ACT (ACT Natural Resource Management Council, 2009) shared the same asset-based objectives with the MCAP 2008: water, land, biodiversity and community (Murrumbidgee Catchment Management Authority, 2008).

The ACT NRM Council is also moving to a more integrated systems view of NRM. An updated NRM plan is not expected until after the implementation of the major water reform for the ACT detailed, below. The more integrated approach is reflected in the *Nature Conservation Strategy* (ACT Government, 2013) which expands the focus of nature conservation in the ACT to one which takes a landscape view including policies to address connectivity in the landscape and off-reserve conservation.

ACT WATER RESOURCES STRATEGY 2004, 2013 AND THE LAKE BURLEY GRIFFIN ACTION PLAN 2012

Think water, act water – a strategy for sustainable water resource management, was released in April 2004 (Environment ACT, 2004) and has guided the management of water resources in the ACT from that time until 2013. The strategy's primary focus was on securing ACT water supplies and improving water use efficiency during a time of drought. It takes a catchment perspective and focuses on the integration of stormwater, water supply and wastewater elements.

The 2004 Strategy also included Actions for the ACT Government to begin to formalise catchment management arrangements across the NSW/ACT border to better protect ACT water supplies. The ACT Water Supply Catchment Management Group was set up to be responsible for overseeing catchment management arrangements in the Cotter and Googong sub-catchments.

In 2014 the ACT Government released *ACT Water Strategy 2014-2044: striking the balance* (Environment and Planning Directorate, 2014). This document details the progress made in securing the ACT's water supply and reducing per capita and total demand (per capita demand is now <50% of what it was in 1997/98). It sets a new agenda focusing on improved water quality and the place of the ACT within the Murray Darling Basin. The three outcomes aimed for in the strategy relate to healthy catchments and water bodies; a sustainable water supply used efficiently; and a community that values and enjoys clean healthy catchments and waterways.

The *Lake Burley Griffin Action Plan 2012* (Lake Burley Griffin Taskforce, 2012) was a significant collaboration between the members of the Lake Burley Griffin Taskforce: ACT Government, National Capital Authority,

Queanbeyan City Council, Palerang Council and ACTEW Water. It takes the original Griffin plan's focus on Lake Burley Griffin as a unifying element for Canberra and its use as the 'playground of the city' as motivation to address the key water quality issues for the lake that were identified by the Commissioner's inquiry in 2010.

The *Lake Burley Griffin Action Plan 2012* lists a number of key actions grouped under governance and community engagement, community awareness raising and education, In-lake management, urban catchment management, rural catchment management, sewerage, river flow management and lake closure protocols and communication. Significant amongst these actions is the recommendation for a statutory catchment office for catchment management across the ACT – an action which has been agreed to by the ACT Government – and the recommendation for an Intergovernmental Catchment Management Agreement between the ACT, Australian and NSW State and local governments. This has resulted in the formation of the 'ACT and Region Catchment Management Coordination Group'.

The move towards statutory catchment management in the ACT is somewhat divergent from current moves away from this in NSW (see above).

THE ACT BASIN PRIORITY PROJECT

In February 2014 the ACT Government signed a successful bid to the Commonwealth Government for the $85 million State Priority Project. This funding has been provided to improve the long-term water quality in the ACT by "cleaning up its lakes and waterways." The project identifies six priority sub-catchments: Upper Molonglo (semi-rural flowing into Lake Burley Griffin); Lower Molonglo (greenfield development flowing into the Molonglo River); Fyshwick (industrial catchment flowing into Lake Burley Griffin and the Molonglo River); Lake Tuggeranong (developed urbanised catchment); Yarralumla Creek (developed urbanised catchment flowing into Molonglo River); and West Belconnen/ Riverview (future greenfield development flowing into the Murrumbidgee).

Phase 1 of the project focuses on implementing a comprehensive ACT-wide water quality monitoring program. Phase 2 will involve the construction of water quality infrastructure and retrofitting existing water quality assets in the six priority sub-catchments, along with the establishment of an ongoing monitoring system to gauge the efficacy of the new infrastructure.

Source: www.environment.act.gov.au/water/act-basin-priority-project

THE STRATEGY INTEGRATES NATURAL RESOURCE MANAGEMENT INITIATIVES

The MCS 2015 has a role in facilitating a 'connection' between all levels of government and the community, thus promoting integrated natural resource management. The strategy has been guided by relevant policies and initiatives, which Local, State and the Federal Government has committed to and is obligated to implement. The Molonglo Planning Framework compiled a comprehensive list of such policies and initiatives; the following describes the most relevant documents used to guide the development of the MCS 2015.

STATE/TERRITORY INITIATIVES

ACT

- *Think water, act water* – Strategy for sustainable water resource management in the ACT (Environment ACT, 2004);
- *ACT Lowland Woodland Conservation Strategy* (ACT Government, 2004);
- *ACT Strategic Bushfire Management Plan 2014* (Emergency Services Agency, 2014);
- *ACT Lowland Native Grassland Conservation Strategy* (ACT Government, 2005);
- *ACT Aquatic Species and Riparian Zone Conservation Strategy* (ACT Government, 2007);
- *Jerrabomberra Wetlands Nature Reserve Plan of Management 2010* (ACT Government, 2010);
- *ACT Nature Conservation Strategy* (ACT Government, 2013);
- *ACT Pest Animal Management Strategy 2012*;
- *ACT Water Strategy 2014-44: Striking the balance* (Environment and Planning Directorate, 2014);
- *ACT Parks, Conservation and Lands Volunteer Policy* (Parks, Conservation and Lands, 2009).

NSW

- *NSW Standard for Quality Natural Resource Management 2005* (www.nrc.nsw.gov.au/nrm-standard-and-targets) ;
- *The NSW Invasive Species Plan 2008-2015* (NSW Department of Primary Industries, 2008)
- *NSW Biodiversity Strategy 1993-2003* and the *Draft NSW Biodiversity Strategy 2010-15* (Department of Environment, Climate Change and Water NSW;Industry and Investment NSW, 2010);
- *NSW Framework for Assessing and Recommending Upgraded Catchment Management Plans 2012* (NSW Natural Resources Commission, 2012);
- *South East NSW Regional Action Plan* (NSW Department of Premier and Cabinet, 2012);
- *South East Catchment Action Plan* (South East Local Land Services, 2014).

REGIONAL INITIATIVES

The MCS is framed to be consistent with the *Lake Burley Griffin Action Plan* (Lake Burley Griffin Taskforce, 2012), ACT Water Strategy 2014-44 (Environment and Planning Directorate, 2014) and South East Catchment Action Plan (South East Local Land Services, 2014). The Strategy uses indicators where possible which are already being collected by the NSW and ACT governments (e.g. State of Environment reporting).

State agencies and non-government organisations have also developed (or are in the process of developing) regional strategies that guide operations and attempt to deliver on state level targets.

Major regional initiatives include:

- *A Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands 2002* (Fallding, 2002);
- *Molonglo Catchment Strategy 2004-2024* (Molonglo Catchment Group, 2005);
- *Sydney–Canberra Corridor Regional Strategy* (NSW Department of Planning, 2008);
- *Molonglo River Rescue Action Plan 2010* (Bowman & Keyzer, 2010)
- *NSW 2021 South East NSW Regional Action Plan* (NSW Department of Premier and Cabinet, 2012);
- *Lake Burley Griffin Action Plan* (Lake Burley Griffin Taskforce, 2012);

- *ACT Planning Strategy* (ACT Government, 2012);
- *Integrated Regional Vulnerability Assessment: South East New South Wales Pilot Study* (NSW Office of Environment and Heritage, 2012);
- *Queanbeyan River Corridor Plan of Management incorporating the Platypus Awareness and Conservation Strategy* (Eco Logical Australia, 2012a);
- *Regional Weed Strategy Murrumbidgee Catchment* (Ash & Verbeek, 2007);
- Research for an NRM Climate Adaptation Plan has been undertaken by the South East Local Land Services in NSW. This project includes components which covered connectivity mapping, hydrogeological landscape mapping, extreme event vulnerability mapping, community capacity assessment workshops and blue carbon hotspots modelling. In the ACT the ACT Hydrogeological Framework Project is also soon to be released.

LOCAL GOVERNMENT INITIATIVES

Local government planning guidelines and environment plans are possibly the most critical element of natural resource management that must be considered in delivering integrated natural resource management. Local government in the catchment is heavily involved in many facets of NRM and notable initiatives in the Molonglo include Regional and ACT State of the Environment Reports, and Local Environment Plans.

The Local Environment Plans (LEPs) for all the NSW councils within the catchment have being reviewed over the past few years, with new LEPs either now adopted or close to being adopted. The revised LEPs were informed by the MCAP 2008, as well as reflecting regional strategies such as the Sydney-Canberra Corridor Regional Strategy.

Additionally a number of important reports are generated at the local council level in NSW. Examples of these include the Biodiversity Study Findings Report: Queanbeyan Local Government Area (Bushfire and Environmental Services, 2008), the Jerrabomberra Creek Plan of Management (Queanbeyan City Council and Maunsell Australia, 2006), and the Queanbeyan River Riparian Corridor Strategy (Eco Logical Australia, 2012b).

8.4 SUMMARY OF GOVERNANCE IN THE MOLONGLO CATCHMENT

As can be seen in this chapter, governance in the Molonglo catchment began as an indigenous system that, although not written down, was codified within Aboriginal cultural practice and law; and appears to have managed large areas of country to maintain a plentiful food supply and a very healthy ecosystem.

Since that time we appear to have completed a full circle. Firstly immigrants to this region attempted to introduce foreign farming methods and large numbers of people into the landscape, precipitating a vast amount of environmental damage. Today our leading land managers are “re-inventing” land management techniques that seek to re-establish/ heal the underlying ecological processes or are in tangible and intangible ways inspired by those Aboriginal practices at 1800 (and still to some extent available today).

What may be apparent from this discussion of governance in the Molonglo Catchment is that institutions of governance are yet to catch up with this trend. Whilst Aboriginal consultation in cultural and some peripheral areas of landscape management have been acknowledged for some time by governments and natural resource managers, we are yet to realise the potential for creating new shared knowledge via a partnership which places this knowledge as central to all of our natural resource management.

PART 3. REVIEW OF THE MCS 2004-24

9. METHODS OF REVIEW

9.1 PROCESS

The MCS 2004-24 proposed an annual stocktake of on-the-ground change attributed to the sub-catchment plan directly and a detailed review of the entire plan every three years. To date neither of these have happened on a formal basis. The MCS 2015 represents the first major revision of the MCS 2004-24.

The review of the 2005 strategy was undertaken by a series of steps:

1. A residents and stakeholder survey was undertaken to assess and review the community's NRM priorities in 2012;
2. Data on Molonglo Catchment Group activities were collated where available from 2004 to 2013;
3. Progress towards the MCS 2004-24 community and resource condition goals was assessed.

9.2 CONSULTATION WITH OUR COMMUNITY – COMMUNITY SURVEY 2012

Stakeholders at the local level were consulted through a ten question survey which was sent by email to the MCG email subscribers in 2012 and promoted on the MCG website survey questions were designed to review the NRM priorities previously identified and prioritised in four community stakeholder workshops held in 2004 prior to the writing of the MCS 2004-24.

Seventy six responses to the survey were received with responses from all the sub-catchments except Coppins. Table 3 shows the results of the community consultation in 2004 and 2012.

Whilst the overall priorities can be compared, small numbers surveyed in individual subcatchments in 2012 compared with the numbers attending the 2004 stakeholder workshops make it difficult to compare priorities at a finer scale within the catchment. Further detail on both surveys can be found in the MCS 2004-24 (Molonglo Catchment Group, 2005) and the MCG Community Survey 2012 Draft Summary (Molonglo Catchment Group, 2012) (see also Appendix 1: Community Consultation for the MCS 2005).

The key result in Table 3 is that biodiversity and river restoration have become much higher priorities amongst the people surveyed in 2012 compared with those attending the stakeholder workshops in 2004. This result was consistent across all sub-catchments of the Molonglo. When we consider how the work of the MCG has altered in the period 2005 -2015 (see Review of 2005 Performance Indicators, below) this may reflect a growing awareness of the issues surrounding biodiversity and riparian restoration as a result of the work of the Molonglo Catchment Group has undertaken. This in turn is likely to be partly a result of investment priorities at the Federal and State level.

Weeds, Water quality and Planning and Development were the top three overall priorities in 2004 and remain the next most significant issues after biodiversity and river restoration in 2012. Concern about Planning and Development is high across the whole Molonglo catchment but there is some evidence for

even greater concern in the sub-catchments of Burra, Upper Queanbeyan and Kowen. Concern about groundwater use, whilst of less concern overall also increased notably in these three sub-catchments.

Table 3. Community NRM priorities in 2012 compared with 2004 (highest at top of table).

Narrabundah 2004	Queanbeyan 2004	Stoney Creek 2004	Royalla 2004	Overall 2004	Overall 2012
Planning and Development	Planning and Development	Weeds	Groundcover management	Weeds	Biodiversity (wildlife corridors & enhancing native habitat)
Cross Border Issues	Water Quality	Water Quality	Sustainable use of Groundwater	Water Quality	Riverbank/ water body restoration
Promoting the Landcare Ethic	Weeds	Erosion	Weeds	Planning and Development	Weeds (incl native weeds)
Weeds	Native vegetation management	Public land management – state and council coord	Riparian restoration	Public land management – state and council coord	Planning and Development
Water quality	Salinity	Tree decline	Biodiversity management & enhancement	Tree decline	Water quality/ sustainable use of surface water/ pest animals

10 REVIEW OF MCG ACTIVITY AND 2005 PERFORMANCE INDICATORS

In preparing the MCS 2015, we collated available MCG activity data from 2005 to 2013 in tables organised by the four assets - Land, Water, Biodiversity and Community - in the same way they were organised within the MCS 2004-24. These trends are reported in a qualitative manner under each asset category below. Despite some missing data and uneven comparisons across the years, these data give an indication of the large range of activities that the MCG has undertaken over the past seven years.

In summary, from 2005 to 2013 at least 7,500 people participated in at least 61 MCS events, 33 on-ground projects, producing 30 written products and assisting over 73 community groups since July 2009 (see also Figure 10). This does not include the Waterwatch program which initially monitored 25 sites in 2006 and in 2013 had regular monitoring of 64 sites. After a year of funding uncertainty in 2013/14 there was a dip in activity but the number of sites being surveyed in February 2015 was 56.

In a separate exercise Molonglo Catchment Group has also kept a record of public money invested in on-ground works in the Molonglo catchment since 1996 (see Appendix 4: Publically funded projects in the Molonglo Catchment since 1996). It is notable from this time how many of the activities were undertaken by other organisations indicating a high degree of coordinated focus, and suggesting that the MCG has been successful in its goal to promote coordination between various stakeholders and government and community initiatives.

The MCS 2004-24 identified a resource condition goal and a community goal for each of four assets – Land, Water, Biodiversity and Community. Performance indicators for these have been selected retrospectively from readily available data from various sources as reported below.

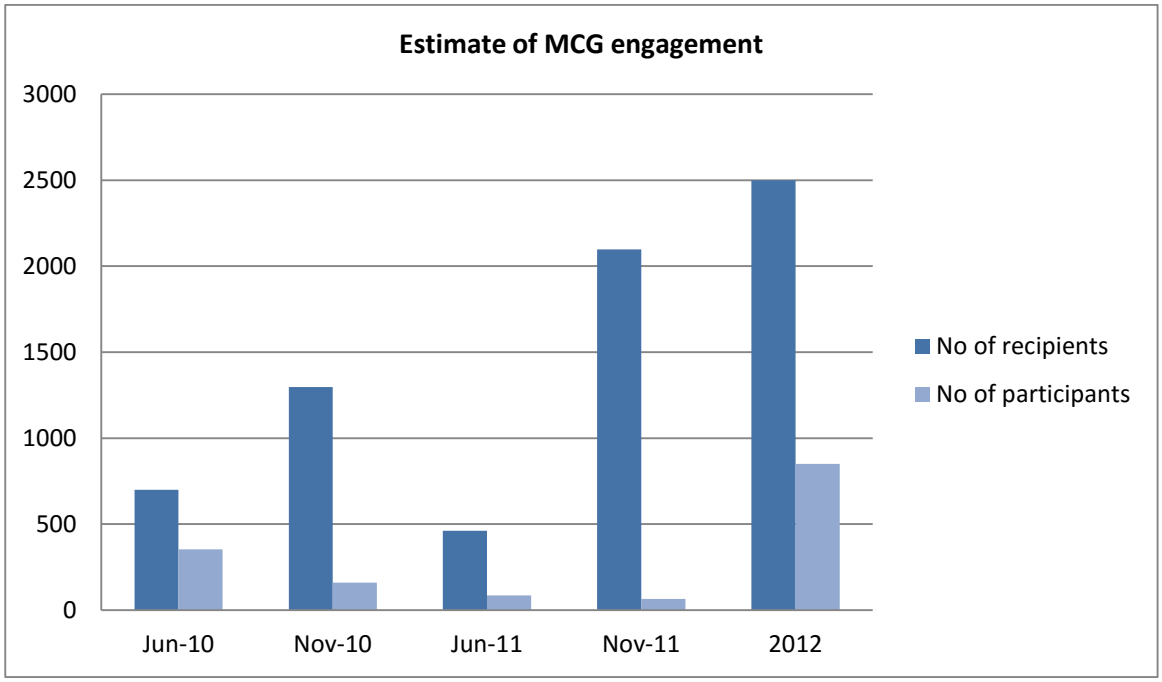


Figure 10. Estimated number of people receiving written material from Molonglo Catchment Group and the number of people participating in workshops and projects for each MER reporting period in 2010 and 2011. The numbers are definitely an underestimate, particularly for participation where often a workshop or school visit was run without recording the number of participants (particularly in 2011).

10.1 WATER ASSET

MCS RESOURCE CONDITION GOAL 2004-2014

Water in rivers, creeks, lakes and wetlands that is above the national standards for healthy ecosystems.

Water bug assemblages in the Molonglo catchment are relatively poor compared with other parts of the Upper Murrumbidgee system, and other streams and rivers in the region (see Figure 7 showing AUSRIVAS assessment of the region summarised from 2003-2010). In the Molonglo sites are rated as significantly or severely impaired compared with reference water bug sites. This was confirmed by the water bug survey reported in the *Upper Murrumbidgee Waterwatch Catchment Health Indicator Program Report Card 2013-14* (O'Reilly, et al., 2014) (see Figure 11).

Water quality has been recently assessed for the Molonglo catchment using Waterwatch data collected by Molonglo catchment volunteers in 2014-15 (O'Reilly, et al., 2015)

Subcatchment	Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
A Upper Molonglo	Molonglo River	MOL1	*	*	*	*	*	*	*	*	*	
A Upper Molonglo	Molonglo River	MOL2	2	3	1	3	3	1	2.17	4	2.78	B-
A Upper Molonglo	Primrose Valley Creek	PRI1	2	5	1	1	3	1	2.17	*	2.17	B+
A Upper Molonglo	Molonglo River incl Plains Ck, Stony Ck & Whiskers Ck	MOL3	2	5	1	1	5	1	2.50	3	2.67	B
A Upper Molonglo	Yandyguinula	YAN1	1	1	1	4	3	1	1.83	*	1.83	A-
A Upper Molonglo	Scabbing Flat Creek	SCA1	*	*	*	*	*	*	*	*	*	
A Upper Molonglo	Molonglo River incl Reedy Creek	MOL4	*	*	*	*	*	*	*	*	*	
A Upper Molonglo	Molonglo River	MOL5	2	3	5	3	3	2	3.00	*	3.00	C+
B Queanbeyan	Queanbeyan River	QUE1	2	2	1	2	3	1	1.83	2	1.89	A-
B Queanbeyan	Burra Creek	BUR1	4	5	5	1	3	1	3.17	2	2.78	B-
B Queanbeyan	Googong Creek	GGG1	2	5	1	1	2	3	2.33	*	2.33	B+
B Queanbeyan	Queanbeyan River	QUE2	3	2	1	1	2	1	1.67	2	1.78	A-
B Queanbeyan	Queanbeyan River including Barracks Flat Creek	QUE3	4	2	1	2	2	2	2.17	2	2.11	B+
B Queanbeyan	Buttles Creek	BTT1	*	*	*	*	*	*	*	*	*	
C Jerrabomberra	Jerrabomberra Creek	JER1	2	3	1	1	*	1	1.60	*	1.60	A
C Jerrabomberra	Jerrabomberra Creek	JER2	3	5	1	2	*	1	2.40	*	2.40	B
C Jerrabomberra	Jerrabomberra Creek	JER3	2	5	5	*	5	1	3.60	4	3.73	C-
D Woolshed	Woolshed Creek	WOO1	2	5	1	1	5	2	2.67	2	2.44	B
E Lake Burley Griffin	Molonglo River	LBG1	2	5	5	1	5	2	3.33	*	3.33	C+
E Lake Burley Griffin	Molonglo River	LBG2	*	*	*	*	*	*	*	*	*	
F Sullivans	Sullivans Creek	SUL1	*	*	*	*	*	*	*	*	*	
F Sullivans	Watson Wetlands	WAT1	2	2	5	1	5	1	2.67	*	2.67	B+
F Sullivans	Dickson Wetlands	DIC1	3	2	1	2	5	1	2.33	*	2.33	B+
F Sullivans	Sullivans Creek	SUL2	*	2	1	*	*	*	1.50	4	2.33	B+
F Sullivans	O Connor Wetlands	SUW1	*	*	*	*	*	*	*	*	*	
F Sullivans	Sullivans Creek	SUL3	2	3	1	5	5	*	3.20	4	3.47	C
G Woden	Yarralumla Creek	YAR1	2	5	5	3	5	1	3.50	4	3.67	C
H Weston	Weston Creek	WES1	*	*	*	*	*	*	*	*	*	
N Lower Molonglo	Molonglo River	MOL6	*	*	*	*	*	*	*	4	4.00	D+

* Insufficient data or intermittent flow

Figure 11 CHiP results for the Molonglo Catchment 2013-14 arranged by order of reaches joining the Molonglo River.

* Insufficient data or intermittent flow

Table 4 Summary of the water quality parameters and the cut-off values between the CHiP score categories. See (O'Reilly, et al., 2014) for further information on how these numbers were sourced and the CHiP methods. These are a higher standard than that set out in the Environment Protection Regulation 2005 which gives pH 6-9, Electrical Conductivity (EC) n/a; Turbidity <30NTU; Dissolved Oxygen > 4mg/L; Total Phosphorus <0.1mg/L; Nitrogen n/a as acceptable standards.

Indicator Rating	Excellent 1	Good 2	Fair 3	Poor 4	Degraded 5	Comment
pH	6 – 7	5.5 – 6 or 7 – 8	8 – 8.5	5 - 5.5 or 8.5 - 9	<5 or >9	
EC (µS)	<=65	<=200	<=350	<=400	>400	
Turbidity (NTU)	<=10	<=12.5	<=15	<=20	>20	
Dissolved oxygen (mg/L)						Not included in CHIP
DO saturation (%)	95 – 105	85 – 95 or 105 – 110	75 – 85	65 – 75 or 115 – 120	<65 or >120	
Total Phosphorus (mg/L)	<0.01	0.01 – 0.02	0.02 – 0.05	0.05 – 0.09	>0.09	
Nitrate (mg/L)	<1.0	1 – 4.9	5 – 9.9	10 – 15	>15	

Indicator Program Report Card 2013-14 (O'Reilly, et al., 2014) for methods of data collection and more detail on the calculation of the CHiP). Raw data is collated for a number of sites within a reach up to twelve sampling points in a year. The median value is then used to assign an indicator rating for each parameter within each reach). From this a combined CHiP score is calculated.

