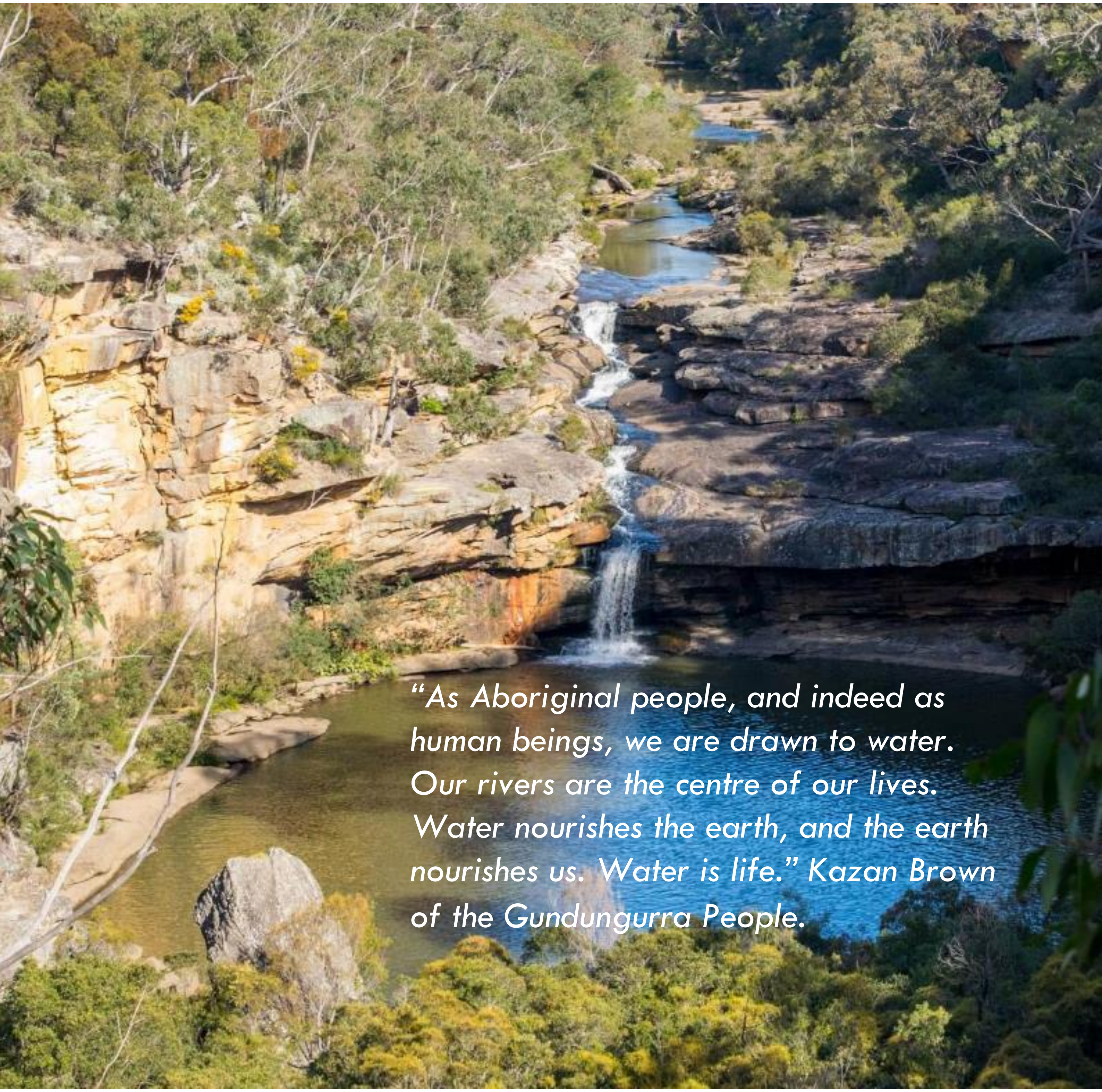
Integrated Water Management Strategy

Wollondilly Shire Council



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Acknowledgements

The Wollondilly area is the land of Dharawal and Gundungurra people. Protecting waterways and the environment in this catchment is consistent with the environmental stewardship the traditional owners have provided for thousands of years. The Council and community need to continue to protect the environment in respect of their stewardship and acknowledge their stories and connections.

Many council staff and stakeholders have participated in this process of drafting a policy and strategy, and they are acknowledged for their contributions, ideas, and data.

The input from external stakeholders, in the form of workshops, meetings and written feedback, is also acknowledged, particularly from representatives from Sydney Water, NSW Environmental Protection Authority, Water NSW, NSW Fisheries, and NSW Planning, Industry and Environment.

Authors

Wave Consulting Australia was engaged to draft this strategy document for Wollondilly Shire Council. Prof Stuart Khan from the University of New South Wales' Global Water Institute partnered with Wave Consulting Australia to draft this strategy.

Table of Contents

Table of Figures

1 Introduction

Water management is a significant issue for the community, economy, and environment in Wollondilly Local Government Area (LGA). The water cycle is managed by not just the WSC, but several state government agencies, landowners, industries, large dams and storages, and community, and it is important to continually identify how the community and agencies can work together to manage this precious resource.

Water plays a prominent role in supporting a healthy community and environment in Wollondilly. A strategic direction for water is important in 2020, due to the combination of new urban development and a changing climate that has the potential to negatively impact Wollondilly's waterways, catchments and the water cycle, particularly in the Nepean catchment.

Actions to a changing climate in the proposed integrated water management approach of this strategy is linked to the preparedness and mitigation for future predicted extreme weather events. Events such as bushfires, floods, storms, droughts, gales and the urban heat island effect are increasing in severity, and the Wollondilly community and environment are particularly susceptible. Wollondilly Shire Council (WSC) has a responsibility to undertake necessary actions within their resource capability and jurisdiction to enable a more resilient future Wollondilly. Enabling a more resilient future for Wollondilly has been the foundation objective in the development of this strategy which will be achieved through:

- protection of the waterways and riparian habitats
- increasing community liveability
- supporting greener neighbourhoods
- supporting recreation and amenity
- supporting local biodiversity
- supporting water conservation
- supporting agriculture and other local economies
- supporting water reuse and recycling

This strategy documents the drivers, threats, options and actions that the WSC will take to manage water into the future. It was developed through intensive consultation with the following agencies and groups:

- Sydney Water
- NSW Department of Planning, Industry and Environment (DPIE; previously NSW Office of Environment and Heritage; OEH)
- NSW Environment Protection Authority (EPA)
- Water NSW
- NSW Department of Primary Industries – Fisheries (DPI)
- surrounding councils
- Indigenous representatives
- community engagement.

The strategy outlines how a range of scenarios were explored to achieve a 'zero impact' outcome, with a focus on stormwater and wastewater in new developments (including residential, commercial, industrial and agricultural), and the actions the WSC will take to move towards a smarter and more resilient water system.

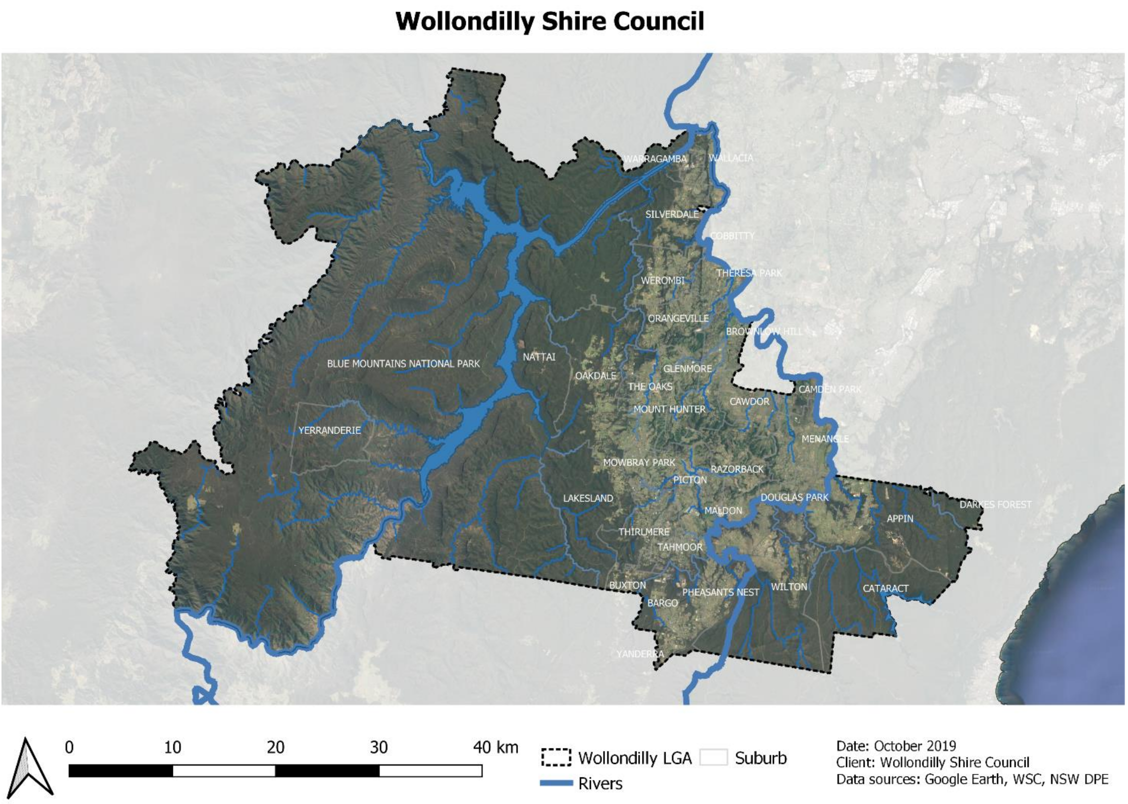

Figure 1. Wollondilly LGA

2 Vision and objectives

2.1 Wollondilly vision

The vision for Wollondilly is '*enviable lifestyle of historic villages, modern living, rural lands and bush*[1]. The WSC Local Strategic Planning Statement states that 'We will protect what makes us special - our unique villages and lifestyle within a landscape that people can celebrate, visit and explore.' WSC's unique and expansive waterways are definitely something that makes us special and are valued by the local and broader community.

The WSC also has a mission statement "*To create opportunities in partnership with the community and to enhance quality of life and the environment, by managing growth and providing sustainable services and facilities*[2]".

A Community Strategic Plan (CSP) has been created for Wollondilly. The CSP expresses the aspirations held by the community of Wollondilly and sets strategies for achieving those aspirations. The CSP has coined the term 'Create Wollondilly' with five distinct themes:

- sustainable and balanced growth
- management and provision of infrastructure
- caring for the environment
- looking after the community
- efficient and effective council

These themes have outcomes and strategies to achieve them.

Care for the Environment OUTCOMES (What do we want?)

1. An environment that is valued, preserved and protected, with new planning and development proposals supporting these values.
2. A community that is engaged with, and cares about, their environment.

Care for the Environment STRATEGIES (how will council work to achieve what we want?)

Strategy EN1 – Protect and enhance biodiversity, waterways and groundwater.
Maintain and enhance the condition of biodiversity including the condition of water sources (both surface and groundwater).

Strategy EN2 – Protect the environment from development pressures.
Contribute to development to achieve positive environmental, social and economic outcomes.

Strategy EN3 – Vegetation management
Achieve a balance between risk-based management and conserving biodiversity and maintaining public and private assets.

Strategy EN4 – Community involvement
Engage the community during the preparation and implementation of Council's environmental activities and programs.

Strategy EN5 – Environmental awareness
Enhance community awareness of the environmental values of Wollondilly's natural resources and rural lands and the threats to these values.

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[1] Wollondilly Shire Council. 2020. Local Strategic Planning Statement.
[2] https://www.wollondilly.nsw.gov.au/council/about-us-2/

Strategy EN6 – Sustainable practices

Enhance the adoption of sustainability practices by Council and the local community which reduce consumption of resources, generation of waste, as well as the level of greenhouse gas emissions.

Strategy EN7 – Agricultural land and capability

Protect agricultural land and the natural resources which support agricultural capability.

Strategy EN8 – Auditing, monitoring and enforcement

Undertake auditing, monitoring and regulatory enforcement and be responsive to community complaints to protect the environment and the health, safety and well-being of the community.

Strategy EN9 – Waste management

Provide the community with a workable and convenient waste management system, which also minimises waste generation, increases resource recovery and protects the environment.

Strategy EN10 – Advocacy

Advocate strongly for the interests of Wollondilly and its community in relation to environmental outcomes.

2.2 Sustainability framework

The purpose of a sustainability framework for Council is to enable the organisation to clearly see how sustainable design should be adopted across the LGA. Sustainable developments aim to provide social, economic and environmental benefits. When development is sustainable it will provide Council and the community with confidence that the growth in Wollondilly will be in line with **the vision of *enviable lifestyle of historic villages, modern living, rural lands and bush***.

As stated in the Sustainable Wollondilly Plan 2009, the most frequently quoted definition for Sustainable Development is from the 1987 report *Our Common Future*:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

It can also be defined as balancing the needs of society, the economy and the natural environment and using the principles of integrated decision making, whole community involvement, the precautionary principle, intergenerational equity, continual improvement and ecological integrity.

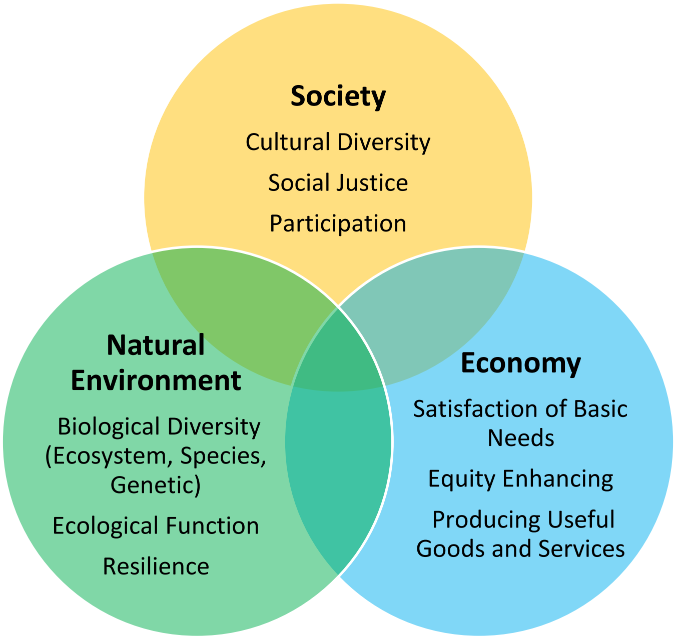


Figure 2. Ecologically Sustainable Development (Source: Wollondilly Shire Council, 2008, and Australian Government, 2007)

The Sustainable Development Framework helps Council create a smarter water strategy and policy as water is closely linked with energy, biodiversity and waste issues. For example:

- Water systems are large consumers of energy. Decentralised water systems, as per unit comparison, can increase emissions, while also saving potable water.
- There is an increasing number of waste to energy plants (where organic and green waste is incinerated and the heat used to generate electricity) that the water authorities are designing and building, to achieve emission reductions.
- Runoff from urban areas affects downstream amenity, recreation and biodiversity.
- Urban developers are more conscious of how improvements to the building envelope improves the thermal comfort of a home, but less conscious of how green walls and irrigated landscape surrounds can also improve the comfort of a home.

One Planet Living is one model for developing a Sustainable Development Framework. One Planet Living is an international initiative of Bioregional and its partners to make truly sustainable living a reality.

One Planet Living is essentially a means to encourage communities to stay within 'one ecological footprint'. In doing an assessment of an ecological footprint, it is possible to understand "How many earths (and resources) would we need if everyone lived like this?"

For example, when academics and not-for-profits have looked at the ecological footprint of whole countries, we see that some people and countries are living on a lot more resources than is considered sustainable.

The One Planet Living vision is of thriving regional economies where we meet more of our needs from local, renewable and waste resources. Enabling people to live happy, healthy lives within the natural limits of the planet and leaving space for wildlife and wilderness. Water is always a key element of all these issues.

One Planet Living uses ecological foot printing and carbon foot printing as its headline indicators. It is based on ten guiding principles of sustainability as a framework. These principles have been used to develop a Sustainability Framework as shown in Figures 3.

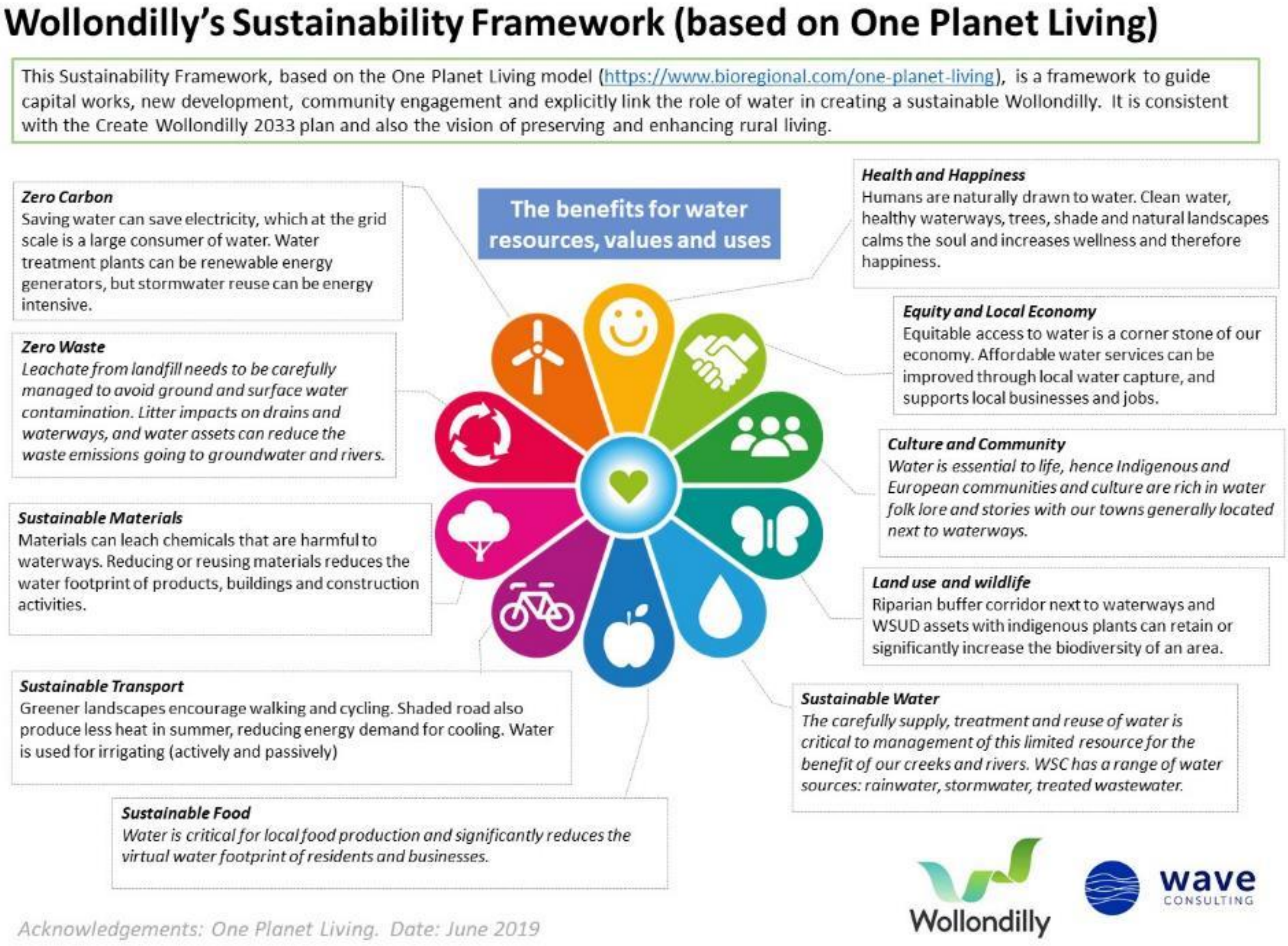


Figure 3. Sustainable Framework for Wollondilly Shire Council.

2.3 Vision for water

Wollondilly's vision for water is to maintain our pristine creeks and rivers to be swimmable and ecologically rich and diverse. This requires that all new development has zero net impact on the waterways with no extra stormwater runoff entering the waterways and wastewater being treated and reused.

Maintaining pristine waterways will:

- Maintain a healthy and diverse ecosystem of plants, animals and insects.
- Maintain good water quality for in-stream health and for downstream water supply.
- Allow for direct contact recreation such as swimming.
- Maintain or enhance vegetation buffer corridors either side of waterways to prevent erosion and provide a robust buffer strip to support all waterway values.

2.4 Delivering on the Western Sydney City vision

The vision for Greater Sydney as a metropolis of three cities – the Western Parkland City, the Central River City and the Eastern Harbour City and a 30-minute city – means residents in the Western City District will have quicker and easier access to a wider range of jobs, housing types and activities. This vision will improve the District's lifestyle and environmental assets[3]. The District Plan's planning priorities and actions include infrastructure and collaboration, liveability, productivity, sustainability and implementation. These synchronise well with Create Wollondilly Community Strategic Plan 2033.

Delivering on this vision, within WSC LGA, means creating liveable sustainable townships, particularly within the Wilton development.

2.5 Objectives

The objectives of this strategy are to:

- Establish a vision for managing water.
- Set out the key drivers and values that are to be protected and enhanced.
- Support the community in reducing their impact and use of water.
- Document the nature of change to the water cycle based on growth rates and climate change.
- Set targets for Council capital works.
- Clearly outline the expectations [(and water sensitive urban design (WSUD) guidelines)] for new developments to achieve a zero impact on waterways.
- Clearly outline the expectations and strategic approach for wastewater management for new developments to achieve a zero impact on waterways and work with Sydney Water to deliver this approach.
- Act on climate change.

2.6 Community support for objectives

Community consultation over many years has confirmed that having access to open space and being close to nature is highly valued by Wollondilly's community. Council's overall position on growth is based on a "balanced" approach involving the protection of our natural environment and retention of our rural lands whilst allowing for the development of highly liveable and sustainable built environments.

[3] https://www.greater.sydney/western-city-district-plan

Community engagement for the development of this strategy was completed in July 2019 to get feedback on the values and issues from the community on water in the LGA. One hundred and fifteen responses were received, across a spread of ages, locations, residents and workers.

People felt most **strongly** about:

- Water conservation should be factored into planning new development within Wollondilly Shire. (90% strongly agree)
- It's important to ensure native fish and aquatic animals have a healthy natural habitat, for example Platypus, Bass and Macquarie Perch. (87% strongly agree)
- Water conservation is important for the community and environment. (86% strongly agree)
- It's important to ensure stormwater discharge will be as clean as possible, when planning new development within Wollondilly Shire. (85% strongly agree)

Further, there was **agreement or strong agreement** for most of the statements:

- WSC should be providing support, guidance and directives in order to improve waterway health and conserve water. (97% agree or strongly agree)
- We need to utilise and manage water within the landscape to provide resilience against extreme weather events, for example extreme heat, wind chill, frost, flooding and drought. (96% agree or strongly agree)
- Wollondilly Shire's waterways and protected catchments help define Wollondilly as a place. (93% agree or strongly agree)
- It is important to improve and protect waterways within Wollondilly Shire out of respect for the traditional custodians of the land. (89% agree or strongly agree)

The one statement in the survey that received a mixed reaction was regarding recreation's importance within the Wollondilly area. Fishing and swimming are important aspects of the recreation and lifestyle available in Wollondilly Shire; (74% agree or strongly agree, 22% felt neutral, 4% disagree or strongly disagree). Some respondents thought these two pursuits should have been dealt with separately, e.g. some people were pro-swimming but anti-fishing. Community sentiment suggests:

- The health of Wollondilly Shire's waterways, water quality and water supply are valued highly by the community.
- The community has an expectation that WSC play a role in establishing regulations and guidelines about water management.
- Awareness of and support for reuse of water and harvest of rainwater.
- Recognition that a water wise education campaign could have a positive impact.
- A feeling that activities which could potentially have a substantial impact on water quality, water supply and the waterways themselves – such as further housing developments and long wall mining – be undertaken cautiously if at all.

