Development of Practical Solutions for the North East of Victoria – adapting to a low water future

Alternative options to manage sullage and sewage in small rural towns

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Glossary of terms and acronyms

0%: **Zero Percent Population Growth Scenario.** A scenario which tests the implications of no change in population of North East Victoria to 2050.

2%: **Two Percent Population Growth Scenario.** A scenario which tests the implications of 2% annual growth in population of North East Victoria to 2050.

ABS: **Australian Bureau of Statistics.** Australia's national statistical agency.

RWH: **Option that includes rainwater harvesting.** Building level intervention that includes rainwater harvesting.

BAU: **Business as Usual.** The Option that accounts for the current state and approach water cycle management.

Blackwater: Wastewater generated by the toilet.

BOD: **Biological Oxygen Demand.** A chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. Widely used as an indication of the organic quality of water.

BWA: **Bulk Water Authority.** The water authority responsible for providing bulk water services to North East Victoria. This is Goulburn Murray Water.

CC: **Climate Change.** A long-term change in the statistical distribution of weather patterns over periods of time.

CPI: **Consumer Price Index.** A social and economic indicator that aims to measure the change in consumer prices and goods over time.

NEW: **North East Water.** The Retail Water Authority responsible for providing retail water services to North East Victoria.

DPCD: **Department of Planning and Community Development.** The Victorian Government agency responsible for managing the State's planning system.

DSE: **Department of Sustainability and the Environment.** The Victorian Government agency responsible for sustainable management of Victoria's water resources and catchments, climate change, bushfires, parks and other public land, forests, biodiversity and ecosystem conservation.

EC: **Economic Structural Change Scenario.** A modelling scenario which tests the implications of a restructure in the economy of North East Victoria from (water intensive) manufacturing into other sectors.

EPA: **Environmental Protection Authority of Victoria.** The Victorian Government agency responsible for the protection, care, and improvement of Victoria's environment.

ESC: **Essential Services Commission.** Victoria's price regulator responsible for determining the prices and charging arrangements for provision of water services.

Greywater: is generated by residential kitchens, bathrooms and laundries.

HE: **High Emissions Climate Change Scenario.** Tests the impact of the IPCC's upper bounds temperature increases on the water cycle in North East Victoria.

IWCM: **Option that includes Integrated Water Cycle Management.** A multi-disciplinary and multi-objective approach for the sustainable use of available resources with the objectives of environmental protection, water supply, stormwater management and wastewater treatment.

LE: **Low Emissions Climate Change Scenario.** A modelling scenario which tests the impact of the IPCC's lower bounds temperature increases on the water cycle in North East Victoria.

LGA: **Local Government Area.** An administrative division defined by the Australian Bureau of Statistics that a local government is responsible for.

MBR: **Membrane Bioreactor.** A modular wastewater treatment process which combines a membrane process such as microfiltration or ultra filtration with a suspended growth bioreactor. Widely used for municipal and industrial wastewater treatment.

NWC: **The National Water Commission.** A Statutory Authority established by the Australian Government in 2004 to provide advice on and drive progress towards the sustainable management and use of Australia's water resources.

Option: A modelling technique which are established to test, compare and contrast a range of alternative future states.

OPS: Combines the WEA Option with an onsite storage and grinder pump that distributes sewage via a pressurised reticulated network to a town scale wastewater treatment plant.

OSIB: Combines the WEA Option with onsite treatment using sub-surface drip irrigation systems

OTR: Combines the WEA Option with onsite treatment and reuse of wastewater for toilet and outdoor uses.

Roofwater: Rainfall collected from the roofs of buildings.

RSS: A traditional reticulated sewage network and wastewater treatment plant for each small rural town.

RWT: **Rainwater tank**. A water tank which is used to collect and store rainwater runoff, typically from rooftops via rain gutters.

SCADA: **Supervisory Control And Data Acquisition**. Control and computer systems that monitor and control industrial, infrastructure, or facility-based processes.

Scenario: A modelling technique established to provide a more detailed understanding of potential opportunities. Constraints including governance arrangements, institutional frameworks and organisational capabilities are introduced to test the practicality of Options.

STEDS: Combines the WEA Option with a small diameter common effluent network that discharges to a town scale wastewater treatment system

Stormwater: Rainfall that runs off all urban surfaces such as roofs, pavements, carparks, roads, gardens and vegetated open space.

TDS: **Total Dissolved Solids.** A measure of the combined content of all inorganic and organic substances contained in a given water sample at certain temperature over a specific time period.

TN: **Total Nitrogen.** The sum of the nitrogen present in all nitrogen-containing components in a given water sample at certain temperature over a specific time period.

TSS: **Total Suspended Solids.** A water quality measurement which measure of the mass of fine inorganic particles suspended in a given water sample at certain temperature over a specific time period.

WEA: **Option that includes water efficiency.** A building scale intervention that includes water efficient appliances and gardens.

SDS: **Water Supply Demand Strategy.**

Wastewater: A combination of Greywater and Blackwater and may include wastewater from non-residential allotments such as used water and sewage that goes down sinks, toilets and outside drains which enters the wastewater system or septic tanks if a dwelling is not connected to the wastewater network.

WEA: Water efficient buildings, gardens and practices.

WSAA: **Water Services Association of Australia**. The industry peak body which represent Australian water authorities. As part of their activities WSAA releases a set of Benchmarking Reports, which are audited annual reports that benchmark Australian water utilities across a range of agreed and consistent parameters.

WSUD: **Water Sensitive Urban Design.** Design principles that aim to reduce the impact of interactions between the urban built form and the urban water cycle as defined by the three urban water streams of potable water, wastewater and stormwater.

WWTP: **Wastewater Treatment Plant.** A centralised wastewater treatment plant operated by North East Water or other responsible entity.

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Executive summary

The North East Greenhouse Alliance commissioned Dr. Peter Coombes and Bonacci Water to investigate options for improving the performance of sullage and sewage in small rural towns whilst adapting to a low water future throughout the North East region. This "Sullage and Sewage" project is funded by the Australian Government's "Strengthening the Basin Communities" component of the "Water for the Future" program. The project is being delivered by the North East Greenhouse Alliance on behalf of the City of Wodonga, Rural City of Wangaratta and Alpine, Indigo, Towong Shires in partnership with the North East Catchment Management Authority, North East Water and Goulburn Murray Water.

A forensic analysis has been undertaken of the existing biophysical systems that are related to North East Victoria. The analysis incorporates inputs from many disciplines, to understand the potential futures of towns in the region.

The existing sophisticated integrated systems models of the North East region developed by Dr Peter Coombes have been updated and enhanced for use in this project. These models subdivide the region into hierarchies of distributed nodes, or 'zones', that represent opportunities, constraints and feedback loops across multiple scales. A selection of indicative alternative Options; WEA, OTR, OSIB, STEDS, OPS and RSS; were compared to the business as usual (BAU) Option to understand the response of the North East Victorian system to alternative strategies. The alternative Options considered in this investigation are:

WEA – this Option includes water efficient buildings, gardens and practices.

OTR – this Option combines the WEA Option with onsite treatment and reuse of wastewater for toilet and outdoor uses.

OSIB – this Option combines the WEA Option with onsite treatment using sub-surface drip irrigation systems

STEDS – this Option combines the WEA Option with a small diameter common effluent network that discharges to a town scale wastewater treatment system

OPS – this Option combines the WEA Option with an onsite storage and grinder pump that distributes sewage via a pressurised reticulated network to a town scale wastewater treatment plant.

RSS – this Option provides a traditional reticulated sewage network and wastewater treatment plant for each small rural town.