In 2013 a review of the Upper Murrumbidgee Waterwatch data and Catchment Health Indicator Program was undertaken by the Institute of Applied Ecology at Canberra University (Harrison, et al., 2013). It showed that volunteer collected Waterwatch data was well correlated with government employee collected data for Electrical Conductivity, Dissolved Oxygen and pH. However other investigations since this (D Starrs *pers. comm.*) have suggested there may be an issue with older pH meters. Turbidity readings were correlated in their direction of movement in time but volunteer data often appeared to undervalue high 'spike' turbidity events. Total Phosphorus was the parameter for which the report had the least confidence in correlation between volunteers and paid workers. Nitrogen was not compared. Overall the report expressed a high confidence in the use of volunteer collected data particularly for early warning of deterioration in water quality.

CHiP scores for the Molonglo catchment 2013-14 are arranged in Figure 11 from the top of the catchment to the bottom in order of how each creek and stream feeds into the overall system. Unfortunately changes in the CHiP methods over time have meant that it is not possible to compare annual CHiP scores without recalculating all the past scores again, a task that was not possible here.

The data show a clear trend of significantly deteriorating water quality further down the catchment according to the CHiP categories. From this analysis it is simple to identify the reaches within the Molonglo catchment that need to be prioritised for remediation: starting with the worst CHiP value the sub-catchments for prioritisation are the Lower Molonglo below Scrivener Dam; the lower reach of Jerrabomberra Creek; Yarralumla Creek; Lower Sullivans Creek; Lower Upper Molonglo River (between ACT border and Lake Burley Griffin in the Fyshwick area); and Lake Burley Griffin and the drains surrounding it.

It is reassuring to see that these places also line up fairly well with the recently identified priority subcatchments from the ACT Basin Priorities Project currently being undertaken. These are: Upper Molonglo River, Lower Molonglo River, Fyshwick, Lake Tuggeranong, Yarralumla Creek, and West Belconnen/ Riverview.

With the rich data of Figure 11 in front of us it is worth taking a closer look at what is going on in the different sub-catchments across the Molonglo for each of the parameters measured by Waterwatch.

PHOSPHORUS AND TURBIDITY

Nutrients like Phosphorus are bound within soil or sediment particles. This means the movement of Phosphorus through the landscape tends to be linked with soil erosion and sediment transport. In the ACT Phosphorus is often a determining factor in the sorts of planktonic algal activity (Environment and Planning Directorate, 2014). Other possible sources of phosphorus within the catchment include sewerage treatment plants, stormwater drains and fertiliser runoff from agricultural activities (e.g. turf farming).

Turbidity indicates the depth to which light can penetrate the water, affecting plant growth and the kinds of algae present. Turbidity of a water body is related to the concentration of suspended solids but also includes colouration. Canberra has soils with very fine clay particles that can cause high turbidity levels even though the actual amount of material suspended in the water column is not significant. The small clay particles remain suspended in the water long after the heavier sediments have settled on the bottom (Environment and Sustainable Development Directorate, 2013a)

Elevated phosphorus levels occurred in the Upper Molonglo, Sullivans and Yarralumla Creek subcatchments in 2013-14[5], although it should be recalled that Phosphorus was the parameter of least confidence in the *ACT Waterwatch data and catchment health indicator review* (Harrison, et al., 2013). Previous ACT Water Reports have identified elevated Phosphorus levels are of concern right across the Upper Murrumbidgee catchment (Environment and Sustainable Development Directorate, 2013a) and have identified levels above regulation levels in the Molonglo River at Dairy Flat Bridge and in the Queanbeyan River at the ACT Border in 2010-11, and at the Flemington Rd Ponds (at the top of Sullivans Creek) in 2011-12.

Interestingly, elevated Phosphorus was not associated with sub-catchments with high Turbidity levels in 2011-12. Across the Molonglo catchment upper reaches tended to have very good turbidity levels (with the notable exception of Burra Creek), whilst reaches in the middle of the catchment just upstream of Lake Burley Griffin switched to turbidity surpassing regulation limits[6]. The Land Asset section below, on page 74, will discuss raw turbidity data in relation to soil erosion and landscape health in greater detail, to explain

[5] Please note that at the cut-off values indicated in Table 4 the "degraded" category is set at the regulatory standard of 0.1mg/L meaning that there is not a lot of sensitivity to values above this. Consequently sites that are grouped within the "degraded" category are significantly different from each other. For example Sullivans Creek has much higher levels of Phosphorus than are found in the reaches of the Upper Molonglo subcatchment.

This may again be an artefact of the way the "cut-offs" were set in as the "degraded" category was set below the regulatory standard of 30 NTU and is not sensitive to the wide range of values above this. The cut-off values may need to be revisited before the next CHiP report.

that the Phosphorus may be historical and that turbidity levels are currently relatively low in the upper reaches due to several years of good rainfall and better groundcover.

NITROGEN, PH AND CONDUCTIVITY

There is no regulated limit for Nitrogen in the ACT as research into nitrogen-fixing potentially toxic blue green algae suggests that they do best when nitrogen is scarce, so that a small release (for example from sewerage treatment plants) may actually be beneficial (Environment and Sustainable Development Directorate, 2013a). In Figure 11 there is no indication that nitrogen is of concern anywhere in the catchment at present, with the exception of Googong Creek which may be related to the development of Googong township.

Conductivity measures can provide a good indication of the amount of inorganic salts in the water in the absence of any unusual factors. Many cleaning agents, fertilisers and surfaces (paint, concrete, and road surfaces) contain salts, and these salts are washed into streams during rainfall. Salts also come from naturally occurring minerals in the stream bed, (such as limestone) and from soils and can be mobilised by erosion in drought periods (Environment and Sustainable Development Directorate, 2013a) and rising groundwater levels in rainy periods. There are no regulated levels for conductivity in the ACT so identifying whether a particular level should be of concern requires some knowledge of the local background hydrogeological landscape.

Figure 11 suggests that salinity levels may be of some concern across the Molonglo catchment. This is an ever present issue for the region which comes into greater focus when wetter periods raise water tables, bringing salt with them. Figure 12 shows conductivity levels for three of the creeks in the catchment with concerning levels of conductivity. When considered in relation to the major rainfall events, Reedy Creek's conductivity in particular appears to be somewhat coupled to rainfall with conductivity dropping to a minimum after a rainfall (dilution) and then building again as the water percolates to the water table. Woolshed Creek exhibits more of a lag time between rainfall and conductivity, whilst Stony Creek's conductivity does not seem to be related to rainfall at all. Other creeks in the catchment which have had high conductivity over the period of Waterwatch sampling include the Upper Molonglo below Captains Flat, Chimney Creek, Stony Creek and Whiskers Creek in Carwoola, Reedy Creek, Burra Creek, Googong Creek, Jerrabomberra Creek, Woolshed Creek, Molonglo River at Lake Burley Griffin, Sullivans Creek and Yarralumla Creek.

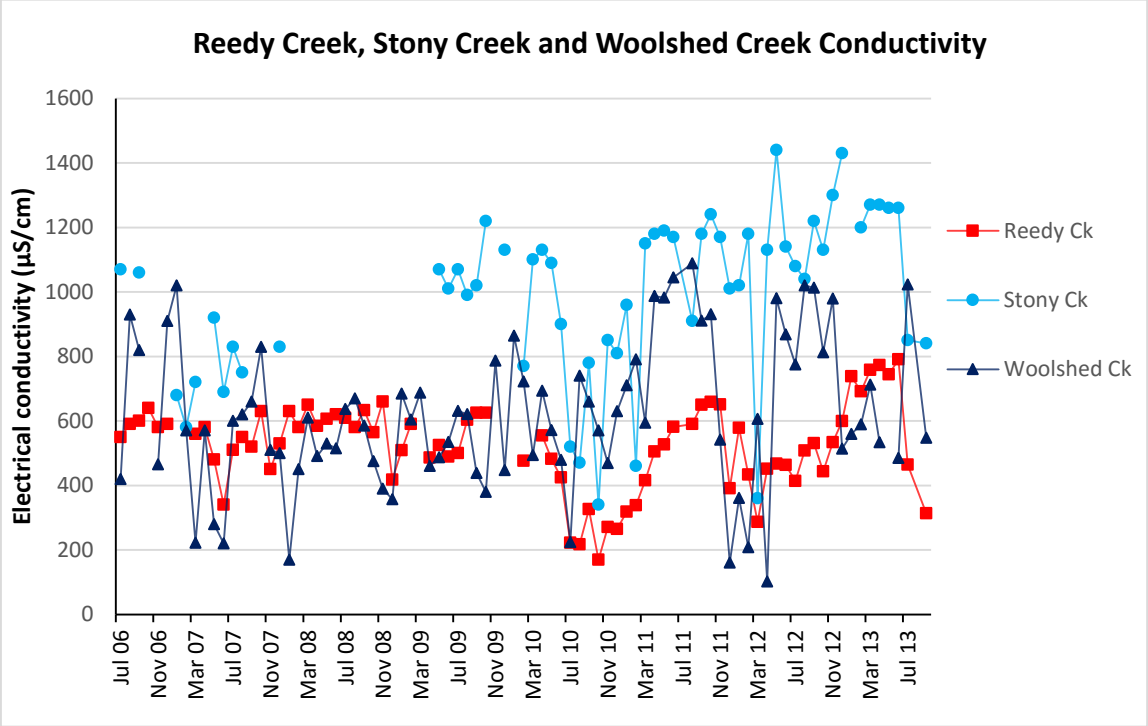


Figure 12 Waterwatch conductivity data for three selected creeks in the Molonglo Catchment. Large rainfall events occurred at Queanbeyan in Feb and Dec 2007; Feb and Dec 2010; Feb and March 2012.

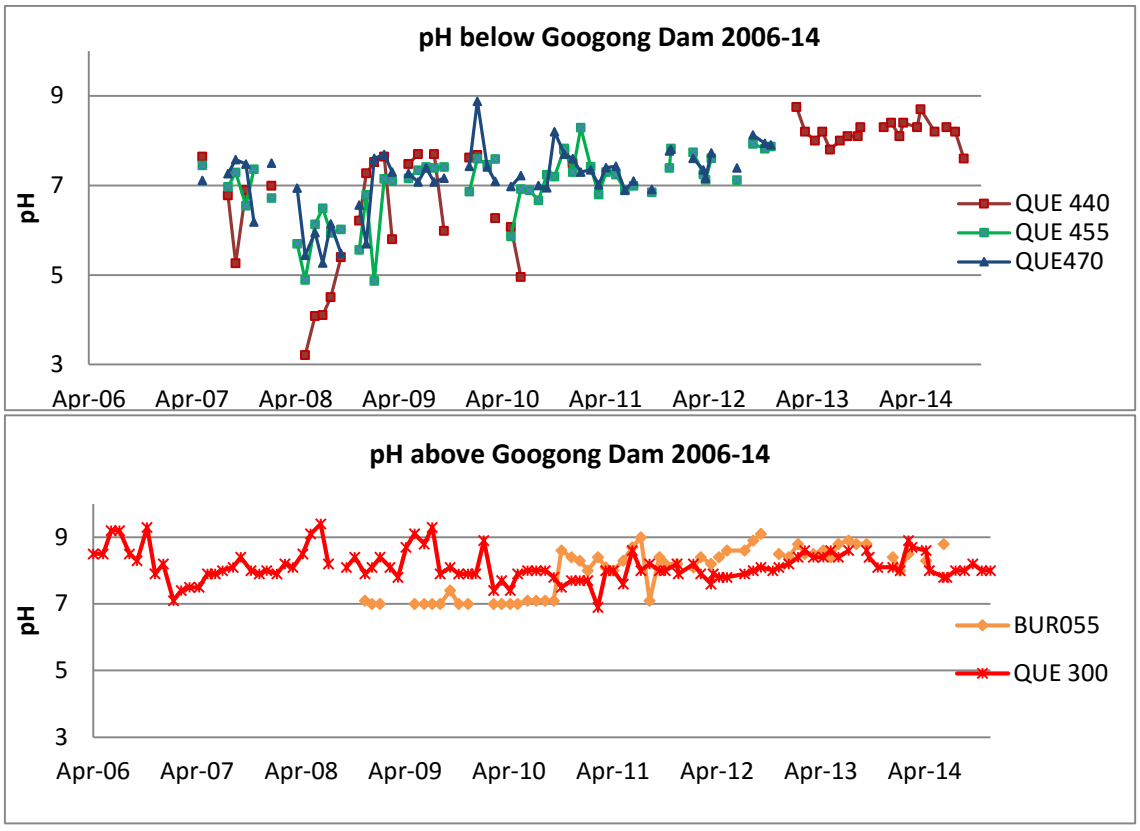


Figure 13. pH measured by Waterwatch above and below Googong Dam.

pH measures the acidity of water, with a measure below seven indicating more acidic conditions. When pH changes it affects chemical processes which may release nutrients or toxic molecules that were previously bound and unavailable.

In Figure 11 the Queanbeyan subcatchment is shown as having some unusually variable pH measures (but recall this is one of the less precise measurements as reported by D. Starrs *pers. comm.*). Figure 13 explores this further by looking at patterns in the fluctuations in pH above and below the Googong Dam. pH values at a number of neighbouring sites below the dam appear to be correlated, which should not be all that surprising. What is surprising is that they are all recording correlated large fluctuations in pH and a gradual increase over the eight years of sampling, arriving at similar levels to above the dam in 2013. One possible explanation is that after the drought finished in 2007 the water in Googong dam had a significantly higher pH than the river below the dam and that over the next seven years with occasional releases from the dam the pH of the water below the dam and above the dam is reaching equilibrium.

DISSOLVED OXYGEN AND MACROINVERTBRATES

Perhaps the most concerning data in Figure 11 is that for dissolved oxygen and macroinvertebrate assemblages. By this measure it appears that the only sub-catchment that has had fairly good values for dissolved oxygen and macroinvertebrates in the past year is the Queanbeyan River subcatchment. We know already that the Queanbeyan River has a long-term relatively depauperate bug community compared with reference sites in the region (see Figure 7 but also Table 5).

These results are most likely due to the loss of native and riparian vegetation in the rural parts of the Molonglo catchment over a long period of time and possibly also longer term lower flow and warmer weather. Fortunately Queanbeyan River still has sections of high quality remnant vegetation including riparian. Its continuing relative good health is testament to the importance of the thick buffer of native vegetation just upstream of Queanbeyan city. Without this it is unlikely that we would continue to see platypus and native water rats in the middle of town.

On the Molonglo River the history of rural clearing and erosion is slightly longer and there is less remnant vegetation remaining, although again the Molonglo Gorge plays an important filtering role in this respect. Another reason for poorer water quality is the Captains Flat mine, situated near the top of the Molonglo.The mine has had a large historical effect from which the river will take a long time to recover.

Elsewhere in the catchment Woolshed Creek offers inspiration; despite low dissolved oxygen measures for the area and its proximity to the city of Canberra there was a good bug score. Again the percentage of good native riparian vegetation is probably the reason that this Creek continues to support a healthy ecosystem.

In the longer term there is some evidence that the recent wetter years are improving things for the macroinvertebrate communities in the Molonglo catchment. Table 5 shows that for Molonglo and Queanbeyan rivers and Jerrabomberra creek AUSRIVAS assessment in the past few years have been stable or improved compared with the long-term trend.

HEALTH OF LAKE BURLEY GRIFFIN

From 2005 water quality in Lake Burley Griffin has trended towards a higher number of blue-green algae break-outs and Lake closures after a relatively stable period of time following the upgrade to the Queanbeyan sewage works in the 1980s (Figure 14 & Figure 15).

SUMMARY WATER ASSET CONDITION

Unfortunately water quality in the Molonglo catchment will provide us with a continuing challenge in the next few years. Given the number of Waterwatch parameters for which the “degraded” class was applied (and the regulated standard was sometimes below this) it would be hard to argue that water quality in the Molonglo Catchment is above the standard for healthy ecosystems.

We do however know what needs to be targeted in each sub-catchment and what is working. Low levels of dissolved oxygen and high conductivity right across the Catchment are of concern and we need to understand better what is driving these two parameters. Hydrogeological data will help with piecing together any rising salinity story, and we need to look more closely at the data on dissolved oxygen for where and when the values are better to try to understand what we can do to improve it.

The Upper Molonglo has particularly high conductivity readings and has a history of turbidity particularly in drier times. It may be that current higher Phosphorus levels are a legacy of past erosion events. Dissolved oxygen and the macroinvertebrate community are more concerning than they should be this high in the catchment but there may be an ongoing legacy of the Captains Flat mine. Reedy Creek had no data in recent times but historically has some high EC readings.

The Queanbeyan River is currently enjoying quite good water quality, with the exception of Burra Creek which continues to indicate active erosion through high turbidity, despite the relatively wet years we have had. We identified some strong fluctuations in pH particularly below the Googong Dam and have suggested that the water below the dam is gradually equilibrating its pH with the water above the dam after dry years with little flow. The impact of this fluctuating environment is unclear – for now at least it seems that the macroinvertebrate communities in this subcatchment are among the healthiest in the whole catchment.

Jerrabomberra Creek is doing fairly well in the upper reaches (though it would be nice to add bug data to this picture). However the CHiP for the lower reach is the second worst for the whole Catchment. Conductivity is high, turbidity is high, dissolved oxygen is low and the macroinvertebrate community is very degraded. This area includes Kellys Swamp adjacent to the Jerrabomberra wetlands and was once a key food bowl to the region. It will probably need a whole of catchment approach to repair to be able to have an impact.

Woolshed Creek continues to concern its residents with high conductivity readings and it is hoped that new information, soon to be released, about the hydrogeological landscape underlying the Majura Valley will help identify ways to improve this situation, as well as follow up on reported drops in water levels in 2014. We will also be looking to identify what is working in Majura Valley to support a good bug community, despite poor dissolved oxygen levels.

Sullivans Creek has the first signs that urban water quality can be improved via the promising water quality in its constructed wetlands, and excellent turbidity results even at the bottom of the catchment.

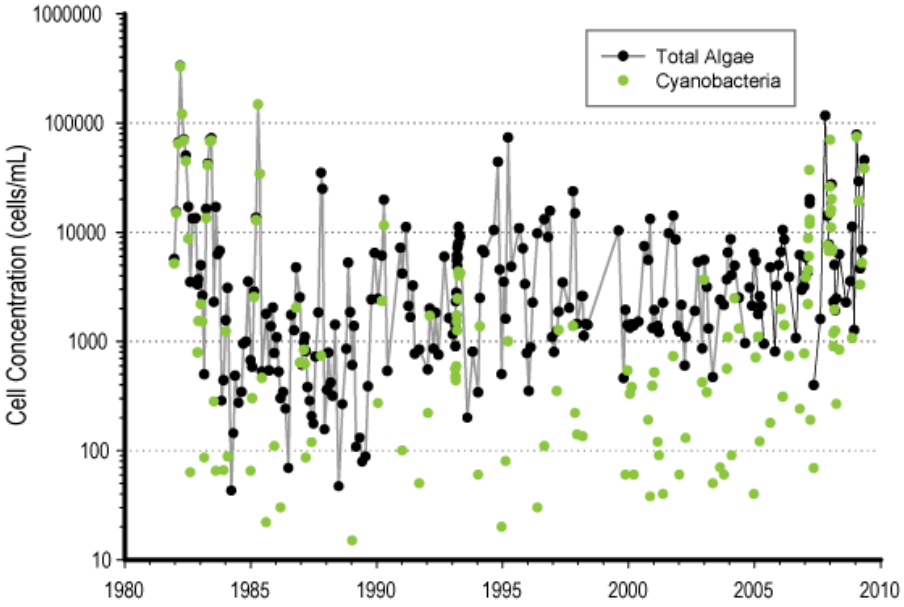


Figure 14 Lake Burley Griffin West Lake (Site 504 tube) Total Algae and Cyanobacteria 1981 – 2009. A general decrease in cyanobacteria can be observed following the upgrade to the Queanbeyan sewage treatment plant in the 1980s, however levels are again increasing. In 2010 the cyanobacterial (blue green algal) guideline for lake closure to body contact water sports was increased from 20,000 to 50,000 cells/ml.

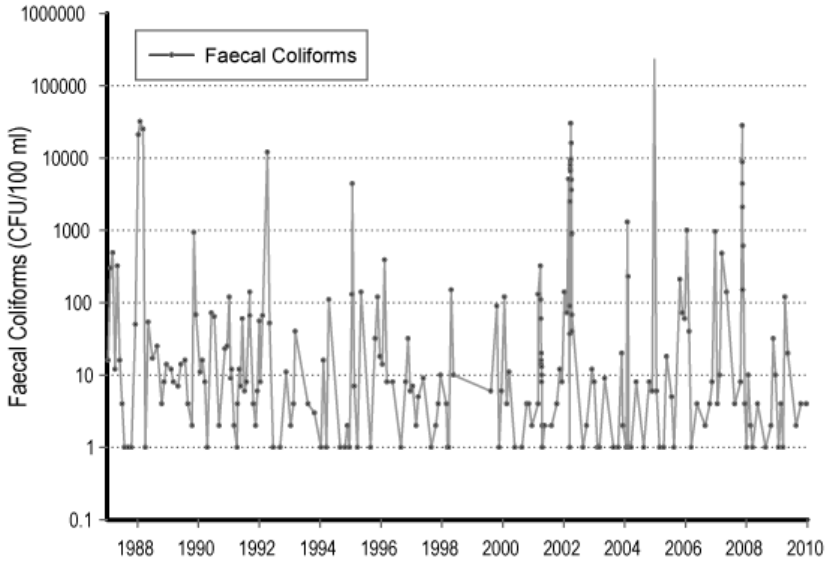


Figure 15 Lake Burley Griffin West Lake (Site 504 tube) Faecal Coliforms 1987 – 2009. In 2010 the guidelines for lake closure to body contact water sports were increased from 35 cfu/100ml enterococci, to 200 cfu/100ml. Source for Figures 16 & 17: Lake Burley Griffin Quality Management Plan 2011.

Table 5 a. AUSRIVAS classifications for assessment of aquatic condition. B. Summary of AUSRIVAS assessment for the Molonglo and Queanbeyan Rivers compared with reference rivers. Source: ACT State of Environment Report 2011 and ACT Water Report 2011-12

Band	Condition	Taxa interpretations
X	More Biologically Diverse than Reference	More families found than expected Potential biodiversity 'hotspot' Loss of pollution tolerant taxa
A	Similar to Reference	Expected number of families
B	Significantly Impaired	Fewer families than expected - Potential impact on aquatic condition or riparian zone (habitat) resulting in a loss of families
C	Severely Impaired	Many fewer families than expected - Loss of families from substantial degradation of the aquatic condition and riparian habitat
D	Extremely Impaired	Few of the expected families - pollution tolerant families remain

Site Name	Spring 05	Autumn 06	Spring 06	Autumn 07	Spring 07	Autumn 08	Spring 08	Autumn 09	Spring 09	Autumn 10	Spring 10	Autumn 11	Spring 11	Autumn 12
Murrumbidgee River at Angle Crossing	B	B	C	A	B	A	A	A	B	A	B	B	B	B
Tidbinbilla River at Paddys River Road	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Paddys River at Murray's Corner	A	B	B	B	B	A	B	A	C	A	A	A	A	A
Molonglo River at Yass Road	B	B	B	B	D	B	A	B	C	B	C	C	C	B
Queanbeyan River at ACT border	C	C	C	C	C	C	D	C	B	C	C	B	B	B
Jerrabomberra Creek at Hindmarsh Drive	D	B	B	C	B	C	C	B	C	C	D	B	B	B

Phosphorus continues to be the major challenge for this subcatchment, as well as understanding how we can improve dissolved oxygen and encourage more macroinvertebrates to feel at home.