In the free text comments section of the questionnaire, the most mentioned issues were:

- potential negative impacts of development on water supply and quality
- the negative impacts associated with long wall mining
- the drainage of water bodies such as Thirlmere Lakes
- the general deterioration of water quality
- opposition to raising the Warragamba Dam wall
- interest in reusing water and harvesting rainwater in order to reduce demand on the current supply
- desire for clear information – in the process of developing this strategy, the wording of the strategy itself, and in a water-wise education campaign
- interest in maintaining sustainable recreational use of natural areas centred on water

3 The LGA

Wollondilly is located to the South West of Sydney, Australia's largest city, and includes Sydney's drinking water catchments and Sydney's largest water supply storage; Warragamba Dam.

3.1 Catchments and Special Areas

Ninety five percent of Sydney's drinking water comes from or through Wollondilly, and hence it plays a significant role in supporting the health and growth of Australia's largest city. This is protected through a planning overlay called the 'Special Areas'. This overlay covers a large proportion of Wollondilly, in the Warragamba, Nepean and a small area of the Georges catchment. See Figure 4.

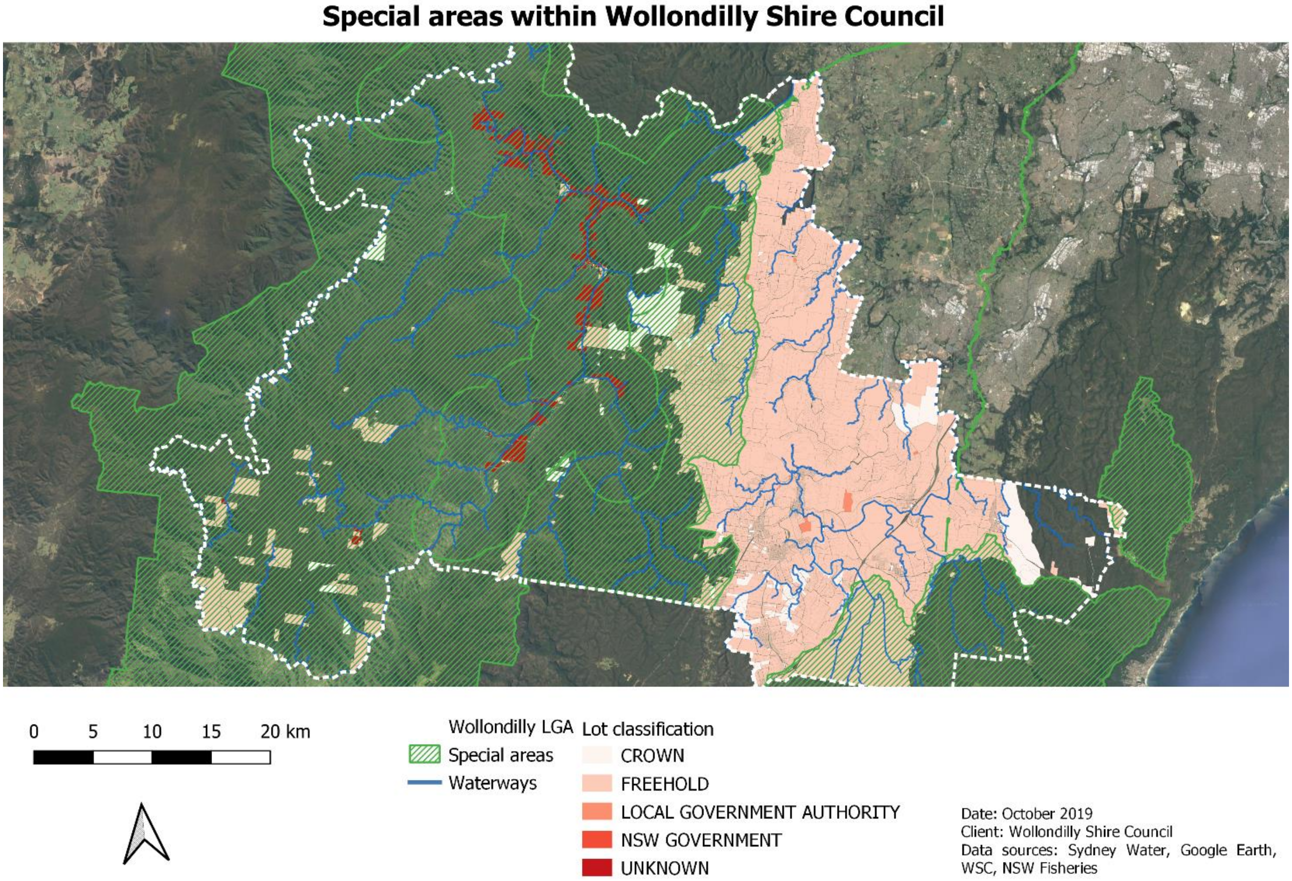


Figure 4. Special Areas and land classification around Wollondilly (Source: Wave Consulting)

An analysis of the entire catchment (including upstream of the Wollondilly LGA boundary) is shown below in Figure 5 and Figure 6.

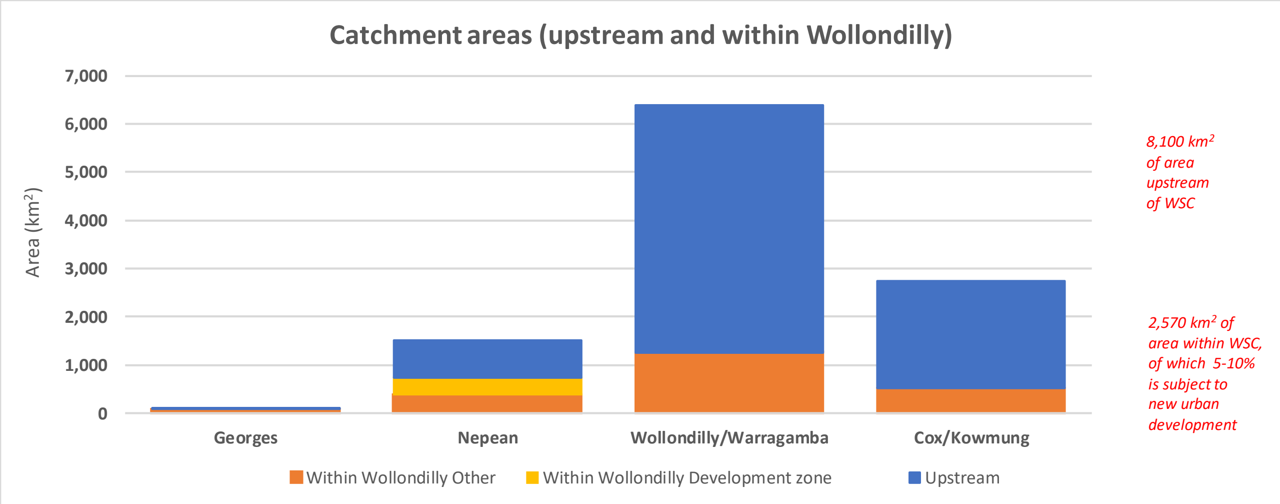


Figure 5. Catchment areas (both upstream and within Wollondilly LGA)

Seventy seven percent of the land area within WSC is classified as within a 'Special Area', as shown above in Figure 5.This means the land is subject to special conditions to ensure that the runoff and flows do not adversely impact on water storage, water quality and yield.

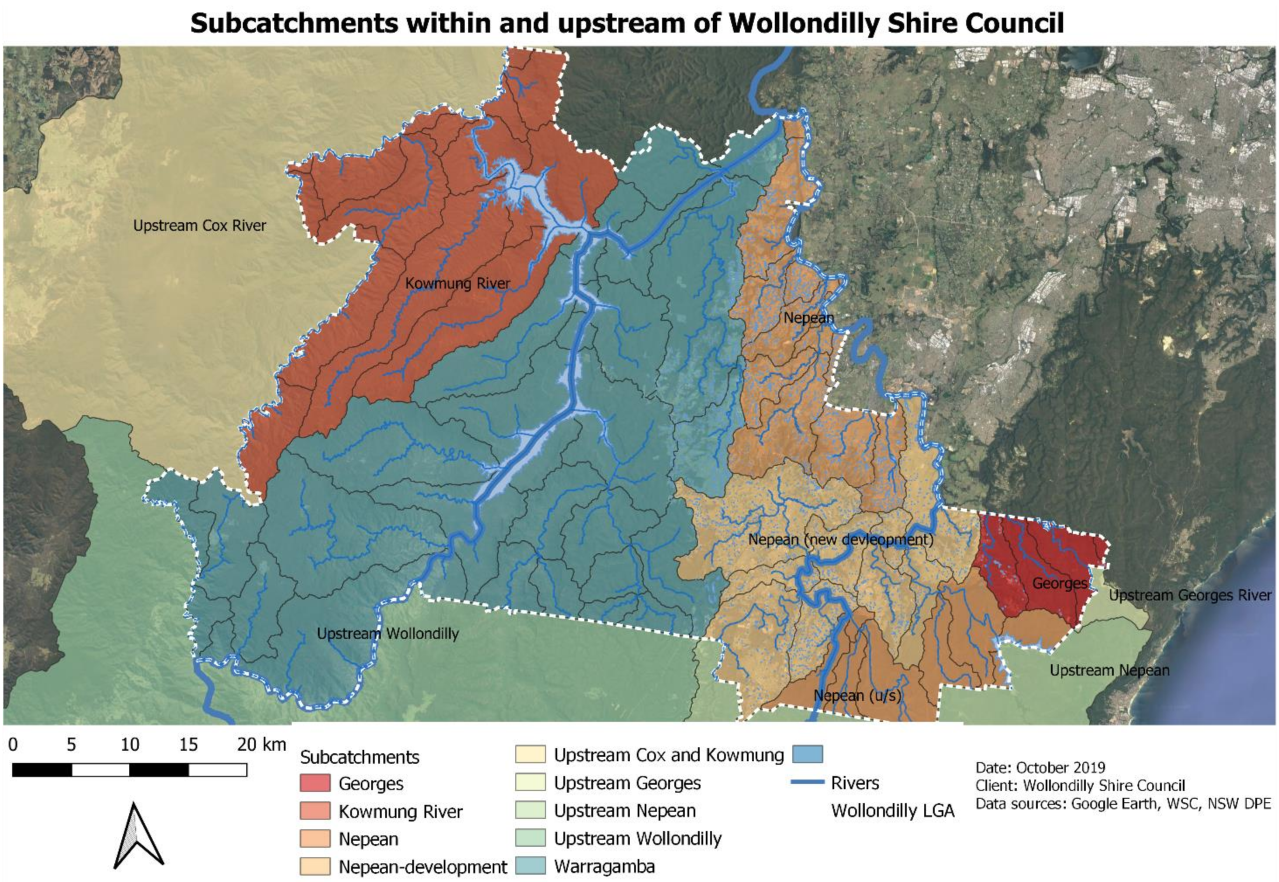
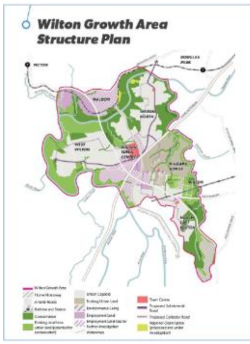


Figure 6. Subcatchments within Wollondilly Shire Council (Source: Wave Consulting)

3.2 Land use

The areas outside of the Special Areas account for 23% of the LGA. Of this the majority is freehold land, with some Crown Land and Local Government land.



The Wilton Growth Area (see figure on the right) was declared as a growth precinct by the NSW Department of Planning, Industry and Environment (previously the Department of Planning and Environment) in July 2016.

Other significant land uses are mining, manufacturing, and agricultural. It should be noted that there are many hobby farms in the LGA as well.

3.3 Wollondilly social profile

There are approximately 48,000 people living in Wollondilly, predominantly in free standing houses, and the majority are families and couples. In the Wollondilly Community Strategic Plan, a concise summary of the community was represented in infographic form. This is shown below in Figure 7.

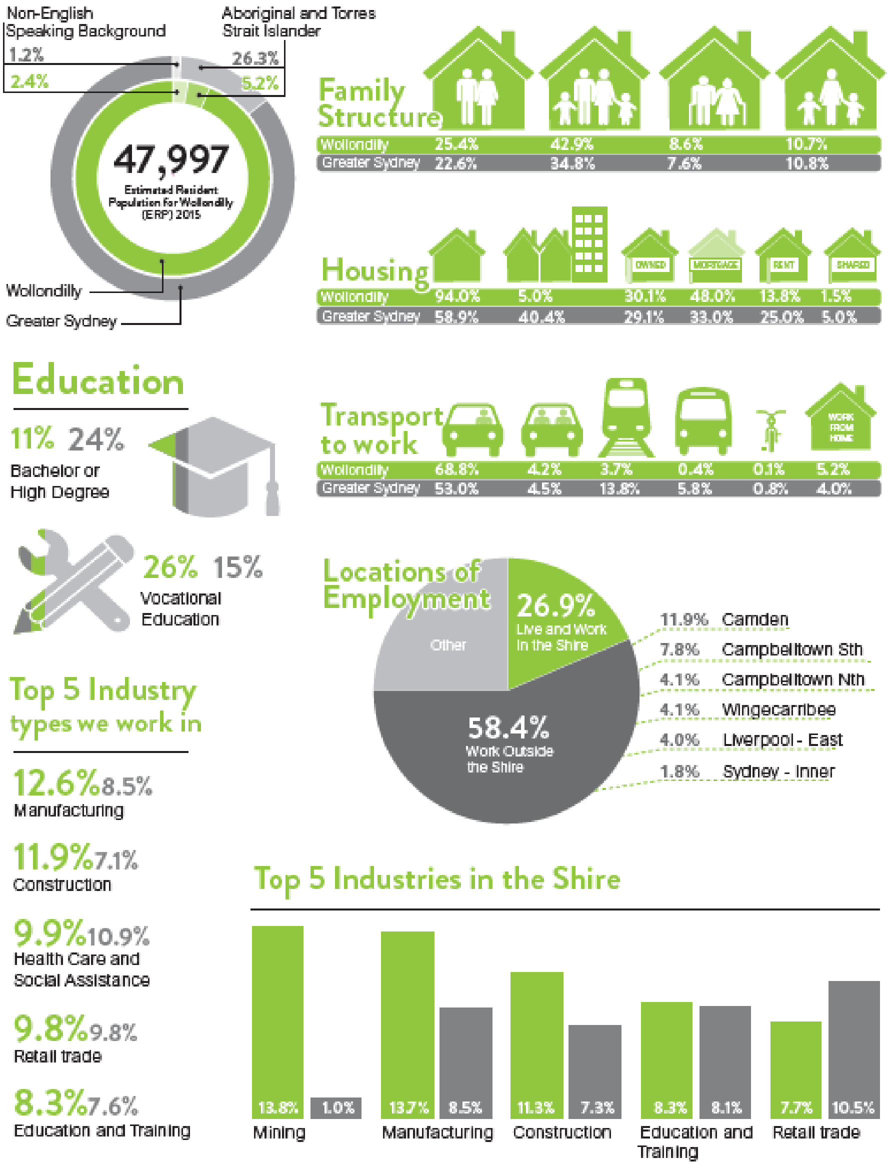


Figure 7. Community profile and statistics (Source: Wollondilly Community Strategic Plan, 2017; Green is Wollondilly, and grey is data for whole of Sydney)

4 The value of water in Wollondilly

Water supports several values in this LGA. Through engagement with the community, stakeholders, and background research, ten values where identified where water plays a vital role in protecting the environmental, social and economic values in the LGA. These are described in this section.

4.1 Waterways and water quality and endangered species

The value of a waterway is greatly affected by the water flowing within it, both its quality as well as the flow regime. Fish, water birds, Platypus, macroinvertebrates, insects and plants living in or next to the waterways all depend on a complex interrelationship between each other and the water flow. Pristine streams are easily compromised by increases in diffuse (stormwater) and point (wastewater and industrial) source pollution. When drainage pipes are connected directly to streams, creeks and rivers without any filtering, these stormwater pipes are referred to as coming from a directly connected imperviousness (DCI) area. Just 2% DCI in a catchment can alter the surface water flow patterns, increasing erosion and peak flows, and altering baseflow, and if over 10% of the catchment is directly connected it will significantly and detrimentally affect the ecology of a stream. Wastewater discharges are an additional change to the hydrology of the waterway with a potentially negative impact.

Waterway values are affected by:

- increased runoff from impermeable surfaces such as roads, roofs and other paved surfaces
- litter, sediments, heavy metals, hydrocarbons, nutrients and other pollutants washed in from the stormwater system
- nutrients and additional flows from wastewater treatment plant discharges
- illegal discharges of toxic products such as paints, oils, hydrocarbons, pesticides and herbicides
- leaking onsite wastewater systems
- point source discharges
- diversions of flow from the waterways from fracking as a result of mining
- alterations to the riparian zone
- instream structures and extractions

4.2 Recreation (passive, active and swimming)

Waterways provide recreational activities such as swimming, fishing and kayaking within the waterway as well as walking, running and cycling along its banks. Waterways form a key part of the natural landscape throughout Wollondilly, and offer the community many opportunities to relax, walk, swim and fish.

Water is also key to providing passive and active recreation opportunities within towns through the irrigation of sports fields, parks and gardens. These spaces, where not irrigated, depend on natural rainfall and good soil management to maintain a green landscape.

Wollondilly has 28 irrigated ovals at 14 different sites. These are concentrated in the Appin, Picton, Warragamba, Thirlmere, Tahmoor, and Wilton areas. One example is shown below.

Figure 8. Example of recreational oval in Tahmoor.

4.3 Protecting the last wild rivers of Greater Sydney

There are few wild rivers remaining within the greater Sydney area that are not modified by development.

In Wollondilly, the Bargo River is considered a wild river and as such should be protected for future generations. The protection of the Bargo River would support the proposal by WSC to establish a National Park around Bargo Gorge near Tahmoor and Pheasants Nest.

4.4 Cultural values

Wollondilly Shire includes substantial pristine landscapes throughout the Sydney drinking water catchment. Within these “protected” areas are an important and substantial array of sites and places of cultural significance to the Dharawal and Gundungurra people. Unfortunately, the protection of these sites does not extend to protection against inundation, such as through flooding and dam building.

Wollondilly also contains locations critical to the development of modern Australia like the agricultural lands around Menangle.

4.5 Protecting Sydney’s drinking supply

The State Environmental Planning Policy (SEPP) Sydney Drinking Water Catchment 2011 document is a legal instrument that sets out obligations relating to the management of water supply catchments, including the planning and regulation of new developments.

WaterNSW is an NSW Government agency charged with the management and protection of Sydney’s drinking water catchments and the supply of raw water to Sydney Water and several local councils and water utilities.

WaterNSW has identified that healthy catchments are the first step in protecting the quality of the water supply. If catchment health deteriorates, then water quality in watercourses will also deteriorate. This impacts on the quality of the drinking water supply, as well as on activities such as stock watering, irrigation and recreation, and the ecological health of native plants and animals.

Five catchments contribute to the Greater Sydney region's drinking water supply including: Warragamba, Upper Nepean, Blue Mountains, Shoalhaven and Woronora rivers.

4.6 Agriculture

The agricultural sector employs approximately 734 people in Wollondilly, 10 times more (per capita) than employment in agriculture in the rest of Greater Sydney.

The availability and supply of water is a critical factor in the sustainable operations of agricultural production, and also needs to be balanced with the needs of the environment and the rivers.

A large user of water in the Wollondilly LGA are agriculture operations. These agricultural users mainly extract water from within their lots by capturing rainfall, extracting bore water or utilising potable water as well as a combination of these sources. Some farms will also have river extraction or diversion licences granted by WaterNSW. This extraction and use of water from the surface water system has an impact in reducing the 'between event' base flows from streams and creeks as well as reducing the runoff during rain events.

WaterNSW oversees extractions, bores and allocations. Most water sources in NSW are fully committed and water access licences can usually only be obtained through the water trading market. However, in water sources with unassigned water, the right to apply for water access licences can also be provided through controlled allocation orders. The water access licences obtained through a controlled allocation include a share component of the available, unassigned water.

Farm activity close to the waterways can lead to erosion and pollution runoff during rain events. Waterways can best be protected with 40-metre-wide buffer vegetation from top of bank on either side, ensuring that any drainage is not flowing directly (through drains or pipes) to the waterway and ensuring no pollution can leave a site during rain events.

4.7 Mining and industry

Mining is the largest employer of Wollondilly LGA residents. Water is critical to a lot of mining and industry operations with many requiring significant daily volumes. Similarly to agriculture, these sectors extract water from within their lots by capturing rainfall or extracting bore water and may also have river extraction or diversion licences granted by Water NSW. Mining and industry can also have a heavy reliance on the potable water supply.

Mines and certain industry activities can have negative impacts on water quality if polluted water from their operations discharge into local waterways. This includes mine tailings that are high in heavy metals, acidic, alkaline; high nutrient and sediment runoff from stockpiles; and / or high sediment runoff from bare earth and dirt roads.

4.8 Biodiversity and koalas

Stream health and biodiversity is linked to rainfall patterns. Changes in rainfall patterns will affect plant growth and health. This has a flow on effect on insects and animals. Extraction of water via bores from groundwater aquifers and dams retaining surface flows also affect the natural flow of water through the landscape. The combined effect of these actions makes landscapes drier, meaning in some places indigenous species struggle to survive.

Non-migratory animals such as koalas are significantly affected if their habitats change. Given their dependence on a select few eucalyptus trees, if these become unhealthy or die without replacement, increased pressure will be placed on the vulnerable koala population. Maintaining connected vegetation corridors along waterways is a way of maintaining koala habitats and ensuring they remain genetically viable by allowing males to move during the breeding season.

4.9 Downstream Hawkesbury Nepean River values

The Hawkesbury Nepean River system has the most development land located within its catchment in Wollondilly LGA, therefore can have a greater impact on its downstream health when compared to another catchment like the George's River which is significantly smaller (as shown by figure 5 previously). The impact of changes to the landscape, flow and water quality in Wollondilly affects millions of individuals and industries downstream. There are 240 kilometres of river downstream of the Wollondilly LGA boundary, ultimately flowing into Broken Bay and the Tasman Sea. An analysis of population in the Sydney Basin revealed that there are approximately 1.9 million people (growing to 2.9 million in the next two decades) that are closer to the Hawkesbury Nepean than the beach. The quality of the Hawkesbury Nepean and its ability to provide physical and mental health benefits to almost 3 million people in the future is of significant value.