A summary of the results of this study is presented below:

Climate

1. The recent drought reduced average annual rainfall by 4.8% to 19.5% throughout North East Victoria and included a 4% (0.9°C) increase in average daily maximum temperatures.
2. Increases in temperaure and evaporation with reduced rainfall in the recent drought reduced annual average streamflow in rivers by 16.5% to 37.9%.
3. The recent drought may not be the worst period of low rainfall on record at many locations throughout North East Victoria and is consistent with the cycles of natural variation in rainfall.

4. The rainfall records in the North East region do not reveal evidence of a step change in rainfall regimes.
5. The region is subject to a high frequency of rainfall events (on average, every 3 to 6 days) and is eminently suitable for highly efficient rainwater and stormwater harvesting strategies.
6. Climate change may generate reductions in annual average rainfall of 9% to 18% and diminish annual average streamflows by 25% to 45% by 2050. It is noteworthy that these scenarios produce years with very low flows in the regions rivers that is consistent with more severe droughts.

Planning and design issues

7. The opportunities for provision of services to small rural towns is limited by a lack of knowledge about the technical and practical options provided by the available alternative systems.
8. There is a perceived reluctance of future users to accept alternative solutions
9. The institutional settings (local government and water authorities) do not encourage the introduction of alternative systems but tend to embrace wherever possible conventional solutions (reticulation and wastewater treatment plants).
10. The highly limited and general nature of planning and design codes for small wastewater management systems is misleading and results in considerable missed opportunities for effective alternative systems.
11. Design guides over-allocate wastewater discharges for onsite systems and under-estimate the capacity of sites
12. The design and operation of apparently "simple" septic tanks systems are poorly understood leading to incorrect design and mismanagement.
13. This report highlights the important legacy issues that were created by historical design processes and attitudes. Many properties include onsite systems that were historically acceptable that are shown to be inadequate by more recent standards and understanding.
14. Publically available reports into sewage strategies for small towns tend to provide considerable over-estimation of the costs of alternative schemes and under-estimate the costs of traditional reticulated sewage schemes
15. In addition, these reports also imply that any other outcome option than do nothing or traditional reticulated sewage systems will produce high costs to land owners. This results in a high level of resistance to alternatives from residents of small towns.
16. A preference for traditional reticulated sewage schemes that require considerable funding by the Water Authority and Councils limits opportunities to improve the amenity and viability of small towns using lower cost alternative schemes.

Lot and town scale insights

17. Although climate change generates large reductions in average annual streamflows in rivers, the reduction average annual yields from rainwater harvesting was insignificant ranging from 0.3% to 4.8%. Reductions in stormwater runoff ranged from 13.2% to 28.7%. Local strategies were resilient to the impacts of climate change.
18. Climate change also generated small increases in outdoor water use ranging from 3.9% to 7.5%.

19. The use of water efficient appliances and onsite wastewater reuse for toilet flushing and irrigation can reduce the volumes of effluent discharging to absorption facilities by 85% to 91% whilst decreasing demands for potable water by 50% to 60%.
20. Water efficiency and onsite reuse substantially diminishes the risk of offsite discharge of effluent.

- Options that improve the performance of onsite wastewater systems in small rural towns also increase the resilience of the towns to the potential impacts of climate change.

21. All of the towns examined in this study contained clusters of higher density housing that can be readily managed by smaller scale solutions such as STEDS Options

- The alternative STEDS Options can provide flexible and easily understood options for low cost management of sewage and sullage in small towns
- Modified STEDS schemes can provide significantly lower costs for management of sewage and sullage from the clusters of higher density housing in small country towns.

Community Understanding and Acceptance

22. Existing and alternative systems to manage sewage and sullage are not “flush and forget” systems – institutions, individuals and the community must take responsibility for the operation and outcomes of these systems
23. The recent report by the Auditor General has noted these responsibilities.
24. There appears to be limited appetite for enforcement of the current codes and responsibilities
25. Utilisation of alternate models for provison of alternative schemes will require community education and a clear strategy for implementation.

Amenity and Liveability

26. Improvements in the management of sewerage and sullage for small towns will improve the amenity, liveability and viability of these townships.
27. Alternative stratregies for management of sewage and sullage has the potential to provide more sustainable water use and create new opportunity for development.

Leadership and Legislation

28. This report questions the current governance model for management of sewerage and sullage in small towns. A new Business Model is required.
29. An opportunity exists for a new authority take responsibility for leadership in this area or alternatively the government can clarify its expectations via revised Statement of Obligations for water authorities or legislation for Councils, Water Authorities and others.
30. At a community level local champions will required to help facilitate changes in attitudes towards management of sewerage in small towns.

1 Introduction

The North East Greenhouse Alliance commissioned Dr. Peter Coombes and Bonacci Water to investigate alternative options to manage sullage and sewage in small rural towns throughout the North East region.

This "Adapting to the Low Water Future" project is funded by the Australian Government's "Strengthening the Basin Communities" component of the "Water for the Future" program. The project is being delivered by the North East Greenhouse Alliance on behalf of the City of Wodonga, Rural City of Wangaratta and Alpine, Indigo, Towong Shires in partnership with the North East Catchment Management Authority, North East Water and Goulburn Murray Water.

The North East region of Victoria makes a significant contribution to the available water resources in the Murray Darling Basin. Although the region only occupies 2% of the Murray Darling Basin, the rivers in the region provide over 38% of the water flows in the Basin.[1] Decreases in rainfall, increases in temperature and higher evaporation rates associated with the recent drought have highlighted the dependence of the region on reliable water resources. Long term reductions in available water resources that may eventuate from climate change will pose considerable challenges to business and the community within North East Victoria.

A number of small rural towns within the region do not have traditional reticulated sewage or water services. In some cases, this has presented persistent and ongoing issues relating to the management of sullage and sewage in small towns. Many of the towns are too small to be included in the business strategies of North East Water for delivery of traditional reticulated sewage schemes. Provision of smaller scale alternative sewage management options in small towns may minimise potential for impacts on human and waterway health whilst reducing demands for regional water resources.

Alternative water management strategies have potential to supplement demands for water supplies, reduce sewage loads and to manage urban stormwater runoff. The benefits of alternative water cycle management strategies apply at different scales, to householders, various agencies and the environment. This study has investigated the detail of the systems benefits provided by use of local strategies for management of sullage and sewage at 45 locations throughout the North East region of Victoria.

This report presents results ranging from the local household scale to town scale that includes consideration of the water cycle management footprint of the region. The results from the systems analysis of the impacts of water cycle management strategies on the performance of small rural towns within North East Victoria, including economics, nutrient and energy impacts, are presented in this report.

[1] NECMA Annual Report 2008/09

2 Background

In recent years there has been an increased international focus on the operations of onsite waste treatment systems. A range of studies and reports have been completed in Victoria that attempted to develop a better understanding of the size and the complexity of the issues involved.

Government concern about water services in country Victoria resulted in a number of grant and incentive schemes. The Country Town Water and Sewerage Program and the Small Towns Water Quality Fund were two initiatives created by the Victorian government that attempted to create a body of practical examples of how to deal with water services in small towns and collect data on both the practical issues as well as the management of such projects. In 2006 the Victorian Government announced a Country Town Water Supply and Sewerage Program funding of:

- $21 million to provide sewerage services to 35 priority towns
- $12 million for developing sewerage service to Gippsland Lakes towns
- $6 million for 13 towns to develop innovative sewerage and water solutions
- $3 million for councils to develop domestic waste water management plans.

The 2007/2008 State Budget allocated a further $16 million for the Small Towns Water Quality Fund. The funding was to develop infrastructure in small towns across regional Victoria. Projects that received funding were to be proportional to the scale of existing issues and provide sustainable solutions.