Lake Burley Griffin foreshores, Yarralumla and Weston Creeks being at the lower end of a by now very urbanised catchment have some of the poorest water quality of the catchment with conductivity, turbidity, phosphorus levels, poor dissolved oxygen levels and bug communities of limited diversity, all requiring attention.

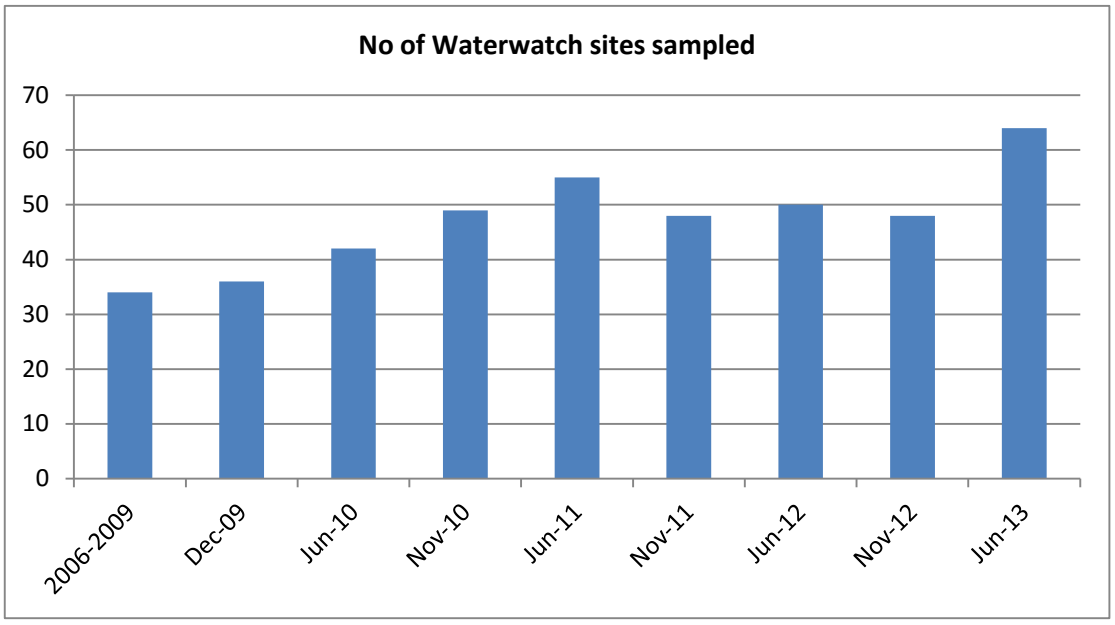
Finally, the Lower Molonglo sub-catchment needs Waterwatchers to let us know how it's going! This year we already have two new Waterwatchers in this reach and hope to improve our knowledge of the area as it becomes the focus for new housing development and a new national park. Bug data is also not looking too healthy here.

MCS COMMUNITY GOAL 2005

A collaborative and coordinated approach to benchmarking surface and groundwater quality in the catchment. Sustained community involvement in water quality monitoring to assess catchment health.

The crowning achievement for the water related activities of the Molonglo Catchment Group must be its very successful Waterwatch program which started in 2005. By 2006 Waterwatch had 25 sites, and by 2013 there were 64 sites monitored regularly (Figure 16). In 2014 there are now 56 sites but rapidly growing again. The importance of the Waterwatch program is realised in two key aspects: data for monitoring the state of the catchment and educating/reporting. Waterwatch is a key engagement strategy with its success indicated by the number of people involved over seven years and the depth of their involvement. This represents a clear achievement of the MCS Community Goal 2005.

Figure 16 No of Waterwatch sites sampled regularly during each MER reporting period for the MCG.



The map series that was envisaged by the MCS 2004-24 has been not been realised in quite the way envisioned, however the MCG's GIS capacity has been vastly improved in the past twelve months by signing a data access agreement with the ACT government and staff receiving training in ArcGIS.

A significant planning achievement was reached in completing the *Molonglo River Rescue Action Plan 2010* (Bowman & Keyzer, 2010) which identifies priority reaches for on-ground work along the Molonglo River itself.

Of late the MCG's role in educating the community about environmental flows, water sensitive urban design and the sustainable use of water has taken more of a backseat. However, with the focus on Lake Burley Griffin in the 2015 Aspirational Goals and the targets set for the urban catchments this area is likely to have more prominence in future.

Another significant achievement in the on-ground works area is the development of a number of urban wetlands.

10.2 LAND ASSET

MCS RESOURCE CONDITION GOAL 2005

Grazing management that excludes stock from riparian areas, maintains groundcover and makes best use of holistic farm management principles

One way to look at this resource condition goal is to look at turbidity of rivers, this being the condition that the maintenance of groundcover will ultimately affect. In the previous section we reported that 2013-14 was a relatively good year for turbidity with measures being excellent for most of the upper reaches. However, Phosphorus remains at raised levels throughout the catchment. Increasing salinity could also be playing a part in that more saline waters can bind particles making them heavier and causing them to drop out of the water column.

Figure 17 gives the Waterwatch data from 2006 to 2014 and shows that whilst there were few turbidity events in the upper half of the catchment in 2013-14 there are quite large events in the recent history of the upper reaches. In 2006 the region was at the end of a bad drought and it is possible to see multiple erosion events at Tinderry Creek, Chimney Creek, Reedy Creek and Woolshed creek from this time. All of these are in a landscape of working farms and it is easy to imagine how lack of groundcover could lead to this. It is also apparent from the figure that once the rains broke and plants were re-established the turbidity events in most of these landscapes have ceased.

Not so for the rural residential areas: Burra and Chimney Creek have on-going turbidity events, which suggest that erosion in these areas is on-going (perhaps heavier traffic in these areas is producing dust from adjacent gravel roads?). Reedy Creek whilst being in a farming area also appears to have an erosion problem to be targeted.

In the urban catchments there are particular areas for concern in the Yarralumla sub-catchment where O'Malley pond has been constructed. In recent years there has been a lot of building in the area. The lower Molonglo as another area of new housing development would be a place to aim to minimize turbidity events.

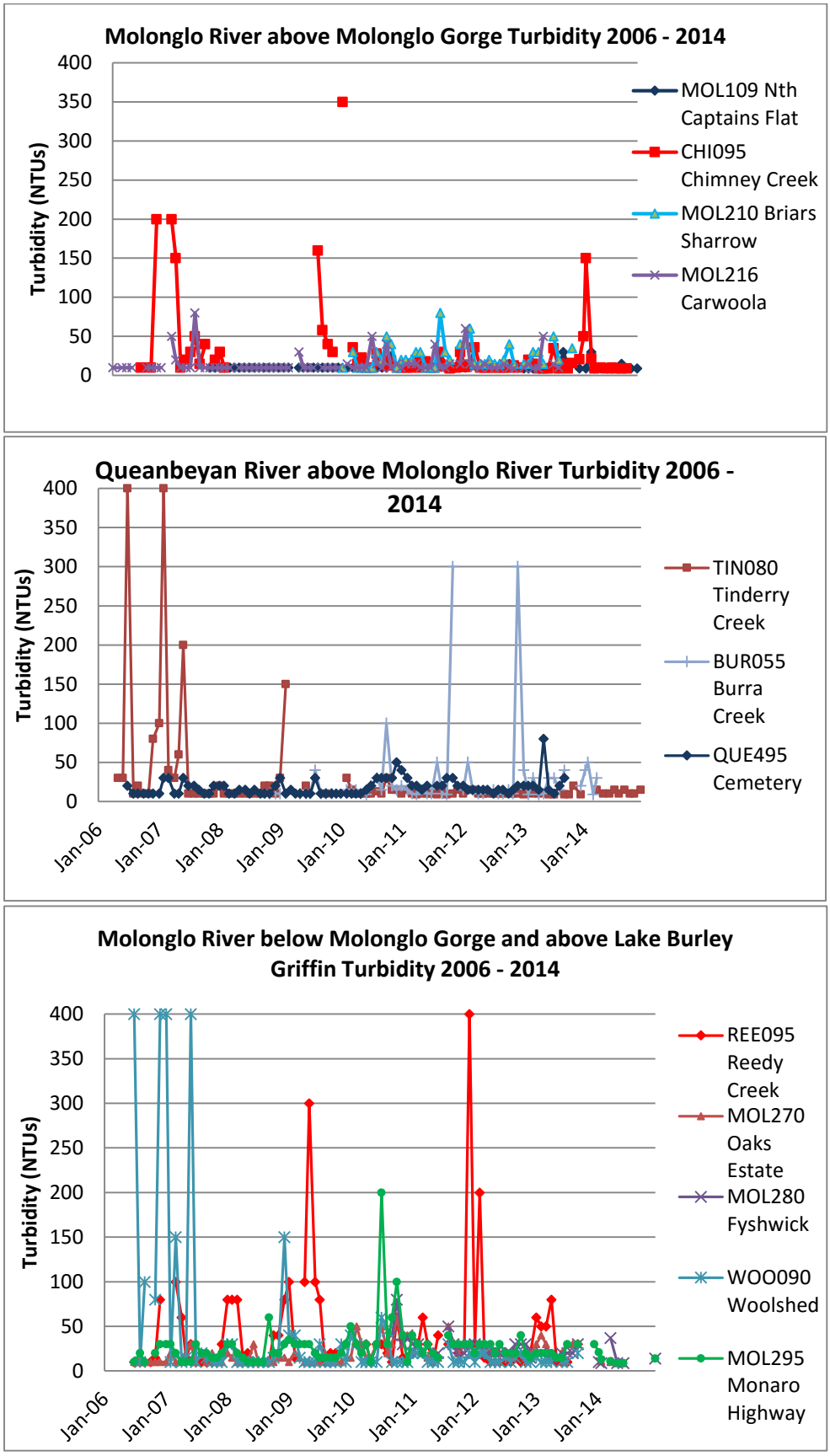


Figure 17 Turbidity on the Queanbeyan and Upper Molonglo 2006 to 2014.

MCS COMMUNITY GOAL 2005

Community involvement in riparian protection, rehabilitation and identification of soil erosion hotspots

This is an area where MCG undertook a fair amount of work in the 2006-2009 period and partnered the Molonglo River Rescue Demonstration Reach in 2010-11. This area has received less emphasis in more recent years (a response of the funding availability), with the significant exception of the Sustainable Horse Management workshops and Pro-Graze (2006).

A key Action that was not achieved was the Erosion Hazard map series for the sub-catchments of the Molonglo.

The MCG has made progress against this MCS Community Goal but perhaps not as much as for the other assets.

10.3 BIODIVERSITY ASSET

MCS RESOURCE CONDITION GOAL 2005

Land and water environments that are rich in species diversity and self-sustaining with a good quality range of amenable habitats

ACT

In the ACT the bulk of available data on biodiversity is targeted at matters of national environmental significance, which include threatened species and ecological communities, threatening processes and pest plant and animal species. The *ACT State of the Environment Report 2011* (Office of the Commissioner for Sustainability and the Environment, 2011) noted that there was a need to capture more information on the distribution and abundance of native fauna and flora, and that regular monitoring of the extent and condition of native vegetation would be valuable although resource intensive. Since this time ACTmapi has expanded to make available layers displaying threatened plants, lowland woodland, endangered ecological community woodland, natural temperate grassland, general vegetation map, threatened fish, invertebrate, reptile and amphibian habitat, as well as various woodland connectivity layers. Bird data is available on the Canberra Ornithologists website.

The story for Yellow Box Red Gum grassy woodland appears to be quite a good one although it can be quite difficult to match up the exact communities and different mapping techniques of different studies. In Figure 18 it can be seen that the mapped area of this ecological community, and that of lowland woodlands as a whole, has actually been increasing for the past decade – partly due to better mapping, but also due to some recovery of the community. There is still a high proportion of substantially to severely modified lowland woodland, but this could also be seen as an opportunity to restore more of the original extent of those woodlands (Figure 19). It is thought that in 2002 25% of the pre-1750 extent of Yellow-Box-Red Gum Grassy woodland remained in varying condition. (Fallding, 2002).

The area of lowland grassland in the ACT has remained steady for the past decade at around 1,000 ha and as can be seen in Figure 20. Some of these areas are in poor condition. Table 6 gives an indication of the

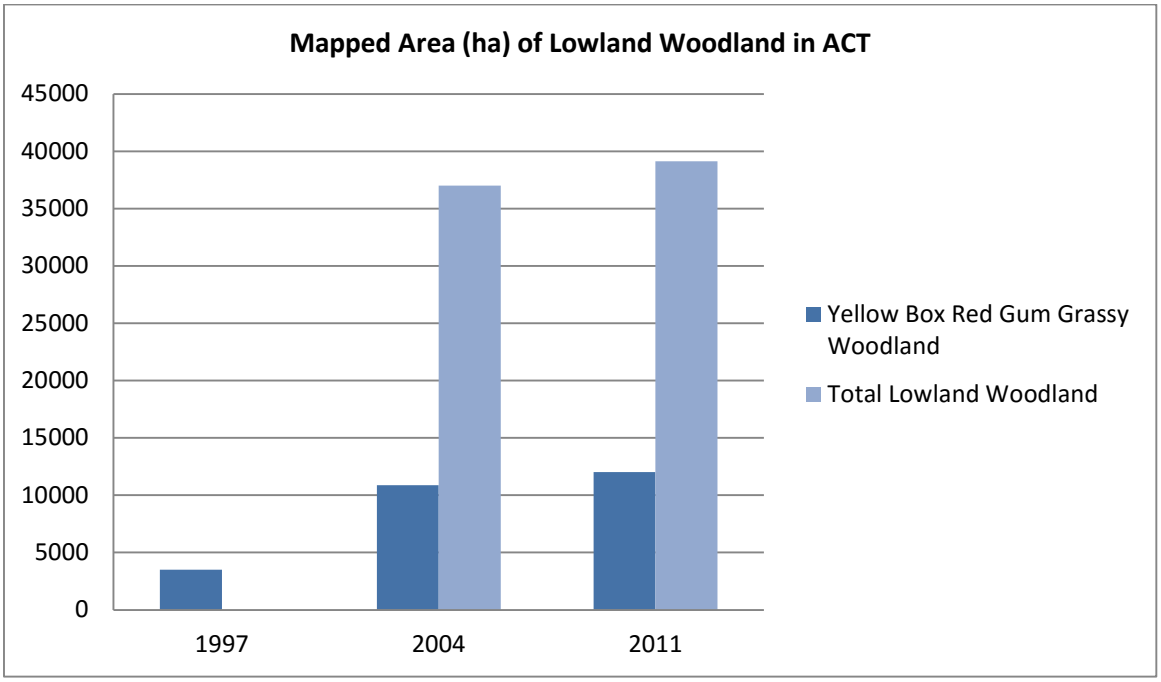


Figure 18 shows the area of woodland (Total and Yellow Box Red Gum Grassy Woodland) in the ACT reported through time with map precision presumably improving as well as some recovery of woodland on the ground. Source: ACT State of the Environment Report (2000) and (2011); Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy (2004). Please note the difficulty in comparing numbers between reports e.g. SoE 2011 also gives Total Lowland Woodland as 51,000 ha but is supposed to be based on the 2004 numbers which seems incongruous.

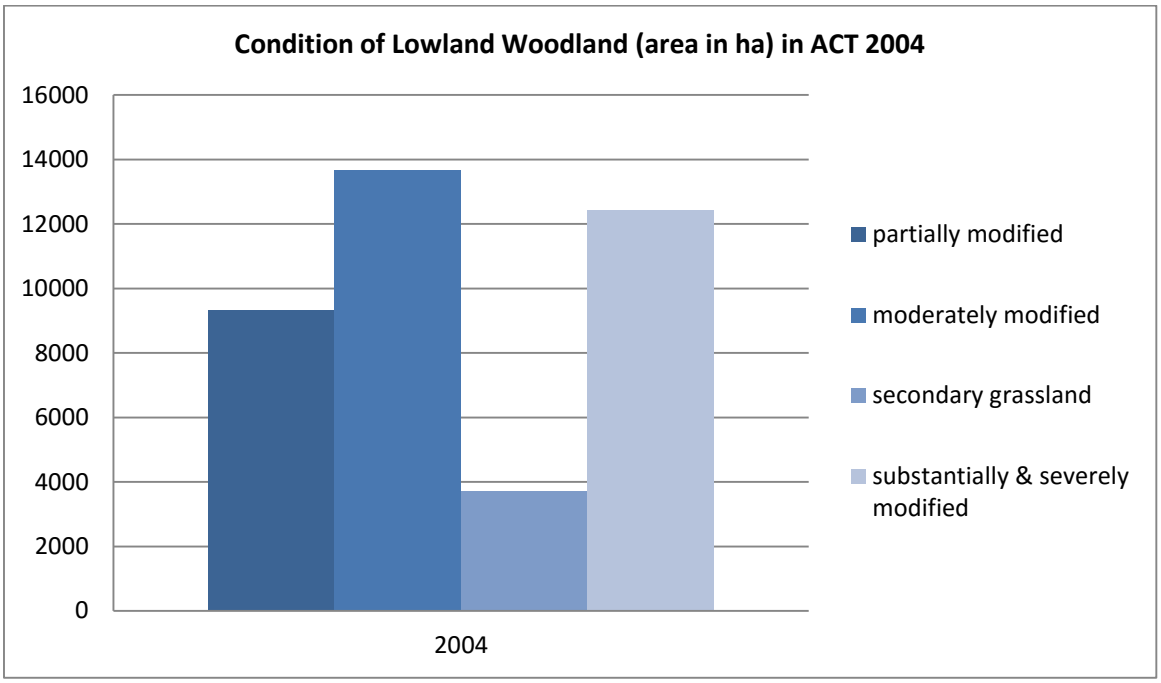


Figure 19 Condition of Lowland woodland in the ACT in 2004 Source: PCL in ACT State of the Environment Report 2011.

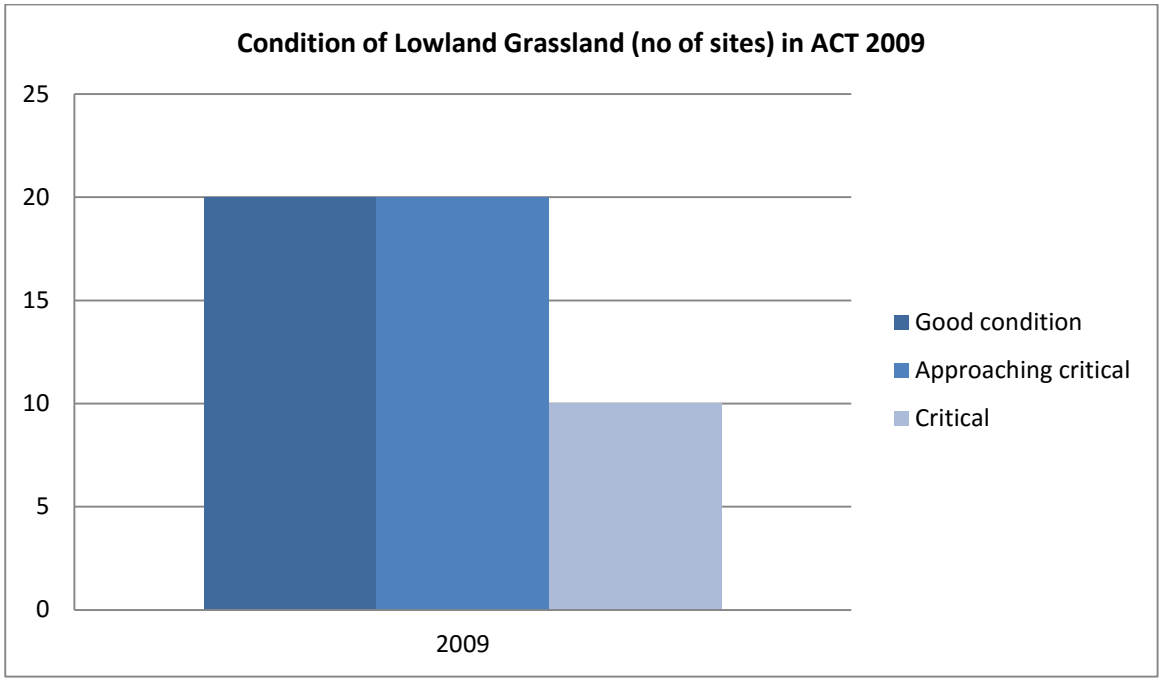


Figure 20 Condition of Lowland Grassland Sites in the ACT in 2009. Source: Report on ACT Lowland Native Grassland Investigation 2009 reported in ACT State of the Environment Report 2011.

*Table 6 Condition of Reserves within the Canberra Nature Park in 2011. * Denotes Reserves that are at least partially in the Molonglo catchment. Source: ACT State of the Environment 2011*

Reserve Condition	Number of Reserves	Names of those with >20% area in critical condition
Satisfactory	28	Callum Brae* Gungaderra Kinlyside Tuggeranong Hill Wanniassa Hills* West Jerrabomberra*
Approaching a critical condition	6	Googong Foreshores* Goorooyarroo* Mulligans Flat Red Hill*
Critical condition	1	Mt Painter*

reserves within Canberra Nature Park which are in satisfactory and critical conditions, as an indication of where future effort might be targeted.

15 fauna species are listed as vulnerable and 9 as endangered in the ACT. These include 3 species listed fairly recently: the Little Eagle, the Glossy Black Cockatoo and the Pink-tailed worm lizard (Office of the Commissioner for Sustainability and the Environment, 2011). The Northern Corroboree Frog and the Grassland Earless Dragon continue to face the real risk of extinction. There is no census of native vertebrates in the ACT.

By contrast, there is a census of native plants in the ACT which has recorded 1655 native and introduced species. A total of 8 plant species are listed as threatened in the ACT and a further six predicted to occur in

the ACT are listed nationally. In 2011 the shrub *Bossiaea grayi* was being assessed for listing as a threatened species. Many of these species are small-ranged endemic species, often with sporadic growth and flowering habits which make them difficult to monitor.

NSW

Sources of information on the status of biodiversity in the NSW part of the Molonglo catchment are difficult to collate because the area of reporting is often much larger than the area of the Molonglo catchment (e.g. NSW State of the Catchment – Murrumbidgee (Department of Environment, Climate Change and Water, 2010)) or very data poor (e.g. Regional State of the Environment Report 2004-2009 Palerang Council (Office of the Commissioner for Sustainablity and the Environment, 2009)).

One source of information for the Molonglo catchment region can be found in (Fallding, 2002) *A Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* (see Appendix 3: Threatened and important species and endangered ecological communities), however a number of additional ecological communities and species have been listed as threatened since this time. This report covered seven local government areas at the time: Goulburn, Gunning, Mulwaree, Queanbeyan, Yarrowlumla, Yass and part of Cooma-Monaro as well as the ACT (a number of these local government areas have since been amalgamated). Other key sources of information for native fauna and flora distributions includes the ACTmapi website, the Canberra Nature Map, the NSW Atlas of Wildlife, Canberra Birds website and the Atlas of Living Australia.

Table 7 After (Fallding, 2002), shows approximate pre 1750 and 2000 distribution of the major vegetation types across the Southern Tablelands of NSW and the ACT.

	Native Grassland	Grassland-Woodland Mosaic	Box-Gum Woodland	Dry Forest	Wet Forest	Riparian Forest	Heathland-Shrubland-Herbfield-Rock	Waterbodies-Wetlands	Other (pasture, cultivation, urban, pine forest)
Proportion of Region pre-1750	11%	11%	23%	38%	14%	1%	1%	1%	0%
Proportion of Region 2000	1%	3%	9%	21%	12%	0.5%	1%	1%	40%

In this area the Framework reports the broad native vegetation types that remain within the region and their approximate proportions (see Table 7). Of these the first three have been most severely impacted on with an estimated 90% of the Yellow-Box- Red Gum Grassy Woodland cleared from the region. 3% of the area thought to have contained Natural Temperate Grassland prior to 1750 currently exists in moderate to good condition (Fallding, 2002).