The industries that are downstream of Wollondilly that are directly affected by the river are the aquaculture, commercial fishing, the oyster industry, recreational boating and fishing, and water supply for North Richmond.

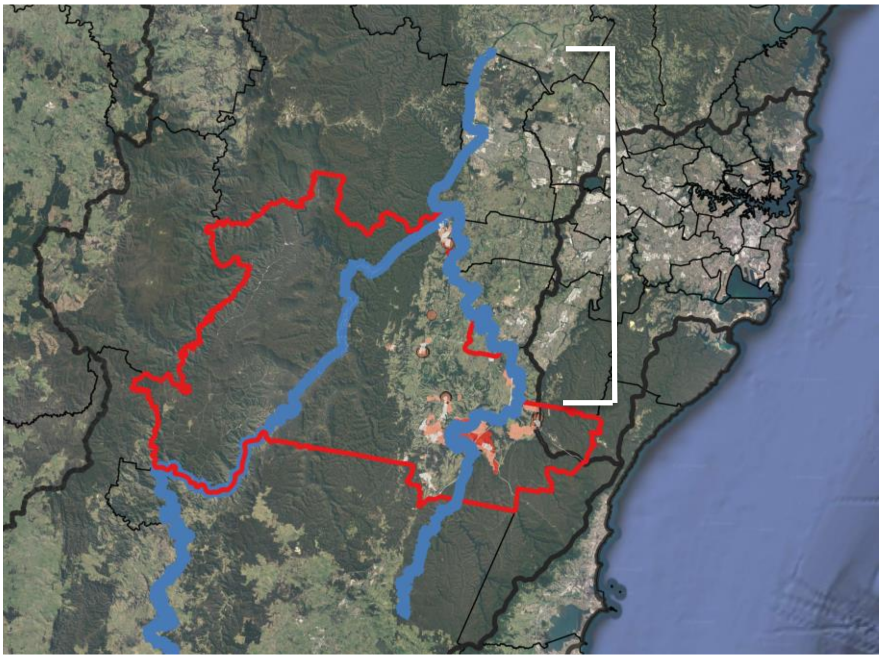


Figure 9. The Hawkesbury Nepean River within the Sydney Basin

4.10 Environmental flows

Environmental flows also have a significant influence on waterway condition and aquatic species. Environmental flows are a term used to refer to the release of water from storages in regulated rivers, to offset the decline in ecological condition that regulation and dams have on river health. There are seven sites in Wollondilly where Water NSW[4] release or divert water as part of delivering environmental flows. The flows delivered in the 2016/17 and 2017/18 years are listed in Table 1. There is a 75% drop in environmental flows between these two years, which is a function of the different inflows and availability of water in these years, as well as the needs of the environment and the needs of other sectors.

[4] Water NSW, 2019. Environmental flow in Greater Sydney. https://www.waternsw.com.au/supply/Greater-Sydney/environmental-flows

Table 1. Environmental flows in the past 2 years from storages and weirs in the Nepean catchment.

Storage / Weir	Streams benefiting from environmental flow release	2015-16 environmental flow release (Ml / yr)[5]	2017/18 environmental flow release (Ml / yr)[6]
Avon	Avon River down to its confluence with the Nepean River and the Nepean River below that down to Pheasants Nest Weir	7,459	856
Cataract	Cataract River down to Broughtons Pass Weir	10,914	4,119
Cordeaux	Cordeaux River down to its confluence with the Avon River, and the Avon and Nepean rivers below that down to Pheasants Nest Weir	5,763	1,068
Nepean	Nepean River down to Pheasants Nest Weir	13,101	3,231
Pheasants Nest	Nepean and Hawkesbury rivers below the weir down to the sea	6,025	5,580
Broughtons Pass Weir	Cataract, Nepean and Hawkesbury rivers below the weir down to the sea	4,574	5,226
Warragamba Dam	Warragamba, Nepean and Hawkesbury rivers below Lake Burragorang (Warragamba Dam) down to the sea	1,730	1,825

There has been a noticeable change in total nitrogen (TN) at specific locations (e.g. Maldon Weir 92), as a result of environmental flows[7], where concentrations dropped by 25% (post 2010 when the environmental flows started, compared to the 1992 – 2010 period).

Environmental flows aim to support river health outcomes downstream of dams, storages and weirs. They may also be used to seasonally increase or decrease flows to mimic the flow regime prior to the dam being put in place. This is important for breeding and migration of fish and other species.

Environmental flows also ensure the vegetation along the waterways has access to water throughout the year. It also helps prevent the build-up of significant sediments, pollution, discharges, and reduce salinity in rivers.

Environmental flows are not applicable to the Georges River catchment, in the Wollondilly LGA, as it is upstream of a reservoir.

4.11 Sustainability, liveability and resilience

Water is a key ingredient to a healthy lifestyle. Increasingly we are realising that not only do we need to have clean water for drinking and cleaning, and safely taking away our wastewater, but we need water to keep our cities green and liveable. The millennium drought showed that, when parks and gardens (and particularly sporting fields) are left to go brown through lack of rain and irrigation it significantly affects the physical and mental health of communities. However, cities produce more stormwater and wastewater than their

[5] Bureau of Meteorology, 2016. Sydney: Water access and use. Accessed at http://www.bom.gov.au/water/nwa/2016/sydney/supportinginformation/wateraccessanduse.shtml

[6] Bureau of Meteorology, 2018. Sydney: Water access and use. Accessed at http://www.bom.gov.au/water/nwa/2018/sydney/supportinginformation/wateraccessanduse.shtml

[7] Sydney Water, 2017. Wastewater Sewage Treatment System Impact Monitoring Program 2016/17.

demand for water. By recycling wastewater and harvesting rainwater and stormwater at source and utilising them for fit-for-purpose reuses we can easily supply all our non-potable demands and keep our cities green.

The greening of open spaces and street trees will mitigate urban heat through shading and cooling by evapotranspiration. This is particularly important in urban areas where asphalt, concrete and other heat absorbing surfaces heat up during the day and slowly release the heat at night, making the night-time temperature in towns and cities 2 to 4°C warmer than in the surrounding countryside.

Extreme weather events such as heat waves, bushfires, high winds and heavy rainfall are becoming more common. As well as urban heat, urban areas also produce a lot of run-off during rain events. This is managed by our drainage system and road network. However, in extreme events such as 1-in-a-100 year or greater type rain events, the overland flow paths may not be enough to accommodate the flood water, particularly in older settlements. Councils and other government agencies need to work with the community to minimise these risks through infrastructure interventions, where possible, but also through identifying and being transparent about the risks, educating the community and working with them to build awareness and resilience to them. Residents on large blocks can also assist by retaining water on their land with rainwater tanks, swales and retarding basins to slow the flow of water downstream, where it becomes more difficult to manage.

Smart water design solutions that are adopted at source (i.e. on lots and within streets and precincts) are very important in maintaining healthy vegetation, increasing soil moisture, decreasing urban heat, and providing additional water sources for irrigation, greening open space and fire management.

5 Pressures (current and pending)

The problems documented in this chapter are not unique to Wollondilly. Cities and regions around the world are grappling with urban development, densification, climate change, keeping up with infrastructure delivery, discharges to the environment, and protecting endangered species.

5.1 Urban development and increased imperviousness

The NSW Department of Planning, Industry and Environment (DPIE) estimates that in order to house Sydney's growing population 725,000 new homes are needed over the next 20 years with 143,000 new homes needed in the South West District. The current population in Wollondilly Shire is approximately 49,000 and DPIE and Council predict that this will rise to almost 88,000 by 2036[8] (see Figure 10).

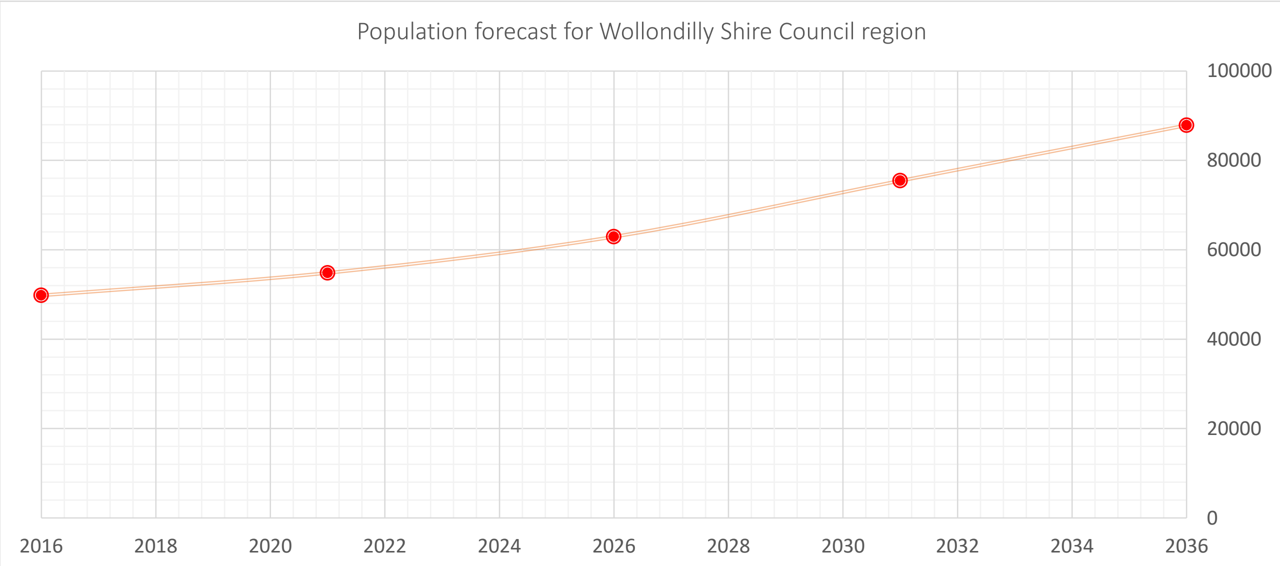
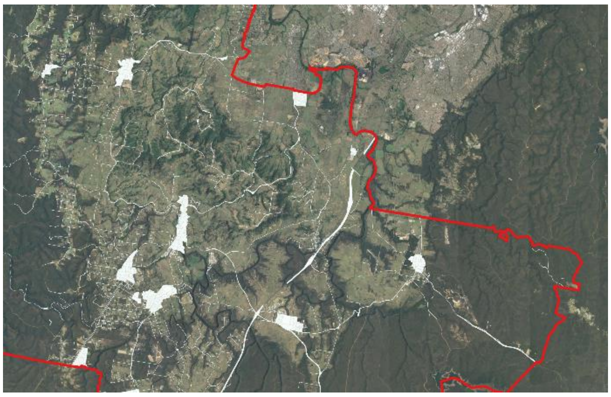


Figure 10. Forecasting population in the Wollondilly LGA

The three images included in Figure 11 below illustrate where this growth is located across Wollondilly LGA, but also models the potential change in imperviousness in each area. It illustrates a potential increase of between 350 and 400%. The first image captures the fact that there are several thousand kilometres of roads in Wollondilly, but the majority of these don't have kerb and gutter drainage, and hence would be passively treating any runoff. If the roads are slowly converted to include kerbs and gutters, this potentially adds 35 km^2 of imperviousness, highlighting how important it is to consider road design and road renewals in a water strategy, and understand the huge impact this could have on waterways.

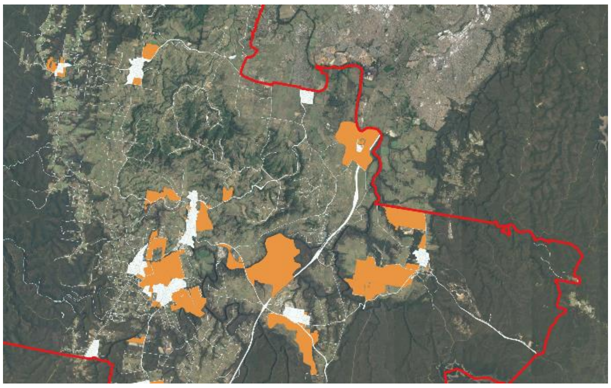
Another pressure embedded in overall pressure of managing urban growth, is the issue of density and sustainable design for example allowing room for sufficient volume reduction of stormwater to meet water quality targets.

[8] ForecastID, 2019. Population and dwellings forecast for Wollondilly LGA. https://forecast.id.com.au/wollondilly/population-households-dwellings



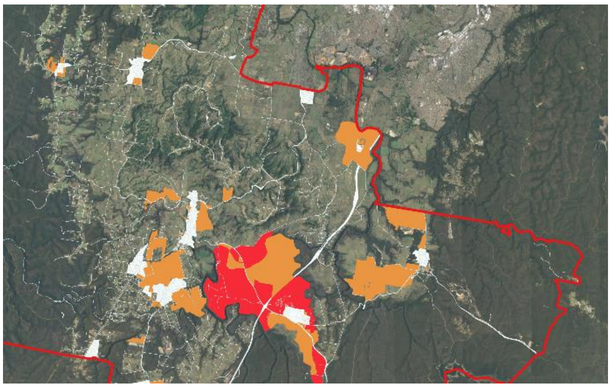
Extent of impervious areas today (displayed in white)

10 km^2



Current (displayed in white) and future extent of impervious areas including developments within LEP (displayed in orange)

25 km^2



Current (displayed in white) and future extent of impervious areas including developments within LEP (displayed in orange) & Wilton Growth Area(displayed in red)

35 to 40 km^2 depending on the nature of density

Figure 11. Current and forecast impervious areas in Wollondilly Shire Council

By modelling the impact of impervious, and comparing it to other land uses, it is possible to get an average annual load of total nitrogen (TN) from each type of land use in the Nepean catchment within WSC LGA. The results from this are shown below in Figure 12. Stormwater and Sewage Treatment Plant (STP) discharges are going to be the main influence in TN loads into the future.

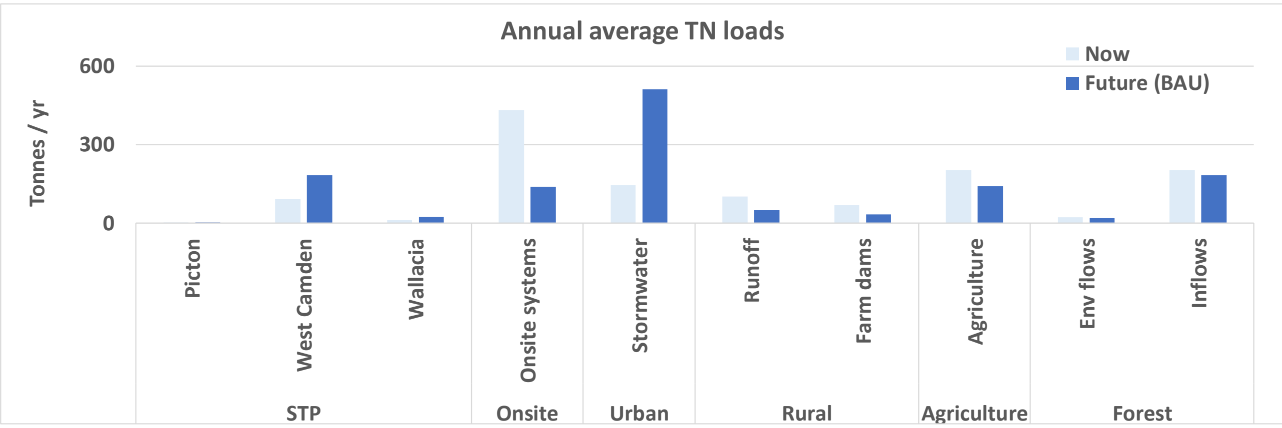


Figure 12. Change to TN loads

5.2 Rate of growth and infrastructure servicing

Planning for, forecasting, and delivering urban growth is a significant issue for all Australian cities, and Wollondilly is on the fringe of this growth in Sydney, Australia's largest city by population.

The need to service this new urban development with roads, telecommunications, electricity, water, drainage, wastewater, open space and other community services is essential before people can move in.

In Wollondilly water servicing (predominantly wastewater) is a critical service under pressure.

Currently 1.07% of the WSC LGA is sewered, or 4% of the Nepean catchment area within Wollondilly. This isn't surprising for a rural living council outside of the main urban area of Sydney. To cater for new growth, and avoid approximately 13,000 [9] more onsite systems, sewer connections and treatment of that sewage will be required.

The areas that are currently sewered include small sections of Appin, Camden Park, Douglas Park, Oakdale, Picton, Bargo, Tahmoor, Thirlmere, Wallacia, Warragamba, and Wilton (see Figure 13 below).

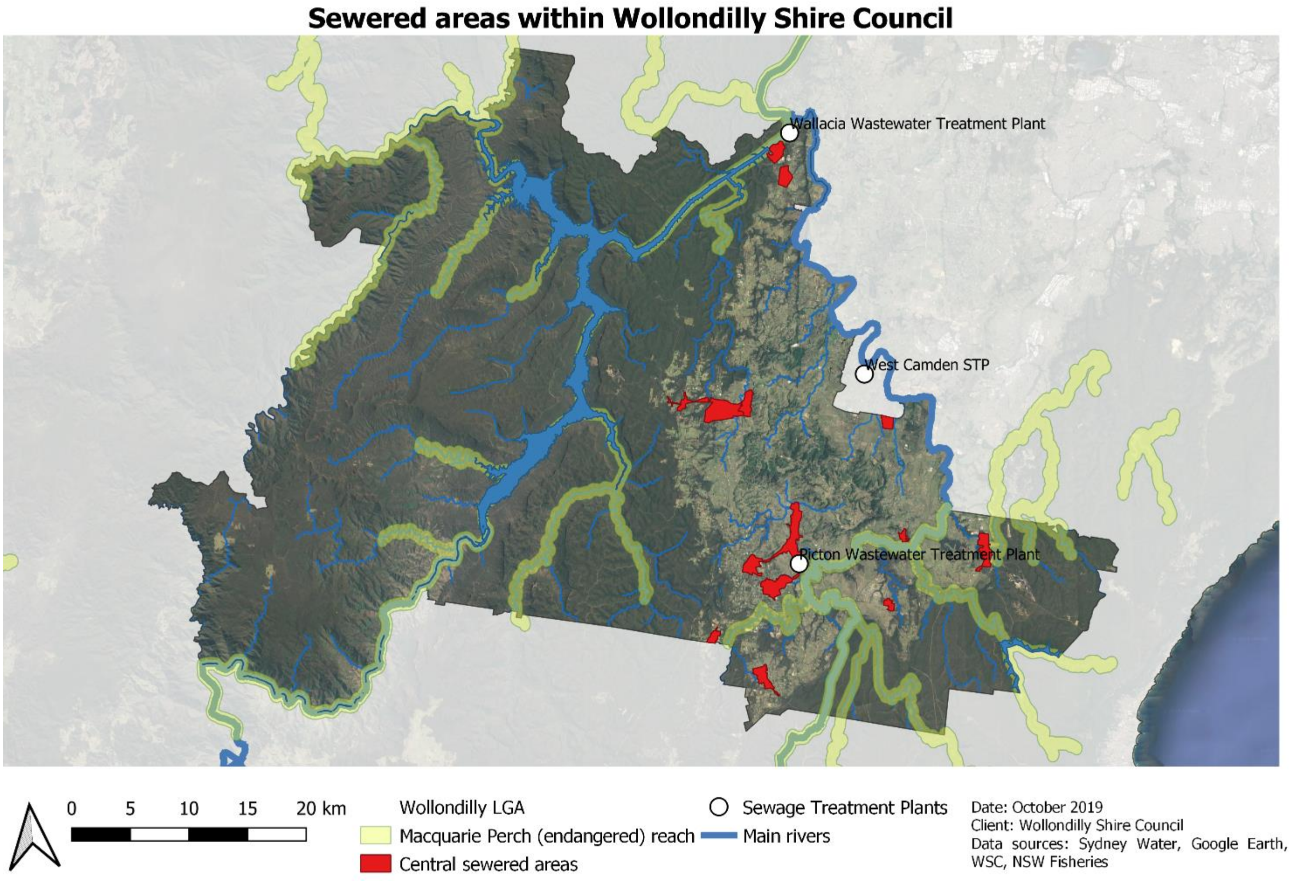


Figure 13. Sewered areas

The challenge is to provide a wastewater connection and treatment service that is consistent with the local objectives and their goal of zero impact, but also enables urban development to proceed.

The challenge with all new development is the ability of authorities to provide the appropriate infrastructure and services to support that community. Strategies and plans to augment the electricity, the National Broadband Network, gas, water, sewerage, stormwater and road networks are essential before councils can approve developments, and before anyone can start any building works.

[9] Forecast ID, 2019. Forecast of dwellings within Wollondilly LGA

The rate of growth is a challenge for the augmentation of the sewerage network, and to a lesser extent the drainage and water supply network.

The 2016 Audit of the Catchment (Alluvium, 2017[10]) noted in their findings:

> *There is evidence that upgrades to sewage treatment infrastructure have been successful in decreasing nutrient loads and improving raw water quality supplied to storages. In particular, compared to the previous audit period, there has been a reduction in nutrient loads discharged to waterways near sewage treatment plants at Wallerawang, Lithgow, Bundanoon, Goulburn and Bowral. Upgrades to Lithgow STP have resulted in notable improvement to Farmers Creek, with no cyanobacteria alerts issued at this site in the current audit period. In comparison, this site had 27 red alerts during the previous audit period. However, there is evidence that some sewage treatments plants are now at capacity and continued investment in sewerage infrastructure is required to keep risks to inflow water quality at an acceptable level. Priority should be given to upgrading the Bowral, Moss Vale and Mittagong sewage treatment plants*

5.3 Climate change

Climate Change is expected to bring higher day and night-time temperatures across all seasons; decrease annual rainfall and therefore stream flows and water captured in dams; longer dry periods and more extreme weather events, such as high intensity storms causing storm damage and floods. This is illustrated in the forecast changes to climate in the Wollondilly Shire, as reported by DPIE (formerly OEH). See Figure 14 below.

Climate change isn't just an issue for the future, but the present as well. An extreme weather event (that climate change influences through increasing the frequency of these events) was experienced in June 2016, when a severe East Coast low weather system impacted many areas across the Wollondilly Shire including causing significant damage to the historic centre of Picton and the closure of Broughton Pass for more than a year.

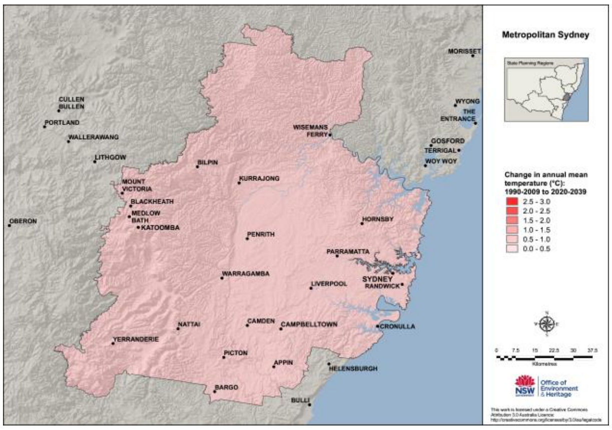
These changes will impact the Shire in numerous ways, and in particular it will impact how water is supplied and used in towns, industry and agricultural areas, and the waterway flows within the shire's waterways. Rainfall is expected to decrease on average but when it does come, it will likely be in shorter, heavier storms.