The projects from these two funding sources covered a wide range of different problem areas for the provision of water and wastewater treatment services to smaller communities. The ambit of the response extended from the supply of individual UV treatment modules for small communities to water treatment plants for potable supply compliant with ADWG standards, or fully fledged reticulated sewerage schemes for communities which in most cases had a population of less than 700 residents.

The programs highlighted the myriad of small and larger barriers to change and innovation that exists at all levels of the community. Residents involved in any new schemes displayed a limited willingness to examine opportunities to more effectively manage domestic wastewater on site as a solution. There were governance issues in relation to who should be responsible for both construction and ongoing operation between local government or water authorities. Legislative impediments and regulatory compliance issues were also found when alternatives were proposed. The existence of these barriers is not a new discovery but the design of programs to manage sewage in country towns has a tendency to generally underrate the size and depth of barriers.

Two international organisations have undertaken significant work to address the problems of delivering water services for smaller towns; the United States Environment Protection Agency[2] and the European Commission[3]. In both jurisdictions the identification of the problem has led to similar results namely that onsite and similarly smaller systems of wastewater treatment are often not well managed and often fail in

[2] U.S Environmental Protection Agency Office of Water (1997) Response to Congress on use of Decentralised Wastewater Treatment Systems
[3] European Commission (2011) Commission Staff Working Paper 6th Commission Summary on the Implementation of Urban Waste Water Treatment Directive

their original purpose of treating wastewater to an acceptable standard for onsite infiltration. The most common problem is the eventual entry of sewage to water bodies including groundwater.

In the USA some 26 million households depend on such onsite treatment systems.[4] The U.S EPA provided advice to Congress[5] on the use of decentralised wastewater treatment systems that the use of decentralized onsite or cluster wastewater systems can be the most cost effective option in areas where extending the centralized treatment system is too expensive including in rural areas and small communities on the fringes of urban areas.

Despite recognizing the value and importance of onsite wastewater treatment, the respective authorities in the EU and the USA recognised the key common element is the lack of supervisory commitment of responsible agencies to onsite domestic wastewater systems.

This can be overcome, for example, Wodonga City Council has implemented an inspection scheme for onsite systems with recommendations for remedial actions to be undertaken as problems are identified.

In the USA, about 25% of households rely on individual or small neighbourhood wastewater management systems. The EU estimates a similar dimension for the member states of the European Union. For example in the Irish Republic approximately 25% of all rural households use small treatment systems. In the case of Ireland the EU[6] insisted on effective management systems for domestic water treatment installations and won a case before the European Court. Ireland is now responding with legislation which provides for a risk based approach where specific sensitive areas have their domestic system inspected while those located in less sensitive areas will have to be registered and conform to specific management practices. In a separate response the Irish Government will also link the building approval process more closely with the provision of onsite wastewater disposal services.

The US EPA in recognition of widely differing state practices published a handbook and very detailed Management Guidelines in 2003[7]. An US EPA Onsite Wastewater Systems web site provides information on onsite and cluster systems. At the national level the US EPA concluded a memorandum of understanding with key national bodies involved in the provision of services initially in 2005 and with a larger number of partners in 2011, aiming at the introduction of improved practices specifically targeting the large group of existing wastewater systems that were deemed to be sub standard.

There are clear differences in the approaches by the EU and the USA. One system sets centrally imposed and managed mandatory standards, while the US relies on voluntary and state based actions. Both however underpin their approaches with a clear and sophisticated system of support using tools and a limited number of trial and experimental schemes. For our purpose it is important to note that the international problems encountered in the provision of water services especially waste water treatment in small towns appear to be very similar to what has been experienced in Victoria. The concerns about environmental outcomes, management issues and the potential solutions resemble the Australian and Victorian experiences.

In 2006, Auditor General Victoria[8] published an audit outlining a range of issues around failing septic tanks including improving prioritisation processes, legislation regulating septic tank management, and reporting and accountability issues.

[4] U.S. Census Bureau. (1999). 1997 National Data Chart for Total Occupied Housing Units.

[5] U.S Environmental Protection Agency Office of Water (1997) Response to Congress on use of Decentralised Wastewater Treatment Systems

[6] European Commission Policy Review (June 2009) European Court of Justice Ruling on septic tanks in Ireland

[7] US Environmental Protection Agency (2002) Onsite Wastewater Treatment Systems Manual Office of Water, Office of Research and Development

[8] Auditor-General Victoria (2006) Protecting Our Environment and Community from Failing Septic Tanks,

2.1 Experience of the Country Towns Water Supply and Sewerage Program 2004-11

Many of the small towns in the North East of Victoria are old towns with a legacy of past development codes, practices, lot sizes, different local government interpretations and applications. The Victorian Government's Country Town Water Supply and Sewerage Program and, the later policy, the Small Towns program represented the previous Government's election commitment to improve water services in country towns throughout Victoria. A major feature of the program was the support for the adoption of alternative approaches in the provision and management of water supply and sewerage services in small country towns.

The experience within the program implementation for both these programs demonstrated the degree of difficulty in using new approaches in Victoria.

The State Government's Country Towns Water Supply and Sewerage Program committed a total of $42 million to help communities, councils and water authorities to:

- Introduce sewerage solutions to rural and regional towns that have critical public health and environment problems
- Introduce new water supply or upgrade existing water supplies
- Identify sewerage needs to prevent future risks to public health and the environment.

The program had at its core an attempt to identify high-risk towns - both in environmental and human health areas. The program also aimed to fund a number of innovative projects. This was in recognition that traditional solutions for water and sewerage services are expensive and often not appropriate for small country towns. Almost without exception the provision of traditional reticulated solutions in the smaller towns requires cross subsidisation from larger towns within the relevant water authorities area.

'The proposed innovative approaches were intended to integrate water management including reuse and recycling water, managing storm water and minimizing the production of wastewater'[9].

In recognition of the complexity of such multi disciplinary approach the Department of Sustainability and Environment (DSE) established a multi-layered process involving the key government areas (health and environment protection). Local government and the regional water corporations were asked for expressions of interest for undertaking innovative demonstration projects.

Finally selected local governments were invited to prepare in cooperation with the regional water authority innovative water service projects for designated localities. These projects were intended to provide models for future projects to be funded under the program. While councils and local communities initially appeared open to alternative solutions, water corporations were generally unable or unwilling to provide alternative solutions.

The next stage of government funding was for local wastewater management plans. The plans were used by local government to prioritize towns in their area based on environmental and/or health risks.

This was achieved using a joint process coordinated by the DSE that included the Department of Human Services (DHS), The Environment Protection Authority (EPA) as well as the Municipal Association of Victoria

[9] Department of Sustainability and Environment(April 2005) Country Towns Water Supply and Sewerage Program Fact Sheet 5

(MAV) with a view of identifying communities which were actually or potentially at human and environmental risk.

The development of wastewater management plans by local government was a key element of the Country Town Water Supply and Sewerage program that served as a management tool for local government and worked as a de facto educational awareness campaign. Clearly it was also a key tool for identifying towns at potential risk for funding under the program.

The Waste Water Management Plans were meant to be used. The intention was that these were living documents, updated and revised as Councils and others completed the management actions identified as required.

In the end a majority of projects funded involved traditional sewage solutions in form of reticulated services and a traditional sewerage treatment plant. A number of projects remain in question today due to the extreme high costs of the solutions proposed and the inappropriateness of the solutions in mostly small towns with less than a population of 1,000 to 1,200 people.