MCS COMMUNITY GOAL 2005

A catchment community that is aware of the value of a biodiverse environment, who strive for habitat protection, work towards eradicating pests and integrate biodiversity considerations into future planning to minimise threats

Biodiversity is the asset that has shown the greatest growth in activity during the period of the MCS 2004-24. This is partly due to branding. Investment priorities set by the Federal and State governments that improve riparian condition, remove willow or control erosion that previously may have been placed under the Land and/or Water assets are now appearing as Biodiversity projects.

However, there has clearly also been a growth in core biodiversity projects including the management of remnant vegetation, and the biodiversity of native woodlands and grasslands. In the Action sphere Weeds have consistently been the main focus. This mirrors their importance as a community NRM priority both in 2005 and 2015, with projects on both weeds and feral animals attracting strong community support.

Data collection and analysis has perhaps suffered more than other priorities with a grassland revegetation and management trial still outstanding and the project of mapping weeds being abandoned due to their distribution moving too much from year to year. Although recently, the MCG has partnered with the ACT Government and the Atlas of Living Australia in the development of a web portal and associated smart phone weed mapping application – Weed Spotter.

Progress has been made in planning for biodiversity over the seven year period of the MCS. For example, the production of the Lake Burley Griffin Willow Management Plan, and some cross-property feral/weed management plans were developed for grazing properties. Much of the connectivity issues were in effect delegated to the Kosciuszko to Coast Partnership (K2C) from 2006 onwards. Nevertheless, a large connectivity project is being developed between Melrose Valley and Jerrabomberra as a pilot to look at how to integrate connectivity planning, council economic strategies, Aboriginal landscape interpretation and management, threatened species recovery and water quality improvement, with a view to extending this approach across the Molonglo catchment.

As suggested in the general comments on the performance indicators, there is good evidence from the community survey that community members are becoming more aware of the value and importance of a biodiverse environment. That seems to be, in part, due to the greater emphasis by the MCG and K2C on this part of the program and the funding strategy of the various agencies.

A large proportion of the on-ground work done by the MCG and its member groups is in the work of eradicating pests so it seems that the MCG has also made good progress against this MCS Community Goal. It is difficult to judge from these Performance Indicators just how well the MCG has been able to achieve better consideration of biodiversity into future planning in order to minimise threats.

10.4 COMMUNITY

MCS COMMUNITY GOAL 2005

A catchment community armed with the knowledge to make justifiable decisions, who are prepared and willing to think regionally, act locally and promote the Landcare ethic.

This is another very active sphere for the MCG with many core activities undertaken as would be expected for a coordinating group.

There is a significant role for the MCG in planning how community engagement can take place in the most effective manner. This was done early in the life of the Strategy via a Media Engagement Plan and continuously ever since through involvement in cross-stakeholder planning and funding negotiations and collaborations. The MCG website has proved to be a valuable source of information for the catchment community and wider – it is frequently used as a source of information for tertiary studies for example. It may be useful now to consider a new proactive Communications and Engagement strategy for the next phase of the Molonglo Catchment Strategy with specific indicators for effectiveness of community engagement (e.g. follow-up surveys done after the Sustainable Horse Management workshops) rather than level of activity (see MCS 2015 Part 3 & 4).

Beyond this the Community sphere is where the MCG takes on its very important role as an umbrella and support group for a number of other community organisations. This is a role it continues to play well given the number of groups engaged with. The Coordinator also has a number of tasks required as part of funding agreements including ongoing monitoring and reporting, assisting the development of funding applications by member groups, attending stakeholder meetings, developing MOUs and coordinating volunteers.

It seems very likely from the engagement statistics quoted at the beginning of this section that there is a segment of the catchment community who the MCG has armed with knowledge to think regionally and act locally with the Landcare ethic. It is difficult to determine from these Performance Indicators how large a proportion of the community this is and whether the MCG has made significant inroads compared with prior to the MCS 2004-24, however anecdotally long-standing members of the MCG committee report that community attitudes towards the environment have changed radically since the inception of the MCG.

10.5 OVERALL PROGRESS TOWARDS 2005 GOALS

The Aspirational Goals of the MCS 2004-24 were as follows:

1. A healthy environment;
2. Sustainable economic use of natural resources;
3. Cohesive, innovative communities;
4. Partnerships between community and government.

Progress towards these goals is not easily measured but we have used some broad indicators as a proxy for measurement of progress. The MCG can count amongst its achievements between 2005 and 2015:

1. Contributing towards a more collaborative and coordinated approach to the management of surface and groundwater quality in the Molonglo catchment by various stakeholders.
2. A sustained community involvement in water quality monitoring to assess catchment health.
3. Community involvement in riparian protection, rehabilitation and identification of soil erosion hotspots.
4. A significant portion of the catchment community that is aware of the value of a biodiverse environment and who work hard to eradicate pests and protect habitat.
5. A significant portion of the catchment community who have been armed with knowledge to think regionally, act locally and promote the Landcare ethic.

PART 4. THE MOLONGLO CATCHMENT STRATEGY 2015

This section begins with a statement of the Vision for the MCS 2015, and the Aspirational Goals. It then proposes a model to create the change the MCG is seeking. The MCG will use this model to underpin its program of actions and activities in this Strategy. Being explicit about this theory of change will make it easier to evaluate in the future why the group has been successful or unsuccessful in reaching its aspirational goals and long-term outcomes. It will then be possible to modify future strategies in response to this information.

The program for the next five to ten years of the MCS is then presented. It identifies specific targets and data sources for measuring these.

11 EVOLUTION OF THE MCS VISION

In 2015 the initial list of aspirational goals identified by the MCG committee, from their 2013 catchment strategy revision workshop, included the following:

- Stabilize rural residential development – aiming for less energy expensive development.
- Conserve farmland – valued for what it produces, for sustainable stewardship of land and for its proximity to Canberra (lower transport/energy costs).
- Integrated pest management – building on work already done and adjusting to the implications of climate change and increased connectivity.
- Healthy Lake Burley Griffin – building on the significant community desire for recreation on the lake, work to reverse the conditions which lead to algal blooms which could be achieved with several decades of good management – what goes into the drain must be clean.
- Maintain the overall bush setting and diverse landscape.
- Educating the public in sustainability thinking by making their relationship to the environment personal, aiming for greater value to be placed on ecosystem services, connectivity and appreciating complexity and 'messiness' in habitat conservation.
- Managing bushfires with increasing frequency to 2050 then predicted to decrease – will this produce a completely different vegetation distribution?

Key drivers in the foreseeable future were identified as: population increase and then stabilization; improvements in house and development design, the need to live as much as we can within the means of our own catchment (food, water, resources); the need to continue to manage 'pest' species; increasing bushfire pressures and the development of new economic models that put a greater value on natural assets, acknowledge ecosystem services and aim to achieve sustainability.

Next the committee discussed a vision statement proposed in a brief review of the MCS 2004-24 undertaken in 2008 by the Catchment Coordinator Andrew Westcott. This was adopted as the Molonglo Catchment Strategy vision 2015:

"A healthy and sustainable environment treasured by the entire catchment community"

Four aspirational goals drawn from the list, presented in section 10.5, above, were then prioritised under this overall vision:

1. *Community that understands and values the local and broader environment,*
2. *NRM based on an integration of western science and Aboriginal knowledge*
3. *A connected, diverse, healthy landscape and sustainable food supply.*
4. *A healthy Lake Burley Griffin.*

12 THE MCG'S THEORY OF CHANGE AND ACTION

12.1 USING PROGRAM LOGIC TO DEVELOP THE MCS 2015

The development of the resilience models of the Molonglo catchment is not only an important conceptual tool but equally an important process for developing a shared understanding of the catchment at these scales that members and partners of the Molonglo Catchment Group can 'own'.

For the MCS 2015 the broader community views and priorities were brought into the conversation by a committee member specifically charged with making sure the perspectives of the two community consultations were reflected in the resultant models. Ideally, next time all of this would be undertaken as part of community consultation, including developing shared sub-catchment models to be fed into an overarching Molonglo catchment model. In this way the model encapsulates more perspectives and generates even wider ownership.

The development of the alternative state models of the history of the Molonglo catchment was used in the 2013 committee workshop as a visioning exercise in order to determine not only where we have come from, but also where we want to be (see Figure 8). This led to four Aspirational Goals (above) and the development of the MCG strategy for the next 15 years, undertaken as a participatory process using Program Logic at that meeting, and several subsequent committee meetings.

Program logic is an element of the evaluation process in the Australian Federal Government's NRM MERI (Monitoring, Evaluation, Reporting and Improvement) framework and is increasingly required as part of any government sourced funding. Program logic is an approach to program planning that captures the rationale behind a program and the anticipated cause-and-effect relationships between program activities, outputs, intermediate outcomes and longer-term desired outcomes. It can be represented as a diagram that shows a series of expected consequences, not just a sequence of events (Roughley, 2009).

Key steps in the building of a program logic include scoping; developing an outcomes hierarchy; articulating and documenting assumptions; and formulating evaluation questions and audiences. We were able to get the first two of these steps done in the committee meeting, review them in a second meeting, and then the remaining steps were circulated for comment to the MCG and other stakeholders.

There are risks to the use of program logic theory. It can produce an incomplete or distorted view of what is happening and mistaken judgements about what is effective or efficient. It can silence voices or fail to speak to those who can act upon it. It can take up time without adding value. The key to the best use of

program logic is to make it 'purposeful' by making a thoughtful assessment of the circumstances to which it is to be applied and to avoid a 'one-size-fits-all' approach (Funnell & Rogers, 2011).

In this context the MCG has learnt by implementation and will go on learning about how best to apply the program logic approach to planning and evaluation over the coming years. The MCS 2015 represents another stage in the evolution of this approach.

12.2 PROGRAM THEORY: THEORY OF CHANGE AND THEORY OF ACTION

A program theory explains how a strategy or other initiative contributes to a chain of intermediate results and finally to intended outcomes. It has two components: a theory of change and a theory of action. (Funnell & Rogers, 2011).

The theory of change can derive from a formal research-based theory or from an unstated widely accepted understanding about how things work. An example of a theory of change might be that *changes in perceived social norms lead to behaviour changes*. The theory of action then explains exactly how the strategy or other initiative will implement this theory of change.

THEORY OF CHANGE: SITUATION ANALYSIS, SCOPE AND OUTCOMES CHAIN

Developing a theory of change begins with an analysis which identifies the problem, causes, opportunities, and consequences of not acting (Funnell & Rogers, 2011). A situation analysis of the Molonglo catchment was undertaken by the committee in developing the state and transition resilience model of the catchment and has already been presented here as Part 2. Resilience of the Molonglo Catchment.

The next step is to determine the scope of the program including which aspects of the problem the program is to focus on (Roughley, 2009). This involves identifying which aspects are important and within the reach and capacity of the project to influence; which are beyond the direct focus of the project but within its reach; and those which are far beyond its scope. This demarcates a program boundary, but not at the expense of keeping the program fluid and flexible enough to move this boundary as circumstances change.

In this case, scope was discussed as an issue of scale among members of the MCG committee. The Molonglo catchment was identified as the spatial scale of operations, and a five to ten year program was set out in the context of a fifteen year vision. However the main activities and policy tools of the MCG can be used to determine the focus and scope as shown in table 8, below.

Table 8 Scope of the Molonglo Catchment Strategy 2015

MSC 2015 Vision	"A healthy and sustainable environment treasured by the whole Molonglo catchment community."
Focus of the MCS 2015	Achieving a high level of community engagement in environmental initiatives, providing foundational resources and support to undertake action, providing best practice understanding of environmental problems and solutions; building partnerships; on-ground works.
Beyond direct reach of the MCS 2015 but has capacity to influence	Fundamental environmental research (with exception of citizen science) and government and other stakeholder policy development, particularly within the region of the catchment
Beyond the scope of the MCS 2015	International and national economic conditions and response to large environmental problems like climate change

The final step is to draw up an Outcomes Chain. This was undertaken as a participatory process with the MCG committee and then refined through a series of iterative drafts with review by various members of the MCG. The result can be seen in Figure 21. This forms the core of the MCS 2015 (see next section for more detailed explanation) (Roughley, 2009; Funnell & Rogers, 2011).

Some of the discussion at the May 2013 Committee meeting focused on the chain of outcomes that might lead to a "Community that understands and values our environment." That particular chain of outcomes is not in the final version of the diagram but it is expressed here as a hypothesis about the sort of behavioural changes that the MCS 2015 is trying to effect. That hypothesis can be summarised as:

Theory of Change 1: "participating in activities leads people to feel connected which leads to environmental values/understanding which leads to more permanent behaviour change which feeds back to reinforce feelings, values and understanding".

This does seem to take the conventional wisdom (that to change behaviour you need to convince someone of the value and wisdom of doing something first) and stand it on its head. However there is evidence that people often act first and reason later, only paying attention to data that confirms their position (confirmation bias). This observation has led to the development of the idea that reasoning may have evolved in order to persuade others to do what we want them to do, rather than to arrive at an independent analysis of the best course of action e.g. Argumentative theory (Mercier & Sperber, 2010)!

For the relationship between people undertaking environmentally friendly actions and their beliefs about the existence of climate change and its causes, CSIRO researcher Professor Iain Walker has found some surprising results (For more information see http://theconversation.com/when-it-comes-to-climate-change-just-do-it-trumps-think-different-506.) A survey of 5,000 Australians in 2010 asked people whether they engaged in a series of different carbon-relevant behaviours, and if they did, why they did so. Was it mostly for environmental reasons, or mostly for other reasons?

It turns out people's carbon reducing behaviours *are* related to their beliefs about climate change, but not strongly. There are a wide range of reasons why people undertake the actions. Even people who had a strong belief in human induced climate change often undertook common environmentally friendly behaviours (like switching off lights and reducing power consumption, buying things locally and fixing things rather than replacing them) mainly for non-environmental reasons. The study concluded that if we want to change people's behaviour in our community we cannot rely on appealing to their values or beliefs. Instead if we focus on a wide range of reasons for doing things then a more diverse group of people would engage in environmentally friendly behaviour and establish a new social norm. Once behaviour becomes a habit in the community it is more likely to persist (McKenzie-Mohr & Smith, 1999).

The theory of change suggested by the MCG committee, suggests a similar approach. The engagement of a wide range and number of people in the immediate activities and programs of the MCG is critical to establishing new social norms, rewarding people with a sense of connection to the environment and providing justification for the new behaviours. Understanding of how this behaviour benefits the environment leads to more permanent behavioural change and a self-reinforcing feedback loop.

Other practitioners writing on how to inspire change go further to say that it often doesn't matter what people's values are. Real change is not about persuasion but designed solutions that will make a real difference to people's lives (Robinson, 2013). That can be summarised as:

Theory of Change 2: "a manager researches barriers then creates a targeted solution that either saves time, saves money, gives more control or more social status to the users; the manager then implements a pilot study then re-evaluates or re-invents it for the next target group" (Robinson, 2013).

These two theories are proposed to guide the delivery of the MCS 2015. At the completion of each project within the Strategy we will briefly analyse the steps that took place and consider what we have learnt and which theory gives a better explanation.

THEORY OF ACTION: SETTING SUCCESS CRITERIA AND REVIEWING ASSUMPTIONS

The MCS 2015 (Figure 21) begins with the premise that the four Aspirational Goals work together in a mutually reinforcing way to achieve the overall MCG vision. Rather than splitting our work between each of these goals into four separate programs we are aiming to take the holistic spirit of the resilience approach and apply it to the way our projects run also. This means that at every level in the program logic we are attempting to consider all the outcomes or goals in an integrated way. However to make sure we also utilise the power of program logic we have colour coded the outcomes at each level that are more related to each other and the higher order outcome.

Under the four Aspiration Goals we identify five long-term outcomes that will need to be achieved in order to reach the Aspirational Goals. These are: Protection of and improving soil health (blue); Increased adoption of best practice NRM (purple); Increased extent, connectivity and condition of native vegetation managed for culture and biodiversity (green); Improved river health (blue); and Viable and resilient communities (purple). Again we are aiming to integrate each of these outcomes into each project in a holistic manner.

At the Program level (Intermediate Outcomes) we have organised our work into a 'landscape' for each subcatchment. These landscape Programs are arranged in Figure 21 spatially so that sub-catchments higher

Table 9 Gives the nine sub-catchment landscapes defined in the Molonglo Catchment Strategy 2015 and their targeted environmental indicators and outcomes. Colour coding shows the long-term outcome in the overall strategy (Figure 21) to which the program is primarily contributing although each project integrates all the long-term outcomes.

Molonglo sub-catchment landscape (Program)	Environmental indicators of concern	Targeted outcome for landscape
Upper Molonglo	P, EC, DO and Bugs, historically turbidity; abundance of Scarlet Robins and Green and Golden Bell Frogs; extent and condition of riparian vegetation.	**Riparian restoration** (erosion, riparian vegetation) and connectivity
Burra Creek	turbidity	Catchment protection & rehabilitation – **feral animal and erosion control**
Queanbeyan River	pH; good DO and bugs; best conditions in the catchment; abundance of platypus and water rat populations; area of native vegetation protected	**Native vegetation protection** via conservation agreements, planning, BioBanking etc.; raising public awareness of what could be lost
Reedy Creek + Mid Molonglo	EC	Further investigation required
Jerrabomberra Creek	EC, turbidity, DO and bugs; good upper catchment but more data needed; area of endangered ecological communities; abundance of site and landscape endangered species; no of new habitat patches >10ha; no of new stepping stones.	Riparian restoration, catchment protection and **connectivity for woodland and grassland species**
Woolshed Creek	EC; good bugs despite low DO; area of endangered ecological communities; abundance of platypus and water rats;	**Hydrogeological landscape repair** and connectivity
Lake Burley Griffin	EC, turbidity, DO.	Focal point for **biodiversity and cultural connectivity**
Sullivans Creek	P, DO, Bugs; Good turbidity	**Connectivity and riparian restoration**
Lower Molonglo	Poorest water quality of all	Catchment protection, **riparian restoration** and connectivity

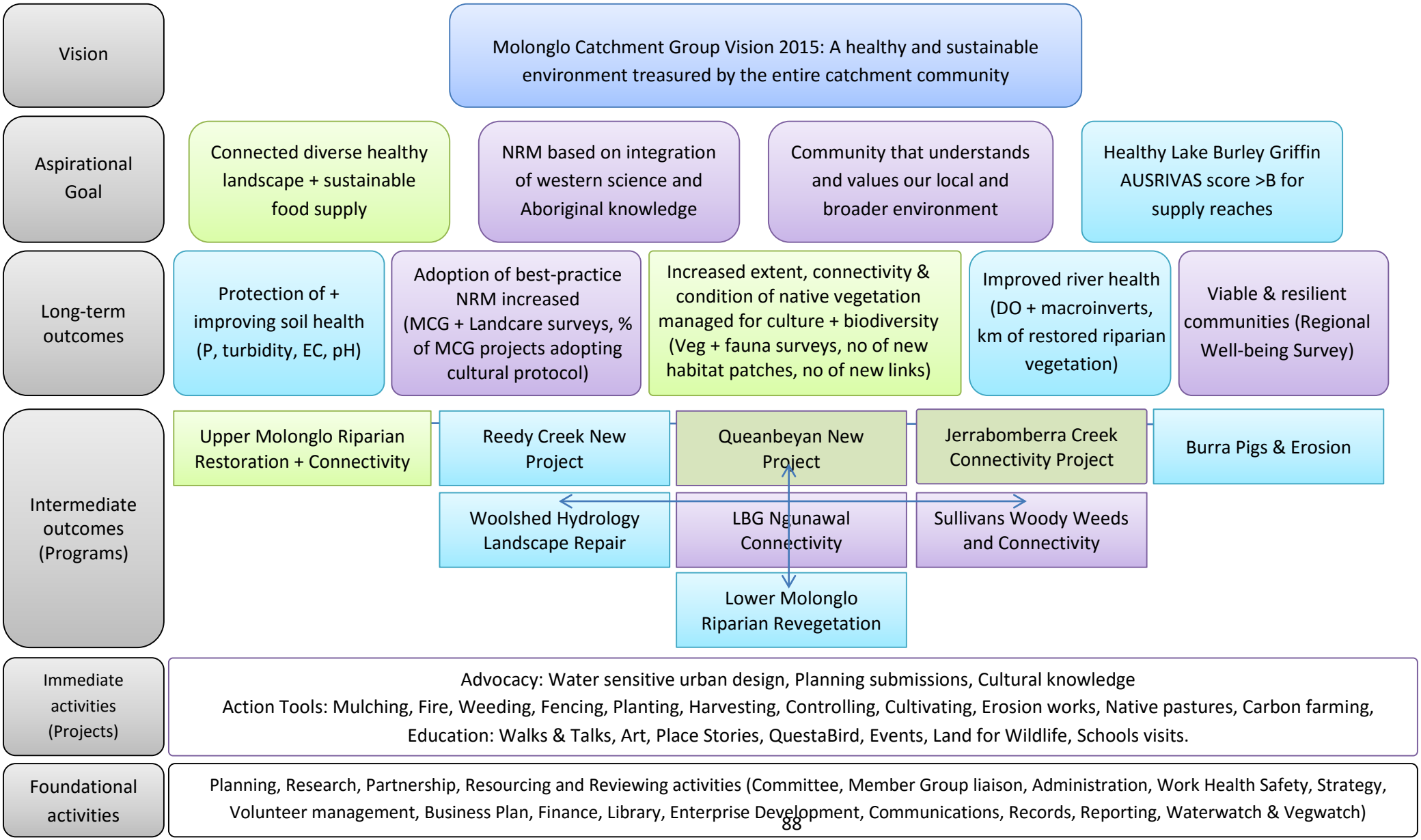


Figure 21 The Molonglo Catchment Strategy 2015 shows how current and future projects can link to achieve long-term outcomes and aspirational goals. Colour coding indicates priority program logic flow up the diagram and sub-catchment Programs are arranged to indicate how they are adjacent in the landscape.

in the landscape are in the top row and adjacent catchments are next to each other within a row. We have looked at the results of the MCG 2005 review to see which environmental parameters should be targeted for each sub-catchment (Table 9). For example, in Burra Creek there is a long history of concern about turbidity. In this catchment we will target projects that have a primary focus on reducing erosion, including managing to land capability, catchment protection works and feral animal control.

The Queanbeyan River on the other hand is in relatively good condition but is coming under increasing development pressures. The challenge here is to protect what remains and create a public story to inspire public support for that protection. Woolshed Creek presents a complex picture that will need to take a whole of landscape approach to hydrogeological repair to address landholder concern over historically low water levels and high EC. Lower in the catchment water quality is the poorest and projects aiming to establish native riparian vegetation will be the highest priority.

Finally within a sub-catchment landscape Program, projects are the level at which we apply for funding, develop partnerships and design and implement actions on the ground. In this way we have been able to incorporate our existing projects across the Molonglo catchment as well as highlighting where new projects should be developed.

This approach has the advantage of also being able to represent the relative location of the sub-catchments in space (shown in the diagram in Figure 21), by placing them in the diagram relative to their location in the catchment (upper, middle and lower). In this way it is also clear where links can occur between subcatchment projects within Programs. We can also develop catchment-wide and non-geographically based projects, as well as looking to collaborations outside of the Molonglo catchment, for example with neighbouring catchment groups and the newly formed peak body for Landcare in the ACT. In this capacity we have been working on the concept of a series of connectivity link projects (incorporating social, cultural and biodiversity links) across multiple sub-catchments, potentially crossing watersheds to partner with neighbouring catchment groups.

PROGRAM LOGIC

Each Subcatchment Program is made up of projects linked by program logic, with a different strategy identified for different target audiences. For our current purposes we have used a hybrid of marketing groups identified from other sources for the ‘uptake curve for innovation’. We have identified three target groups: ‘Early Adopters’, ‘Willing Majority’ and ‘Reluctant communicators’. These groups can occur within the wider community and within other institutions including government, corporations and the not for profit sector.