Bushfires also have huge impact on the environment, the community, and on infrastructure. From a water perspective bushfires have a large impact on the quality of surface water running into storages and rivers, and also the yields into storages.

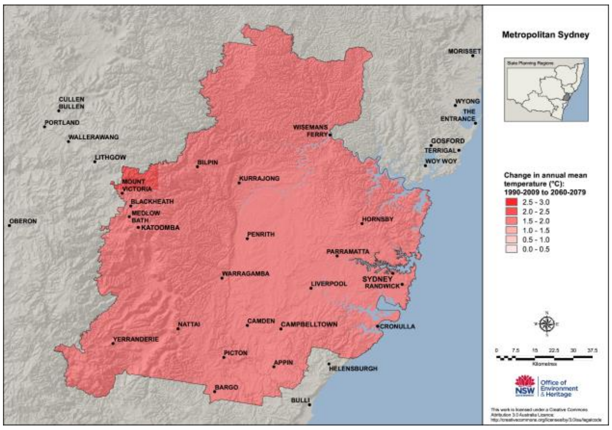
[10] Alluvium Consulting Australia. 2017. 2016 Audit of the Sydney Drinking Water Catchment for Water NSW.

Change in mean temperature

2020-2039

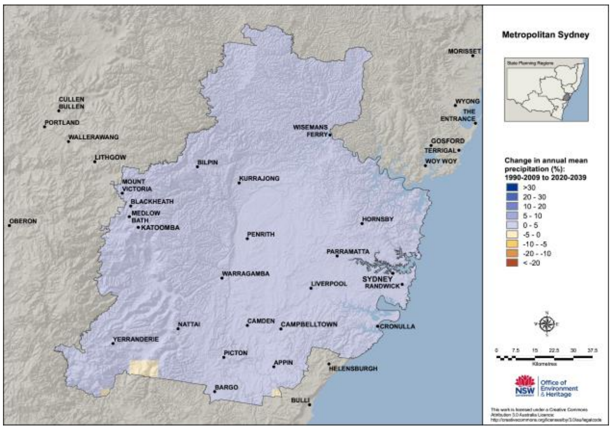


2060-2079

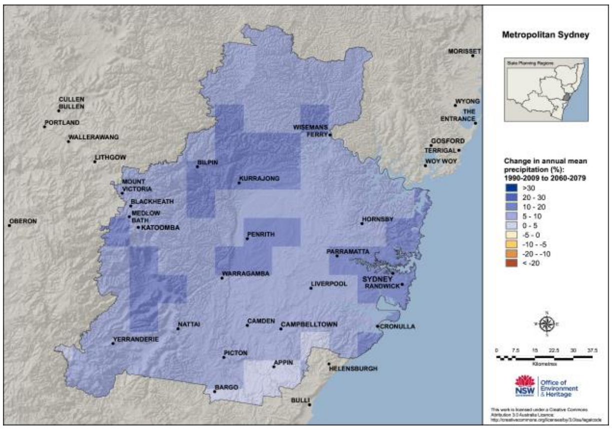


Change to mean annual rainfall

2020-2039

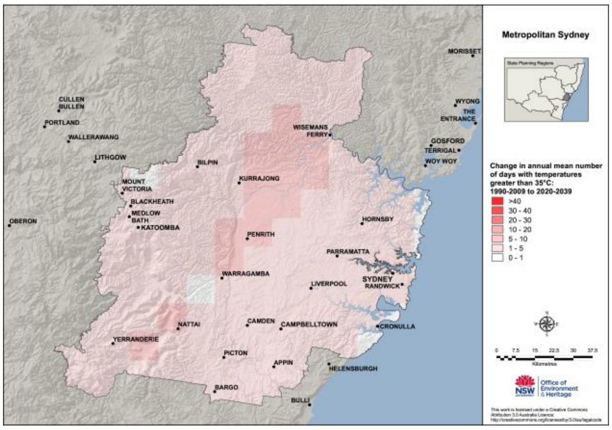


2060-2079

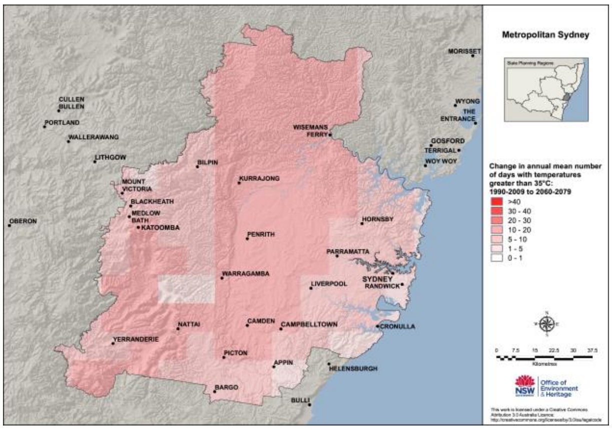


Change to number of days over 35 degrees

2020-2039

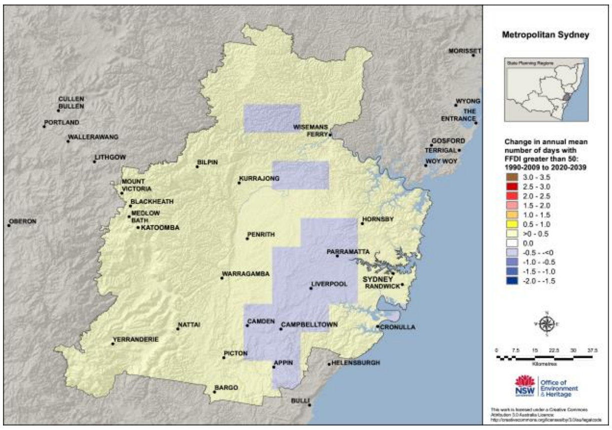


2060-2079



Forest Fire Danger Index

2020-2039



2060-2079

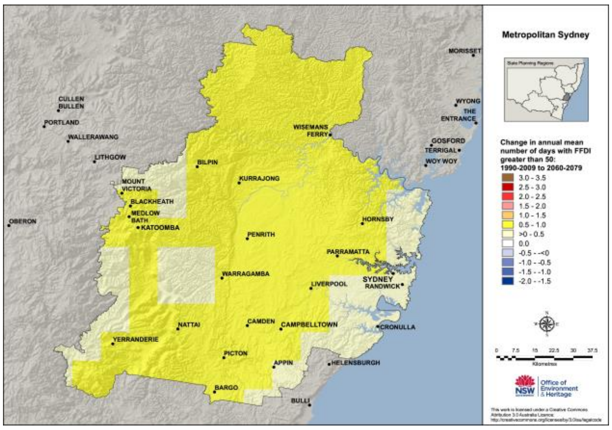


Figure 14. Climate change related forecasts for NSW for temperature, rainfall, extreme heat and fire risks (Source: OEH)

5.4 Managing climate extremes

The day-to-day influence of climate change is particularly apparent in summer, when we consider how the combined impact of hard surfaces, that retain heat and influence the microclimate, and climate change, we expect to see suburbs and centres becoming significantly hotter than natural areas. In 2016/17, OEH measured surface temperatures across major urban and peri-urban areas, as shown below.

This means water will be even more important to retain healthy vegetation and build strong and healthy canopies. Irrigation becomes necessary to enable trees and vegetation to evapotranspire and increase the moisture levels and decrease the temperature in the air near the surface. An un-irrigated (or dry) area of grass is almost as hot as concrete, which gets to over 50 degrees at the surface on hot days![11]

[11] Tapper, N., Lloyd, S., McArthur, J., Nice, K., and Jacobs, S. (2019). Estimating the economic benefits of Urban Heat Island mitigation – Biophysical Aspects. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities Flood

Urban heat effect as measured over 2016/17 summer (Data source: OEH)

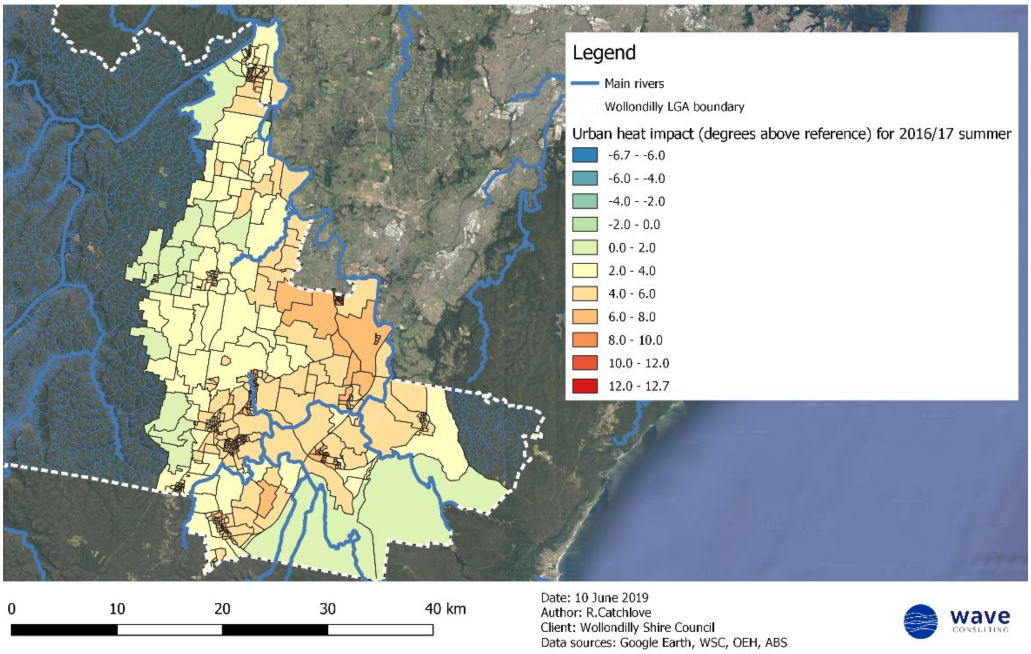


Figure 15. Urban heat impact on communities within Wollondilly Shire LGA

5.5 Mining

The WSC LGA contains four existing underground longwall mining projects comprised of the Bulli Seam, Tahmoor Colliery, Dendrobium Colliery and Wollongong Projects. Three of the projects are in the Drinking Catchment Area (operating under approvals issued in 1994 and 1996).

From a water perspective, WSC has had a long-standing opposition to any mining that affects the rivers[12].

The exact nature of the impacts of underground coal mining in this catchment on the water cycle are complex issues and have been the subject of several inquiries and reviews. Council has engaged several times on this issue and provided submissions to the several inquiries. For example, in 2018, WSC submitted a 20-page response to the Chief Scientist for the Independent Panel for Mining in the Catchment[12].

Wollondilly was also involved in the 2017 NSW Government 'Thirlmere Lakes research' program, a $1.9 million program to help understand the fluctuating water levels in the lakes[13]. Mining, as well as other groundwater activities, is a critical part of the investigation and concern raised by the community.

The 2016 Audit of the Catchment (Alluvium, 2017[14]), that preceded the Independent Panel for Mining in the Catchment, is a 150-page report on water quality and many other factors in the whole Hawkesbury Nepean Catchment, Illawarra and southern Tablelands region, the main findings in relation to mining are stated below:

- *Mining in Special Areas: The Audit found an emerging issue of unquantified loss of surface flows associated with the cumulative impacts of underground coal mining activities. This issue requires attention and should be considered in implementation of the Metropolitan Water Plan and activation of licencing under Section 60I of the Water Management Act 2000 and in*

[12] Wollondilly Shire Council, 2018. Submission to Independent Panel for Mining in the Catchment, page 17, referencing Council Minutes 16th July 2007.
[13] OEH, 2017. https://www.environment.nsw.gov.au/research-and-publications/our-science-and-research/our-research/water/freshwater-and-wetlands/thirlmere-lakes-research
[14] Alluvium Consulting Australia. 2017. 2016 Audit of the Sydney Drinking Water Catchment for Water NSW.

accordance with the NSW Aquifer Interference Policy. Greater understanding of the effect of multiple mine workings on Catchment water yield is required, and this understanding should be reflected in relevant mine planning, appropriate water licencing, and the regulation of those licences.

Underground mining does have an impact on the flows and quality of rivers, and this strategy relies on analysis and data in the Independent Panel for Mining in the Catchment to quantify this impact in the context of an integrated water analysis and modelling. Page 63 of the Independent Panel for Mining in the Catchment report states that over an eight year period up to 12 gigalitres of surface water (not including the six gigalitres of rainfall percolation) is lost through cracking and fracking, associated with underground long wall mining. This is a substantial amount of water, compared to latest data on the total consumption of potable water in the LGA.

5.6 Wollondilly Shire Council resourcing and maintenance

With the increased development and population, demand on council resources will be greater and greater (and has already had an impact with development to date). This will become increasingly challenging as more people move to Wollondilly's new suburbs with the expectation of service levels they experienced in the middle and outer suburbs of Sydney. This is already being experienced by the on-ground crews. Funding these services will need careful consideration. The type of water management infrastructure provided in future developments will play a significant role in the amount of resourcing and maintenance requirements necessary.

6 The Wollondilly water story today

6.1 Current water balance

A water balance analysis aims to track all water flows (over an average annual period) in and out of a region of interest. It helps in developing a strategy as it identifies options where we can get multiple benefits, and make smarter use of existing water sources, and reduce the impact of diffuse and point source discharges on the local environment, and the downstream environment. It also helps quantify how the water cycle may change over time, with the pressures described in the chapter above.

In this case the area of interest and the **focus of the water balance is the Nepean and Georges catchment** within Wollondilly Shire Council. The Warragamba / Wollondilly / Kowmung / Cox catchments and storages were excluded from the water balance, as they are managed by WaterNSW (and have large upstream inflows) and this strategy has a limited focus on that geographic area.

By analysing various climate, environmental, water and geospatial data, a water balance was developed for WSC, and found that on an average annual basis:

- Rainfall falling on the whole Nepean catchment in Wollondilly (and the upstream catchments of the Nepean) is in the order of 1500 GL a year, but the majority of this water is evapotranspired (1100 GL), and the role of vegetation in this is very important (changes to land clearing and the loss of trees will reduce that quantity of water that is evapotranspired).
- Approximately 15% of the rainfall flows as surface flow to local rivers, and 10% is captured in the storages in the Special Areas.
- Stormwater flows (including flood events) add another 32 GL a year of water, which is relatively large considering that it is a rural area with small pockets of urbanisation.
- Treated potable water is imported into the catchment, through a complex network that Sydney Water manages.
- Wastewater discharges into the waterways and is then exported from the catchment via the Nepean River.

The water balance was developed using both observed and modelled data. It is difficult to verify a water balance, and it should be used as an indicative guide only that represents an annual average year, recognising that year to year the water balance varies a lot. The water balance of today is shown below in Figure 16, using annual average figures.

In most cases the data represents the most up to date data, and / or represents an average of the current conditions / climate.

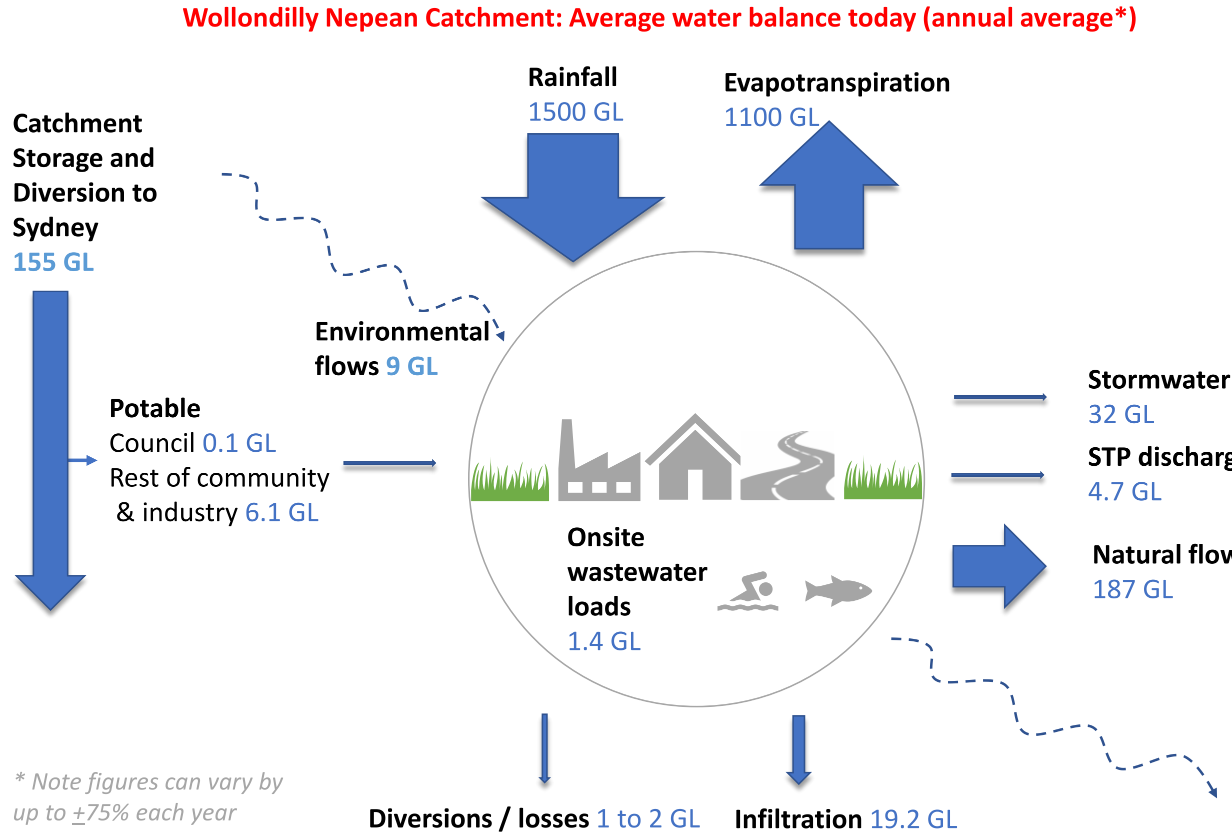


Figure 16. Current water balance for Wollondilly (Nepean catchment)

6.2 Current policy and guidelines

Wollondilly is predominantly a rural council, with limited drainage assets (compared to most greater Sydney councils), and hence the policies in existence now relate mostly to the management of onsite wastewater systems and stormwater.

The current **Wollondilly Development Control Plan** (DCP; 2016) refers to meeting the following objectives:

> *1. To improve and maintain environmental outcomes for the areas mapped as natural resources biodiversity and natural resources water under Wollondilly Local Environmental Plan, 2011.*
>
> *2. To improve and maintain environmental outcomes for unmapped areas of biodiversity and/or riparian value.*
>
> *3. To maintain links between identified environmentally sensitive land and provide habitat and riparian corridors and appropriate buffer zones to these areas.*

The DCP states that for stormwater:

> *All stormwater generated from any development shall be treated to an acceptable standard to maintain water quality. In determining the "acceptable standard" the consent authority shall be mindful of the relevant guidelines of the State and Federal Governments. This treatment must be undertaken outside any areas mapped as sensitive land in the Natural Resources – Water map under Wollondilly Local Environmental Plan, 2011.*

The council's **Engineering Guidelines**[15], specify that developments must reduce stormwater diffuse source pollution by specific percentages, outlined in the figure below.

Pollutant	Description	Treatment Objective
Gross Pollutants	Trash, litter and vegetation larger than 5 mm	70% of the load
Coarse Sediment	Contaminant particles between 0.1 mm and 5 mm	80% of the load
Fine Sediment	Contaminant particles 0.1 mm or less	50% of the load
Nutrients	Total phosphorus Total nitrogen	45% of the load. 45% of the load
Hydrocarbons, motor oils, oil & grease		Whichever is greater: 1. 90% of the load; or 2. Total discharge from site of Total Petroleum Hydrocarbons (TPH) <10 mg/L at all times.

Figure 17. Current stormwater pollution reduction requirements

The **On-site Sewage Management and Greywater Re-use** policy is used to regulate "all development that is not serviced by a reticulated sewerage system in the Wollondilly Local Government Area".[16] It requests that developments manage wastewater on site, establish methods to treat wastewater, model inflows based on the number of bedrooms and people on site, establish buffer zones to protect downstream waterways, and maintain the systems to ensure they are functional and don't pose a health or environmental risk to the community and environment.

The State Government oversees the Development Control Plan for growth areas like Wilton. A **Draft Wilton DCP** was released in August 2019[17]. It specifies in Table 4 of the document, the pollution reduction targets for the site, as well as an ideal outcome. The Draft DCP also includes a variety of other controls that relate to flooding, wastewater and water efficiency.

Table 2. Draft Wilton DCP stormwater objectives

	Water quality (% reduction in pollutant loads)				**Environmental flows (stream erosion control ratio)**
	Gross pollutants (> 5mm)	**Total suspended solids**	**Total phosphorous**	**Total nitrogen**	
Stormwater management objective	90	85	65	45	3.5 – 5.0 :1
'Ideal' stormwater outcome	100	95	95	85	1:1

[15] https://www.wollondilly.nsw.gov.au/planning-and-development/engineering-design-and-construction-specifications/
[16] Wollondilly Shire Council, 2016. On-site Sewage Management and Greywater Re-use – PLA0033
[17] DPE, 2019. Wilton Draft DCP.

And finally, the other policy that is important in Wollondilly is the WaterNSW policy for the **Neutral or Beneficial Effect on Water Quality** in Special Areas (see Figure 4). This is applied to ensure there is no impact on the drinking water catchments from wastewater and stormwater discharges / runoff in any new developments in this geographic area. Under State Environmental Planning Policy (Sydney Drinking Water Catchment 2011), proposals need to be assessed to identify potential risks to water quality (e.g. sediment from construction) and ways to avoid any impacts from those risks (e.g. by applying current recommended practices and standards).

The policy requires proponents to demonstrate how the treatment of wastewater and stormwater in their proposed development will have a neutral or beneficial effect on water quality, and is satisfied if the development:[18]

- (a) Has no identifiable potential impact on water quality
- (b) Will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site
- (c) Will transfer any water quality impact outside the site where it is treated and disposed of, to standards approved by the consent authority.

6.3 Waterway condition

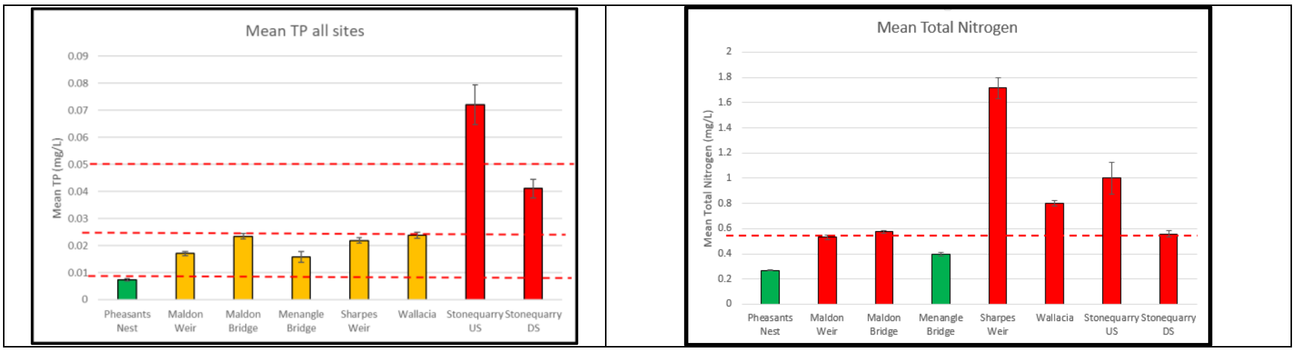
Based on currently available data, waterways in the Wollondilly LGA are in a mostly pristine condition. Council, in partnership with Western Sydney University (led by Dr Ian Wright), has reviewed available water quality data to better understand the waterway conditions and quality. This is focused on water quality data as sourced from Sydney Water, WaterNSW and EPA, and doesn't include a review of other waterway attributes (geomorphology, riparian zones, aquatic data, etc).