The failure by local government and regional water authority to design appropriate alternative solutions can be attributed to a number a factors. Most of the required solutions would have involved hybrid solutions where some existing septic tanks would have to be upgraded or replaced and others would have needed to be retained. In many cases wastewater could not be adequately retained onsite and therefore whole of town approaches were required.

Local solutions were also hindered by the lack of local accountability and clear responsibilities. Does the responsibility accrue to Council or the Water Authority? There was a perceived lack of legislative responsibility. The challenge to find such solutions rested on finding a mix of approaches for the specific local conditions and developing integrated solutions that clustered a number of local properties for provision of common solutions while retaining as much of existing infrastructure as possible. For most local governments such complex systems were outside their range of expertise and experience.

Water corporations have not been traditionally involved in management of septic tanks and other water services within property boundaries. They proved to be unwilling to take on any responsibility in this area and were generally unwilling to explore business models that included septic tank management and local water service management, advice or operations.

Given the large numbers of properties without reticulated water and sewage services the lack of expertise within government entities and the private sector is surprising but real at least in the Victorian case. The experiences resulting from the government programs highlighted the need for broadening the professional experience of key staff in both local government and within the water authorities. But the response to the program also highlighted the need for developing business models which will allow water authorities to work with alternative water services systems as part of their normal business operations. The professional experience of key staff has been dominated by the planning, construction and operating of reticulated systems and all management systems within water corporations have been designed to cater for these businesses. Should it be intended to broaden the scope of water services to be provided by water authorities to include water services in small towns using low cost alternative systems there is a need to set up new operational units which would be able to cater for the new type of services to be provided. It will also be essential to develop a flexible business model which would allow water authorities to recover cost for operation and investment.

The DSE has in the perceived absence of any providers of alternative schemes (local government and water authorities) responded to regional water authorities and their strong preference for traditional packages of reticulation and localized treatment plants by funding a limited number of traditional schemes. DSE have also embraced a limited number of alternative projects with a view of establishing demonstration projects and gaining more expertise in the development of alternative service packages.

Generally local government expected that once a town was identified for the provision of some level of new or additional water services the responsibility would pass to the water authority and that tariffs would be raised by the authority.

Integrated water planning has not been undertaken in Victoria and it is only under the Living Melbourne Living Victoria policy initiative of the present Government that an intention for integrated water management has been clearly expressed.

It became clear that local government officials, water authority engineers and most consultants did not show any enthusiasm for establishing new systems. Lack of knowledge, familiarity with these new approaches and traditional behaviour, which prefers ‘text book’ solutions to more experimental designs, might have been responsible for the limited response to the government initiative. This issue of inertia will be discussed later in this report in the context of ‘barriers to change’.

2.2 The current setting

Throughout regional Victoria reticulated sewerage and water supply systems in towns that are declared sewerage districts are managed by 13 water authorities. The water authority funds this infrastructure using borrowings and distributes the cost of servicing the loans over their customer base via increased tariffs.

Property owners usually contribute about $800 to the capital cost of schemes. The State Government contributes approximately 20% of capital costs using the Country Town Water Supply and Sewerage program. Importantly the CTWSSP limited offsite contribution by individual land owners to $800 per lot but was silent on the amount of contribution or effort that may have been required by owners of sites. The later Small Towns Water Quality Fund did not impose the $800 limit on off site contributions.

The property owner pays for the cost of works from their house to the connection point at the boundary of the property. The Auditor Generals Report 2006 quoted cost of $2,000 to $25,000 for connection to the scheme. In 2005, DHS advised that the average cost of connecting a property was about $4,000.

There are over 400 small towns[10] and settlements that are not declared sewerage districts. These towns do not have reticulated sewerage and, usually, reticulated water supply. Water authorities do not have jurisdiction over these towns unless they are within a water supply catchment or designated area of interest. In fact local governments in co-operation with the EPA and the individual property owners are responsible for managing any potential risks of domestic wastewater on public health and the environment in these towns.

Local government is responsible under the *Environment Protection Act 1970* for issuing permits to regulate the installation, maintenance and monitoring of septic tanks within their municipal boundaries. Local Government adheres to *EPA’s Septic Tanks Code of Practice for on-site domestic wastewater management* in the setting of condition for the permits.

In 2006 the Auditor General raised concerns about the capacity or commitment of local government to the management of public health and environmental issues. The Auditor General drew the conclusion that: ‘Most local governments have not allocated adequate resources to effectively carry out their legislative

[10] Auditor-General Victoria (2006) Protecting Our Environment and Community from Failing Septic Tanks.

responsibilities for septic tank management. The level of resources allocated to septic tank management or the level of responsibility expected from local government needs to be reviewed.' [11]

Property owners are responsible for managing their own septic tank as outlined in their permit conditions.

Local government is also responsible for monitoring permit holders adherence to the conditions of their permit and for identifying failing septic tanks that are causing environmental, public health risks.

The EPA is responsible for issuing licences to those sites that discharge over 5, 000 litres of wastewater per day. These are usually commercial premises.

Local government, the EPA, regional water corporations and Catchment Management Authorities have various responsibilities for identifying risks to public health and the environmental that may arise from failing septic tanks.

The *State Environment Protection Policy (SEPP) - Waters of Victoria* identifies local governments as being responsible for developing domestic wastewater management plans the management of septic tanks in towns within their municipality. Regional water authorities also have a role in ensuring that septic tanks do not adversely impact on drinking water supplies.

Catchment Management Authorities have responsibility in accordance with the *Catchment and Land Protection Act 1994* for preparing catchment management strategies and river health strategies which address any adverse impacts of septic tanks on the environment of the catchments.

The Department of Human Services is responsible for implementing *Australian Drinking Water Guidelines* and for administering the *Safe Drinking Water Act 2003* and the *Health Act 1958*.

If examination of small country towns identifies a preferred option of reticulated sewage treatment, the relevant water authority must prepare a sewerage management plan which examines various options for the provision of the service.

In 2006 the Auditor General indicated that there is no state-wide planning for the provision and management of sewerage services:

'We are concerned that the government's commitment to eliminating sewer backlog is not supported by a state-wide plan. Such a plan would help to identify the most cost-effective solution for areas that have been historically difficult to sewer. In the absence of a state-wide plan, the backlog plans prepared by water companies and authorities reflect self-imposed commitments, which may or may not complement the Government's commitments.'[12]

The local solution chosen for these small rural towns can also be applied in un-serviced areas of larger region towns and even Melbourne and Sydney.

2.3 North East Victoria

There are many rural townships throughout the North East region of Victoria that are not connected to traditional reticulated sewerage systems.

Households in these towns rely on domestic wastewater management systems that are predominately septic tank and absorption trench or aerated wastewater treatment systems.

[11] Auditor-General Victoria (2006) Protecting Our Environment and Community from Failing Septic Tanks.
[12] Auditor-General Victoria (2006) Protecting Our Environment and Community from Failing Septic Tanks.

(Aerated wastewater treatment systems are required in areas where a land capability assessment has identified land that is unsuitable for an absorption trench. Unlike septic tanks there are maintenance cost and obligations associated with the use of these systems, often in the form of ongoing maintenance contracts.