Early Adopters are the group of people the Molonglo Catchment Group has traditionally engaged with very well. They include members of Landcare and Parkcare groups, our traditional stakeholder groups within government and the not for profit sector, and individuals who self-nominate to be involved in programs. They are self-motivated and would generally prefer to implement a solution themselves, once they have learnt/ or co-developed a way to do so.

The ‘Willing Majority’ is a group the MCG sometimes meet through our projects but with whom, for a multitude of reasons, the solutions we offer have not always been well taken up. For this group the desire

to undertake the best environmental behaviours is already there or there is no objection to it. Other competing priorities or the lack of a solution that makes a particular practice less time consuming, gives more control or is more socially rewarding, have been a barrier. This group may have resources they are willing to spend on the right solutions. They include members of the wider community and people within government and other institutions with problems that a traditional 'environmental education' approach does not satisfy.

The 'Reluctant Communicators' describe a group of people who could be described as community leaders from one perspective, or gatekeepers to change from another. They may lead opposition to a particular program, or be outside environmental networks but be an influence on many people. Strategies to work with this group will require coming to a new shared understanding and being prepared to change our own approaches.

Within each Sub-catchment Program the goal is to have projects throughout the next fifteen years that address each of these target groups with the aim of moving the community norm for a particular environmental challenge. Let's consider the Jerrabomberra Creek sub-catchment landscape as an example.

The overarching goal for the Jerrabomberra Creek landscape over the next fifteen years is to increase connectivity for woodland and grassland species; with a secondary goal of improving riparian vegetation. This is building on past native vegetation planting undertaken by Little Burra, Royalla, Fernleigh Park and Queanbeyan Landcare members in NSW and Parkcarers and ACT Parks within the ACT at Mugga Lane (see Appendix 4: Publically funded projects in the Molonglo Catchment since 1996). There are also important cultural links within this landscape – both from a history of indigenous pathways and cultural sites along the Jerrabomberra valley/ hills and peaks; and from early European settlement which often utilised these existing pathways.

Molonglo Catchment Group is continuing its strong history of engagement with the 'Early adopters' along the Jerrabomberra sub-catchment with multiple projects partnering with Landcare groups to undertake revegetation projects and protection of existing significant habitat patches. These projects are critical to re-establishing habitat connectivity across the sub-catchment, but on their own will not be enough to achieve our goals. There is also a pressing need to expand the number of people in this category as those who are currently contributing are aging and feel over committed.

Consequently new projects are needed which target the 'Willing Majority'. These are projects that might replace the request to provide volunteer time with a contribution to project resources, that in return provide intensive bursts of information (for example through a Land for Wildlife assessment) and pay for on-ground work to be undertaken. These projects need to identify a frustration – e.g. the landholder who finds the demands of managing a rural property are greater than they expected and they need convenient help. New technology (e.g. drones) could combine with new business models of delivery to provide a service which assesses NRM issues, provides a plan of management and manages contractors to undertake the work. All of this which can also be undertaken with a view to regional habitat and riparian connectivity such that where options are available, under consultation with the landholder wider regional objectives can also be considered.

Another type of project that might fall under those targeting the 'Willing Majority' are projects that engage with planners and developers who might be pre-disposed to considering environmental concerns up front. A potential frustration in this field that could be addressed is the sense that it is difficult to access definitive information or to juggle multiple sources on information on which areas are environmentally sensitive or strategic and should be protected, and which areas represent relatively low cost to the environmental estate. Groups like Molonglo Catchment Group need to find resources to work with these people, provide the products they need and try to grow support for them within their organisations. Examples of these sorts of projects include the Bush on the Boundary forums that bring developers, local residents and environmental groups together to discuss issues in a respectful and confidential way.

Projects designed for the 'Reluctant Communicators', are not common although they do sometimes come about serendipitously when the right people cross paths. In the Jerrabomberra catchment these could be particular landholders, government staff, residents or other interest groups or developers or companies. A first step might be to actively try to identify some of these key players and influence holders. The next step is to try and identify the frustrations that motivate them, or the personal connection they may have to a particular place or species. A project may evolve, but for it to be successful it may need to involve transformation on both sides. A pre-requisite to this approach may need to be an open mind.

Each individual project will have its own program logic nested within this overall program structure. It is anticipated that each project will 'hypothesize' a particular set of tools. This 'program logic hypothesis' will draw from the immediate activities and outcomes list in order to achieve a key intermediate goal set for that project, with a view to achieving the long-term outcomes at the top of the page. This hypothesis can then be compared with the actual delivery path at the end of the project, indicating which theory of change was in action.

13 MOLONGLO SUBCATCHMENT PROGRAMS, TARGETS AND CURRENT (2015) PROJECTS

13.1 UPPER MOLONGLO + REEDY CREEK RIPARIAN RESTORATION

2014 DATA: (MOL 5 is included in Lake Burley Griffin)

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	2014 score
Molonglo River	MOL1	*	*	*	*	*	*	*	*	*	
Molonglo River	MOL2	2	3	1	3	3	1	2.17	4	2.78	B-
Primrose Valley Creek	PRI1	2	5	1	1	3	1	2.17	*	2.17	B+
Molonglo River including Plains Ck, Stony Ck & Whiskers Ck	MOL3	2	5	1	1	5	1	2.50	3	2.67	B
Yandyguinula	YAN1	1	1	1	4	3	1	1.83	*	1.83	A-
Scabbing Flat Creek	SCA1	*	*	*	*	*	*	*	*	*	
Molonglo River incl Reedy Creek	MOL4	*	*	*	*	*	*	*	*	*	

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Molonglo River between Captains Flat and Briars Sharrow Rd	MOL 2 & MOL 3	% Dissolved oxygen saturation	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Yandyguinula Creek	YAN 1	Phosphorus	Annual Median <0.02 mgL^{-1} (a score of "1" or "2") or for 50 to 80% of the time.
Primrose Valley Creek, Plains Creek, Stony Creek & Whiskers Creek, Reedy Creek	PRI 1 & MOL 3 & MOL 4	Electrical Conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. It may be that a "5" (>400µS) is natural for these systems.
Chimney Creek & Primrose Valley Creek	PRI 1	Turbidity	Annual Median ≤10 NTU (a score of "1") or for >80% of the time
Upper Molonglo Catchment		Macroinvertebrates	AUSRIVAS score of A or B at Molonglo River at Yass Road >80% of the time. Improved scores on reaches
Upper Molonglo Catchment		Connectivity	Five additional 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.
Molonglo River between Captains Flat and Briars Sharrow Rd, or tributaries; Reedy Creek	MOL 2 & MOL 3 (PRI 1 & YAN 1); MOL 4	Riparian vegetation	30km of restored or revegetated riparian vegetation by 2030.

The Upper Molonglo is a large area, but it has also been host to a sustained effort, via private landholders, Palerang Council and the members of Captains Flat, Hoskinstown and Carwoola Landcare groups to address significant issues including riparian weeds, riparian revegetation and catchment protection, and planting for connectivity over many years. These continue to be the areas of priority action in the MCS 2015, targeting high EC and historical turbidity in some reaches, and moderate to low dissolved oxygen and poorer than expected macroinvertebrate scores.

A current project is being undertaken in partnership with Captains Flat Landcare group and a group of individual landholders with Molonglo River frontage. The main goal of the project is to remove willows and other woody weeds from along a 12 kilometre stretch of the Molonglo River to improve the opportunities for native vegetation to re-establish and builds on work undertaken by Palerang Council and Captains Flat Landcare upstream.

This project is using weeding, fencing, vegetation monitoring (via Vegwatch) and landholder agreements to clear and maintain a corridor of woody weed free river.

The success of the project will be measured by a Vegwatch plot that has already gathered the pre-treatment data. Longer term outcomes will be monitored via any impact on Waterwatch parameters at the near-by Waterwatch site. It is hypothesized that the parameters most likely to be affected will be turbidity, dissolved oxygen and, ultimately, the macroinvertebrate community (this is also a site monitored for waterbugs).

Some ideas for future projects in this area include building on earlier connectivity planting to increase connectivity for small woodland birds, particularly the Scarlet Robin which has a known population on the Hoskinstown plain. A catchment protection incentives program would also be desirable in the Primrose Valley, Hoskinstown and Carwoola areas. There is also a need to engage with the community living above Captains Flat both to become aware of the issues in that part of the world, and to start collecting data where historically there has been very little.

The rural residential areas of the Upper Molonglo are places in which Land for Wildlife and associated services could be targeted, as well as better targeted engagement with Palerang Council on planning for this region.

Reedy Creek is included here as it enters the Molonglo River just before the confluence with the Queanbeyan River. It also has some parallels with Woolshed Creek because of some apparent hydrogeological connections that are emerging. It has been the focus of riparian restoration work in the past and MCG will be looking for opportunities to work with landholders to progress this further.

13.2 GOOGONG TO BURRA EROSION AND PIG CONTROL

2014 DATA:

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Burra Creek	BUR1	4	5	5	1	3	1	3.17	2	2.78	B-

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Burra Creek	BUR 1	Electrical Conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. It may be that a "5" (>400µS) is natural for these systems.
Burra Creek	BUR 1	Turbidity	Annual Median ≤15 NTU (a score of "1" or "2" or "3") or for 50% to 80% of the time
Burra Creek	BUR1	% Dissolved oxygen saturation	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Burra Creek	BUR 1	Riparian vegetation	10km of restored or revegetated riparian vegetation by 2030.
Burra Creek	BUR 1	Catchment protection	Catchment Protection program initiated

This sub-catchment also has a long history of focus on a particular issue: erosion. From the days of the Lake Burley Griffin Catchment Protection scheme, Burra Creek has been identified as a particular source of turbidity and sediment movement. Continued focus on this environmental parameter is not an indication of failure. The LBG Catchment Protection scheme was held up in its time and since as an innovative and effective scheme. The soils in this landscape are particularly vulnerable and repair of this landscape will be measured in decades if not centuries. It is part of the 'bounce back' we are seeing as the system adjusts in the long-term to the shock of European immigration, and the attempt to re-establish a new equilibrium between indigenous ecological understanding and contemporary NRM thinking and best practice.

One project currently being undertaken in the Burra catchment has produced a partnership between NSW Parks and Wildlife Service, South East Local Land Service, ACT Parks & Conservation Service (Googong Foreshores) and the MCG, as well as some 15 property holders who are being encouraged to extend the project onto private land. The main goal of the project is to control pigs over 9 square km of public and private land. The project has mapped pig damage, used workshops to recruit and educate landholders, and is coordinating the trapping and eradication of feral pigs across public and private land managers. The success of the project will be measured by a follow-up pig survey.

Other potential projects in this area that are being investigated include establishing a new Burra Creek protection scheme, to build on the work done previously. This could potentially be linked to a recent hydrogeological mapping project which has identified the Burra valley as one which could be used as a case study to test the delivery and uptake of their mapping products via an extension service to landholders.

13.3 QUEANBEYAN RIVER PROTECTION

2014 DATA: (see also Burra Creek)

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Queanbeyan River	QUE1	2	2	1	2	3	1	1.83	2	1.89	A-
Googong Creek	GGG1	2	5	1	1	2	3	2.33	*	2.33	B+
Queanbeyan River	QUE2	3	2	1	1	2	1	1.67	2	1.78	A-
Queanbeyan River including Barracks Flat Creek	QUE3	4	2	1	2	2	2	2.17	2	2.11	B+
Buttles Creek	BTT1	*	*	*	*	*	*	*	*	*	

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Googong Creek & Queanbeyan River below Googong	GGG1 & QUE 2	Electrical Conductivity	Annual median <200µS (a score of "2") or for 50 to 80% of the time
Googong Creek & Queanbeyan River below Googong	GGG1 & QUE 2	Nitrogen	Annual median <4.9mgL^{-1} (a score of "1" or "2") or for 50 to 80% of the time.
Googong Creek & Queanbeyan River below Googong	GGG1 & QUE 2	Turbidity	Annual Median ≤10 NTU (a score of "1") or for >80% of the time
Queanbeyan River below Googong Dam	QUE 2 & QUE 3	pH	Equalise with above the dam and within recommended water quality
Queanbeyan River catchment		% Dissolved oxygen	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Upper Queanbeyan Catchment		Macroinvertebrates	AUSRIVAS score of A or B at ACT border >80% of the time.
Upper Molonglo Catchment		Connectivity	50 ha native vegetation (woodland or grassland) with connectivity to patches within 1.5km protected by 2030 in the Upper Molonglo.

The Queanbeyan River subcatchment is the landscape in the best condition of the whole of the Molonglo catchment. However it is also the one under the most immediate pressure from rapid development. This could lead to rapid deterioration of the system from its current high conservation value, or with careful planning and implementation there is an opportunity to be a best practice example. At the moment there are some worrying indications, particular with a number of sedimentation events down Googong Creek.

MCG facilitates a Bush on the Boundary initiative with the Googong Township Development, which is a forum to promote communication between developers, researchers, Queanbeyan Council (both planning and management sections), conservation groups and residents of this area. We are optimistic that this forum can help lead to some best practice management in the area, and with improved water quality in Googong Creek.

The other priority in the Queanbeyan River catchment (with the exception of Burra Creek which has its own subcatchment landscape) is for the maintenance and protection of native vegetation in the catchment. Native vegetation is clearly protecting the river currently and enabling populations of platypus and water rats to persist in the river and even within the town of Queanbeyan. MCG will work with Queanbeyan City Council and other stakeholders to ensure that retention and revegetation of native high quality habitat is planned and implemented at the strategic planning level, within development proposals and in the selection of offsets, and in street scaping and on individual properties. There is an opportunity here to ensure that connectivity is maintained and enhanced right across the landscape.

A particular focus of the next few years will need to be securing the conservation status of some of the large areas of native vegetation that remain unprotected.

13.4 JERRABOMBERRA CREEK CONNECTIVITY

2014 DATA:

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Jerrabomberra Creek	JER1	2	3	1	1	*	1	1.60	*	1.60	A
Jerrabomberra Creek	JER2	3	5	1	2	*	1	2.40	*	2.40	B
Jerrabomberra Creek	JER3	2	5	5	*	5	1	3.60	4	3.73	C-

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Jerrabomberra Creek	JER 2 & JER 3	% Dissolved oxygen saturation	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Jerrabomberra Creek	JER 2 & JER 3	Electrical Conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. It may be that a "5" (>400µS) is natural for these systems.
Jerrabomberra Creek	JER 3	Turbidity	Annual Median ≤15 NTU (a score of "1" or "2" or "3") or for 50% to 80% of the time
Jerrabomberra Creek Catchment		Riparian vegetation	20km of restored or revegetated riparian vegetation by 2030.
Jerrabomberra Creek Catchment		Connectivity	Five additional 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.

As mentioned previously, the overarching goal for this landscape over the next fifteen years is to increase connectivity for woodland and grassland species; with a secondary goal of improving riparian vegetation. This is building on past native vegetation planting undertaken by Little Burra, Royalla, Fernleigh Park and Queanbeyan Landcare members in NSW and Parkcarers and ACT Parks within the ACT at Mugga lane (see Appendix 4: Publically funded projects in the Molonglo Catchment since 1996). There are also important cultural links within this landscape – both from a history of indigenous pathways and cultural sites along the Jerrabomberra valley/ hills and peaks; and from early European settlement which often utilised these existing pathways.

One current project is a partnership between Queanbeyan Landcare, Queanbeyan Council's Environment Section and five private landholders. The goal of the project is to recreate one 10 ha patch of grassy box woodland between two existing patches along Jerrabomberra Creek in Fernleigh Park; and to link these three habitat patches with small 10m x 40m stepping stones to assist threatened small bush birds to move along the Jerrabomberra Creek Corridor.

An adjacent project has just been funded to fence a gorge on a cattle property that neighbours Fernleigh Park. This will create another >10 ha patch of native remnant vegetation whose understorey condition should improve with the removal of grazing. This project also links via another property right through to the Queanbeyan Council managed Stringybark reserve. The project aims to generate local resident interest in

the management and rehabilitation of the reserve and to assist Queanbeyan Landcare to recruit new members via the possible formation of an affiliate group 'Friends of Jerrabomberra Bushland'.

The success of these projects will be measured by Vegwatch sites located within the new 10 ha habitat patches, with some pre-treatment data already gathered. The project has also initiated a base-line bird survey. The best outcome would be an increase in small bush birds in the immediate area.

A much larger project is being considered for a comprehensive connectivity strategy for the Jerrabomberra Valley, which would involve managing for threatened woodland birds and other endangered species in the area over a ten year period, and creating the best woodland/grassland spatial matrix to promote these species. To date we have had interest from Queanbeyan Council's Planning Department (for the location of offsets), Environment Department, South East Local Land Services, NSW Office of Environment and Heritage, Buru Ngunawal Aboriginal Corporation and Thunderstone Aboriginal Cultural and Land Management Services, Kosciuszko to Coast and Queanbeyan Landcare in partnering on the project. We have also discussed with ACT Environment and Planning Directorate the possibility of extending the project, with separate funding, beyond the ACT side of the border.

13.5 WOOLSHED CREEK RIPARIAN CORRIDORS

2014 DATA

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Woolshed Creek	WOO1	2	5	1	1	5	2	2.67	2	2.44	B

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Woolshed Creek	WOO 1	Electrical Conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. It may be that a "5" (>400µS) is natural for these systems.
Woolshed Creek	WOO 1	% Dissolved oxygen	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Woolshed Creek Catchment		Riparian vegetation	5 km of restored or revegetated riparian vegetation by 2030.
Woolshed Creek Catchment		Connectivity	One additional 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.

The Majura valley is a complex microcosm with a wide variety of land uses, significant development pressures owing to its proximity to Canberra and the Canberra airport, and its strategic location as a major road transport route into and out of the ACT as illustrated in the recent construction of the Majura Parkway which is nearing completion. Leasehold tenures in the valley vary from 101 year leases at the top of the Woolshed creek catchment, to three year leases in some places, to some leases of just three months – a situation which has existed for years. More recently we are learning from the ACT Hydrogeological Framework Project just how complex the geology, soils, geomorphology and topography are also, with a major fault line running down the centre of the valley, and with significantly different processes occurring on either side of it.

It should come as no surprise then that the valley defies easy generalisations, and past projects and NRM focus in this region have been quite diverse (see Appendix 4: Publically funded projects in the Molonglo Catchment since 1996). One key initiative was the ACT Woodlands Project which chose the Majura valley as one of four key connectivity areas in the ACT.

The current MCG project in the Majura valley came about as a partnership with ACT Roads and the contractors Fulton Hogan as a result of construction work for the Majura Parkway and MCG's prior involvement with local landholders in developing a vision for the valley with the impending Parkway development. The project was only able to attract a small amount of interest from neighbouring landholders. However, the consultation process does involve attending a monthly stakeholder meeting for the Majura Parkway, which could provide new avenues for future projects.

The first two segments of the project involved re-vegetating two 200m sections of Woolshed Creek that were re-aligned for the building of the Majura Parkway. The last segment will be to revegetate a section of the Molonglo River riverbank adjacent to a new bridge over the river.

This project is being monitored by photo points, the three Waterwatch sites along Woolshed Creek, and one just above the new bridge over the Molonglo River. The amount of revegetation is probably not sufficient to have much of an impact on the Waterwatch sites, which are not located near the revegetation sites. A wider riparian revegetation and weeding strategy will be needed to have an impact on dissolved oxygen levels in Woolshed Creek. There are also kangaroo management concerns in the Majura Valley so any strategy will need to consider how any revegetation might benefit or exacerbate this situation. The valley also has high levels of electrical conductivity in the water so hydrogeological information will need to be reviewed before further vegetation work. There are plans to try and develop a project to deliver the mapping products of the ACT Hydrogeological Framework Project to landholders and help provide extension services to make use of them.

13.6 LAKE BURLEY GRIFFIN CONNECTIVITY

2014 DATA

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Molonglo River	MOL5	2	3	5	3	3	2	3.00	*	3.00	C+
Molonglo River	LBG1	2	5	5	1	5	2	3.33	*	3.33	C+
Molonglo River	LBG2	*	*	*	*	*	*	*	*	*	

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Molonglo River & Lake Burley Griffin	MOL 5 LBG 1 LBG 2	Turbidity	Annual Median ≤15 NTU (a score of "1" or "2" or "3") or for 50% to 80% of the time
Molonglo River & Lake Burley Griffin	MOL 5 LBG 1 LBG 2	Electrical Conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. Is high EC coming from Jerrabomberra Creek and Woolshed Creek?
Molonglo River	MOL 5	Phosphorus	Annual Median <0.02 mgL^{-1} (a score of "1" or "2") or for 50 to 80% of the time.
Molonglo River & Lake Burley Griffin	MOL 5 LBG 1 LBG 2	% Dissolved oxygen	Annual Median between 85 -110 (a score of "1" or "2") or for 50 to 80% of the time.
Molonglo River & Lake Burley Griffin		Riparian vegetation	5 km of restored or revegetated riparian vegetation by 2030.
Molonglo River & Lake Burley Griffin		Connectivity	Three culturally & ecologically restored 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.

Lake Burley Griffin and the reach of the Molonglo River immediately upstream (as well as the lower part of Jerrabomberra Creek which is also proximate) have long been focal points of the Molonglo River both ecologically and culturally. This area has been a food bowl for Aboriginal people for thousands of years, an important meeting place and the nexus of several important pathways. At the heart of the city of Canberra and the National Capital of Australia, immigrant Australians have also made this area an important meeting and thoroughfare.

Unfortunately the increased pressure on the area following the construction of Canberra has also had the result that this section of the Catchment has significantly worse water quality than the reaches upstream of it. Having an impact on the water quality of Lake Burley Griffin requires improved catchment management upstream, however it is clear that urban catchment management can also be improved, particularly with regards to phosphorus, dissolved oxygen and turbidity. MCG will be working the stakeholder consultative committee of the ACT Basin Priority Project to ensure that these parameters are a focus of any works undertaken in the Fyshwick priority catchment of that project. In particular understanding sources and potential control for Phosphorus in this landscape will be important, as is increasing the amount of native riparian vegetation along creeks and rivers and decreasing the percentage of hard surfaces in urban areas.

This subcatchment has been the location of a new project where the MCG and partners are trialling a cultural and ecological approach that we hope to adopt across all of our projects. The project is located at Yarralumla Block 2 Section 128 which is adjacent to Stirling Park in Yarralumla, not far from Parliament House.

The aim of this project was to undertake some exploratory work in how to undertake biodiversity and riparian restoration on a site with significance to Ngunawal people. This project has been developed in partnership with the Bell Family (via Buru Ngunawal Aboriginal Corporation, and Thunderstone Aboriginal Cultural and Land Management Services), Friends of Grasslands, Save Stirling Park, Yarralumla Residents Association, and the ACT Government via the Environment and Planning Directorate - encompassing both NRM and Heritage sections. The site is on land managed by ACT City Services.

This site was identified initially as having a small population of endangered Button Wrinklewort, and heritage items of significance for both pre- and post-contact indigenous cultural heritage. Block 2 is also recognised as being a remnant site of significance for post-colonial history and the construction of Canberra and Old Parliament House. Stirling Park, which is immediately adjacent to the west, is recognised as Ngunawal land and a meeting place for a number of Aboriginal groups including the Walgalu, Monaro, Yuin and Ngarigu.

As the project has developed, vegetation on the site has been identified as remnant Yellow Box - Blakely's Red Gum Grassy Woodland, and more than five patches of the endangered Button Wrinklewort are mapped.