The water quality data analysed by Dr Ian Wright (University of Western Sydney) confirms that most of Wollondilly's waterways are currently swimmable.

Initial results from this review are:

- Several sites in the upper and middle catchment are in very good condition and below ANZECC (2000) guidelines
- At and downstream of Sharpes Weir (Camden) the TN and TP levels increase and water quality declines
- TN at Stonequarry Creek is steadily increasing over time

Some figures from Dr Ian Wright are presented below in Figure 18.



[18]WaterNSW, 2015. Neutral or Beneficial Effect on Water Quality Assessment Guideline.

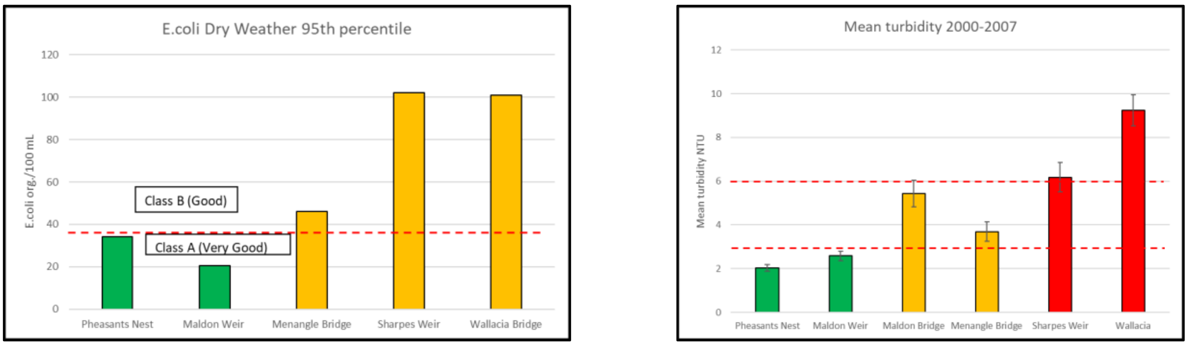


Figure 18. Water quality trends and analysis (Source: Dr Ian Wright, UWS)

Pheasants Nest Weir is an excellent reference stream and should be used to as a comparison site for future monitoring of precincts and development areas.

Sydney Water reports annually on the water quality downstream of all their sewage treatment plants, as per their licence requirements overseen and regulated by the NSW EPA. There are two Sydney Water sewage treatment plants (STPs) within WSC LGA: Picton STP and Wallacia STP. West Camden STP is just outside of WSC and takes sewage from some parts of Wollondilly and discharges into the Nepean River.

Sydney Water reports that discharges of flow and TN are as follows[19]:

- Picton 0.92 Kg TN / day and 1.5 ML / day
- West Camden 94.3 Kg TN / day and 10.7 ML / day (which services a wide area, not just the Wollondilly LGA)
- Wallacia 1.9 Kg TN / day and 0.6 ML / day

Discharges from STPs into receiving waters (inland water, estuaries and coastal waters) are a long-studied issue over many decades. The issue is the quality of the water and how it relates to the sensitivity of the mixing zone downstream of a discharge point, and the volume of the water discharged (in the context of a natural flow regime).

Sydney Water are currently required to comply with the NSW EPA licence conditions at each STP, as well as ensure that discharges (or TN) do not exceed a catchment wide nutrient load cap for this part of the Nepean River.

Another influence on waterway condition is the diversion of surfaces from mining sites, and discharges from these sites. As noted in Section 5.5, the community is concerned about the impact of underground mining and fracturing on local creeks and rivers, and in particular the long term ecology of the Thirlmere Lakes. Monitoring data from mining sites is not publicly available.

As per Figure 12, it is noted that the modelling undertaken shows that currently agriculture, onsite systems and stormwater are also significant influencers on waterway condition in the Nepean catchment within WSC LGA.

[19] Sydney Water, 2018. Sewage Treatment System Impact Monitoring Program – 2017/18. Volume 1 and 2. Reports available at https://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/wastewater-network/stsimp-reports/index.htm

6.4 Sediment

Runoff from construction sites without sediment control or runoff from clear felled / fallow plots in rural and agricultural areas will result in large volumes of sediment (coarse and suspended) flowing into local rivers and creeks.

Excess sediment will have a detrimental impact on waterways, from a bank and bed stability perspective, and a habitat perspective. The NSW Managing Urban Stormwater: Soils and construction - Volume 1 (2004) (otherwise known as the 'blue book')[20] is a well-known resource that should be used by all builders and civil constructors to prevent runoff from construction sites. WSUD asset located downstream of a construction site that results in a large and sudden pulse of sediment will be written off very quickly and require resetting to perform properly over their whole life cycle.

6.5 Flood events

In 2016, Stonequarry Creek had a significant flood event. Over 36 hours in early June 2016, 330 millimetres of rainfall was recorded, causing a major flood event in Picton[21]. The flood peak reached 8.8 metres at the Stonequarry Creek Gauge (Gauge No. 212053) and caused damage to businesses, council infrastructure, houses and farms.

The last major flood event at Penrith, on the Nepean River, (noting there are four upstream dams in the Nepean catchment, and Warragamba Dam on the Wollondilly River) was in August 1990[22]. This was the eighth largest event recorded in the past 200 years[23].

The last major flood event that caused Warragamba Dam to spill was in 2012, when a heavy rain event filled the dam[24], after 14 years without spilling.

6.6 Council assets

The WSC has a database to track its assets. Water related assets on this database include the number and location of stormwater pits, stormwater pipes, onsite detention basins, gross pollutant traps, and parks and reserves. A typical distribution of assets in an urban area is shown below in Figure 19.

Current number of assets are:

- gross pollutant traps – 26
- onsite detention basins - 103
- stormwater pits - 1293
- stormwater pipes - 28.8 km of pipe (varying from 150 mm diameter to 1050 mm diameter)
- WSUD assets - 8 handed over to Council, but many more on private land.

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[20] Landcom, 2004. Managing Urban Stormwater: Soils and construction - Volume 1. 4th edition
[21] Advisian, 2016. Picton Post Event Analysis June 2016 Weather and Flood Event. A report for Wollondilly Shire Council.
[22] Penrith City Council, 2019. Penrith City Local History. https://penrithhistory.com/environmental-heritage/floods-in-the-nepean-district/
[23] Mark Babister, Monique Retallick, Melanie Loveridge, Isabelle Testoni, Carlos Varga & Robert Craig (2016). A Monte Carlo framework for assessment of how mitigation options affect flood hydrograph characteristics, Australasian Journal of Water Resources, 20:1, 30-38, DOI: 10.1080/13241583.2016.1145851
[24] Sydney Morning Herald, 2012. There she goes: Warragamba took 14 years to fill, and only moments to spill. https://www.smh.com.au/environment/weather/there-she-goes-warragamba-took-14-years-to-fill-and-only-moments-to-spill-20120302-1u89j.html

The 2018 Wollondilly Shire Council Annual Report noted that stormwater drainage assets totalled $41.98 million in total asset value[25]. As a reference point, Blacktown City Council, a highly urban and growing LGA in greater Sydney, has $1,200 million[26] of stormwater related assets.

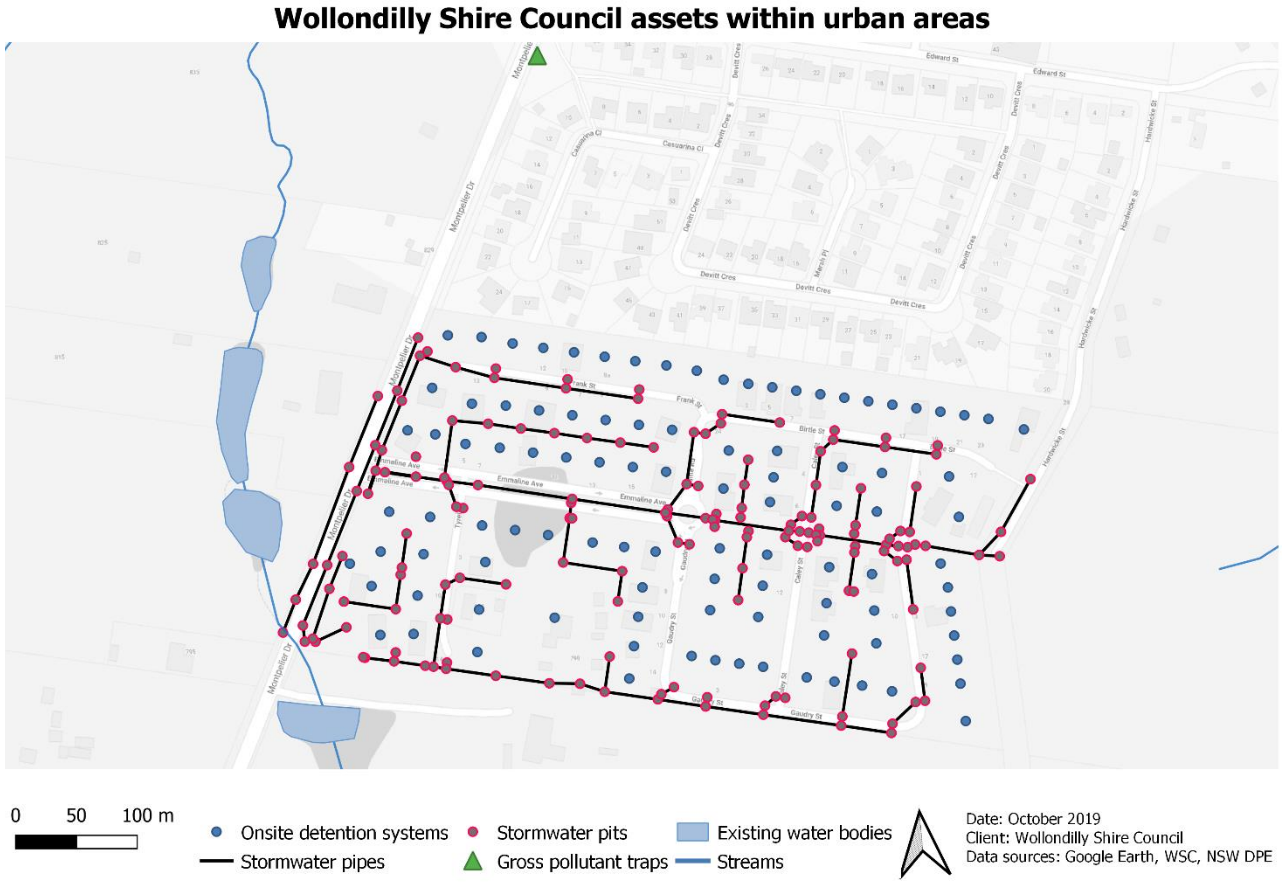

Figure 19. Council water related assets in The Oaks area.

Each asset has a maintenance frequency and life cycle, including depreciation rate, which then influences the maintenance and capital replacement forecasts that feed into budget bids. For example, stormwater drainage infrastructure depreciated by $458,000 in 2018[27].

6.7 Council and community water consumption

Sydney Water provided data on the volume of potable and recycled water being consumed within Wollondilly Shire Council. Council currently uses 101 ML per year of potable water, of which 70% is related to watering of reserves and ovals. See Figure 20 below. There are no significant alternative water supplies currently being used by Council, beyond small rainwater tanks on buildings. No recycled water was being consumed in the LGA (as documented by data supplied by Sydney Water).

All other sectors within the Wollondilly LGA consumed 6,100 ML of potable water in 2017/18.

6.8 Council open space and irrigation

Wollondilly Shire Council currently has 28 sports fields, with a total area of 29.3 hectares. These are spread across the Shire near the major towns. Analysing historic irrigation demand we find that WSC has increased its irrigation substantially since 2011 to 2017 (see Figure 20). We have assumed that the 2017 level of

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[25] Wollondilly Shire Council, 2018. Annual report, pp 52 of Financial Statements.

[26] Blacktown City Council, 2018. Annual Report.

[27] Wollondilly Shire Council, 2018. Annual report, pp 23 of Financial Statements.

irrigation will be required into the future as climate change affects the variability and mean annual totals of rainfall.

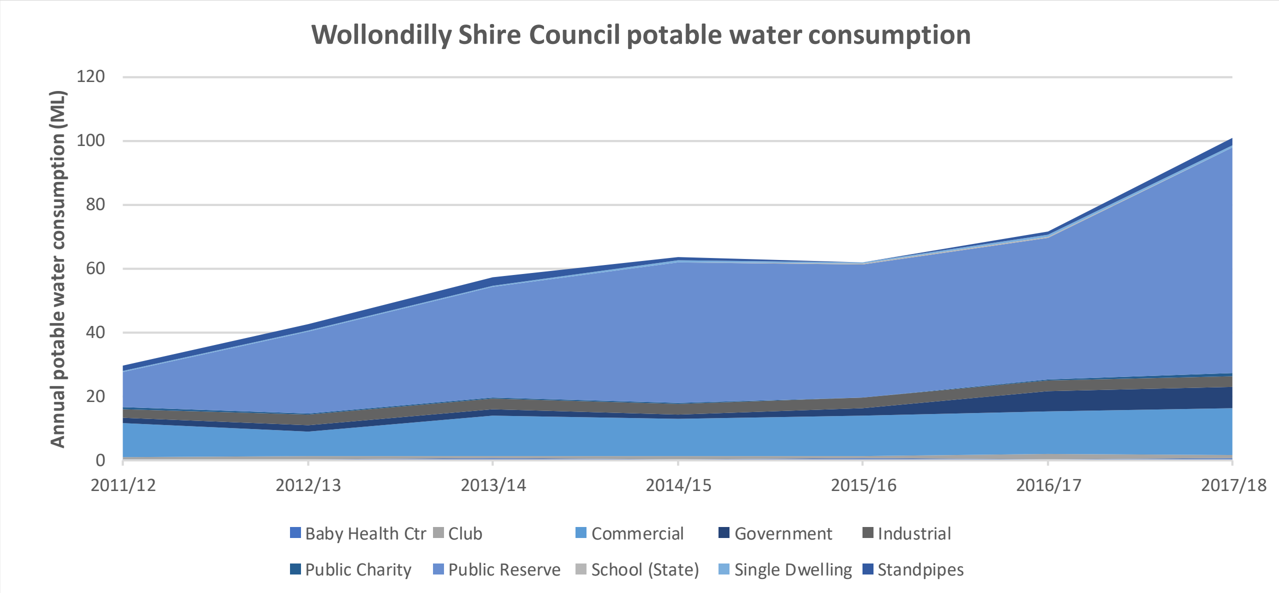


Figure 20. Council's potable water consumption over time

An analysis of irrigation areas at each of the current sports fields found that 80% of the total area is probably irrigated. 71 ML of potable water is used for irrigation, and this equates to approximately 2.5 ML / hectare of water for local sports and recreation, and 4 ML / hectare are the two regional quality sports fields. Irrigation rates are therefore assumed to be 2.5 to 3.0 ML / ha (see Table 3

Applying this rate of irrigation to future projects, it is forecast that future irrigation demand would be between 146 ML /year and 440 ML / year of water, depending on the area of new open space, and the rate of irrigation (noting in theory there is a standard practice of providing 2.83 hectares of open space per 1,000 people).

The actual water use of 71 ML / year in the most 2017/18 indicates both a reduced number of reserves are watered, and that Council is very efficient in its use of potable watering.

Table 3. Forecasting Council irrigation water use

Water use zones	**Irrigation demand for some reserves and ovals (ML/yr)**		**Irrigation demand for all reserves and ovals (ML/yr)**	
	2.5 ML/ha	**3 ML/ha**	**2.5 ML/ha**	**3 ML/ha**
Silverdale, Warragamba	10.4	12.5	26.0	31.2
The Oaks, Oakdale, Belimbla Park, Nattai	8.4	10.0	20.9	25.1
Brownlow Hill, Glenmore, Mount Hunter	1.8	2.1	4.4	5.3
Bargo, Pheasants Nest	7.1	8.6	17.8	21.4
Buxton, Couridjah	3.3	4.0	8.3	10.0
Picton	8.8	10.6	22.1	26.5
Tahmoor, Thirlmere, Yanderra	19.8	23.8	49.6	59.5
Appin	26.6	31.9	66.5	79.8
Wilton Growth Area (Wilton, Maldon)	46.4	55.7	116.1	139.3
Camden Park, Menangle	4.8	5.8	12.1	14.5
Cawdor	0.6	0.8	1.6	1.9
Douglas Park, Razorback	3.6	4.3	9.0	10.7
Orangeville, Werombi, Theresa Park	3.8	4.5	9.4	11.3

Rest of Shire	1.3	1.6	3.3	4.0
Total	**146.8**	**176.2**	**367.1**	**440.5**

Water restrictions were introduced in September 2019 by Sydney Water, that specifically affect Council's operation of open space irrigation systems (limiting them to 1 hour of irrigation a week), and therefore the use of alternative water sources (e.g. stormwater and recycled water) in the future for irrigation of open space should be a high priority.

Alternative water supplies provide some level of water security that is independent from the drinking water supply. It would also maintain access to sports, especially in summer, therefore maintaining community health. Irrigated green spaces also provide urban cooling through evapotranspiration. Alternative water can be harvested stormwater or recycled water, both of which, towns produce in abundance and are currently discharged into local streams and creeks.

6.9 Onsite wastewater

There are approximately 7800 onsite wastewater systems within Wollondilly. This is necessary as there are only small areas of trunk sewerage networks in the LGA, and residents must instead have onsite systems to manage wastewater.

There is a large degree of uncertainty as to the health and environmental impacts of non-compliant and non-functioning onsite systems. While WSC has a compliance officer to oversee onsite wastewater systems, it is virtually impossible to monitor all these systems.

Withers et al. (2014)[28] reviewed the possibility that septic tank systems were affecting water quality, and noted in their paper that in the US, 7 to 13% of septic tanks are failing, but in Ireland it could be up to 70%. Failure was defined as "surfacing effluent, greywater discharge, or sewage backup into the residence."

Research in Melbourne[29] by Prof. Chris Walsh from the University of Melbourne found that if septic tanks are within 10 metres of a waterway, they will most likely be contributing faecal and nitrogen pollution to the waterway. This reinforces the need for appropriate setbacks (locating a septic system 100 metres from a waterway as per WaterNSW's recommended practices).

The modelling in this project assumed that 1% of onsite wastewater systems in Wollondilly are failing and all flows will end up in the local waterway. This 1% estimate was supported by Council staff, but it is very low compared to other regions around the world (in the UK it was estimated up to 70% could be failing due to inadequate maintenance). The number of onsite systems in Wollondilly are forecast to decline over time as urban development rolls out, and new developments have a connection to a central sewer system.

A spatial distribution of the current onsite system was modelled as part of this project. See the analysis below in Figure 21.

[28] Withers et al, 2013. Do septic tanks pose a hidden threat to water quality? Front Ecol Environ 2014; 12(2): 123–130, doi:10.1890/130131

[29] Walsh and Kunapo, 2009. The importance of upland flow paths in determining urban effects on stream ecosystems. J. N. Am. Benthol. Soc., 2009, 28(4):977–990

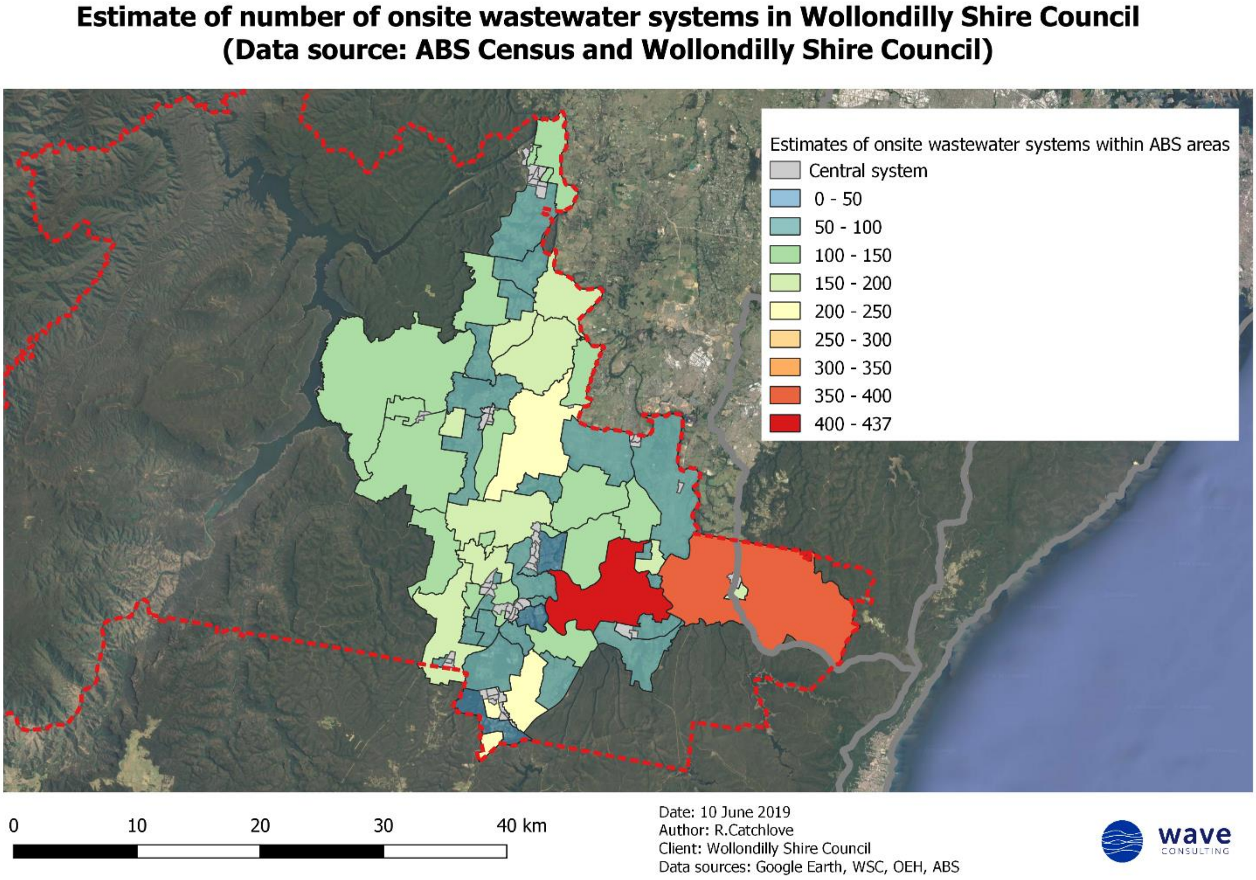


Figure 21. Onsite systems distribution (estimate) (Source: Wave Consulting)

6.10 Current revenue streams and resourcing

All local governments rely on a combination of grants, charges, developer contributions, and general rates to fund capital works, maintenance, and investigation / strategy work.