The number dwellings in the selected towns not connected to traditional sewerage systems within the five local government areas included in this study are shown in Figure 2.1.[13]

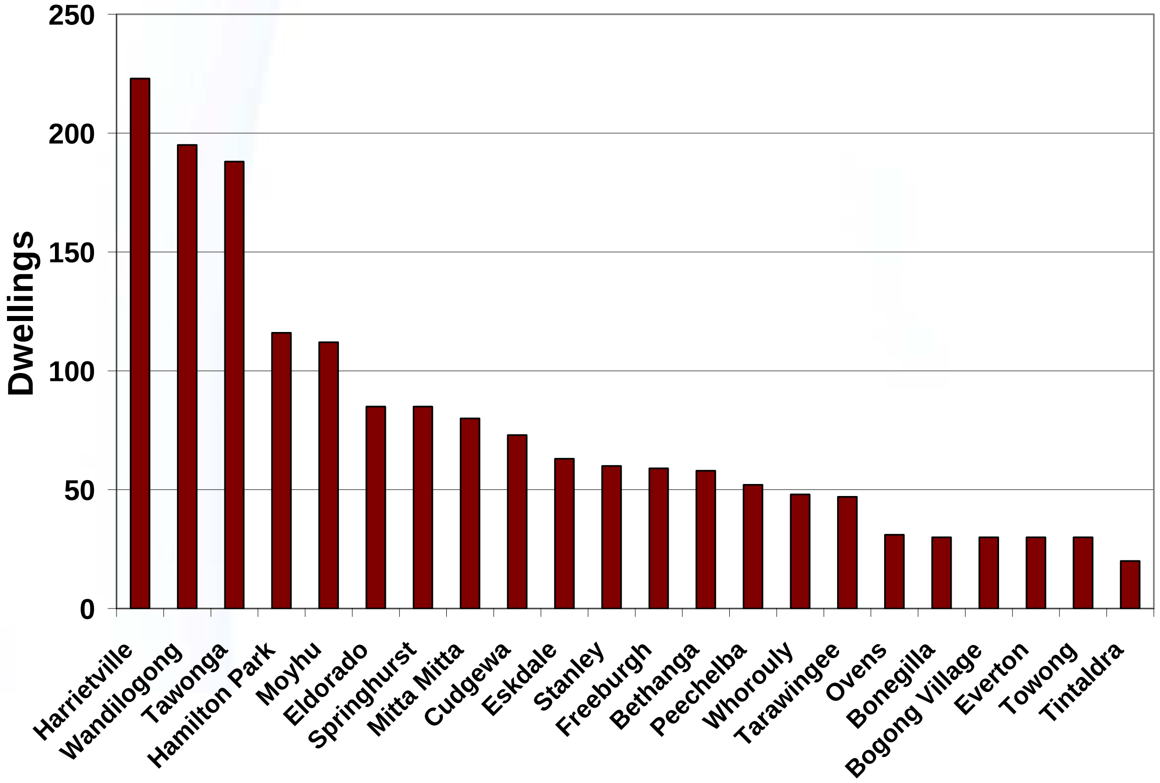

Figure 2.1: Number of dwellings in towns not connected to traditional sewerage systems throughout North East Victoria

Figure 2.1 highlights the current numbers of dwellings in the selected towns without traditional sewerage systems. It is noteworthy that the region also includes many unoccupied landholdings with the potential for future subdivision of land and redevelopment of existing properties remote from traditional sewerage systems.

Note that in Figure 2.1 that Harrietville, Wandiligong and Tawonga are relatively high up in the catchments of the Ovens and Kiewa Rivers and thus impact on the stock and domestic use of these receiving waters by many downstream users including Water Authorities.

Septic tanks with absorption trenches have a long history of management of sewage and sullage in areas remote from traditional sewerage systems.[14] The septic tank provides the primary biological treatment of sewage prior to discharge to an absorption trench that infiltrates effluent into the surrounding soil. The absorption trench and surrounding soil provides secondary and tertiary treatment of the effluent.[15,16]

[13] North East Water (2011). Draft water supply demand strategy.
[14] Geary P., V. Shah., H. Dunstan, P. Coombes and T. Rothkirk (2006). Tracing faecal contributions from on-site wastewater systems. Water. Australian Water Association. pp 38-41.
[15] Yeager J.G., and O'Brien R.T. (1979). Enterovirus inactivation in soil. Applied Environmental Microbiology, 38, pp 694-701

Alternative options to manage sullage and sewage in small rural towns

A relatively recent movement to replace domestic septic systems with traditional sewerage systems operated by water monopolies is based on the following concerns:

- Aging septic tanks may leak effluent into soil
- Potential for offsite discharges of septic effluent during winter as a consequence of insufficient disposal areas
- Possible direct discharge of sullage (greywater) to public drainage systems and waterways
- Potential for contamination of shallow groundwater.
- A lack of regular desludging of septic tanks that minimises primary treatment of sewage prior to discharge to absorption trenches
- The existing situation in the small towns impedes the economic redevelopment of these townships with the small lots being unsuitable for higher value uses including unit development, restaurants, accomodation, and other high visitation tourism development.
- The general requirement for large allotment areas (4,000 m^2) for septic systems limits the potential economic development of peri-urban towns

Recent studies into the business case for wastewater management at the towns of Milawa, Glenrowan, Tungamah, Oxley, Eskdale and Bethanga by North East Water are based on the above concerns. These concerns are described as risks to public health and waterways.

In contrast, many authors highlight that over one million septic systems are operating in Australia and the USEPA have reported that "adequately managed decentralised wastewater treatment systems are a cost effective and long term option for meeting public health and water quality goals, particularly in less densely populated areas".[17] Moreover, evidence of offsite impacts to waterways and to public health is limited and is often speculative. The impacts of domestic septic systems are subject to considerable conjecture in the peer reviewed liturature.

Nevertheless, domestic septic systems are also subject to variable perceptions of performance by the Australian community and regulatory authorities. It is commonly believed that septic systems are an inferior or outdated method of wastewater management. In addition, the traditional centralised management of wastewater generates fixed and variable revenues to water monopolies and ultimately state governments.

Prior to 2005, traditional sewage systems were provided to small communities with populations greater than 500 throughout North East Victoria. These sewage infrastructure programs were subsidised by government and North East Water. After 2005, water and wastewater management strategies have been investigated for nine small rural towns. North East Water also investigated options for providing wastewater management to areas in Wangaratta that are not connected to the sewage network.

The potential to implement traditional sewage systems in small rural towns can be described as fringe in accordance with criteria developed by the USEPA. The potential to connect fringe rural towns to existing sewage systems can be assessed by the distance and height (Cumulative) to the adjacent system. Other issues also relate to density of development, land size and soil types. The relationship between small rural towns without traditional sewage systems and the nearest sewage system is provided in Table 2.1.

[16] Goyal S.M., and C.P. Gerba. (1979). Comparative absorption of human enteroviruses, simian rotavirus and selected bacteriophages to soils. Applied Environmental Microbiology, 38, pp 241-247.
[17] Gardener E., A. Vieritz and C. Beal (2006). Are on-site systems environmentally sustainable. Water. Australian Water Association. pp 37-42.

Table 2.1: The distance and cumulative height difference between rural towns without traditional sewage and the nearest sewage system

Town	Nearest WWTP	Distance (km)		Cumulative Height difference (m)
		WWTP	Sewer	
Bethanga	Bellbridge	3.5		200
Glenrowan	Wangaratta	12		95
Oxley	Wangaratta	11		101
Moyhu	Wangaratta	25		171
Whitfield	Myrtleford	37		1,347
Harrietville	Bright	24		258
Eskdale	Dartmouth	29		560
Springhurst	Chiltern	10		78
Walwa	Corryong	28		446
Cudgewa	Corryong	11		135
Wandiligong	Bright	9.3		52
Tawonga	Mount Beauty	7.2		386
*Hamilton Park	Wangaratta	9.4	1.3	103
Eldorado	Wangaratta	15.3		91
Mitta Mitta	Dartmouth	15.6		380
Stanley	Beechworth	12.5		108
Freeburgh	Bright	18.5		119
Bonegilla	Wodonga	6	0.9	43
Whorouly	Myrtleford	8.5		88
Tarrawingee	Wangaratta	9.9		58
Ovens	Myrtleford	14.4	8.5	56
Bogong Village	Tawonga South	11		504
Everton	Beechworth	17.8		240
Towong	Corryong	3.6	2	127
Tintaldra	Corryong	15.6		225

Note that the completion of the current planned works to implement a reticulated sewage scheme and wastewater treatment plant for Glenrowan will change the relationships for Hamilton Park. Table 2.1 demonstrates that only Hamilton Park, Bonegilla and Towong can be classified as fringe communities that could be connected to existing sewage networks.