As the significance of the site has become apparent the original project plan has been modified to include Ngunawal supervision of all work on the site, and to develop a protocol for how volunteers can be invited to work in different parts of the site; particularly those areas which are restricted to women only; and to extend an invitation to residents of the area, members of NRM networks and other indigenous groups. Restoration work on the site has been re-prioritised to focus on control of St Johns Wort, Chilean Needlegrass and woody weed removal, with a secondary emphasis on other weeds and native plantings.

The project will be monitored via vegetation and fauna surveys (preliminary already undertaken), mapping of Button Wrinklewort, weed populations, and a heritage survey. Community awareness and engagement will be gauged via stories and numbers of groups and volunteers attending working parties. It is expected that there will be a significant decrease in the weed abundance on the site; that Button Wrinklewort populations will be maintained; and heritage values documented and better protected. The greatest impact of the project however will be in the piloting of a protocol for cultural connectivity projects.

13.7 SULLIVANS CREEK CATCHMENT WOODY WEEDS AND CONNECTIVITY

2014 DATA

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Sullivans Creek	SUL1	*	*	*	*	*	*	*	*	*	
Watson Wetlands	WAT1	2	2	5	1	5	1	2.67	*	2.67	B+
Dickson Wetlands	DIC1	3	2	1	2	5	1	2.33	*	2.33	B+
Sullivans Creek	SUL2	*	2	1	*	*	*	1.50	4	2.33	B+
O Connor Wetlands	SUW1	*	*	*	*	*	*	*	*	*	
Sullivans Creek	SUL3	2	3	1	5	5	*	3.20	4	3.47	C

CONDITION TARGETS:

Reach Name	Reach code	NRM Measure	Target
Sullivans Creek Catchment		% Dissolved oxygen	Annual Median between 75 -110 (a score of "1" or "2" or "3") or for 50 to 80% of the time.
Lower Sullivans Creek	SUL 2 & SUL 3	Phosphorus	Annual Median <0.02 mgL^{-1} (a score of "1" or "2") or for 50 to 80% of the time.
Watson Wetlands	WAT 1	Turbidity	Annual Median ≤15 NTU (a score of "1" or "2" or "3") or for 50% to 80% of the time
Sullivans Creek Catchment		Riparian vegetation	2 km of restored or revegetated riparian vegetation by 2030.
Sullivans Creek Catchment		Connectivity	Three culturally & ecologically restored 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.

Sullivans Creek is one of the most urbanised creeks in the Molonglo catchment, but also one that has had significant resources targeted toward trying to improve its water quality, specifically the reduction of turbidity via various sediment traps and urban wetlands, with some success. It is also situated between two very significant ridgelines in the Canberra landscape: Mt Majura/Mt Ainslie to the east and Black Mountain to the west, which again, has featured in the cultural lives of both Aboriginal and immigrant peoples.

The urban nature of the catchment means it faces similar challenges to the Lake Burley Griffin landscape in understanding and managing sources of Phosphorus in the landscape and restoring native riparian vegetation along creek ways. Significant development pressure is having an impact in Watson where remnant bushland that was formally producing water of a high quality is now being impacted by high turbidity. There is a need to re/engage with planners and developers in this part of the catchment.

A significant project is currently being undertaken by three MCG member groups (Friends of Black Mountain, Mount Ainslie Weeders and Friends of Mount Majura) in partnership with ACT Parks and Conservation and MCG for control of woody weeds over significant areas, with a particular focus on Cootamundra Wattle.

13.8 LOWER MOLONGLO RIPARIAN REVEGETATION

2014 DATA

Creek Name	Reach	pH	EC	Turbidity	Total P	D O	N	WQ Score	Bug Score	WQ+WB score	
Yarralumla Creek	YAR1	2	5	5	3	5	1	3.50	4	3.67	C
Western Creek	WES1	*	*	*	*	*	*	*	*	*	
Molonglo River	MOL6	*	*	*	*	*	*	*	4	4.00	D+

* Insufficient data or intermittent flow

CONDITION TARGETS:

* Insufficient data or intermittent flow

Reach Name	Reach code	NRM Measure	Target
Lower Molonglo Catchment		% Dissolved oxygen	Annual Median between 75 -110 (a score of "1" or "2" or "3") or for 50 to 80% of the time.
Lower Molonglo Catchment		Phosphorus	Annual Median <0.02 mgL^{-1} (a score of "1" or "2") or for 50 to 80% of the time.
Lower Molonglo Catchment		Turbidity	Annual Median ≤15 NTU (a score of "1" or "2" or "3") or for 50% to 80% of the time
Lower Molonglo Catchment		Electrical conductivity	Investigate hydrogeological mapping (once available) and set appropriate target. Is high EC more widespread than Yarralumla Creek?
Lower Molonglo Catchment		Riparian vegetation	5 km of restored or revegetated riparian vegetation by 2030.
Lower Molonglo Catchment		Connectivity	Three culturally & ecologically restored 10 ha native vegetation patches (woodland or grassland) with connectivity to patches within 1.5km by 2030 in the Upper Molonglo.

As the lowest reach in the Molonglo catchment, and located below a major city, it is not surprising that this subcatchment should have the poorest water quality in the catchment. However there are also lots of opportunities in this landscape, both for best practice development and planning, maintaining and building on past land care work and riparian restoration and connectivity.

A current project in this landscape is a partnership between MCG and ACT Parks and Conservation Service in the Lower Molonglo River Corridor Nature Reserve, created to offset development in the lower Molonglo River corridor. The project aims to supplementary plant 240 ha of native vegetation to assist with restoration of the habitat of the pink tailed worm lizard *Aprasia parapulchella*, improve native connectivity and to improve the water catchment and water quality of the lower Molonglo River.

MCG also participates in / facilitates a Bush on the Boundary initiative in the Molonglo Valley Development, which is a forum to promote communication between developers, researchers, ACT Government (both planning and management sections), conservation groups and residents of this area.

Earlier work in the Lower Molonglo River Corridor Nature Reserve has successfully eradicated woody weeds including African Boxthorn and Cotoneaster. The most recent phase of the project has planted over 7,500 seedlings as well as direct seeding. This was to improve the native vegetation that was not regenerating naturally due to weed competition, overgrazing and a depleted seedbank.

Monitoring has been undertaken via several Vegwatch sites, monitored jointly with the Regional Investment Strategy team from the ACT Government Environment and Planning Directorate. In the longer term, improved water quality (in particular turbidity, electrical conductivity and phosphorus levels) may be seen in Waterwatch results further downstream. Unfortunately there is not a long history of Waterwatch records below the Lower Molonglo River Corridor Nature Reserve, due to inaccessibility. However data for the Murrumbidgee River may be available in this area and the Waterwatch site has been recently reactivated. It should be noted that improvements in water quality may be masked by the discharge from the Lower Molonglo Water Quality Control Centre not far downstream.

14. MCS MERI PROCESS

An advantage of the MCS 2015 is that monitoring and evaluation can be simplified to the collation of data at the long-term outcomes level to be monitored; covered by the Waterwatch (water quality, macroinvertebrate, riparian condition assessment and Frogwatch) and Vegwatch or equivalent (vegetation biodiversity and condition monitoring) programs; and an annual MCG survey of members. Other sources of government monitoring data; as well as the Regional Wellbeing Survey being undertaken by the University of Canberra will also be used in reviewing the Molonglo Catchment Strategy 2015; and perhaps an annual MCG survey of members.

Evaluation at the end of the project will look at any impact on local Waterwatch, Vegwatch (or other) monitoring sites; participant surveys that may be done collectively to avoid survey fatigue (see Molonglo Catchment Group event feedback survey); and map the program logic that the project actually implemented, comparing it to that planned.

The final advantage of this structure for the MCS 2015 is its flexibility. As one project is completed it will be a simple task to look back at the Subcatchment Condition Targets for guidance to identify whether the intermediate goal for that subcatchment has been met. Some goals will need multiple projects in the same subcatchment over several years to see any progress. Once a goal has been met, or there are no further opportunities to work on it, we can look back to the MCS 2015 to identify the next priority subcatchment and the issues there, which need addressing. We can then have this in mind as opportunities arise with our various partners until a new project proposal evolves to take the place in the chart of previously completed projects.

The success of the MCS 2015 can then be judged both on the achievements at the end of each project, and the impact on the long-term outcomes and aspirational goals, when the strategy is next reviewed in 2025.

The MCG will review the MCS in a two-step nested process. Firstly, each completed project will be reviewed at completion, in light of the MCS 2015, against available MCG activity data, Waterwatch and Vegwatch data. Secondly, after ten years, the overall MCS 2015 will be reviewed against long-term data on the state of the catchment, the views of the catchment community and the success of the MCG in achieving progress against our long-term outcomes, aspirational goals and the MCG vision statement.

Each project review (at completion) will:

- compare the path of its program logic to that hypothesized at the planning phase of the project;
- utilise available Waterwatch, Vegwatch, event feedback surveys and other monitoring data to assess impact on the Subcatchment Condition Targets; and
- assess whether the project has contributed in a significant way to the achievement of the long-term outcomes under the MCS 2015.

The ten-yearly review of the MCS 2015 will:

- review the information in the resilience assessment of the Molonglo catchment including any new regional governance documents, legislation and policies;
- consult with the sub-catchment community to assess and review the community's NRM priorities;

- review the performance of the MCS 2015 by looking at the results of each project and the assessment of the long-term outcomes and aspirational goals via Waterwatch, Vegwatch , workshop and field day feedback, MCG activity data, MCG member survey and other data like the Regional Wellbeing Survey, Annual Water reports, ACT State of the Environment report etc.; and
- review the MCS 2015.

14.1 DRAFT MOLONGLO CATCHMENT GROUP EVENT FEEDBACK SURVEY

This survey is designed so that it can be undertaken by individual participants where greater detail is required or, in a shortened format, as questions on a single large feedback sheet that participants can quickly mark their responses collectively along a response gradient for each question.

Q. Before today have you ever undertaken an activity recommended by this event/ been to an event like this before? Please nominate the activity and how frequently you did it.

Not at all	Once or twice	A few times a year	Monthly	Weekly

Q. Before today would you have described yourself as someone who feels connected to the natural environment?

Not at all	A little	Moderately	Fairly strong	Passionately

Q. After today is there a recommended activity that you are more likely to undertake? Please nominate the activity.

Probably not	Maybe a small change	Yes definitely

Q. If yes/ If no, which of the following reasons is **most** likely to be the reason?

It will/won't save me time or money	It will/won't give me more control	It will/won't keep other people in my life happy	I am/am not convinced this is the right thing to do	None of these (please describe)

Q. Has your participation in today's event changed your feeling of connection to the natural environment?

- Yes this event really connected me to the environment in a way I hadn't felt before
- Yes this workshop made me feel ***less*** connected to the natural environment
- No I still feel moderately or strongly connected to the environment
- No I still feel fairly unconnected to the environment

Only for individual responses:

Q. What was the best thing/ worst thing about the event?

Q. Would you be interested in future MCG events? If so please provide contact email.

14.2 DRAFT MOLONGLO CATCHMENT GROUP ANNUAL SURVEY

Q. How many MCG events did you attend this past year?

Q. How often did you access the website? Weekly, Monthly, Occasional, Not at all

Q. How often did you see/hear about MCG in the media? Weekly, Monthly, Occasional, Not at all

Q. How often did you refer to written material from MCG (not including web)? As above

Q. Would you describe yourself as someone who feels connected to the natural environment?

Not at all	A little	Moderately	Fairly strong	Passionately

Q. After a MCG event this year or reading information from MCG have you significantly changed anything you do? Please explain. Is this an occasional, weekly or monthly activity?

Q. If yes/ If no which of the following reasons is **most** likely to be the reason?

It did/didn't save me time or money	It will/ won't give me more control	It will/ won't keep other people in my life happy	I am/ am not convinced this is the right thing to do	None of these (please describe)

Q. Did your membership of MCG change in your feeling of connection to the environment this year?

- Yes this event really connected me to the environment in a way I hadn't felt before
- Yes this workshop made me feel ***less*** connected to the natural environment
- No I still feel moderately or strongly connected to the environment
- No I still feel fairly unconnected to the environment

APPENDICES

APPENDIX 1: COMMUNITY CONSULTATION FOR THE MCS 2005

Stakeholders at the local level were consulted through a series of 4 workshops conducted throughout the catchment. Together with the planning coordinator, the host Landcare groups/organisations were encouraged to invite a mix of people involved in NRM to reflect the issues of their area. A call for public involvement in the planning process was issued in the local media and websites.

Attendees at the workshops were asked to list and prioritise the issues, as they saw them, within their local area. The issues were then assigned a score according to its 'popularity'. The tables below present the issues raised and their scores.

Table 10 Results of the Community Consultation workshops held for the 2005 MCS

Venue	Stoney Creek		Queanbeyan		Narrabundah		Royalla	
Existing Issue	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Stormwater Management	24		30		21		0	
Waste Management – Dumping	17		4		0		0	
Water Quality	67	2	59	2	25	5	61	
Tree Decline	42	5	27		16		37	
Feral Animals	7		27		0		22	
Weeds	88	1	42	3	26	4	73	3
Vandalism	0		4		3		0	
Public Land Management – State and Council Coord	43	4	28		3		57	
Fire Risk – Management	9		16		7		35	
Air Quality	0		0		0			0
Regrowth	5		3		6			13
Erosion – All its forms	56	3	23		0		35	
Sedimentation	32		6		8		0	
Willows	10		22		1		3	
Planning & Development – Rural Subdivision issues	38		80	1	32	1	49	
Cultural Sites Management	0		9		0		0	

Venue	Stoney Creek		Queanbeyan		Narrabundah		Royalla	
New Issue	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Roadside Vegetation Management	8							
Communication of NRM / Rural Living issues	35							
Whole of Landscape issues	10							
Water use and sustainability	38							
Vegetation Management – laws and regulations	2							

Venue	Stoney Creek		Queanbeyan		Narrabundah		Royalla	
New Issue	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Commercial Forestry – Clear felling natives	0							
Management of Biodiversity	22							
Promotion of Landcare and the Catchment Group	29							
Recreation and its Pluses and Negatives	12							
Enhancing native fauna habitat	1							
Water supply			28					
Biodiversity improvement			29					
Planning for climate change			14					
Holistic farm management			21					
Equity – Mobilising urban resources			10					
Native Vegetation Management			35	4				
Salinity			32	5				
Commercial Forestry			0					
Aesthetics – Landscape			2					
Groundwater supply and quality			12					
Identification and protection of wildlife corridors			19					
Agency cooperation and coordination			16					
Land use implications of cash crops			0					
Limiting chemical use – Management of chemicals			6					
Appropriate revegetation citing, techniques, species selection, education					21			
Local community environmental awareness					12			
Fire risk and management in urban areas					5			
Engaging the decision makers					15			
Cross border communication of whole of catchment issues					29	2		
Engaging the community to promote the Landcare Ethic					16	3		
Accessing technical advice					16			
Land management and grazing							9	
Groundcover management							103	1

Venue	Stoney Creek		Queanbeyan		Narrabundah		Royalla	
New Issue	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Sustainable use of Groundwater							82	2
Increasing water use in peri-urban areas							53	
Groundwater Quality							27	
Education of NRM							48	
Dissemination of NRM information							17	
Wildlife corridors – establishment, mgt, protection							41	
Riparian Restoration							72	4
Defining riparian rights							22	
Fire succession management							22	
Biodiversity management and enhancement							70	5

Table 11 Top five issues from Community Consultation for the MCS 2005.

Queanbeyan	Stoney Creek	Royalla	Narrabundah
Planning and Development	Weeds	Groundcover management	Planning and Development
Water Quality	Water Quality	Sustainable use of Groundwater	Cross Border Issues
Weeds	Erosion	Weeds	Promoting the Landcare Ethic
Native Vegetation Management	Public Land Management	Riparian Restoration	**Weeds**
Salinity	Tree decline	Biodiversity management & enhancement	Water Quality

APPENDIX 2. POPULATION IN THE MOLONGLO CATCHMENT

Prepared by Martin Butterfield

This document is being prepared for the information of the Molonglo Catchment Group following a suggestion by a member of that group. I have prepared it using my knowledge of Census Data gathered while employed as an officer in the Census area of the Australian Bureau of Statistics (ABS) some years ago and other aspects of my career in official statistics in various organisations. A key tool used has been the Tablebuilder facility offered through the ABS. While I have taken care in undertaking the work, and attempted to highlight possible areas in which the results proffered may not match precisely with what is expected there is still scope for error. If any questions arise please contact me.

SUMMARY OF SUGGESTIONS

For current (2011) Census data use Tablebuilder to access required statistics. Required geographic units are as follows:

ACT

- SA3 units
    - Fyshwick - Pialligo – Hume
    - North Canberra
    - South Canberra
    - Weston Creek
    - Woden
- SA1 units
    - 8102701 (=SA2 Molonglo)
    - 8102801 (=SA2 ACT South West)

NSW

- Queanbeyan LGA
- State suburbs
    - Burra Palerang
    - Carwoola
    - Captains Flat
    - Hoskinstown
    - Jerangle
    - Primrose Valley

Note (a) SA1 units 1101119 (mainly Wanna Wanna) and 1101128 (mainly Clydesdale) are in both Queanbeyan LGA and Carwoola so adjustments are needed if aggregating to catchment totals.

Note (b) the designation by ABS of ACT SA2 level unit, Molonglo, is very strange as it does not cover most of the area currently under development as Molonglo Township. I expect there to be significant revision to the boundaries of that unit as development proceeds.

For estimated Resident Populations use ABS Bulletin 3218.0

2011-12 onwards

- ACT: as above
- NSW
    - SA2 units
        - Karabar
        - Queanbeyan
        - Queanbeyan – East
        - Queanbeyan Region
        - Queanbeyan West - Jerrabomberra

For years prior to 2011-12 see discussion in text below.

For Time Series Census data use Census Time Series Profile for effectively the same geographic units as Estimated Resident Population above but see discussion in text (Sources of Long-term Data p122) for adjustments from Place of Enumeration basis to Usual Residence basis.

WHAT IS THE MOLONGLO CATCHMENT?

The Molonglo catchment is the area drained by the Molonglo River and its major tributary the Queanbeyan River. A number of named creeks also flow into these Rivers.

It is difficult to describe this area as text. For ease of computation the data was extracted in 3 parts:

- 15 State suburbs in NSW;
- 5 Statistical Sub-Divisions in the ACT and
- 2 Level 1 statistical areas in the ACT.

Maps showing the extent of these 3 areas are shown in Figure 26 at the end of this Appendix.

A particular problem arose with the new McMansion developments of Molonglo since the areas they are now occupying was not recognised by ABS at the State Suburb (or SSD) level for the output of the 2011 Census. Instead first level standard geographic units (#8102701) had to be used. While much of these areas drain to the Murrumbidgee rather than the Molonglo the current population is very small (489) and will have no impact on any results for 2011. However to disregard the area and the impact of massive population change expected in this area by 2016 would severely limit the value of any strategies.

A second level 1 unit (# 8102801 – which actually forms an SA2 unit called Molonglo by ABS) with population of 27 was also selected since it covers the Northern bank of the Molonglo downstream of Scrivener Dam.

POPULATION AIN'T POPULATION

In the past a series of TV ads used the catchphrase "*oils ain't oils*" to emphasise that while there were many oils and that the featured product wasn't just another oil, in much the same way there

are many different ways of measuring the population of an area. For the purposes of this note two approaches need consideration:

- Population estimates; and
- Census counts.

POPULATION ESTIMATES

This term refers to the official estimates of the population of an area produced by the Australian Statistician. They are the measures used for distribution of the population between electorates and for the distribution of many aspects of public funds between sub-areas.

The estimates are made each year using the following broad approach for each region:

*Population at time n = Latest Census count of usual residents **+** net undercount in Census **+** inwards migration (international and intranational) **–** outwards migration (international and intranational) **+** births **–** deaths.*

Due to difficulties in measuring the undercount and migration for small areas these estimates are only produced for relatively large areas, mainly ones for which the two core purposes are relevant.

Further, the estimates are only prepared for a small range of attributes, of which age and sex are the most important.

CENSUS COUNTS

Census counts are direct counts of the population at a point in time. While the Australian Census has extremely high levels of public support there is always a small (3% or less) undercount, and the results are only available once every 5 years. (However the Census does include Time Series Profiles for LGAs or Higher level units which enable comparisons over 3 Censuses.)

A crucial attribute of the Census counts is that they may be presented in 2 ways:

- According to where people were physically located on census night (Place of Enumeration basis - POE); or
- Where they usually live (Usual Residence basis - UR).

This difference proved to be significant when looking at the utility of some areas for this study since a large number (500+) of visiting children were located in the motels on the Federal Highway just across the ACT border. This issue is discussed below.

They are now available for very small areas (called mesh blocks) which can be added together in a variety of ways to produce customised statistics required by users. These include Statistical Local areas (suburbs in the ACT, Local Government Areas in New South Wales) and State Suburbs. (In the past the smallest area was an ABS administrative unit Collection District (CD) based upon the collection workload unit: an important limitation of this was that many CDs cut across boundaries of other areas – such as catchments – of interest to users.)

As well as basic demographic statistics the Census counts are classifiable by a range of other attributes including industry of employment and occupation.

WHAT IS NEEDED FOR THE MOLONGLO STRATEGY?

For examining change over time in broad population numbers the best approach is to use the population estimates. As discussed below, that becomes somewhat difficult since the NSW LGAs of interest do not fit well with the catchment boundary.

For looking at non-demographic attributes of the population at small area levels the Census is the only game in town. It is difficult at present to make comparisons over time since the changes to Census geography in 2011 make an exact comparison with 2006 and 2001 impossible for the rural areas of the Molonglo catchment. However, it is hoped that some indicative comparisons will be able to be produced.

SOME INITIAL DATA FOR 2011 CENSUS

INDUSTRY

Once I had gathered together a collection of areas to reflect the Catchment extracting the data for industry of employment in 2011 was quite straightforward. The numbers for the highest level of the Industry Classification for the whole catchment are provided below.

For development of a strategy I would suggest that there is merit in examining the components of the catchment separately. Quite how that could be done is not my area, but I might suggest that the 4 ‘typical’ SSDs of the ACT plus Queanbeyan made a sensible grouping while the remaining areas had a more ‘rural’ feel and could be considered as a group. Alternatively, Fyshwick etc. plus the two ACT Level 1 areas could form a second group while the 6 rural areas in NSW formed a third. To facilitate this an Excel workbook will be provided with the data as downloaded.

It might be even better to perform the analysis at the State Suburb level, but this does not permit the ready inclusion of the two level 1 units and some questions also arose about “what was included where”. However, the 59 State suburbs contributing to the Catchment are listed in Appendix 2 and a table of Industry of employment x State Suburb is in the Excel Workbook for manipulation if that is seen as useful.

Table 12 Industry of Employment in the Molonglo Catchment 2011

Agriculture, Forestry and Fishing	**341**
Mining	64
Manufacturing	2285
Electricity, Gas, Water and Waste Services	715
Construction	5107
Wholesale Trade	1220
Retail Trade	6378
Accommodation and Food Services	5179
Transport, Postal and Warehousing	1894
Information Media and Telecommunications	1725
Financial and Insurance Services	1434
Rental, Hiring and Real Estate Services	1262
Professional, Scientific and Technical Services	9274
Administrative and Support Services	2129
Public Administration and Safety	30912
Education and Training	7879
Health Care and Social Assistance	8521
Arts and Recreation Services	1579
Other Services	2790
Inadequately described	737
Not stated	623
Not applicable	78774
Total	170822

DENSITY OF POPULATION

Acquiring this data turned out to be quite frustrating. As far as I can see, the only place in Census results in which the area of the geographic unit is specified is in the Community Profiles. While very useful documents for some applications, it was annoying in the extreme to have to download, for each area, a 300Kb file to obtain 7 characters of information. (The area of each SA2 unit is in the ABS Estimated Resident Population publication but that is far from convenient when using Tablebuilder). ABS will be getting the edge of my tongue over this.