Council currently budgets in the order of $286,000[30] on stormwater related capital works, funded from development works and maintenance and land dedication in planning agreements.

Several councils in New South Wales have introduced a Stormwater Management Services Charge[31], which is possible under the NSW Local Government Act 2005, and first introduced in 2006. Residential properties are levied $25 / year, and commercial properties at $25 / year per 350 m^2 of land[31].

The stormwater charge in Wollondilly, applied to properties with nearby drainage infrastructure or waterway assets, is forecast to grow to $750,000 to $1,000,000 a year, depending on the rate of growth, number of new dwellings, and indexing of the charge.

[30] Wollondilly Shire Council. 2018. Annual report, page 71.

[31] Office of Local Government, 2006. Stormwater Management Services Charge Guideline. Accessed at https://www.olg.nsw.gov.au/sites/default/files/Stormwater-Guidelines.pdf

7 The future Wollondilly water story

The volume of surface water runoff, the velocity of the water, the timing of the flows, the concentrations of nutrients and pathogens, and the overall load of nutrients and sediment that enter local waterways have a large impact on the opportunity for the community to swim in the rivers, and the aquatic fauna and flora to survive.

In considering how to ensure there is zero impact from surface waters and wastewater discharges from new urban developments on waterways, an average annual flow volume is used as the main metric. Flow volumes are also useful in considering the integrated benefits of linking surface water runoff with harvesting and reuse, to offset potable water consumption in residential and commercial buildings.

In the longer term, the use of a reference stream location and its associate water quality monitoring station could be used to assess the implementation of this strategy.

7.1 Future water balance

Without any new state or local government policy interventions, it can predicted (based on several assumptions) that there will be a large difference in the volumes and quality of water that are discharged into the Nepean River (and all creeks and tributaries to the river), and large volumes of potable water consumed.

A future water balance shown below is essentially a 'worst case', as it doesn't consider any policy changes or interventions outlined below in this strategy.

Wollondilly Nepean Catchment: Average water balance in the future (annual average*)

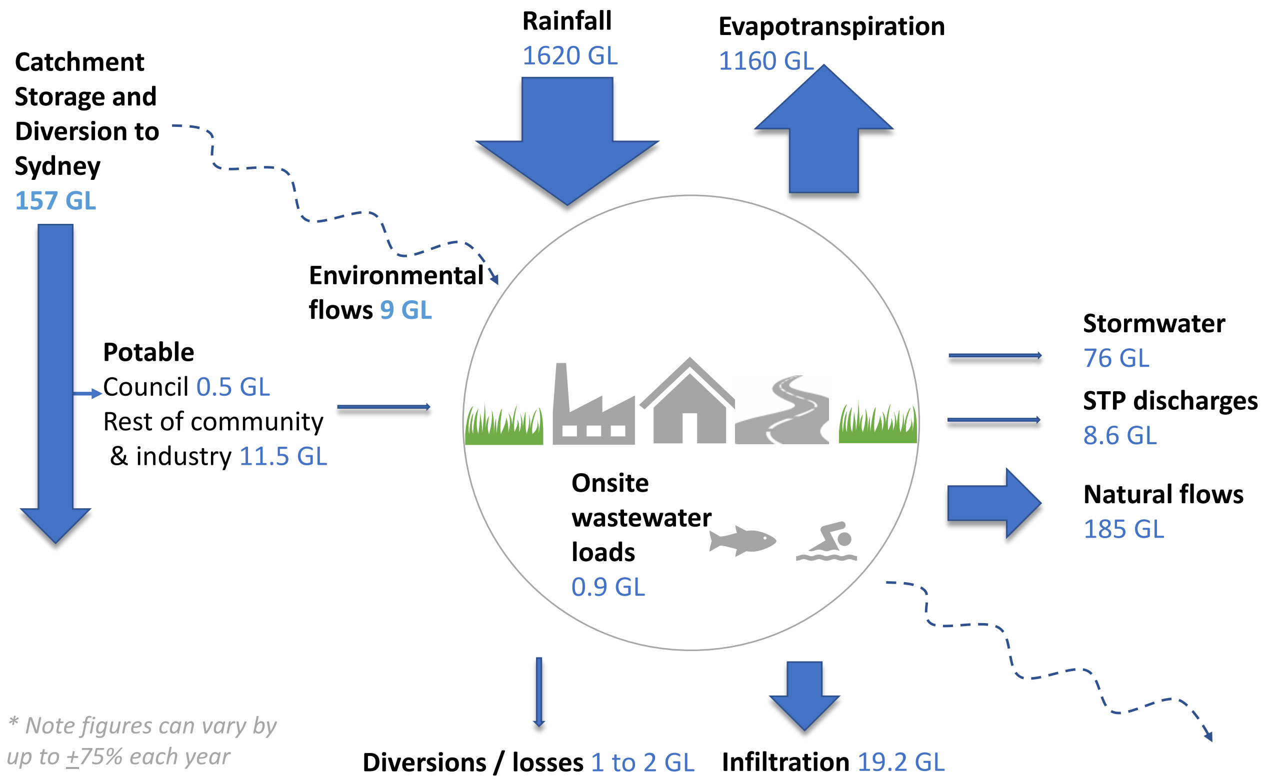


Figure 22. Future (worst case) water balance for Wollondilly (Nepean catchment)

Figure 22 highlights the large increase in stormwater discharges to the downstream water, assuming there is no treatment of this discharge. Rainfall may increase or decrease and will become more variable. Catchment yields and environmental flows are hard to predict, as are any diversions due to mining and fracking.

The increase in stormwater discharges, and discharges from sewage treatment plants and the need to source more potable water for new developments, is the focus of the scenarios below.

7.2 Scenarios

The scenarios outlined below specifically look at the potential for smarter use of rainwater, stormwater and wastewater, compared to a business as usual approach. The scenarios consider how each of the main institutions and influencers (Council, Sydney Water, developers and community) can do things differently through:

- The capture of rainwater and stormwater.
- The substitution of potable water with rainwater, stormwater and recycled water.
- Placing higher demands on water in a rainwater tank.
- Introduction of a slow leak from rainwater tanks (0.33 litres / square metre of a lot / day) would replicate a base flow contribution for the catchment).
- Dynamic and coordinated management of rainwater tanks (which allows for spilling of rainwater tank water to the drainage system, to create space for a new storm event, which is designed to harvest more water and reduce flood peaks).
- More disconnected surfaces (i.e. surface water drainage that doesn't flow through pipes)
- More green streets and landscape environments to soak up and infiltrate surface water runoff – a biomimicry method.
- The density of development and the percentage of green space.
- The percentage of road reserve dedicated to green infrastructure.
- The reuse of wastewater to reduce or eliminate discharges to the local environment.
- Consider wastewater as an energy and nutrient source, and as an option to replace potable water use.

The scenarios consider how to alter the impact of urban development on the water cycle, to achieve 'zero impact'. The scenarios are outlined in Table 4 below. Several iterations of these scenarios were run to test the sensitivity of the results.

Table 4. Scenarios and key results

Scenario	BAU w BASIX	BASIX Plus	Almost Zero	Zero
Need for end of line WSUD	End of line WSUD	25% less space required for end of line WSUD	100% less space required for end of line WSUD	100% less space required for end of line WSUD
Rainwater tanks on each lot	2kl per lot	5 kL per lot	10 kL per lot	15 kL per lot
Use of rainwater tank water	Toilet and laundry	Toilet and laundry and outdoor and hot water	Toilet and laundry and outdoor and hot water	Everything but drinking, and leak to support baseflows
Streetscape design	Traditional	Traditional	Median swales	Median swales & fully disconnected
Runoff volume reduction	29%	36%	50%	79% (* this is near natural condition)
Potable demand reduction	40%	51%	63 %	72%
Other supply	Potable & third pipe	Potable & third pipe	Potable & third pipe	Potable
Precinct harvesting required	Yes	Yes	Yes	Only for large catchments
Zero impact	No	No	No	Yes

** Commercial / industrial developments that don't have ability to reuse water will require 5 to 7% of impervious area dedicated to linear vegetated infiltration systems (use of permeable pavements and nature strips will contribute to this)*

The main variables that influence the ability to meet a 'zero impact' objective are:

- changes to the size of rainwater tanks
- changes to the demand for water on rainwater tanks
- changes to the width and area of road reserves that can be used for multiple benefits (amenity, urban cooling and water management)
- changes to the source of water used within a home / business (i.e. what type of water is used to flush toilets – is it rainwater, or recycled water through a third pipe network, or potable water).

All scenarios were modelled over a wet, dry and average rainfall period.

7.2.1 Business as usual with BASIX (with typical DCP water quality objectives)

A business as usual (BAU) model for urban development, as observed and adopted across several councils in Greater Sydney, would be to meet the NSW planning requirements of BASIX, and require:

- A nutrient reduction load target to be met, usually in the form of a downstream water quality asset (e.g. biorientation or wetland).
- A connection to the potable and sewer trunk systems.
- BASIXs to be met – requiring a 40% reduction from usual potable consumption and a two kilolitre rainwater tank on each residential dwelling.

The nutrient reduction targets (80% reduction of Total Suspended Solids; TSS, 65% reduction in Total Pollutants; TP, 45% reduction in TN), do not prevent increased pollutant loads, but rather reduce loads by a 'reasonable' proportion compared to doing nothing.

Connecting to centralised water and sewerage networks is not normally a problem in established urban areas (assuming there is capacity in the network). However, on the fringe of the existing network, like the towns of Wilton, Appin and Picton, it is a more complex task to augment and extend the water infrastructure network. A traditional sewage treatment plant would result in local discharges to the creek. Discharges from a typical urban development (as per the modelled surface water system) would require the treatment and discharge of approximately 15 ML per year, or 41 kL a day.

Modelling a BAU scenario of surface water discharge would result in, on average, 11 ML of stormwater flowing into the creek each year, per one hectare of urban development, which is more than a 100% increase compared to the predevelopment conditions. Note that the forecast new urban area in Wollondilly is in the order of 3000 to 4000 hectares of new urban development over the next 16 years.

Rainwater tanks in this scenario are approximately 72% reliable (i.e. has water in the tank to meet demands 72% of the time). This suggests that recycled water (a purple pipe) or an alternative water source could also be connected and play a significant role in offsetting potable water use and could also replace more outdoor water use.

BAU meets a 40% reduction in potable demand but doesn't go beyond this level. It is assumed that the rainwater tank delivers 20% of that reduction, and 20% comes from water efficient appliances.

While wastewater management and potable supply is the jurisdiction of Sydney Water, the assumption is that a traditional approach to managing discharges would be adopted. It is forecast that a business as usual strategy for wastewater would see additional wastewater treatment plants built with discharges to be sent into the Nepean River, while complying with the necessary load limits that the EPA specify. The Environment Protection Authority have advised that the current load limit may be reduced in the future[32], thus requiring higher treatment of wastewater.

[32] EPA spokesperson, 2019.

7.2.2 BASIX plus

The next scenario is where residential lots upsize the rainwater tank to 5 kL and use the rainwater for more demands within the home. The BASIX plus scenario still requires all road runoff and excess residential runoff to be treated with downstream assets.

Modelling the 'BASIX Plus' scenario for surface water results in more than an 80% increase in discharge compared to the pre-development conditions, or 5.9 ML of stormwater discharged to the creek each year, per one hectare of urban development.

Rainwater tanks in this scenario are approximately 50% reliable (i.e. has water in the tank to meet demands 50% of the time). This suggests that a purple pipe could also be connected and play a role in offsetting potable water use in this scenario and reducing discharges to the Nepean River.

Water quality assets at the downstream point of the catchments and drainage lines would reduce in size by 25% with this scenario (to meet the BAU stormwater quality pollution reduction targets).

Wastewater discharges would most likely still be as per BAU.

7.2.3 Almost zero

To further reduce the impact of urban development, this scenario uses 10 kL tanks, and uses rainwater for all non-potable uses, and models the impact of distributed 'green streets' to passively manage road runoff within the existing road reserve.

Street design is a complex area, and in a business as usual practice, involves a lot of pits and pipes to convey all rainfall events. The concept modelled in this scenario was to bring all water into a central median strip and allow infiltration and conveyance of stormwater above ground and through this central swale. The distributed nature of this design ensures that the infrastructure requires near zero maintenance.

Runoff in this scenario is reduced by 50%.

This scenario eliminates the need for any downstream water quality assets (noting that traditionally this would take up 1 -2% of the developed area). Sensitivity modelling was conducted on the operation of the tanks, and if 50% failed (i.e. are not working and just overflowed), then the system would still reduce flows and nutrients to a degree that didn't require any downstream water quality assets.

This scenario is referred to as 'almost zero' since while there is no need for any water quality downstream assets, it doesn't replicate a natural catchment's flow and pollutant regime. Further volumes and nutrients must be filtered before this scenario could genuinely be called zero impact.

Cost savings associated with the elimination of bioretention and wetland assets at downstream locations in this scenario could be reinvested in required monitoring technology attached to rainwater tanks, to facilitate smart tank operations, and the maintenance of green streetscapes, to deliver a cost neutral solution with several additional benefits.

In this scenario the business case for recycled water (or purple pipe) to all residential homes would be harder to make, as there is less volume required and therefore less revenue to be gained through the selling of this water, as rainwater is used instead.

7.2.4 Zero impact

The final scenario analysed how to reduce all stormwater runoff to replicate a natural hydrological regime. This can be achieved through introducing additional demand on the rainwater tanks on lots (which in turn then increases the amount of water harvested, and supports the slow release of water into the subsurface which supplies water for baseflows in rivers), and increasing the road reserve to filter and convey more stormwater runoff.

Potable water consumption would drop by approximately 72% (well passed the BASIX minimum requirement of 40%). With most of the water in homes being supplied by rainwater tanks, there is no need or business case for a recycled water connection.

This scenario assumes that the median strips would increase from 5 metres to 7 metres, with a 2-metre base, which creates a larger surface area for trees and native vegetation to thrive and passively reduce runoff and stormwater pollutants. Flood peaks would also be reduced through both rainwater tanks and green streets.

This scenario also eliminates the need for any downstream water quality infrastructure, as all nutrients and excess stormwater is evapotranspired or infiltrated within the streetscape environment.

This scenario could also be used to rethink stormwater drainage in general, flipping it around to ensure low flows remain above ground, remove the need for trenches and pipes, and potentially reduce the costs to build and sustain urban developments. Further work on the design specifics and economics of this design solution is required.

A 79% reduction in impervious flows would be as close as possible to a zero impact scenario, as in predeveloped catchments some water still flows to waterways. So, it is not practical or appropriate in protecting the downstream environment to reduce impervious flows by 100%.

Wastewater treatment and discharges would also need to be reviewed to ensure they also have zero impact (otherwise a new strategic design approach for rainwater and stormwater is undermined through other water network discharges).

A long-term strategic direction, further discussed below, is to consider options to do advanced water filtration, to produce raw water augmentation.

This 'zero impact' scenario would be consistent with draft Wilton DCP controls.

7.2.5 Zero impacts from non-residential development

Non-residential development (i.e. factories, warehouses, shopping centres, office buildings, schools) have a different and less regular demand for non-potable water, and hence the use of rainwater tanks to influence an integrated water outcome is more challenging.

The scenario modelling considered the design of distributed landscaping to ensure impervious areas always flow to a vegetation / infiltration system, to absorb runoff and filter pollutants, and deliver on the zero-impact objective.

An analysis of existing industrial and commercial areas indicated that sites are never more than 90% impervious, and that a creative use of existing spaces (like driveways, front and rear gardens), would ensure this target of ensuring there is no directly connected impervious surfaces is still possible within commercial and industrial sites.

If commercial and industrial developments could reuse rainwater (approximately 4 kL tank required for each 100 m^2, and a reuse rate of at least 600 L / day), then there would be less area required for other bioretention / infiltration / swale assets.

If there are no rainwater tanks and reuse proposed for a commercial / industrial / retail development, then runoff from the roof and impervious areas must drain to an area that is 5 to 7% of the total impervious area.

Precinct wide solutions may be possible where there are commercial or industrial premises that require large volumes of non-potable water.

The graph below shows the relationship between run-off from roofs; storage; and reuse, to illustrate why the demand on a tank is more important than the size of the tank but note that in applying this target, it must be proportional to each 100 m^2 of roof area.

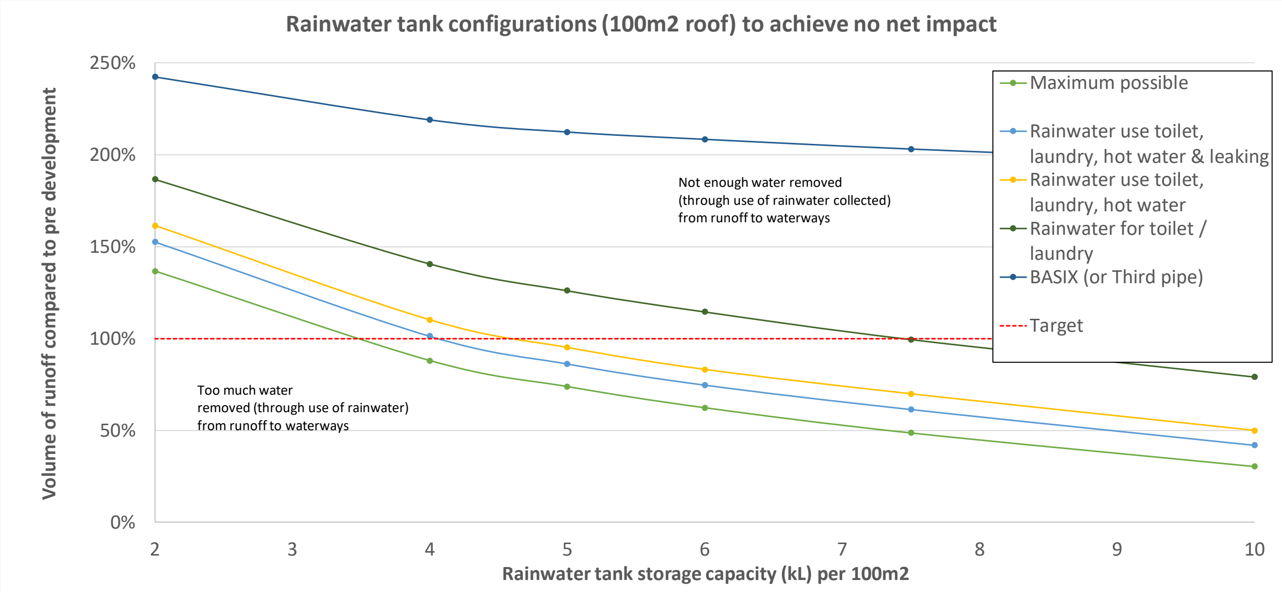


Figure 23. Size and demand for water in rainwater tanks to meet a zero-impact objective

7.3 Regional analysis

In applying the scenarios to the whole LGA (Nepean catchment only), we can test different scenarios in each development area / catchment and identify the potential impacts (volume or financial) of different scenarios in different areas / suburbs of Wollondilly.

Table 5 below summarises the land area, current and future water demands, and current and future water flows with the adoption of a BAU or a Zero Impact scenario.

Table 5. Summary of water, area and scenarios when scaled across the LGA (by suburbs and catchments)

	Catchments	Georges, Cataract & Nepean	Bargo			Back & Horse Creek	Stonequarry	Werriberri	Myrtle	Nepean				
	Development areas	Appin - Cataract - Darkes Forest	Bargo - Yanderra - Pheasants Nest	Buxton - Couridjah	Tahmoor	Oakdale - Nattai - National Park	Picton - Mowbray Park - Maldon	The Oaks - Belimba Park - Glenmore	Thirlmere - Lakesland	Wallacia - Warragamba - Silverdale	Camden Park - Mount Hunter - Cawdor	Douglas Park - Wilton	Menangle - Razorback	Orangeville - Werombi & District
Current conditions														
Area (ha)	255600	19,310	7,830	1,140	1,700	160,090	5,290	4,910	10,650	6,470	6,400	13,590	8,050	10,170
Urban area (ha)	1658	81	246	72	217	40	214	136	133	300	79	125	15	0
Impervious area today (ha)	995	49	148	43	130	24	128	82	80	180	48	75	9	0
Total road surfaces (ha)	3787	214	398	72	107	1,214	175	156	282	164	133	381	255	236
Population today	49062	2,716	5,834	2,314	5,174	1,980	5,081	3,335	4,589	4,589	3,343	4,580	2,283	3,244
Dwellings today	16722	883	2,077	763	1,939	713	1,852	1,100	1,619	1,619	995	1,464	736	962
Avg potable water demand today (ML/yr)	3857	204	479	176	447	164	427	254	373	373	230	338	170	222
Future conditions														
Forecast population	87,342	3,975	6,365	2257	7,115	2,335	6980	3,850	6,323	6,323	2,981	31,861	2,987	3990
Forecast dwellings	30,044	1,362	2399	810	2,672	899	2666	1,335	2,361	2361	1,035	9,946	999	1199
Forecast urban area	6,880	1,330	360	70	700	110	800	250	500	490	70	1,480	720	0
Forecast impervious area (ha)	3,784	732	198	39	385	61	440	138	275	270	39	814	396	0
Forecast area open space (ha)	247	11	18	6	20	7	20	11	18	18	8	90	8	11
Forecast Council water demand for open space (Ml/	1,112	50.6	81.1	28.7	90.6	29.7	88.9	49.0	80.5	80.5	38.0	406	38.0	50.8
Forecast Council budget for potable water ($ m /yr)	1.39	0.06	0.10	0.04	0.11	0.04	0.11	0.06	0.10	0.10	0.05	0.51	0.05	0.06
Forecast res water demand (ML/yr)	6,931	314	553	187	616	207	615	308	545	545	239	2,294	230	277
Total forecast water demand (Ml/yr)	11,551	524	922	311	1,027	346	1,025	513	908	908	398	3,824	384	461
Potential res water efficiency (Ml/yr)	1,475	53	36	5	81	21	90	26	82	82	4	939	29	26
Future development volumes using BAU														
BAU stormwater (Ml/yr)	41,397	8,003	2,166	421	4,212	662	4,814	1,504	3,009	2,948	421	8,905	4,332	0
BAU wastewater (Ml/yr)	8,663	393	692	234	770	259	769	385	681	681	298	2,868	288	346
BAU WQ assets (capex $ m)	$ 149.47	$ 28.89	$ 7.82	$ 1.52	$ 15.21	$ 2.39	$ 17.38	$ 5.43	$ 10.86	$ 10.65	$ 1.52	$ 32.15	$ 15.64	$ -
BAU total res water bills ($m / yr)	$ 38.85	$ 1.76	$ 3.10	$ 1.05	$ 3.45	$ 1.16	$ 3.45	$ 1.73	$ 3.05	$ 3.05	$ 1.34	$ 12.86	$ 1.29	$ 1.55
Future development volumes using 'Zero impact'														
Zero impact stormwater (Ml/yr)	10,974	2,121	574	112	1,117	175	1,276	399	798	782	112	2,361	1,148	0
Zero impact wastewater (Ml/yr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zero impact WQ assets (capex $)	0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0	$0	$0
Rainwater tanks no.	13,322	479	322	47	733	186	814	235	742	742	40	8,482	263	237

7.4 Wastewater management

Centralised management of wastewater is the jurisdiction of Sydney Water, but with an integrated approach to water management, and implications in land use planning, it is important to include options for wastewater management as part of this water strategy. Local onsite wastewater management is and will remain the jurisdiction of Council (with reference to EPA guidelines).