The Board of North East Water has endorsed five business cases for implementation of new traditional sewage services in response to demonstrated community support and satisfaction of the financial principles held by North East Water as shown in Table 2.2.

Table 2.2: Status of current progress towards wastewater management in small rural towns

Town	Status
Bethanga	Investigated - unlikely
Eskdale	Investigated - unlikely
Glenrowan	Proceeding to implementation
Harrietville	Investigated – no to proceeding with current funding.
Milawa	Proceeding to implementation
Oxley	Proceeding to implementation
Tungamah	Proceeding to implementation
Walwa	Proceeding to implementation, undertaken by Towong Shire Council

Table 2.2 highlights that the investigations of wastewater management strategies at Bethanga, Eskdale and Harrietville have not progressed to implementation status. This implies that strategies for these towns have not demonstrated satisfactory financial performance or sufficient community support.

If it was economical and practical to service these townships using traditional systems and approaches it is likely that it would have already been done. The hard ones are left to last.

A large number of small rural towns throughout North East Victoria do not have traditional water or wastewater services (for example see Figure 2.1) for the following reasons:

- A requirement for large capital investment from government and water monopolies
- Residents of small rural towns are unable or unwilling to met the ongoing costs of traditional sewage systems
- The financial principles set by water monopolies to contain impact on regional pricing for all customers do not allow smaller traditional systems
- The aspirations of many small rural towns is for sustainable decentralised systems
- Impracticality or un-availability of a suitable water supply source.
- Townships within flood prone areas may pose additional challenges.

Walwa – Sewerage and Sullage Scheme.

After 4 hard years of community consultation, design, construction, project variations and statutory approvals this project is finally coming to fruition. This project has been managed by Towong Shire Council and the intention is that it will be handed over to North East Water to operate. The first properties were connected to this scheme in November 2011 and all but 2 of the 78 properties within the township are now connected in some way.

Originally proposed by some in the community as a “reed bed” system, it has developed into a “hybrid” STED scheme. It comprises traditional sewerage piping, grades and pump stations connected to the outlet of the existing septic tanks or on-site treatment systems. The partially treated effluent, effectively devoid of solids is reticulated to a 3 pond oxidisation, maturation and winter storage facility located adjacent to the town football ground. The treatment system also incorporates a small 3m by 6m bio-filtration reed bed. A sub-surface irrigation system on the adjacent football oval will dispose of the treated effluent.

This project is the first township in the North East to be retro-fitted with a reticulated sewerage-sullage system for quite some time. This project represents a huge commitment by Towing Shire Council in political will, financial terms, project facilitation, engineering and project management. Final costs for this project are yet to be completed but they may be in the vicinity of $1.2 million. Towong Shire Council was successful in obtaining state government funding of $267,000 through the Small Towns Water Quality Fund and a further $200,000 through Regional Development Victoria. The funding shortfalls were a big impost on a small municipality.

An issue still to be resolved is the connection of the separate sullage lines on the older properties where sullage is not directed through the septic tank but is directly disposed either onto or off-site.

The experience at Walwa has demonstrated that a true STED scheme would have been considerably cheaper and easier to construct than the “hybrid” scheme adopted. It has also demonstrated that legislative change or new governance arrangements may be required to overcome the issue related to sullage connection non-compliance with current plumbing regulations and practices.

Criteria applied by North East Water

North East Water, the responsible statutory water monopoly in the region, applies a hierarchy of priorities to towns of different sizes. They will not consider reticulated solutions for small rural towns with less than 50 dwellings unless directed by Government. A low number of lots are considered to have low public health and environmental risk. Improved onsite solutions are more cost effective than a traditional reticulated solution. North East Water does not allocate resources to investigate or design possible solutions for these towns.

Traditional reticulated solutions for towns with between 50 and 100 dwellings are considered where local government has demonstrated a compelling need and demonstrated that decentralized solutions will not reasonably address any risks.

Towns with greater than 100 occupied lots that are generally less than 4,000 m^2 are subject to planning for reticulated sewage solutions in Water Plan 3. The towns of Harrietville, Wandiligong, Tawonga and Moyhu generally meet these criteria. Nevertheless, a strategy to install traditional sewage systems is also dependent on infrastructure and cost sharing agreements.

A Domestic Wastewater Management Plan published by local government can also trigger provision of reticulated sewage solution infill development areas with lot sizes less than 4,000 m^2.

New developments in areas adjacent to existing small sewage systems are connected to the traditional sewage system provided the adjoining system has sufficient capacity. The developer pays for the reticulation and transfer systems plus new customer contributions.

North East Water will also consider a management arrangement for the operation of onsite wastewater treatment systems. This action is subject to demonstration of a compelling need for centralized management.

Specification of onsite wastewater management systems

The installation of onsite wastewater systems is subject to approval and oversight by local government in accordance with guidelines published by the Environment Protection Authority (EPA).[18] Guidelines published by the EPA commence with the statement “centralised sewerage systems are the best way of dealing with wastewater in cities and towns” and proceed to outline assessment criteria for installation of septic tanks. Thus the potential for onsite management of wastewater is narrowly defined by assumptions relating to specification and management of septic tanks or aerated wastewater treatment systems.[19]

The Australian and New Zealand standards for onsite domestic wastewater management are specified by the EPA and local government.[20] These guidelines include a range of general parameters for design and installation of septic tanks and absorption trenches, aerated wastewater treatment plants and irrigation using greywater, composting toilets and onsite systems that also rely on evapotranspiration. Importantly, the standard does not preclude first principles analysis of domestic wastewater systems to achieve more representative understanding of local inputs and performance.

It is noteworthy that the available guidelines and standards do not account for water efficient households and sustainability measures including reuse of wastewater.

Assessment of onsite wastewater management systems is dependent on a land capability assessment (LCA), the capacity of septic tanks and design loading rates (DLR). The DLR is based on excessive production rates for sewage of 300 Litres/bedroom/day and the LCA is based on the assumption that relative large volumes of untreated sewage will be discharged to soil. In addition, a septic tank with a capacity of 3,000 litres is also specified for domestic housing.

It is noteworthy that the standards specify an area of 400 m^2 for drip or sub-surface irrigation system associated with aerated wastewater treatment systems and the use of the DLR for a heavy clay site results in an absorption trench with a length of 240 metres (0.45 m deep by 0.75 m wide). First principles analysis of these general assumptions using the above conservative production rates (3 bedroom house) yields over 27 days of storage capacity for effluent. It is difficult to understand the local government requirement for lots with areas greater than 4,000 m^2 for properties that are not connected to traditional sewage.

In any event, the collective guidelines and standards used by local government and the EPA do provide important objectives for management of domestic wastewater, including:

- Slope of the property
- The characteristics of property drainage
- Potential for flooding
- Depth to seasonal water table
- Permeability of soils
- Local climate
- Soil texture
- Proximity to and use of surface waters

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[18] EPA Victoria (2003). Land capability assessment for domestic onsite wastewater management. Publication 746.1
[19] EPA Victoria (2003). Septic tanks CA1.1/03.
[20] Standards Australia/Standards New Zealand (2000). AS/NZS 1547:2000 On-site domestic wastewater management.