However, I persevered and here is the result (see Table 1). **Note** (a): SA1 units 1101119 (mainly Wanna Wanna) and 1101128 (mainly Clydesdale) are in both Queanbeyan LGA and Carwoola so adjustments are needed if aggregating to catchment totals.

Note (b): the designation of ACT SA2 level unit 'Molonglo' is very strange as it does not cover most of the area currently under development as Molonglo Township. I expect there to be significant revision to the boundaries of that unit as development proceeds.

Again, this data is available in the Excel file provided separately.

CHOICE OF LONG-TERM TREND DATA

This section examines the nature of data available for the Catchment. Where to get the data is covered by the following major section, “Sources of data”.

There are two aspects to consider under this heading but similar issues arise:

- Comparing census data over a number of collection cycles; and
- Having a source for annual broad level trend data.

It might have been hoped that accessing Collection District (CD) level data and aggregating to the Catchment level, would enable very similar data to be generated from each census. However to do this effectively requires some form of GIS which I don’t have and CD level data appears to no longer be available (being replaced by SA1 level data which is only available for 2011. Thus it is necessary to use a higher level unit.

- For the 2011 Census the level of State Suburb unit seems very useful, but for the Catchment,
    - data for some of these units in the NSW rural area (e.g. Hoskinstown) does not exist for past censuses, and
    - State Suburb units are not covered by the population estimates annual estimation cycle.
- Local Government areas – in this case Queanbeyan and Palerang – offer benefits in terms of little workload and direct links to key stakeholders but,
    - do not follow the catchment boundaries; and
    - are inherently influenced by political action (which appears to be gathering strength at present).
- The new ABS statistical structure (represented by the Queanbeyan SA3 unit (excluding the Braidwood SA2 unit)within the Capital Region) could also be used with little workload and will:
    - match more closely the catchment boundaries; and
    - (hopefully) be more stable than the LGA structure.

However they don’t:

- have direct links to Council Areas;
- follow the catchment boundaries.
- Some current output still includes the SLA level used in the previous statistical geography. This includes a unit defined as Palerang part A which is broadly similar to the previous Yarralumla Shire. However it:
    - doesn’t follow the Catchment boundaries;
    - doesn’t follow current Council boundaries;
    - may not be acceptable to use in discussion with Palerang Council as perpetuating the angst-ridden East/West divide; and
    - is subject to ‘boundary issues’ if attempting to use this as part of a series also using Queanbeyan Region SA 2 data.

As the State Suburb data is not available, the choice comes down to using Queanbeyan and Palerang LGA data vs Queanbeyan Region SA2 data to represent the NSW rural part of the catchment. The two areas are illustrated in the following screenshots from the ABS Quickstats facility.

Figure 22 Palerang LGA

Figure 23 Queanbeyan Region

Some elements of the Queanbeyan LGA (e.g. Googong; The Ridgeway; Carwoola-Queanbeyan) are included in the Queanbeyan Region but not (obviously) in Palerang. The other major difference is that Palerang stretches well to the East of the Shoalhaven but excludes the State suburbs of Royalla and Michelago (which are included in the Queanbeyan Region but drain to the Murrumbidgee). Both areas include some country to the North and East of Bungendore (including Bungendore village, Bywong and Wamboin) which drains to Lake George or the Yass River rather than the Molonglo. It is clear that a far higher proportion of the Queanbeyan region (either as population or land-area) is relevant to the Catchment than is the case for Palerang. The following section compares the NSW Rural section of the catchment (i.e. NSW section excluding the urban parts of the City of Queanbeyan) with the Queanbeyan Region SA2 unit.

COMPARING QUEANBEYAN REGION SA2 AND NSW COMPONENT OF MOLONGLO CATCHMENT

At the broadest level the SA2 unit has nearly three times the population of the NSW Rural catchment (14,110 vs 5733 residents). In forming an indicator, this in itself should not matter as long as the two areas have broadly similar profiles. I have examined two approaches to the profiles as set out in the following sections.

INDUSTRY OF EMPLOYMENT: NSW RURAL CATCHMENT AND QUEANBEYAN REGION SA2

This comparison relates to the Industry in which residents of the 2 areas are employed. It does not imply that their workplace is in either of the study areas (indeed, anyone driving along Captains Flat Road between 6am and 9am on a weekday is very aware of many people driving into Canberra for work).

The comparison is illustrated in Figure 24 (with the underlying census statistics shown in Table 14 at the end of this report).

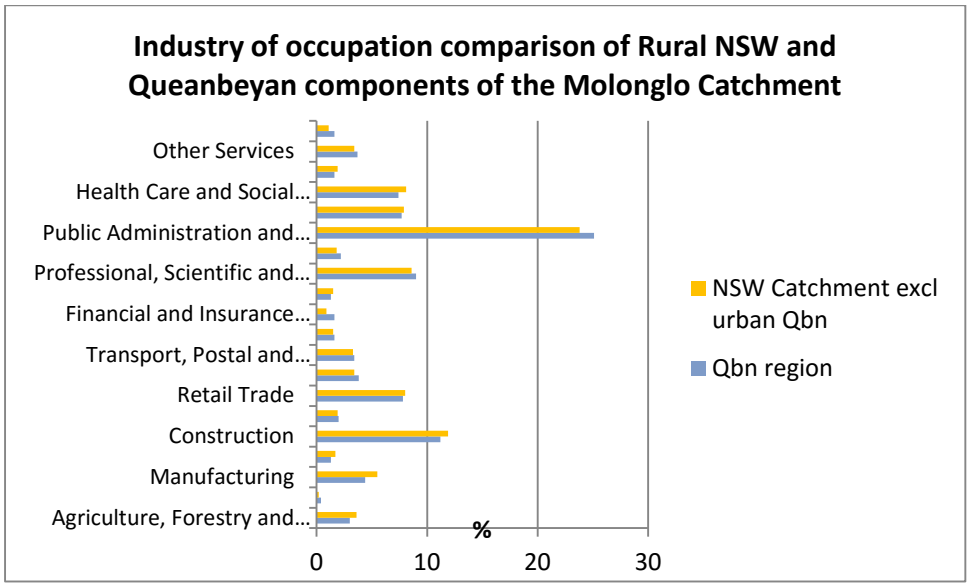


Figure 24 Industry of occupation: NSW rural catchment compared with Queanbeyan Region

The similarity of the profiles is visually obvious and is confirmed by the two series having a correlation coefficient of 0.9951.

5 YEAR AGE GROUPS: NSW RURAL CATCHMENT AND QUEANBEYAN REGION SA2

The following Chart shows this comparison using Census data relating to Usual Residents of the two areas. Underlying data is in Table 15 at the end of this report.

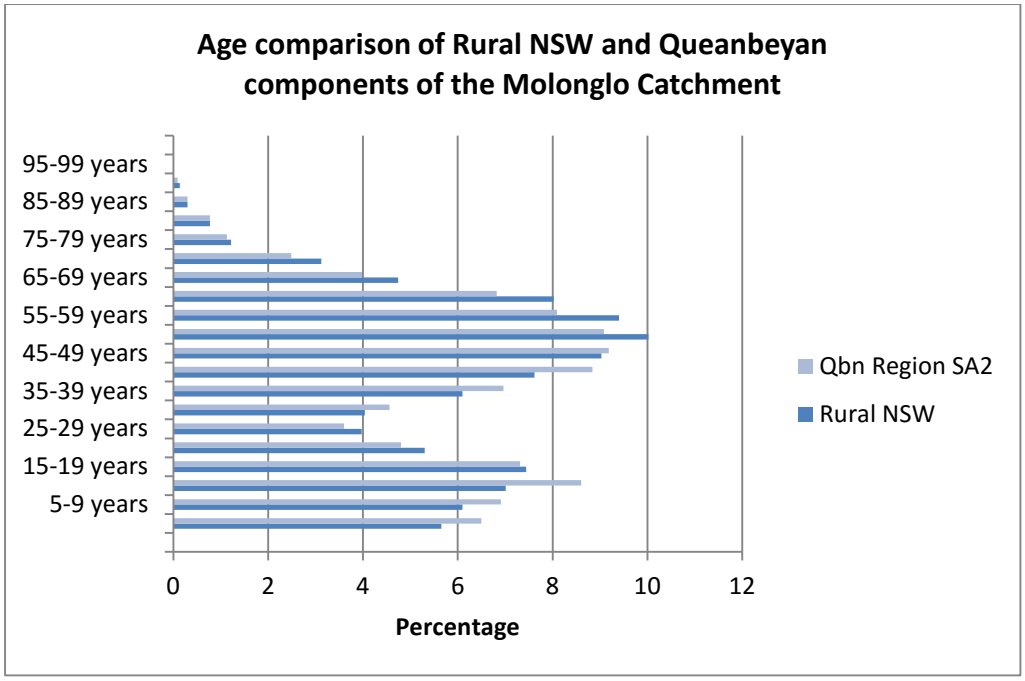


Figure 25 Five year age groups: NSW rural catchment compared with Queanbeyan Region

The correlation coefficient for the two series is again high at 0.9736. However it does appear that there are some differences between the series, with older (50+) people over-represented in the Rural Catchment and (particularly) the 10-14 age group over-represented in the Region. (To some extent the latter issue is explained by one SA1 unit (1101104) having an extraordinary 32% of the population (143 people out of 547) in this age group. I believe that this reflects a response error regarding their usual residence.)

The issue with 10-14 year-olds provided a salutary lesson in the distinction between population counted as usual resident and place of enumeration. The Queanbeyan Region SA2 includes, on a UR basis, 1213 people aged between 10 and 14 years. (This is 8.6% of the population in contrast to 7.0% of the population in the Rural Catchment and 6.5% for NSW as a whole.) If, however, a basis of Place of Enumeration is used the proportion of 10-14 year olds rises to 11.43%. This is almost entirely due to 543 people in that age group enumerated in the motels beside the Federal Highway near the ACT border. **I see it as very important that usual residence based statistics are used for matters relating to the catchment**.

CONCLUSION

I believe that overall the Queanbeyan Region SA2 data on a Usual Resident basis forms a reasonable **indicator** to represent the NSW Rural element of the Catchment in most cases where the suburb based information is not available. (Quite how that indicator would be combined with the rest of the catchment is not immediately clear to me!) This applies to past Census data and to the Estimated Resident Population.

If the need is for information classified by detailed age groups (or a topic heavily influenced by age group) I recommend that great caution be used in view of the matters raised in the preceding section.

SOURCES OF LONG-TERM DATA

The ABS produces information relating to various spatial units in a wide range of forms. As a general point the information is the same if the parameters (classification, geographic unit and counting unit) are the same. However, not every form of presenting the data necessarily uses the same parameters and great care is required.

ESTIMATED RESIDENT POPULATION (ERP) DATA

This is available on line from ABS Bulletin 3218.0 (go to the Downloads tab and select "3218.0 Population Estimates by Statistical Area Level 2, 2011 to 2012". The latest ERP for Queanbeyan Region SA2 can be located there.

Accessing the tab "Past and Future releases" gives access to the 2011 issue of the Bulleting which contains both ASGS SA2 based information (as above) and under the download "3218.0 Population Estimates by Statistical Local Area, 2001 to 2011" information for Palerang part A. These can be used to develop an updating ratio to convert the old Palerang part A to an indicative estimate for Queanbeyan Region SA2.

INFORMATION FOR PAST CENSUSES

The Table Builder facility has information for the 2011 and 2006 censuses but not for 2001. In addition, the information available for 2006 is only available for the ASGC (i.e. SLA basis) geography – for which Palerang part A is the closest match to what is needed.

The simplest source for 2006 and 2001 for Queanbeyan Region SA2 unit is the Community profiles: Time Series Profile which can be downloaded from the ABS site. However this information is only available on a Place of Enumeration basis

As noted above, this is not appropriate to use where age is important and/or if absolute numbers are required. Where these conditions apply I suggest that 2006 Census Community Profile data, which can be found as UR based information in the basic Community Profile and PoE based information in the Time Series profile, be used to build a statistical bridge from PoE data to UR data.

ADDENDUM RE: TIME SERIES DATA

The State suburb unit is, I think, going to be excellent for the future but is currently very difficult to work with when looking backwards.

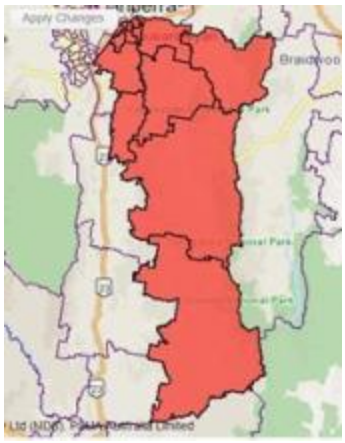
I know that Hoskinstown doesn't exist in 2006 (and the CDs which cover the area we call Hoskinstown also include a lot of Tallaganda). The area called Carwoola in 2006 only includes two CDs equivalent to the Palerang part. The Queanbeyan part of Carwoola is another CD for which separate data can be extracted for 2006 (but which is included in Queanbeyan LGA!).

In summary, it is a mess trying to work with State Suburbs. CDs are not, I suspect, the solution as they don't seem to be generally available for 2011. The SA1 units are output units rather than collection units - a very good idea for the future - but don't line up well with 2006 CDs as far as I can judge.

I really think the best indicator to use as a broad measure is the ERP population on Palerang Pt A (2001 - 2011) and then Queanbeyan Region for 2011 onwards. I have attached a spreadsheet with two approaches: one back casting the SA2 data and the other forecasting the Palerang Pt A data using the ratio of the common year 2011 as a bridge. (Once we get to 2016 state suburb could be used as a more accurate measure.)

The Palerang Pt A data is more consistent with Yarralumla Shire but would be more difficult to fit into the SA 2 data available for the rest of Queanbeyan unless you use Queanbeyan SLA until 2016. I think the State boundary stays secure so the ACT elements can use either SLAs/SSDs or SA2/SA3 units.

Figure 26 Mud Maps of Statistical areas used for population estimates in the Molonglo catchment a) NSW catchment (6 state suburbs and Queanbeyan LGA); b) SA3 units in the ACT; c) SA1 units from the ACT included to capture future growth in Molonglo valley.



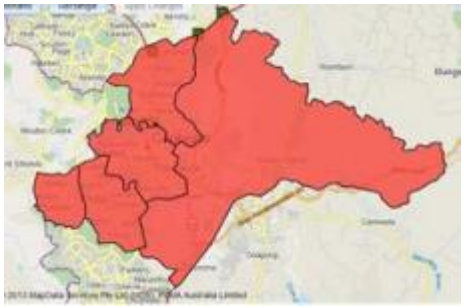


Table 13 List of State Suburb units contributing to Molonglo catchment area. Please note these are statistical units not a list of Molonglo catchment suburbs.

Ainslie
Barton
Braddon
Burra (Palerang - NSW)
Campbell
Captains Flat
Carwoola
Chapman
City
Crestwood
Curtin
Deakin
Dickson
Downer
Duffy
Farrer
Fisher (ACT)
Forrest (ACT)
Garran
Googong
Greenleigh
Griffith (ACT)
Hackett
Holder (ACT)
Hoskinstown
Hughes (ACT)
Hume
Isaacs
Jerangle
Jerrabomberra
Karabar
Kingston (ACT)
Lyneham
Lyons (ACT)
Mawson
Narrabundah
O'Connor (ACT)
O'Malley
Oaks Estate
Parkes (ACT)
Phillip
Pialligo
Primrose Valley
Queanbeyan
Queanbeyan East
Queanbeyan West
Red Hill (ACT)
Reid (ACT)
Rivett
Stirling (ACT)
Symonston
Tharwa
The Ridgeway
Turner
Waramanga
Watson
Weston (ACT)
Yarralumla

Table 14 Industry of Employment: residents, NSW rural catchment and Queanbeyan Region SA2

	Usual Resident Population		Percentage of Population		
	Qbn region	NSW Catchment excl urban Qbn	Qbn region	NSW Catchment excl urban Qbn	% Difference
Agriculture, Forestry and Fishing	231	113	3.0	3.6	17.0
Mining	30	7	0.4	0.2	-73.9
Manufacturing	346	174	4.4	5.5	19.3
Electricity, Gas, Water and Waste Services	98	54	1.3	1.7	26.3
Construction	874	378	11.2	11.9	6.2
Wholesale Trade	154	60	2.0	1.9	-4.2
Retail Trade	611	255	7.8	8.0	2.7
Accommodation and Food Services	298	109	3.8	3.4	-11.0
Transport, Postal and Warehousing	265	104	3.4	3.3	-3.4
Information Media and Telecommunications	125	48	1.6	1.5	-5.7
Financial and Insurance Services	128	30	1.6	0.9	-73.2
Rental, Hiring and Real Estate Services	101	48	1.3	1.5	14.6
Professional, Scientific and Technical Services	703	272	9.0	8.6	-4.9
Administrative and Support Services	175	56	2.2	1.8	-26.8
Public Administration and Safety	1960	754	25.1	23.8	-5.5
Education and Training	600	252	7.7	7.9	3.4
Health Care and Social Assistance	577	257	7.4	8.1	8.9
Arts and Recreation Services	124	59	1.6	1.9	14.7
Other Services	293	108	3.7	3.4	-10.1
Inadequately described	127	36	1.6	1.1	-43.2
Total	7820	3174	100.0	100.0	
Correlation coefficient			0.9951		

Table 15 Five Year age groups: residents, NSW rural catchment and Queanbeyan Region SA2

Age group	Rural NSW Catchment		Qbn Region SA2
	# Usual Residents	%	
0-4 years	324	5.65	6.50
5-9 years	350	6.10	6.91
10-14 years	402	7.01	8.60
15-19 years	427	7.44	7.31
20-24 years	304	5.30	4.80
25-29 years	228	3.97	3.60
30-34 years	232	4.04	4.56
35-39 years	350	6.10	6.96
40-44 years	437	7.62	8.84
45-49 years	518	9.03	9.18
50-54 years	575	10.02	9.08
55-59 years	539	9.40	8.09
60-64 years	460	8.02	6.82
65-69 years	272	4.74	3.98
70-74 years	179	3.12	2.49
75-79 years	70	1.22	1.13
80-84 years	44	0.77	0.77
85-89 years	17	0.30	0.30
90-94 years	8	0.14	0.09
95-99 years	0	0.00	0.02
100 years and over	0	0.00	0.00
Total	5736	100.00	100.00
Correlation coefficient		0.9736	

APPENDIX 3: THREATENED AND IMPORTANT SPECIES AND ENDANGERED ECOLOGICAL COMMUNITIES

After *A Planning Framework for Natural Ecosystems of the ACT and NSW Southern Tablelands* (Fallding, 2002) updated by ACT State of the Environment Report 2011 (Office of the Commissioner for Sustainability and the Environment, 2011). Since then, NSW has declared the Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions an endangered ecological community. Further species listed as threatened include the Scarlet Robin, Flame Robin, Little Eagle.

	Vegetation Status	Threatened & important species & endangered ecological communities
Canberra – Queanbeyan	Grasslands have been largely cleared and replaced by urban developments and infrastructure. Much of the surrounding Box-Gum Woodland remains, though part of this area in the ACT is occupied by rural land uses. Dry forests are largely intact. Within the ACT large proportions of Grasslands, Box-Gum Woodlands and forests are protected within nature reserves. No large reserves exist to protect these communities in the NSW section of the unit. There are: o Grasslands and Box-Gum Woodlands of considerable diversity including the Barton and Majura Grasslands, Ainslie-Majura and Mulligans Flat nature reserves, Queanbeyan Nature Reserve and Woodlands at the Gale Precinct; and o Many secure Grassland and Box-Gum Woodland sites, and their associated threatened species in the ACT.	**Plants:** Pale Pomaderris**,** Button Wrinklewort**,** Tarengo Leek Orchid**,** Small Purple-pea**, Silky Swainson-pea,** Ginninderra Peppercress**, Golden Moths Orchid,** Hoary Sunray (white form)**, Australian Anchorplant, *Caladenia tessellata* (a spider orchid), *Bossiaea grayi,*** Canberra Spider Orchid**,** Brindabella Midge Orchid**,** Tuggeranong Lignum**,** Small Snake Orchid, *Gentiana baeuerlenii*
		Mammals: **Squirrel Glider, Spotted-tailed Quoll, Eastern Bent-wing Bat, Koala, Brush-tailed Rock Wallaby, Smoky Mouse**
		Birds: **Blue-billed Duck, Latham's Snipe,** Glossy Black-cockatoo**,** Superb Parrot**,** Swift Parrot**, Grey-crowned Babbler (early records),** Brown Treecreeper**,** Regent Honeyeater**, Speckled Warbler, Olive Whistler,** Hooded Robin**, Diamond Firetail,** Little Eagle**,** Painted Honeyeater, White-winged Triller, Varied Sitella
		Reptiles, frogs and fish: **Pink-tailed Worm-lizard, Striped Legless Lizard, Grassland Earless Dragon, Rosenberg's Monitor, Northern Corroboree Frog, Macquarie Perch, Trout Cod, Silver Perch, Two-spined Blackfish**
		Invertebrates: **Golden Sun Moth, Perunga Grasshopper, Murray River Crayfish**
		Vegetation communities: **Natural Temperate Grassland, Alpine Fens and Bogs, Yellow Box / Red Gum Grassy Woodland (ACT only), White Box – Yellow Box - Blakely's Red Gum Woodland (NSW only).**

	Vegetation Status	Threatened & important species & endangered ecological communities
Captains Flat	Grasslands and Grassland-Woodland Mosaic are modified and partly cleared. The Forests are largely uncleared. There are: 0 Samples of Grasslands and Grassland-Woodland Mosaic of considerable diversity, including Captains Flat Cemetery and some roadside reserves.	**Plants:** **Tarengo Leek Orchid, Golden Moths Orchid, Hoary Sunray (white form), Australian Anchor-plant.**
		Mammals: **Eastern Pygmy Possum, Spotted-tailed Quoll**
		Birds: **Powerful Owl, Regent Honeyeater, Brown Treecreeper, Speckled Warbler, Diamond Firetail, Hooded Robin.**
		Vegetation communities: **Natural Temperate Grassland.**
Bungendore	Grasslands and Box-Gum Woodlands are largely cleared or modified. The Dry Forest are partly cleared. There are several samples of Grassland and Box-Gum Woodland of considerable diversity.	**Plants:** **Hoary Sunray (white form), Button Wrinklewort, Golden Moths Orchid, Buttercup Double tails, Australian Anchor-plant, *Euphrasia scabra* (an early record), *Wilsonia rotundifolia* (a wetland forb).**
		Mammals: **Spotted-tailed Quoll, Koala, Eastern False Pipistrelle.**
		Birds: **Australasian Bittern, Blue-billed Duck, Freckled Duck, Latham's Snipe, Superb Parrot, Powerful Owl, Diamond Firetail, Speckled Warbler, Hooded Robin.**
		Reptiles and frogs: **Striped Legless Lizard, Little Whip-snake, Green and Golden Bell Frog.**
		Vegetation communities: **Natural Temperate Grassland, White Box - Yellow Box - Blakely's Red Gum Woodland.**
Royalla	Grasslands and Box-Gum Woodlands are highly modified and cleared. The Wet and Dry Forests are partly cleared. There are: 0 Samples of Grasslands and Box-Gum Woodlands of considerable diversity, including Royalla and Burra TSRs and a railway reserve.	**Plants:** **Small Purple-pea, Silky Swainson-pea, Button Wrinklewort, Hoary Sunray (white form), Golden Moths Orchid, Michelago Parrot-pea.**
		Mammals: **Koala, Spotted-tailed Quoll, Little Bent-wing Bat, Eastern Bent-wing Bat.**
		Birds: **Latham's Snipe, Glossy Black-cockatoo, Diamond Firetail, Hooded Robin, Speckled Warbler, Brown Treecreeper.**

	Vegetation Status	Threatened & important species & endangered ecological communities
		Reptiles and frogs: **Pink-tailed Worm-lizard, Rosenberg's Monitor, Giant Burrowing Frog, Green and Golden Bell Frog (early records), Southern Bell Frog (early records).**
		Vegetation communities: **Natural Temperate Grassland, White Box - Yellow Box - Blakely's Red Gum Woodland.**
Tinderry Range	Forests are largely uncleared, except along the edges of ranges. There are: 0 Large areas protected within Tinderry Nature Reserve.	**Plants:** **Pale Pomaderris, Golden Moths Orchid.**
		Mammals: **Koala, Spotted-tailed Quoll, Eastern Pygmy Possum, Eastern False Pipistrelle, Eastern Bent-wing Bat.**
		Birds: **Barking Owl.**
Lake George Range	Box-Gum Woodlands and Grasslands are largely cleared or modified. Dry Forests are cleared in places. There are: 0 Reserves, including the extensive area surrounding Googong Reservoir and several newly proclaimed nature reserves in the Queanbeyan area; and 0 Samples of Box-Gum Woodlands and Grasslands of considerable diversity, including various sites on private land.	**Plants:** **Pale Pomaderris, Silky Swainson-pea, Small Purple-pea, Button Wrinklewort, Hoary Sunray (white form), Golden Moths Orchid, Australian Anchor-plant, *Senecio macrocarpus* (a ragwort).**
		Mammals: **Koala, Spotted-tailed Quoll, Eastern Pygmy possum, Eastern Bent-wing Bat, Little Bent-wing Bat, Eastern False Pipistrelle.**
		Birds: **Barking Owl, Superb Parrot, Latham's Snipe, Diamond Firetail, Hooded Robin, Speckled Warbler, Brown Treecreeper, Regent Honeyeater, and Painted Honeyeater.**
		Reptiles and frogs: **Pink-tailed Worm-lizard, Rosenberg's Monitor, Green and Golden Bell Frog (early records), Southern Bell Frog (early records).**
		Invertebrates: **Golden Sun Moth.**
		Vegetation communities: **Natural Temperate Grassland, White Box - Yellow Box - Blakely's Red Gum Woodland.**

APPENDIX 4: PUBLICALLY FUNDED PROJECTS IN THE MOLONGLO CATCHMENT SINCE 1996

Table 16 Shows all the on-ground projects that have been publically funded in the Molonglo catchment that the Molonglo Catchment Group is aware of since 1996.