To deliver zero impact on waterways through smarter wastewater management, the strategy must:

- Reuse all wastewater through irrigation, agriculture, industrial / commercial sites, or where appropriate consider reuse through the Sydney Network through raw water augmentation.
- Where appropriate consider reuse through residential areas (as a back up to rainwater systems).
- Carefully consider options to supplement environmental flows (i.e. water released from the upper Nepean dams) with treated wastewater and consult with the EPA, Council and OEH, as the timing and quality of this water may not be acceptable (in an ecological and scientific perspective) as an environmental flow. The capacity of slow releases from rainwater tanks should also be discussed in this manner with these stakeholders.

While options in the short and long term may vary, it is important that short term options don’t prevent the delivery of a long-term solution or set a precedent in the short term that prevents the move towards a long-term strategy.

The options include:

- Traditional treatment and discharge (assuming this is compliant with EPA regulations and licencing).
- Reuse for agricultural uses and no additional discharge.
- Reuse in residential areas as back up to rainwater tanks, and no additional discharges.
- Reuse in industrial / commercial areas, and no additional discharges.
- Reuse for irrigation of open space, and support for recreational activities, and no additional discharges.
- Replacement flows project.
- Advanced treatment and raw water augmentation.
- Exporting wastewater from the catchment (to Malabar treatment plant and ocean outfall).

Directing treated wastewater to lakes and ponds is not a viable long-term option, as the treated water will ultimately then flow to the waterways (only a small percentage is evaporated from lakes), so this option is only marginally different to a traditional discharge option.

From a wastewater treatment perspective, there are various reuse technologies available to Sydney Water to deploy, but all have varying costs, capital implications, operating implications, waste streams, produce different qualities of treated water, and have different regulatory and policy implications.

To avoid an impact on Wollondilly’s pristine waterways and rivers, wastewater must be reused locally, reused through a regional reuse scheme to replenish / augment other supplies, or exported from the catchment altogether. The last option (exporting from the catchment) is expensive and will transfer the problem somewhere else.

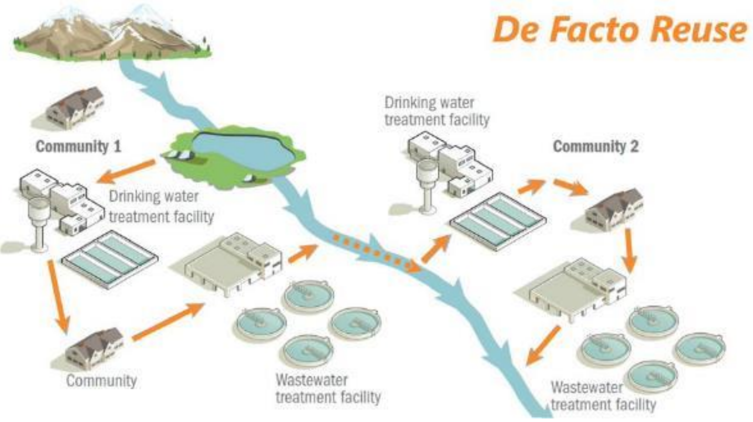
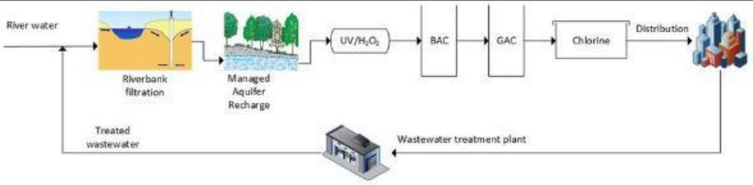
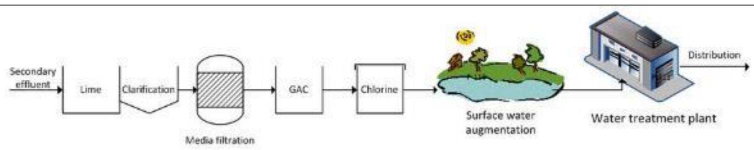
The first option for local reuse is already happening in Wollondilly, through reuse around the Picton sewage treatment plant in nearby agricultural areas. The scaling up of this option, as more sewage is generated in the Picton catchment via urban development needs to be managed carefully, noting the downstream values and presence of Dragonfly and Macquarie Perch in this area of the Nepean River.

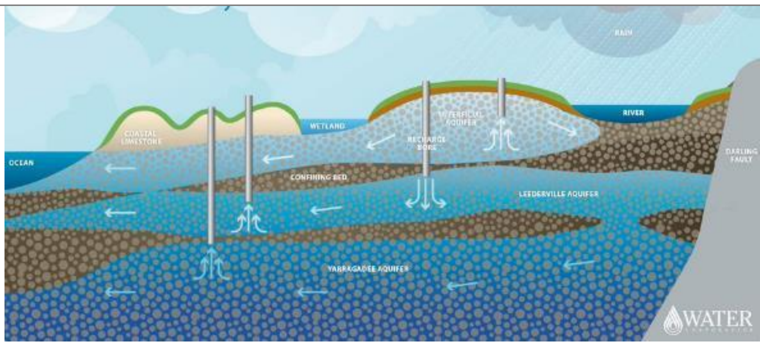
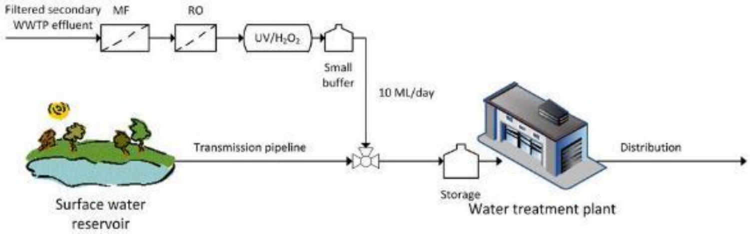
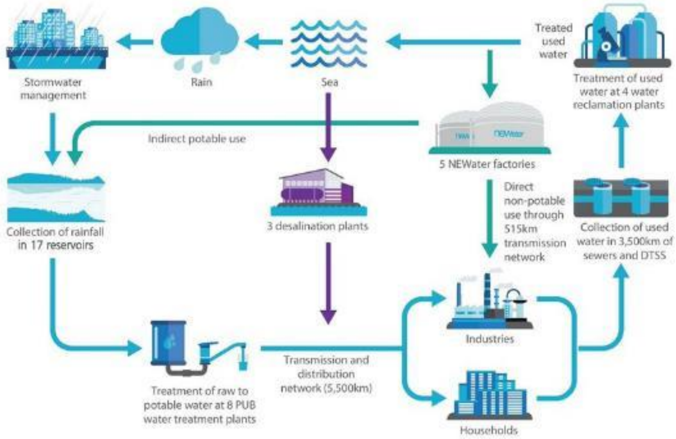
A strategy that uses the first (local reuse) and / or the second (reuse and potable substitution through raw water augmentation) would achieve the desired zero impact objective. A BAU treatment and discharge option would not meet the zero impact objective.

Local reuse (i.e. third pipe or purple pipes) in residential areas would compromise the effectiveness and value of rainwater systems in reducing stormwater runoff (through competition for water demands in a house between using a rainwater tank or third pipe) and is not recommended in this LGA.

Table 6 below notes some of the different types of recycling / reuse systems used around the world.

Table 6. Wastewater treatment models (Source: S.Khan, 2019)

Name	Concept	Description
De Facto reuse		In this option authorities source drinking water from rivers, which have other cities discharging treated sewage effluents into them upstream. While these may not be “acknowledged” recycling projects, they're sometimes called "de facto" potable reuse. This is in operation already in Sydney (upstream of Warragamba Dam, and downstream in North Richmond).
Indirect potable reuse (Surface water and aquifers)		This option is where wastewater is recycled through advanced treatment (ultra-violet / biologically activated carbon / Chlorine) and then pumped back to storage reservoirs and replenishes the surface / aquifer system.
Indirect potable reuse (Surface water)		The use of recycled water to recharge surface water systems, such as rivers, lakes or dams. This practice is known as surface water augmentation.

<table>
<tr>
<td>Indirect potable reuse (Ground water)</td>
<td>
</td>
<td>Perth (Western Australia) has developed the Groundwater Replenishment Scheme (GWRS). The GWRS began operation in 2017. Water from Beenyup sewage treatment plant is now purified and used to recharge two important drinking water aquifers (Leederville & Yarragadee aquifers).</td>
</tr>
<tr>
<td>Direct Potable reuse</td>
<td>
</td>
<td>Water recycling doesn’t have to replenish groundwater or surface systems but can be directly connected into the distribution network. This is known as direct potable reuse.</td>
</tr>
<tr>
<td>Integrated reuse</td>
<td>
</td>
<td>Singapore goes to another level again by recycling stormwater and wastewater for potable reuse – in some instances directly and in others through surface water augmentation.</td>
</tr>
</table>

7.5 Wastewater pathways

As the 13,000 new dwellings (and other retail and commercial areas) are built, there is a need to augment the wastewater network and treatment system over time and do so in a way that facilitates and enables a long term vision of ‘zero impact’.

While the Picton STP currently has a licence to discharge 1.5 ML / day of treated sewage, Table 5 reveals the forecast development in the Bargo, Thirlmere, Tahmoor and Picton area would rise to over 8 ML / day. The Wilton area would generate in the order of 7 to 8 ML / day of treated sewage as well.

Pathways shown below (Figure 24) are based identifying agricultural and industrial land in the Wollondilly and surrounds area, as locations that may require large (i.e. > 1 ML / day) of recycled water, which reduces the loads of TN and TP into the Nepean River.

Depending on the volumes generated, water efficiency rates, irrigation rate of agricultural land, proximity to treatment plants, climate and seasonal variations, there is between 250 and 1000 hectares required to prevent direct discharges into the Nepean River. An analysis of low lying areas, downstream of the development zones and adjacent to the Nepean River, indicates that there is 200 times this desired area of land (zoned rural or industrial) and it is may be therefore feasible to engage with land owners and find a suitable location and cost effective solution to achieve a zero impact. See Figure 25 below.

The various pathways for managing increased sewage loads and treatment options are illustrated below.

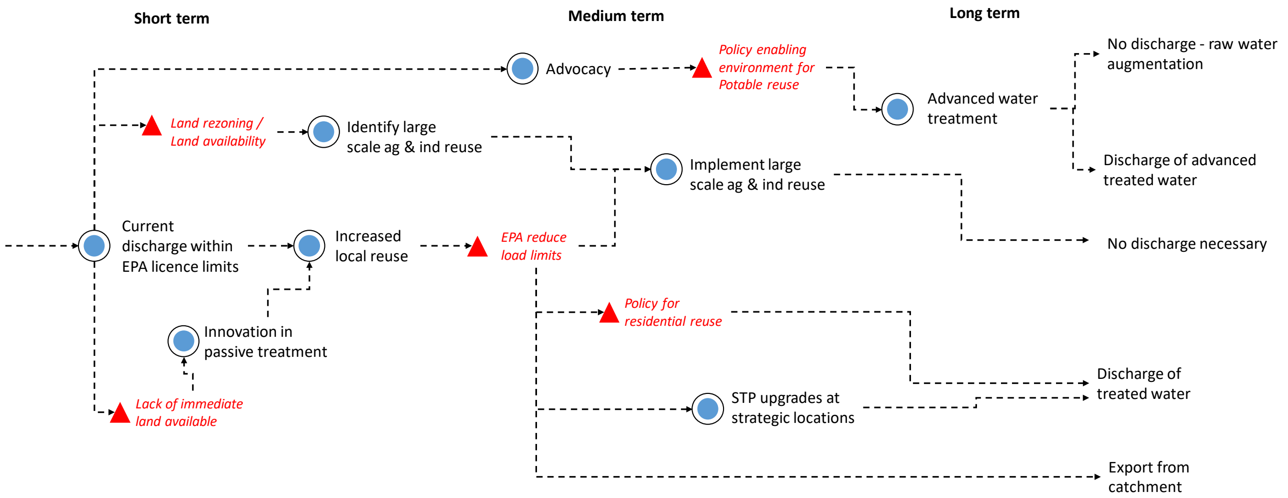


Figure 24. Options and pathways for augmenting sewer treatment and reuse

The pathways capture the broad pressures and potential augmentations that may be adopted. Some of the main influences on the decisions and introduction of new treatment processes are:

- The EPA nutrient load limits in this part of the Hawkesbury Nepean system
- The state government policy of reuse and its impact on how Sydney Water approach integrated treatment options
- Capital costs for upgrades
- The use of rainwater in lots (that reduces the need for a third pipe scheme and therefore creates the need to identify other uses
- Land use and zoning and arrangements to irrigate local agricultural lots

Wollondilly Shire Council zoning and opportunities for reuse of treated wastewater

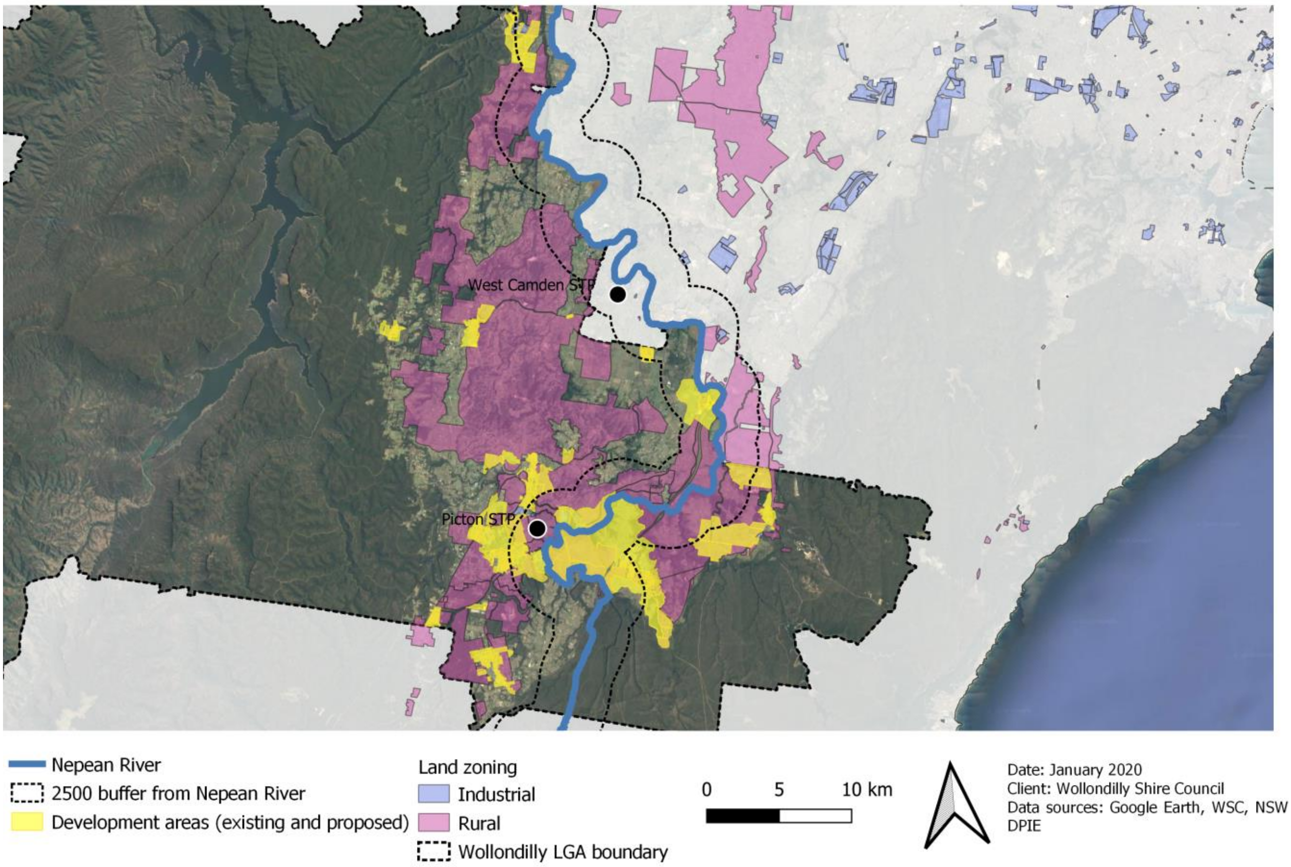


Figure 25. Review of zoning and land near the Nepean River in context of water reuse on agricultural and industrial land

7.6 Smart infrastructure

The 'zero impact' scenario described in Section 7.2 requires an integrated approach to water supply, rainwater, stormwater, and wastewater issues. To ensure the distributed systems work as designed over a long period, and maximise the benefits, the adoption of a 'smart infrastructure' model is required. A rethink and new model for the management, maintenance and optimisation of all water infrastructure is required.

A smart infrastructure solution in this case specifically means all rainwater tanks must have a monitoring and remote release system as part of the installation, to enable authorities to release water prior to storms and identify when pumps or filters fail. This is referred to as **'smart tank technology'** in the water industry and can be extended to respond to rainfall events to enable a greater volume of storms to be retained in the tanks.

The benefits of this method are that authorities (such as Sydney Water and Council) can then have confidence that the rainwater tanks, at every lot, will be reducing stormwater pollution and nutrients from entering waterways, saving potable water, and reducing flood peaks through the detention of storm events.

7.7 A new opportunity to deliver environmental flows

The 'zero impact' scenario described above is designed explicitly to promote leaking of rainwater tanks. This leaking of the rainwater tank, across a whole development, is then actually providing an environmental flow of equivalent or greater than the regulated storage releases.

Predevelopment, a one square metre of land would result in 120 litres a year of water infiltrating the ground and contributing to baseflow. A leaking rainwater tank can easily provide this volume of water through leaking to landscape areas on the property or road reserve.

If this type of system was in place for all 13,000 new dwellings, then approximately 400 ML of water would be 'leaking' across the catchment, either being evapotranspired or contributing to the baseflow of waterways, that would genuinely be delivering environmental flows and benefits to the waterways. This doesn't replace or compare to the current 9 to 32 GL / year of environmental flows delivered by WaterNSW from the four storages in the Nepean catchment, which is focused on environmental flows within the larger Nepean Hawkesbury river system. The additional benefit of this type of environmental flow is the distributed nature of the leaks, that would support every single small tributary and creek, rather than just the Nepean River.

7.8 The opportunity for water intensive industries

The future water story notes that there is an excess of stormwater and treated wastewater forecast to be produced in urban areas that potentially could be used through water intensive industries in the LGA.

Industries such as agriculture, manufacturing, cooling systems, textiles, cleaning / laundry, are all water intensive industries and could potentially be attracted to the Wollondilly LGA if there is access to abundant non-potable water supplies. Chapter 6 above notes that this equates to 5 ML / day of recycled water, and 50 ML / day of stormwater in key locations. If a local irrigation reuse system was in place, then this equates to approximately between 250 to 1000 ha of land (over the whole LGA by 2036) to be irrigated and ensure no wastewater is discharged to local waterways.

The caveat for the location and uses of alternative water volumes and networks is that the costs for transport to the site is born by the user and can't be transferred to Council or Sydney Water.

7.9 Levers to enable zero impact

To influence and change the number of assets, design solutions, and the overall impact on waterways, there are some critical factors that could be used to help deliver a zero impact scenario.

The first is **land use planning**. Strategy planning, water infrastructure planning (and capacity limits), and environmental values (and capacity limits) should be integrated to reduce the stress on services and the environment. This is a complex area though and requires collaboration between local government and state government strategic planners and technical experts.

The second is the **density** of development. A more compact development, with less impervious area, would support a zero impact scenario, and reduce the need for storage of rainwater and use of that water.

The third is the **width of road reserves**. A wider road reserve enables more water to be retained, evapotranspired, filtered and support the creation of cool green spaces in urban areas. The 'almost zero' scenario assumes a 20-metre-wide road cross section, and within that a 5-metre-wide swale. The 'zero impact' scenario assumes that this swale increases to 7 metre in width, which may fit within a 20-metre road cross section, or ideally be located within a 22 to 25-metre-wide cross section.

The fourth is the inclusion of **monitoring** of distributed systems to enable authorities to have confidence that all water infrastructure is working as designed. The funding of this monitoring equipment is possible through savings to less infrastructure in downstream areas.

7.10 Strategy outside of urban growth areas

Four percent of Wollondilly is within a land use zone that allows urban growth to occur (either infill development, subdivisions or new greenfield development). The other areas of the LGA are within the Special Areas (77%) of rural / farming land that is outside the urban growth corridor (19%).

For land within Wollondilly Shire Council that is within the Special Areas, the neutral or beneficial effect (NorBE) policy applies (see Chapter 6).

The strategy for water outside of the urban growth areas and Special Areas is for developments to:

- Comply with WSC On-site Sewage Management and Greywater Re-use Policy, specifically in regard to ensuring there is zero wastewater discharged to waterways
- Ensure there is minimal poor quality stormwater discharged to waterways, through above ground filtering and conveyance.
- Ensure all appliances are Water Efficiency Labelling Scheme (WELS) rated 5 stars or above.

8 Summary of strategic approach

8.1 Short to medium term

Several stakeholders have expressed in principle support for the long term solution for managing water in Wollondilly (Nepean catchment), and the community consultation also supported a zero impact strategy (see Section 2.6).

Nonetheless, in the short and medium term, there is still some complexity to managing development and moving towards this long-term vision.

In the short term, WSC, stakeholders, and landowners must:

- Continue to identify opportunities to irrigate rural land with recycled water from local STPs to support local agriculture, noting overall wastewater volumes will more than double over the time period of this strategy.
- Engage with relevant stakeholders to move towards raw water augmentation solutions.
- Work with the EPA and Sydney Water to better understand the nutrient load capping in this zone of the Hawkesbury Nepean River, and how an integrated approach can protect and maintain ecological objectives in this catchment.
- Continue to review the performance, maintenance and impact of onsite systems.
- Work with local developers to support design solutions in streetscapes that deliver multiple benefits (water quality, flood detention, amenity, urban heat) and remove the need for downstream water quality infrastructure.
- Review the cost effectiveness of daylighting stormwater drainage systems to identify potential cost savings (for both the construction and long term operation of the assets) against existing maintenance costs.
- Trial a model (like the Aquarevo development in Victoria) where the water authority monitors and maintains rainwater tanks to demonstrate that an active and dynamic approach to monitoring this distributed infrastructure will deliver better results for the community / residents and the environment.

8.2 Long term

The long-term strategy for Wollondilly can succinctly be summarised as follows, noting that several of these strategic directions are not always within the jurisdiction of WSC:

- Advanced treatment of wastewater to support raw water augmentation, and hence no discharge of wastewater to the local reach of the Nepean River (or other tributaries).
- Advanced use and monitoring of rainwater tanks at all residential lots.
- Redesign of road cross sections and streetscape environment to deliver significant stormwater treatment benefits and eliminate the need for downstream water quality assets.
- Opportunities for reuse of treated wastewater and treated stormwater to suit large scale agricultural and industrial uses.
- Monitor specific locations in the Nepean River and tributaries to ensure that the strategy is maintaining and protecting the environmental values of the LGA.
- Maintain and protect swimmable rivers and protected endangered species throughout the LGA.