3 Options

In accordance with the objectives of the North East Greenhouse Alliance for North East Victoria, this study has focused on the opportunities to reduce the impacts of sullage and sewage generated by small rural towns. It is a key objective to minimise the impacts of small rural towns on waterway and human health whilst mitigating the impacts of expected climate change.

A range of alternative Options have been examined for management of sullage and sewage throughout North East Victoria. The performance of each Option was compared to the performance of the Business as Usual (BAU) Option. The Options were established to test, compare and contrast a range of alternative futures.

The purpose of establishing Options is to enable testing of the physical, technical and commercial performance of the system without the influence of opinions, perceptions and agenda. Defining a base case (Business as Usual) and alternative Options enable the testing, comparison and understanding of the behaviour of selected small rural towns throughout the North East region.

It is important to note that this analysis has been constructed to understand the response of water cycle management throughout North East Victoria to a range of stressors and opportunities. This study does not endeavour to design the ultimate detail of solutions. This understanding will provide useful insight into systems behaviour that can inform decision making. The Options for management of sullage and sewage throughout North East Victoria examined in this study are discussed below.

3.1 Option 0 – Business as Usual (BAU)

Option 0 is the base case which assumes towns without reticulated services includes water supply from rainwater tanks (capacity of about 30 kL) and management of wastewater using septic tanks (capacity of 3 kL) that discharge to absorption trenches (240 m long, 0.45 m deep and 0.75 m wide).

Variations of the BAU Option accounts for selected small rural towns that have reticulated water supplies and includes onsite septic systems that only receive sewage discharging from toilets whilst greywater discharges to drainage systems.

3.2 Option 1 – Water efficient appliances, gardens and practices (WEA)

This Option investigates the impacts of adopting water efficient buildings, gardens and practices throughout the region. The WEA strategy includes the use of water efficient toilets, clothes washers, shower heads and gardens. It is assumed that all buildings in small rural towns throughout the region will be progressively upgraded with the equivalent of six star appliances as shown in Table 3.1. A strategy for the community education and progressive implementation of this outcome will be required.

Table 3.1: Characteristics of water efficient appliances in the WEA option

Appliances	Water use	Reduction (%)
Toilets	4.5/3 Litre flush	20
Taps	6 Litres/minute	50
Showers	7 Litres/minute	20
Clothes washers	80 Litres/wash	38
Outdoor	Low irrigation gardens	50

Table 3.1 shows that substantial water savings can be achieved using readily available products and approaches available to the industry. It is expected that the incorporation of water efficient gardens will be supported by Council planning policies, developer driven landscaping guidelines and education programs.

3.3 Option 3 – Onsite treatment and reuse (OTR)

Option 3 includes onsite treatment of sewage using an aerated treatment plant and reuse of treated effluent for toilet flushing and irrigation as shown in Figure 3.1.

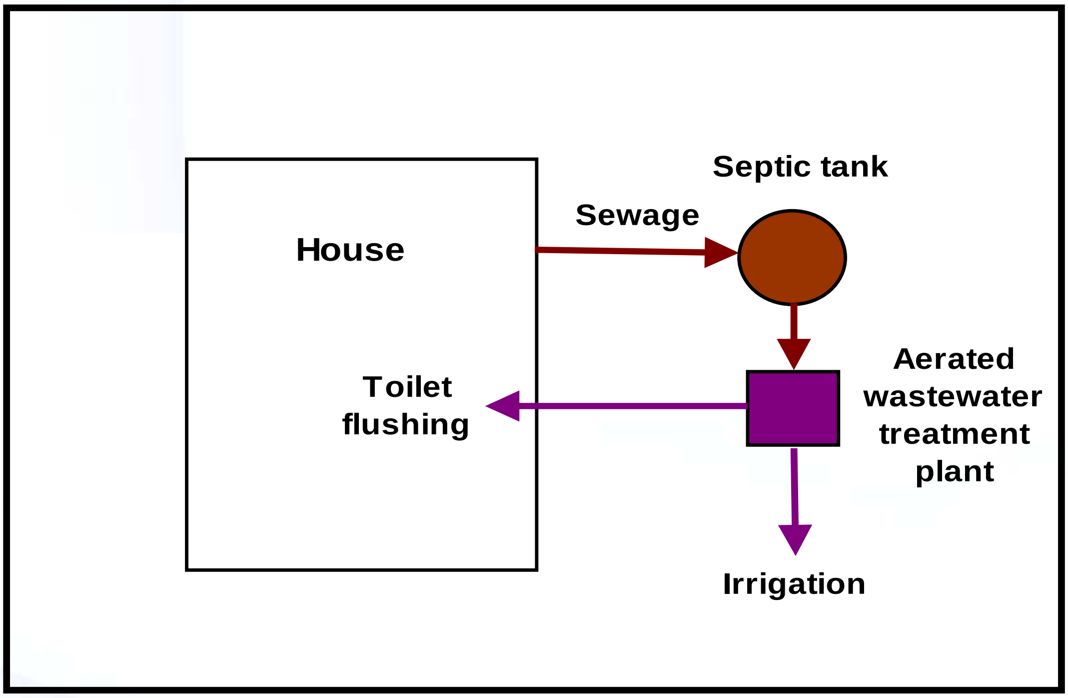

Figure 3.1: Schematic of the onsite treatment and reuse Option

Figure 3.1 shows that in Option 3 sewage discharges to the existing septic tank that provides primary treatment and then to the aerated wastewater treatment plant (AWTP). The AWTP provides secondary treatment and disinfection of the effluent prior to supply for toilet flushing and irrigation. A secondary water supply, possibly potable water will provide a back up supply for toilet flushing as required.

3.4 Option 4 – Onsite sub-surface irrigation and bio-retention (OSIB)

Option 4 includes onsite treatment of sewage using a septic tank that overflows to an absorption trench that ultimately discharges remaining effluent to a bio-retention facility. Greywater from the house discharges to a sub-surface drip irrigation system that surcharges to the bio-retention facility as shown in Figure 3.2.