Projects/Actions	Date	Agency	Location	Funding Approved
Upper Molonglo/Hoskinstown				
Save The Bush Project-Hoskinstown Landcare Group Remnant Vegetation Protection & Wildlife Corridors Project: Establish green corridor from Kowen and Brooks Hill Reserve in the west to Black range and Tallaganda Forest in the East	1996-97	Hoskinstown Community Landcare Group Inc.		$4,700.00
Save The Bush Project- Remnant Vegetation Project on 'Woodend', Rossi via Hoskinstown: Fence off 4.7 ha of remnant vegetation to conserve and enhance area of remnant bushland and connect with existing corridor system	1996-97	Hoskinstown Community Landcare Group Inc.		$2,300.00
Murray-Darling 2001 Project-Hoskinstown Landcare Group Remnant Vegetation Protection & Wildlife Corridors: Stage 2 of long-term plan to establish a green corridor from Kowen to Brooks Hill Reserve, and to Black Range and Tallaganda Forest	1997-00	Hoskinstown Community Landcare Group Inc.		$4,531.00
Bushcare Project-Greening to the Molonglo High Plain: Protect and enhance existing areas of remnant vegetation and link these with corridor networks	1998-01	Hoskinstown Community Landcare Group Inc.		
Bushcare Project-Greening to the Molonglo High Plain: Protect and enhance existing areas of remnant vegetation and link these with corridor networks	1998-01	Hoskinstown Community Landcare Group Inc.		
Bushcare Project-Bungendore Hoskinstown Rossi Revegetation: Develop and implement plan to reverse the long-term decline in native vegetation and encourage sustainable agriculture within the Bungendore/Hoskinstown/Rossi area	1999-01	Hoskinstown Community Landcare Group Inc.		$116,250.00

Projects/Actions	Date	Agency	Location	Funding Approved
Murray-Darling 2001 Project:-Upper Murrumbidgee Streamside Revegetation: Restoration of Upper Murrumbidgee River & its tributaries by removing problem willows & replacing them with native riparian vegetation as well as fencing off sections to manage stock access	1999-01	Upper Murrumbidgee Landcare Committee, Carwoola Landcare Group	Carwoola	
MCSIS3-Site visit 11/4/07 - fence both sides creek to exclude horses and future alpacas, natural regen occurring, provide stock water both sides fence (existing bore and dam on house side of creek - may be included in future application - fencing to be done first), 50 tubestock for drainage line above house block	2007			$5,620.00
MCSIS3-Vegetation enhancement along gully (some existing overstorey - weedy instream currently). No stock/no fencing required	2007		Kowen	$615.00
Revegetation of 300m Molonglo River + 300m tributary gully (both sides) - currently few goats on property - to be removed before planting	2007		Carwoola	$1,120.00
MCSIS3-Revegetating bare areas previously horse yards, and paddock above Little Whiskers Creek. Direct seeding during Spring 2007	2007		Carwoola	$820.00
MCSIS3-Willows poisoned several years ago by previous owner and neighbours. Native regen is good (shrubs, grasses, forbs). Tubestock approved to supplement native regeneration	2007		Carwoola	$320.00
MCSIS3-Fencing both sides of Primrose Valley Creek plus revegetation	2007		Primrose Valley	$2,460.00
MCSIS3-Revegetation of 250m both sides Primrose Valley Creek	2007		Carwoola	$825.00
MCSIS3-Site visit 6/6/2007 - Tubestock and direct seeding front paddocks around drainage lines. Direct seeding in Spring 2008	2007-08		Carwoola	$1,575.00
MCSIS2-Fencing both sides of creek, direct seeding and tubestock, off-creek water. Fencing inspected - complete July 2008. Direct seeding in Spring 2008	2008		Carwoola	$12,560.00
Molonglo Gorge Riparian Corridor: 15km of follow-up weed control (Willows & Blackberry)	2008/09	PCL		

Projects/Actions	Date	Agency	Location	Funding Approved
Molonglo River Park (800m riparian strip): Willow & Blackberry Control, Revegetation including mechanical ripping and weed management, Fencing and signage, On-going monitoring and follow-up weed management	2009	Palerang Council, Carwoola Landcare, Murrumbidgee CMA	Carwoola	
Trial Willow Removal: 1km of river frontage with various landholders over a 3km discontinuous reach with rehabilitation of the Molonglo River at Wilkins Park	2009	Carwoola Landcare, Captains Flat Landcare, GA, Local Landholders	Carwoola	
CIC Australia Development Fyshwick: Establishment of wetland run-off, Rehabilitation of riparian vegetation including weed removal and revegetation	2010	CIC Australia, GA, MCG	Beard	
Envirofund Round 8 Project: Fencing and Regeneration of Native Pasture and Trees: Fencing and preparing site for planting by distribution of fallen timber to slow surface water runoff and weed management, Distribute native grass seed			Carwoola	
Envirofund Round 7 Project-Restoration and Conservation of Native Vegetation and Waterways: Fencing 1.5km to exclude stock and protect riparian zone along a 1km section of Molonglo River and plant 350 native seedlings			Carwoola	
MCSIS2-Fencing 1.4km of riparian zone and revegetation				$2,920.00
MCSIS2-Fencing 0.21km and tubestock			Carwoola	$2,520.00
MCSIS2-Fencing 1.2km and revegetation of 0.13 ha of riparian zone			Carwoola	$1,300.00
MCSIS2-Fencing tributary gully and revegetation of 2ha			Carwoola	$2,020.00
MCSIS2-Fencing creek line and remnant plus fencing drainage line in front paddock and revegetation of 1 ha			Carwoola	$2,580.00

Projects/Actions	Date	Agency	Location	Funding Approved
Bushcare Project-Stoney Creek Enhancing Remnant Vegetation: Conserve and enhance areas of remnant native vegetation in the Stoney Creek Landcare area. Through the development of a Native Vegetation Management Plan, areas of quality native vegetation will be identified. On ground works will then be implemented at priority sites through the fencing out of remnants and linking remnants through corridor plantings. The project will be widely publicised to encourage landholder involvement and raise the awareness of the importance of native species. A monitoring program will be implemented to evaluate the success of the project				$14,075.00
MCSIS2 -Fencing, off-point water, tubestock. (Marginally outside catchment, however in light of previous restoration works undertaken, support of further works is warranted)				$5,500.00
NSW Environmental Trust Restoration & Rehabilitation - Woody Weed control in the Upper Molonglo River	2013-16	Captains Flat Landcare, Palerang Council	Captains Flat	$99 912.00
Burra Creek				
MCSIS2- Tubestock for promotion of project to local community at field	2006	Burra Landcare Group		$55.00
MCSIS3-Native bush block. Destocked 3 years ago when current owners purchased. Seeking advice of small gully and outflow of dam. General good condition across block. Tubestock approved to assist veg enhancement around dam and outflow	2007			$320.00
MCSIS3-Continuation of planting along creek line on community land. Green Team volunteers to help out with planting in early Spring 2007	2007	Little Burra Community Association		$800.00
MCSIS3-Tributary gully - paddock already fenced. Direct seed with natives. Stock to be removed. Direct seeding booked for Spring 2007	2007			$500.00
MCSIS3-Vegetation enhancement in destocked TSR to aid gully stability and improve biodiversity/habitat. Community/GA planting to be done Spring 2007	2007	Rural Lands Protection Board		$1,600.00

Projects/Actions	Date	Agency	Location	Funding Approved
MCSIS3-Site visit 14/11/2006 - tubestock and fencing of drainage line and dam	2007			$1,910.00
MCSIS3-Site visit 27/6/07. Good remnant vegetation onsite. Fence and revegetate sections of creek over time. Tubestock planting	2007			$480.00
MCSIS3-Clumped plantings to provide connectivity with neighbouring remnants	2008			$272.00
MCSIS3-Infill of area planted previously	2008			$112.00
MCSIS3-Direct seeding of failed planting area (funded under MCS1) along creek, plus tubestock for areas inaccessible to direct seeder				$670.00
MCSIS2-Fencing 1km of Holdens Creek and revegetation of 70ha			Burra	$2,030.00
MCSIS2-Tubestock only			Burra	$640.00
MCSIS2-Fencing 0.54km, off-point watering and tubestock				$5,770.00
ACTEW Water Burra Weed Management - Spray Safe and Weed ID course, and fencing subsidy	2013-14	MCG /ACTEW	Burra	$11,670.00
SELLS - Control of feral pigs, Burra Queanbeyan.	2014	SELLS	Burra	$6,000.00
Queanbeyan River				
Bushcare Project-Bicentennial Park Wildflower and Orchid Protection: Raise public awareness of sustainable land management and the importance of biodiversity through community consultation; to focus attention on grassland and wildflower community, promoting their presence by preparing a flowering calendar and establishing a (natural) heritage walk/trail	1995-97	Queanbeyan Landcare Inc.		$7,400.00
National Landcare Program Project-Oaks Estate Strategic Environmental Action Plan: To appoint a Coordinator who will, through community consultation, and on-ground research, ascertain the major environmental issues in the area and develop an Environmental Action Plan	1998-99			$5,000.00

Projects/Actions	Date	Agency	Location	Funding Approved
National Wetlands Program Project- Tin Hut Wetland Project: Increase biodiversity of wetlands, Decrease impacts from user groups by establishing formal interpretation infrastructures and other lowering impact from other threatening processes by establishing mechanisms to support biodiversity	1998-00	Friends of Googong Foreshores Inc.		
Envirofund 5 Project-Gale Precinct Rehabilitation and Reinvigorating Queanbeyan Landcare: Collect native grass understorey and tree seeds for direct seeding rip 6km of hard packed dirt roads and tracks which will be direct seeded and divert water from numerous nick points to halt erosion. The project will commence eradicating weeds and will attempt to reinvigorate the membership of Queanbeyan Landcare	2004-05	Queanbeyan Landcare Inc., Interim Gale Precinct Management Committee		
Tributaries (willow & woody weed control), targeted projects: Jerrabomberra Creek & Jerrabomberra wetlands, Queanbeyan River (Googong), Woolshed Creek (upper reaches)	2005-10	PCL		
MCSIS3-Continued revegetation of Queanbeyan River. Owner undertakes weed control and revegetation along his and neighbours reach of river.	2007		Lower Queanbeyan	$160.00
MCSIS3-Site visit 2/5/07 - owner grows own local euc and acacia sp - requires some understorey sp plus grasses/sedges for instream. Native remnant along gully - upstream neighbour has poplars in gully.	2007		Lower Queanbeyan	$210.00
Envirofund 9 Project- Linking of Remnant Vegetation and Establishing Wildlife Corridors: Establishing wildlife corridors to link remnant vegetation across five sites in the Jerangle area by revegetation and fencing	2007-08	Upper Queanbeyan/Bredbo Rivers Landcare Group		
ACT Environment Grant Project- Googong Foreshores Understorey Planting Project: Revegetation of three creek beds at the Googong Foreshores to re-establish wildlife corridors, riparian stabilization and contribute to water quality	2007-08	Friends of Googong Foreshores Inc.		

Projects/Actions	Date	Agency	Location	Funding Approved
MCSIS3-Fencing section of Lyons Creek. Direct seeding banks. Tubestock for slopes/in-stream	2008		Upper Queanbeyan	$2,760.00
MCSIS3-Two shelter belts fenced and direct seeded. Connecting Snowgum remnant area to riparian area. Fencing small regen area and minor supplement planting	2008		Jerangle	$5,530.00
MCSIS3-Fencing Roberts' Creek, upslope along ridgeline, including head gullies, providing >100m buffer in most areas. Protecting remnant riparian/slope veg. Fencing remnant vegetation along section of Lyons Creek also			Upper Queanbeyan	$11,760.00
MCSIS2-Fencing Queanbeyan River - willows removed under MCMA project funding earlier in 2006, along with neighbouring properties. Medium priority sub-catchment, but high priority site - good quality remnant vegetation along river, revegetation to be carried out in patches where required.			Upper Queanbeyan	$18,720.00
MCSIS2-Fencing 1.6km of Queanbeyan River and incorporating woodland remnant.			Upper Queanbeyan	$3,720.00
Envirofund Project: Gale Grassy-Box Woodland Rehabilitation Project Stage 2			Lower Queanbeyan	
Reedy Creek				
Rivercare Project-Integrated Rehabilitation of Reedy Creek: Stabilisation of Reedy Creek to minimise erosion, reduce silting and nutrient flowing into the Molonglo/Upper Murrumbidgee Catchment, Conserve and restore vegetation along the riparian zone and adjacent land, Improve habitat to encourage biodiversity and restore wildlife corridor, Improve productivity of adjacent farming, grazing and forestry activities	1998-01	Reedy Creek Landcare Group		$192,935.00
GA Rivers of Carbon: Lower Reedy Creek woody debris removal	2015	GA		
Jerrabomberra Creek/Royalla				

Projects/Actions	Date	Agency	Location	Funding Approved
Landcare and Environment Action Program	1993	ACT Government, Youth Conservation Corps, Greening Australia, CIT	Mugga Lane	
MCSIS2-Tubestock only - community planting undertaken	2006	Little Burra Community Association		$660.00
Envirofund 6 Project-Fernleigh Park Estate-Jerrabomberra Creek Restoration Project- Stage One: Construction of 2.5km of fencing to exclude stock from constructed vegetation corridors on six properties. Installation of additional stock watering points for affected landholders and planting 1550 native trees to assist regeneration	2004-05	Fernleigh Park Estate Community Group		
Tributaries (willow & woody weed control), targeted projects: Jerrabomberra Creek & Jerrabomberra wetlands, Queanbeyan River (Googong), Woolshed Creek (upper reaches)	2005-10	PCL		
MCSIS2-1,000 tubestock collected in October 07. Remaining collected in August 2008.	2007-08	Royalla Landcare	Jerrabomberra Creek (Royalla Estate)	$3,350.00
MCSIS3-Tubestock for connectivity along boundary fence, plus wetland species for dam/gully area	2008		Royalla	$320.00
MCSIS2-Revegation of drainage line and wetland. No stock - no fencing required.			Royalla	$900.00
MCSIS2-Tubestock for additional/replacement planting along Jerrabomberra Creek (original planting funded via Envirofund).				$80.00
Great Eastern Ranges Initiative Grants Program: Increasing Habitat Value via Land for Wildlife Program In Molonglo Catchment - workshop plus four properties LfW plus Swainsona Reserve planting	2013/14	MCG	Royalla	$12,000.00
Great Eastern Ranges Landcare Grant: Jerrabomberra Creek Small Bird Habitat at Fernleigh Park	2014/15	MCG/ Queanbeyan Landcare/ GA	Fernleigh Park	$9985.5 + $9676

Projects/Actions	Date	Agency	Location	Funding Approved
Woolshed Creek				
National Landcare Program Project-Duntroon Paddocks Shelter Belt Planting-Implement good pasture management, put in shelter belts which would also attract bird life to help reduce insect burden	1998-99	Duntroon Paddocks Landcare Group		
ACT Environment Grant Project-Rehabilitation of the Majura Dams: Improve environmental and community value of the two dams in the Mt. Majura Nature Park to create a wetland environment as a haven for birds and other wildlife, particularly frogs, The project was named Project Dragonfly as the indicator of success was the emergence of the first dragonfly	2005-06	MCG, Friends of Mt. Majura Parkcare Group, ACT Environment Grant, PCL		
Tributaries (willow & woody weed control), targeted projects: Jerrabomberra Creek & Jerrabomberra wetlands, Queanbeyan River (Googong), Woolshed Creek (upper reaches)	2005-10	PCL		
MCSIS3-Landowner has fenced 0.5km of creek and started revegetation. Tubestock will supplement existing plantings	2007		Majura	$160.00
Molonglo River from Woolshed Creek to Dairy Road Bridge: 650m of Willow & woody weed control	2008/09	ACT Roads		
Water plant establishment in realigned section of Woolshed Creek next to Majura Parkway	2013	ACT Roads/ MCG		
Riparian revegetation along northern realigned section of Woolshed Creek (opposite Mt Majura Rd)	2014	ACT Roads/ MCG/CVA		$12,032.00
MCSIS3-Perrenial Pastures Funding: Site visit 28 May 2008. Two paddocks totalling 9 ha to be put down to perennial pasture in Spring 2008			Majura	$900.00
Lake Burley Griffin + Mid Molonglo				
Lake Burley Griffin: 80m west of Sullivans Creek outflow & woody weed removal	2008/09	PCL		
Scrivener Dam Outflow: 400m Willow and other woody weed control	2008/09	NCA/PCL		

Projects/Actions	Date	Agency	Location	Funding Approved
Lake Burley Griffin (various foreshore areas managed by PCL west of Commonwealth Avenue Bridge): Blackberry control	2008/09 2009/10	PCL		
Molonglo Reach Riparian Restoration Project: Included large scale removal of woody weeds and revegetation with natives, Repair of eroded shoreline	2008/09	PCL		
Molonglo River Rescue Pilot Reach: 3km of fencing along the river corridor to restrict access of stock, Provision of alternate stock watering where applicable, Follow-up control 8km of Willows, Follow-up control 20km of Blackberry in the ACT	2009/10	MCG, GA, PCL, Murrumbidgee CMA		
Molonglo Reach (Campbell): 1.5km of Willow removal follow-up	2008/09	PCL		
Lake Burley Griffin: 600m Black Alder control from Black Mountain Peninsula & Lady Denman Drive, 900m Willows	2009/10	PCL		
ACT Environment grant: Enhancing the biodiversity value of Block 2 Section 128 Yarralumla - building Ngunawal engagement in natural resource management	2014/15	MCG/ Buru Ngunawal Aboriginal Corporation/Thunderstone Aboriginal Cultural and Land Management Services/ FOG	Block 2 Section 128 Yarralumla, Adjacent to Stirling Park	$6,508.00
Sullivans Creek				
Murray-Darling 2001 Project: Implementation of Sullivans Creek Catchment Management Plan: Implement plans to retro-fit two constructed demonstration urban wetlands adjacent to the tributary draining the O'Connor sub-catchment in the ACT, Rehabilitation of a 10 ha saline area in Crace Nature Reserve, Lyneham	1996-98	North Canberra Community Council, Sullivans Creek Catchment Group, DUS, ANU		

Projects/Actions	Date	Agency	Location	Funding Approved
National Landcare Program-Sullivans Creek Catchment Regeneration: The main aim of the project is to improve land and water quality within the Sullivans Creek catchment through increasing involvement and coordination with the community and stakeholders of the area. The major steps involved will include: Year 1: Consultation with various stakeholders in the catchment to formulate a plan of action. Year 1: Establishment of pilot works to tackle environmental hot spots within the catchment	1997-98			$41,000.00
ACT Environment Grant - Managing threats to biodiversity across Black Mountain, Mount Ainslie and Mount Majura (Cootamundra wattle and other weed removal)	2014-15	Friends of Mt Majura, Friends of Black Mountain, Mt Ainslie Weeders.		$40 267.00
Yarralumla Creek				
Bushcare Project- Farrer Ridge Re-vegetation Project: Planting 1000 trees in the Farrer Ridge	1996-97			$1,600.00
Bushcare Project-Farrer Ridge Resource Base Map: Consultant is required to compile/draw up a basic resource map of Farrer Ridge to build an inventory on the map which will give detail of the topographical & flora features	1996-97			$1,100.00
Bushcare Project-Ground Stabilization and Vegetation Planting Farrer Ridge: Stabilise degraded land, increase native vegetation, establish natural windbreak and shelterbelt, create wildlife corridor and remove Herbaceous and woody weed	1996-97			$1,450.00
Bushcare Project-Restoration and Revegetation of Hughes Buffer Area: The project aims to maintain the first intertown buffer zone in Canberra as an essential element of the Canberra 'Bush Capital'Plan. Previous community efforts have removed all wooden weeds from the area in preparation for revegetation using seed collected from the adjoining Red Hill Nature Park	1996-98			$6,700.00

Projects/Actions	Date	Agency	Location	Funding Approved
Lower Molonglo River				
Save The Bush Project-Aranda Bushland Documentation Project: Produce a comprehensive photographic field guide to Aranda Bushland	1996-97	Friends of Aranda Bushland Inc.		
Bushcare Project-Planning and Planting for Mt. Painter: Vegetation management plan to enable a coordinated and successful reintroduction of indigenous species to Mt. Painter	1998-01	Friends of Mt. Painter Inc.		$23,334.00
Bushcare Project-Aranda Snow Gums Heritage Site: Conserve & rehabilitate for the site at Block 1399, Involves fencing, rabbit control, weeding and planting using local provenance	1999-01	Friends of Aranda Bushland Inc.		$12,200.00
Molonglo River Below Coppins Crossing: 13km of Blackberry Control	2008/09	PCL		
Upstream of Coppins Crossing: 3km of Blackberry control	2009/10	PCL		
Downstream of Coppins Crossing: 3km of Willow control	2009/10	PCL		
ACT Environment Grant: Lower Molonglo Revegetation	2013/14	TAMS/MCG	Lower Molonglo Nature Reserve	$73,151
MCSIS2-Perrenial Pastures Funding: 50 ha perennial pasture establishment			ACT	$5,000.00
CATCHMENT WIDE				
MCSIS2-Replacement Tubestock: As needed by landowners - or if new sites identified which require tubestock only. Approx. 1900 tubestock and guards. OR if other works including small amount fencing can be fitted into this funding amount.			Various	$3,162.00

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