Wollondilly water policy: conceptual diagram

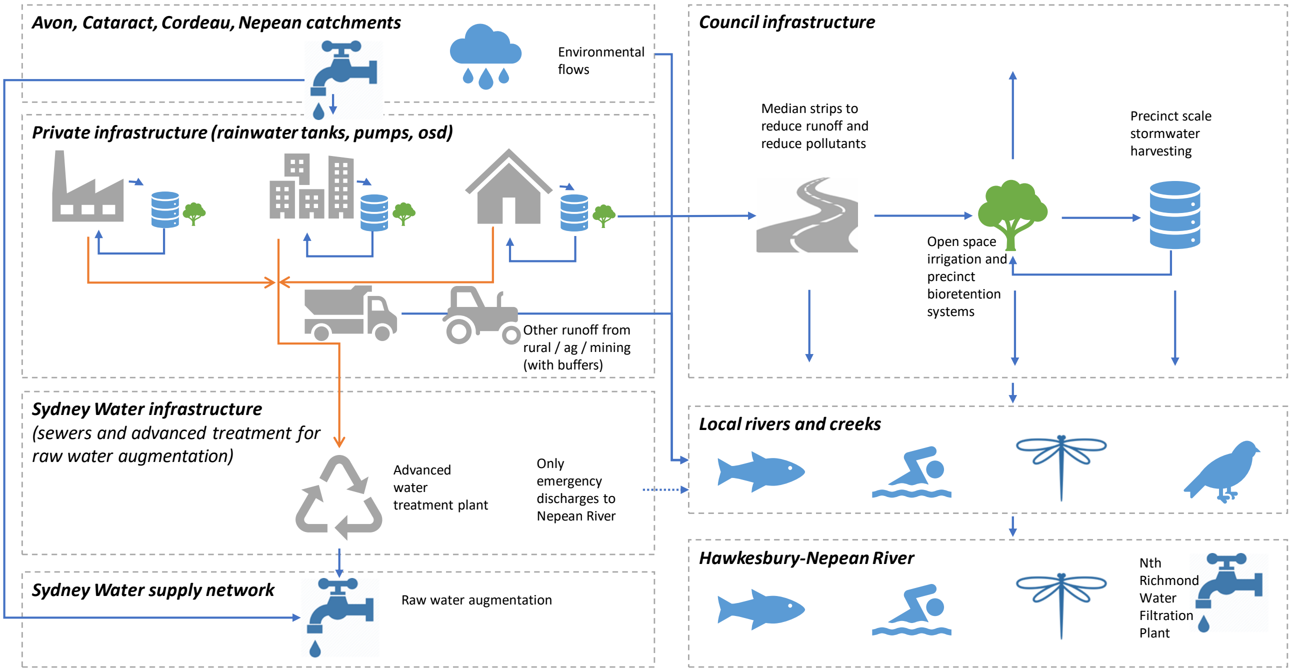


Figure 26. Long term water strategy

9 Targets

For each one hectare of impervious development (residential, commercial, or industrial), a sustainable development concept was modelled to determine how it can deliver a 'zero impact' and protect the values outlined in Section 4.

For each additional **one hectare of urban developed area (impervious and pervious)** that is developed within the growth areas of Wollondilly, a zero impact development must:

- Have between 2.5 and 3 ML of runoff on average, per year.
- Reduce TN, TP and TSS by the ideal stormwater outcomes (85, 95, 95%) respectively.
- Have either:
    - Five hundred square metres of green infrastructure to filter and infiltrate runoff.
    - Two megalitres of reuse of water per year.
    - A combination of the above two criteria.
- Require zero downstream water quality assets, as all runoff and stormwater treatment are managed within development lots and precincts.

The actions table below will assist Council and other stakeholders in the ongoing work to monitor the impact of land use change and urban development on waterways. This strategy could be updated with additional research (as noted in the Actions Table), that would take account of how best to monitor downstream impacts of developments through a reference water quality station, what type of nutrients load the river system is able to absorb with minimal ecological impact, the impact of changes to environmental flows, and potable water saving targets for all sectors in the LGA.

10 Cost estimates

There are cost implications (capital and operating) for WSC in adopting different scenarios as described in Section 7. Council already has almost $42 million of stormwater drainage assets[33], and this will rise significantly by 2036, particularly if the strategy and policy requires several larger end of pipe water quality assets to be built and maintained by Council. Table 5 notes that a business as usual scenario would require developers to fund $150 million in capital to remove stormwater pollutants to a 'best practice standard', which would cost the Council in the order of $4 to $5 million to maintain each year.

In addition to the value of the civil and landscape assets, there is the value of the waterways themselves. While Council doesn't have an estimate of the 'natural value' of the waterways in the region, other economic evaluation assessments of a similar nature indicate that an equivalent value is very significant.

Another method is to also consider what the restoration or rehabilitation cost of environmental degradation. Projects across Australia that have 'naturalised' urban creeks are listed below, with documented capital costs:

- Stony Creek nautralisation (Victoria) (1.2 km) - $ 11.35 million[34]
- Dandenong Creek nautralisation (Victoria) (0.8 km) - $14.5 million[35]
- Cooks River (1.1 km) (New South Wales) - $8.6 million
- Small Creek nautralisation (Queensland) (1.6 km) - $9 million[36]

Base on this very limited sample size**, restoration of urban creeks in Australia cost in the order of $10 million / km for capital works, and at least $100,000 / year for ongoing maintenance**. Rehabilitation of urban rivers is expensive, and Wollondilly has the opportunity to prevent this issue and avoid this expense that will be borne by Council, government agencies and the community.

This section briefly summarises how Council would benefit, in a budget sense, through the adoption of a 'zero impact' scenario. This shouldn't be seen as a cost benefit study, but rather an indicative estimate of the value of assets that WSC will ultimately accumulate over this urban development period.

The assets included in this analysis, over a 50 year period with a 7% discount rate (as recommended by NSW Treasury)[37], are all stormwater drains and pits, median centre swales, and water quality assets (e.g. wetland and raingardens) to reduce stormwater pollution. These stormwater assets are within the jurisdiction of WSC. Wastewater treatment plants, distribution infrastructure, and water mains and meters are not included in this analysis.

The same scenarios that were modelled in Section 7 were used in this analysis, and the results are shown below in Figure 27.

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[33] 2018 Wollondilly Shire Council Annual Report

[34] Development Victoria, 2018. https://www.development.vic.gov.au/news/news-articles/works-to-begin-for-the-upper-stony-creek-transformation-project

[35] CRC Water Sensitive Cities, 2018. https://watersensitivecities.org.au/wp-content/uploads/2018/10/18-Dandenong_FINAL.pdf

[36] CRC Water Sensitive Cities, 2018. https://watersensitivecities.org.au/wp-content/uploads/2018/10/5-Small-Creek_FINAL.pdf

[37] NSW Treasury, 2017. https://www.treasury.nsw.gov.au/sites/default/files/2017-03/TPP17-03%20NSW%20Government%20Guide%20to%20Cost-Benefit%20Analysis%20-%20pdf_0.pdf

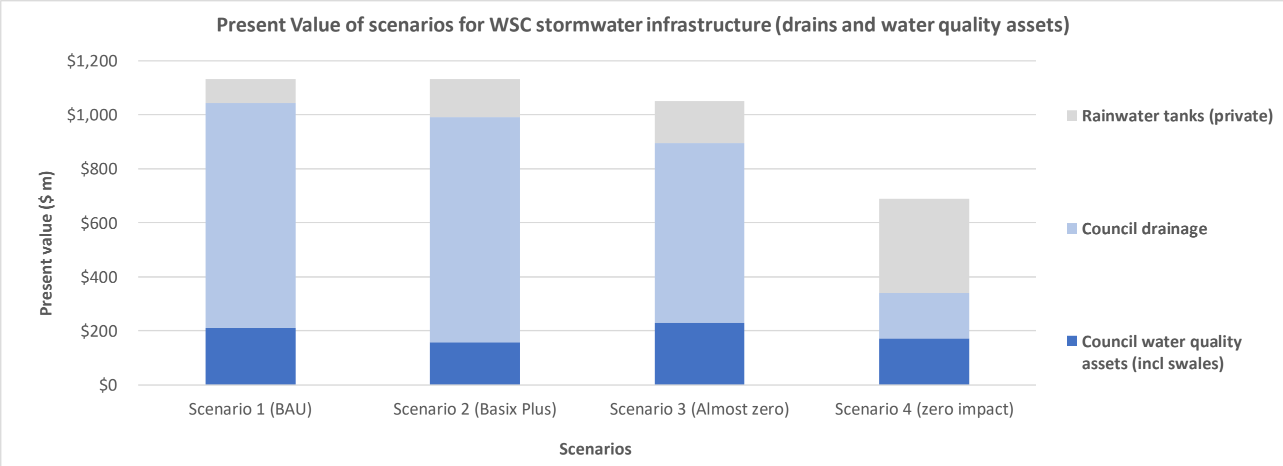

Figure 27. *Net present values of scenarios*

The civil infrastructure associated with stormwater drains and pits have a much larger asset value (and associated maintenance cost), compared to the water quality assets. Rainwater tanks were included here as a reference since this type of infrastructure don't become WSC assets and are important pieces of infrastructure in terms of water quality and drainage in the 'zero impact' scenario.

Figure 27 shows that there is a tipping point in achieving a cost effective solution for the whole LGA, which is achieved with a consistent delivery of the 'zero impact' scenario in all new urban developments.

The 'Almost zero' scenario assumes that 80% of all new urban development will still require underground drains, but the 'zero impact' assumes that only 20% of new development requires that civil infrastructure, with the investments in swales used as both a conveyance and water quality treatment (and biodiversity and shading) asset.

11 Actions

This section outlines the range of actions that Council will deliver over the short and long term. Several actions relate to engaging with or working with other stakeholders, as water is managed by several stakeholders.

The community have a strong role to play in saving water, visiting and enjoying open spaces and waterways, and continuing to advocate for better social, environmental and economic outcomes for water management.

The first table of actions relate to meeting the strategic goals for stormwater management.

Table 7. Stormwater actions

Action No.	Description	Timeframe	Responsibility	Target Outcomes
1	Undertake capacity building within Council to support the implementation of Council's Integrated Water Management Policy, Strategy and WSUD Guidelines.	Short Term	Council	All staff in Planning, Engineering, Compliance and Environmental have attended at least one training course (internal or external) on the subject of WSUD (planning, design, construction and maintenance), by the end of 2020/21 FY.
2	Embed Council's Integrated Water Management Policy, Strategy and WSUD Guidelines in relevant planning instruments.	Short Term	Council	Wollondilly LSPS and DCP updated to reflect requirements specified in strategy and policy by end of 2020/21 FY.
3	Undertake compliance action on sediment and erosion controls issues within Wollondilly LGA	Ongoing	Council and EPA	Compliance staff trained to support their ability in monitoring and assessing sediment and erosion controls.
4	Work within Council and with local developers to trial design solutions in streetscapes that deliver multiple benefits (water quality, flood detention, amenity, urban heat) and remove the need for downstream water quality infrastructure.	Ongoing	Council and Developers	All new and renewed streetscapes designed in accordance to the principles and targets in the Integrated Water Management Strategy and Integrated Water Management Policy from 20/21 FY onwards.
5	Review the direct development works and maintenance and land dedication in planning agreements for stormwater, with a focus on an alternative design of daylighting the stormwater drainage system.	Short-Medium Term	Council	Environment, Engineering, and Strategy Planning teams of Council work with DPIE and interested developers to cost the delivery of developments greater than 10 lots by the end of 21/22 FY.
6	Advocate for a precinct (like the Aquarevo development in Victoria) where the water	Short-Medium Term	Council and Developers	Constructed on ground trial in a new urban development precinct, managed by Council or Sydney Water, how a

Action No.	Description	Timeframe	Responsibility	Target Outcomes
	authority monitors and maintains rainwater tanks to demonstrate that an active and dynamic approach to monitoring this distributed infrastructure will deliver better results for the community / residents and the environment.			monitoring system on each rainwater tank in a development area can reduce peak flows downstream, and increase the yield from rainwater tanks, by the end of 21/22 FY.
7	Review and update of road cross sections and streetscape environment to deliver significant stormwater treatment benefits and eliminate the need for downstream water quality assets.	Short Term	Council	Council developed a standard drawing for road cross sections, consistent with the Western Sydney Engineering Guideline. Council advocated to RMS to incorporate the same design principles and objectives in their standard drawings.
8	Installation of new stormwater infrastructure to deliver on water management principles in strategy and policy.	Short-Medium Term	Council	All new stormwater infrastructure designed, built and maintained within the LGA according to the WSUD Guidelines and Dedication of Land Policy.
9	Review current and historical water quality to better inform future works and to better assess the performance of future developments.	Short Term	Council and University of Western Sydney	Data analysis for water quality monitoring within the Wollondilly LGA from 2000 – present finalised to determine the following: a. Current and historical water quality state of the waterways b. Water quality trends against ANZECC Guidelines c. An indication of potential pollution sources or locations d. Review of any historical and current flow rates Results from the water quality analysis used to define the exact parameters, or range, of a pristine stream that all new monitoring can be compared to, by the end of 2019/20 FY.
10	Monitor specific locations in the Nepean River and tributaries to ensure that the strategy actions are maintaining and protecting	Medium-Long Term	Council	Developed an MOU with Environment Energy and Science (EES), EPA, WaterNSW and Sydney Water to clarify and source the necessary funding for monitoring of waterways to evaluate the impact of stormwater and wastewater

Action No.	Description	Timeframe	Responsibility	Target Outcomes
	the environmental values of the region.			infrastructure on downstream environments. Monitoring commenced in partnership with EES, EPA, WaterNSW and Sydney Water, as per MOU arrangements.
11	Undertake community awareness and education on stormwater management	Ongoing	Council	Provide community education materials and events to communicate the function, value and benefits of water sensitive urban design and healthy riparian zones..
12	Council to get additional resources to help implement Integrated Water Management Policy, Strategy and WSUD Guidelines.	Medium-Long Term	Council	Council employed a Water Management Officer to check compliance of WSUD during design, construction and handover stage, compliance of sediment and erosion control, undertake water monitoring of waterways and educate the community on stormwater issues.
13	Retrofit or upgrade existing Council infrastructure to incorporate smarter WSUD as opportunities arise.	Ongoing	Council	Existing infrastructure upgraded to incorporate WSUD in accordance with this Strategy.

The next set of actions relate to meeting the strategic goals for groundwater management.

Table 8. Groundwater actions

Action No.	Description	Timeframe	Responsibility	Target Outcome
14	Continue to advocate for the full assessment of potential impacts associated with underground mining operations on surface and groundwaters at the application stage and full rehabilitation of any impacted waterways to their former ecological health.	Ongoing	Council	Council advocated for the maintenance and rehabilitation of waterways and ecological health, particularly through any formal inquiries, reviews or research projects in the LGA.
15	Continue to advocate community concerns regarding causes of reductions in the levels of the lakes within the World Heritage listed Thirlmere Lakes National Park	Medium-Long term	Council in partnership with key stakeholders	Council's Action Plan for Thirlmere Lakes finalised and implemented.

The next set of actions relate to meeting the strategic goals for wastewater management.

Table 9. Wastewater actions

Action No.	Description	Timeframe	Responsibility	Target Outcome
16	Continue to review the performance, maintenance and impact of onsite systems.	Ongoing	Council	Council continued to, over the duration of the Strategy, inspect and ensure compliance of onsite wastewater systems, with the aim of reducing failure rates to 1% by 2030.
17	Adopt a Council position on preferred wastewater treatment solutions and objectives for Wollondilly LGA.	Short Term	Council	Council considered and updated its position on preferred wastewater solutions within Wollondilly LGA to reflect community objectives and value of swimming in all rivers and creeks, by the end of 2020/21 FY.
18	Identify land and associated agricultural and industrial industries that can use recycled water and prevent any additional discharges of treated wastewater into rivers.	Ongoing	Sydney Water, NSW Health, DPIE, WaterNSW, NSW EPA, Developers, Community.	240 hectares of land identified that has the capacity to use and benefit from the irrigation of recycled water, by the end of 2020/21 FY. Council to advocate and assist other agencies in their investigations.
19	Investigate and implement planning mechanisms that enable recycled wastewater reuse.	Short – Medium Term	Council and Sydney Water	Council planning mechanisms adopted to support wastewater reuse systems within Wollondilly LGA.
20	Advocate to the EPA, state government and state agencies for a catchment wide risk based assessment, to protect and maintain ecological values, and better understand the nutrient load limits of the waterway system.	Short – Medium Term	Council, EPA and Sydney Water	Council advocated for a catchment wide assessment of the Nepean catchment to Penrith Weir.
21	Advocate for advanced treatment of wastewater to support raw water augmentation, to benefit local waterways in Wollondilly through reduced no discharge of wastewater to the local reach of the Nepean River (or other tributaries).	Long Term	Council, Sydney Water, NSW EPA, DPIE, NSW Health	Council advocated for raw water augmentation implemented in Wollondilly LGA to support water supply and prevent wastewater discharges to waterways over the life of the Integrated Water Management Strategy.

12 Implementation and resourcing

12.1 Roles and responsibilities

The implementation of this strategy will require support from several areas of Council:

- Planning (strategy and statutory)
- Engineering
- Maintenance
- Environment

Council will receive millions of dollars of more infrastructure assets from urban development, that must be approved, transferred to Council through a handover process, tracked through WSC's asset management database, maintained, and reported on re condition and influence on environmental and water targets.

Clear roles and responsibilities in WSC, as well as collaboration across WSC to share issues and successes is important in delivering on this strategy.

12.2 Advocacy

A key part of this strategy and ability to meet the zero impact strategy, is advocacy and engagement with external stakeholders.

Water NSW, Sydney Water, NSW EPA, NSW Health, NSW DPIE and representatives of the development industry are critical stakeholders in delivering on this strategy.

Advocacy is critical to developing this strategy. This relies on the adoption of policy and a collaborative approach to broader water strategy problems (like the water supply reliability for Greater Sydney).

For example, there are 35 km^2 of roads in the LGA, and changes to road design standards and road management by state government agencies could have a significant impact on the rivers and the ability of the community to swim in all the creeks and rivers in this LGA.

12.3 Capacity building

There is a real need for capacity building within Council.

Underpinning this strategy is a vast body of research, science and engineering on the subject of water sensitive urban design, waterway health, and water infrastructure systems, that practitioners will need to broadly understand to help advise, approve, maintain and report on these assets.

Capacity building within local government is usually developed through a combination of approaches, including site visits, seminars, policy development, setting organisational and environmental targets, linking policy with position descriptions, development of funding streams and budget allocations, executive support, champions, cross organisational working groups and building relationships with external agencies and institutions.

Capacity building within local government is a well-studied issue, particularly within the water sensitive urban design industry. Prof Rebekah Brown first studied this issue within several councils in Greater Sydney, and Dr. Peter Morison then did further research on the institutional and policy environment surround water sensitivity urban design[38].

[38] PJ Morison, RR Brown , 2011. Understanding the nature of publics and local policy commitment to Water Sensitive Urban Design. Landscape and urban planning 99 (2) pp 83 -92.

Another resource is a chapter in the recent publication 'Approached to water sensitive urban design' edited by Ashok Sharma, Ted Gardner and Don Begbie, on capacity building (Catchlove et al, 2019)[39].

There are several organisations that are explicitly designed to support local governments in building their capacity, such as Splash (supported by Sydney Water), CRC Water Sensitive Cities (and their NSW Regional Advisory Panels). The Council should engage with these programs to consider what resources are available and

University researchers from University of New South Wales and University of Western Sydney are also another good resource that can be used in building capacity.

It is recommended that a) the Executive Team routinely monitor the implementation of this strategy, b) a cross council working group be established to engage and share intelligence, and c) a specific position be created to drive the implementation.

[39] Catchlove, R., van de Meene S., and Phillips, S., 2018. Capacity building for WSUD Implementation in Approaches to Water Sensitive Urban Design 1st Edition Potential, Design, Ecological Health, Urban Greening, Economics, Policies, and Community Perceptions. Edited by: Ashok Sharma Ted Gardner Don Begbie.

13 Conclusion

The value of water in the Wollondilly LGA extends across many areas of the community and the landscape, from healthy swimmable rivers, to agricultural production, to the support for biodiversity hotspots, and the support of green infrastructure to support vegetation and trees in the urban landscape. The sustainable use of water, and the use of water to support green and liveable urban development is critical in a world now experiencing the impacts of climate change.

The scale of urban development and climate change are two significant issues that affect the way we approach water issues. This Council Integrated Water Management Strategy sets out the problems, options, solutions and actions that WSC will undertake, to deliver the best value to the community and manage urban growth in an integrated manner.

This strategy outlined the evidence behind 10 values that the community want protected in this LGA, and four scenarios that have varying degrees of success in protecting and maintaining those values.

This strategy has 20 actions for Council that will address the many different issues and opportunities in creating a sustainable Wollondilly. Critical to the delivery of this strategy is the need to work with Sydney Water, DPIE, EPA, Water NSW, urban developers and large landowners.

Without the adoption of this policy, urban development within the LGA will result in, on average each year, an additional 5.5 GL of potable water being consumed, an additional 4.0 GL of wastewater to be treated and discharged, and an additional 40 GL of stormwater flowing into waterways.

With the adoption of this strategy there is an opportunity to reduce stormwater runoff to near pre-development conditions, reuse wastewater, save on the potable water used by residents and businesses, as the LGA sees the population almost double in the next 18 years, to 2036.

This strategy is important in setting clear rules for way urban development is delivered in the LGA, but also in meeting the vision of "*enviable lifestyle of historic villages, modern living, rural lands and bush*".

14 Appendix A - Assumptions

The modelling in this strategy uses several assumptions based on the best available research and empirical data available. For reference, the following parameters or assumptions were used:

- Water / WSUD
  - Business as usual water use in single dwelling of 632 litres / day
  - Toilets, laundry, outdoor watering, hot water use accounts for 75% of residential demand
  - Bioretention systems sized to be 1.58% of upstream catchment (impervious area only) to meet best practice
  - Irrigation rate of 2.5 ML / hectare / year to 4.5 ML / hectare / year
  - Open space of 2.84 hectares per 1000 people in new urban areas
  - Infiltration rate of 0.36 mm / hr
  - Onsite systems assumed to be used when population density less than 5 people / ha
- Population
  - Population / dwelling ratio of 3.0
  - 75% of potable water sent to sewage in residential areas
- Imperviousness
  - Impervious percentage rate of 60% for new urban areas
  - Impervious percentage rate of 50% for whole precincts, when including open space and all land uses
  - Road network predominantly drains to swales and is infiltrated
- Climate
  - Average annual rainfall of 941 mm / year
  - Min annual rainfall of 617 mm / year
  - Max annual rainfall of 1449 mm / year
- Financial
  - Discount rate of 7%
  - Life span of WSUD asset 25 years
  - Life span of stormwater pipes 50 years
  - Cost of WSUD $250 / m2
  - Cost of drainage $500 / metre
  - 300 metres of road per / 1 ha of urban development
  - 5000 litre tank capital $5000
  - 15000 litre tank capital $12,500
  - Maintenance of WSUD 3% of capital cost
  - Maintenance of drains 1% of capital cost