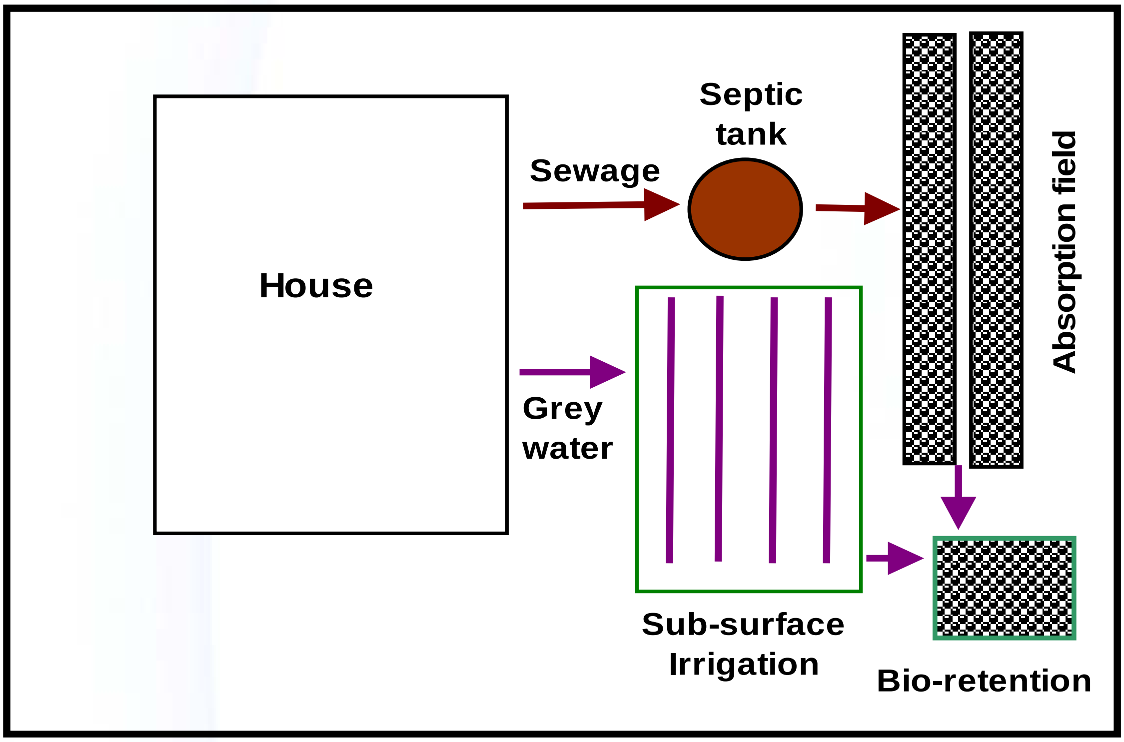

Figure 3.2: Schematic of the Option using sub-surface drip irrigation and bio-retention

Figure 3.2 reveals that Option 4 utilises sub-surface irrigation and bio-retention processes to allow vegetation to improve the quality of effluent whilst eliminating overflows to the environment. This option can influence how the limited site area of the lot is utilised by the land owner for more traditional uses. It may include some complexity and costs for the landowner.

3.5 Option 5 – Septic tank effluent disposal scheme (STEDS)

Option 5 is a Septic Tank Effluent Disposal Scheme (STEDS) or a small bore sewage scheme by another name. An estimated 110,000 people in South Australia have their wastewater services provided by these schemes with the largest scheme at Mount Barker that services a population of 10,000 people.[21] A schematic of a STEDS scheme is presented in Figure 3.3.

[21] Palmer, N, Lightbody, P, Fallowfield, H and Harvey, B (1998), Australia's most successful alternative to sewerage: South Australia's Septic Tank Effluent Disposal Scheme

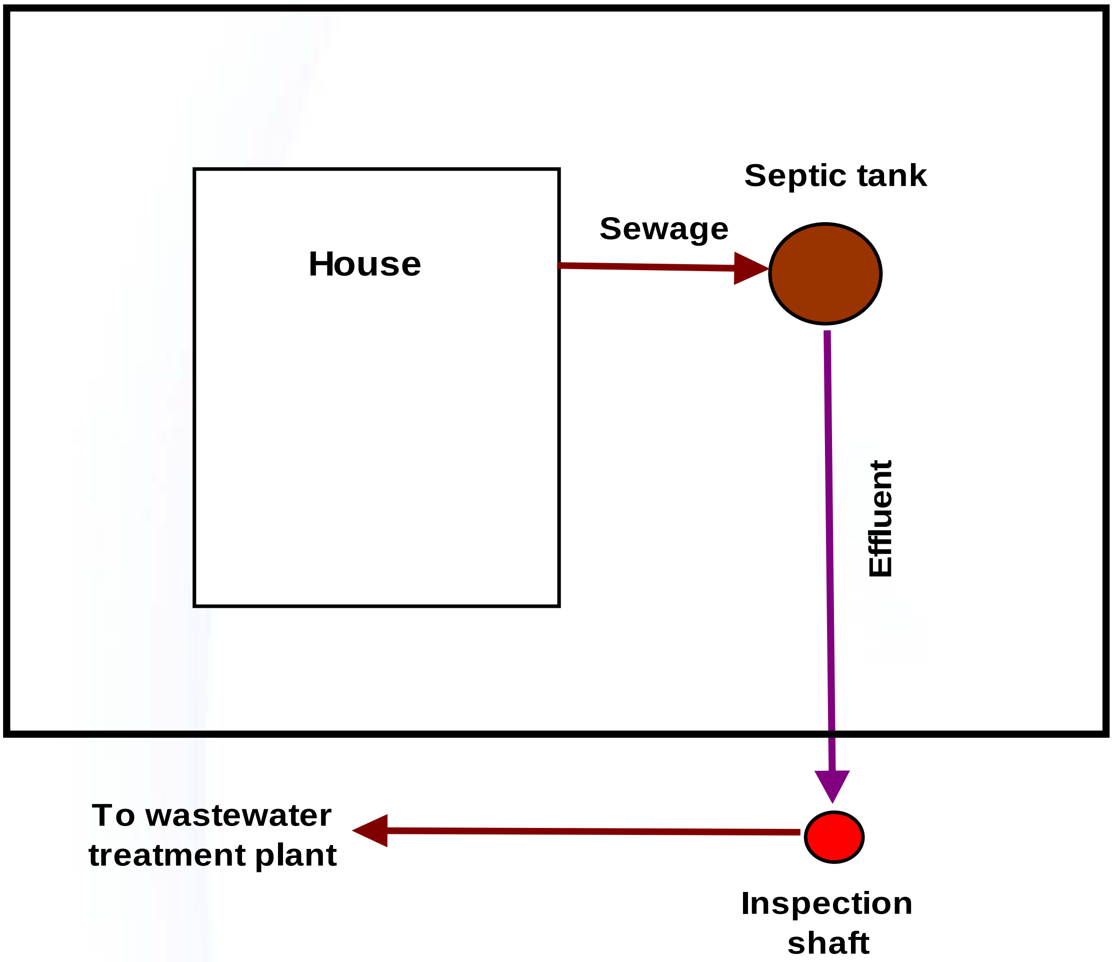

Figure 3.3: Schematic of the STEDS scheme utilised in this investigation

Figure 3.3 shows that a STEDS scheme retains existing septic tanks on each property and connects a 100 mm diameter overflow pipes to each the septic tank. Effluent from each septic tank flows into the STEDS system effectively mitigating the dominant problem associated with septic tanks – overflow from the tanks due to high volumes of grey water from housing. The Average Dry Weather Flow of STEDS schemes has been determined to be half that of a conventional system (125 L/person/day versus 250 L/person/day) in a range of studies.

The STEDS scheme achieves savings through a simplification of the collection network including reduced pipe sizes and grades with the use of flushing points instead of manholes. Importantly the scheme eliminates the need to remove the septic tank, invasive construction works and the need for expensive infrastructure items such as grinder pumps.

Wastewater in the STEDS network would then be transferred via gravity and strategically placed pumps (if required) to a small scale local modular wastewater treatment plant (WWTP). The WWTP plant would be located in close proximity to the town. A small package plant is only required because the scheme is treating effluent and not the total sewage load. A modular WWTP plant allows for future expansion of the plant as demand for wastewater services increase.

The proposed solution also includes the purchase of a septic tank pumping truck specifically for the purposes of periodically removing sludge from the septic tanks throughout the region. This material will be transported and disposed at the nearest suitable wastewater treatment plant. A full time maintenance and pump-out truck operator is included in the scheme.

It is desirable that the costs imposed by the Water Authority for disposal of this material at the wastewater treatment plant encourage this approach and are not seen as punitive.

3.6 Option 6 – Onsite pressure systems (OPS)

Option 6 involves the use of a pressure sewer scheme and a local wastewater treatment plant in each rural town. The system consists of a prefabricated plastic pit that provides wastewater storage, grinding and pumping in a single self-contained unit. This is called a pressure system unit. The unit is installed in a property and the house plumbing is redirected from the septic tank to connect into the unit. A small diameter discharge pipe goes from the unit to the pressure sewer pipe into the street as shown in Figure 3.4.

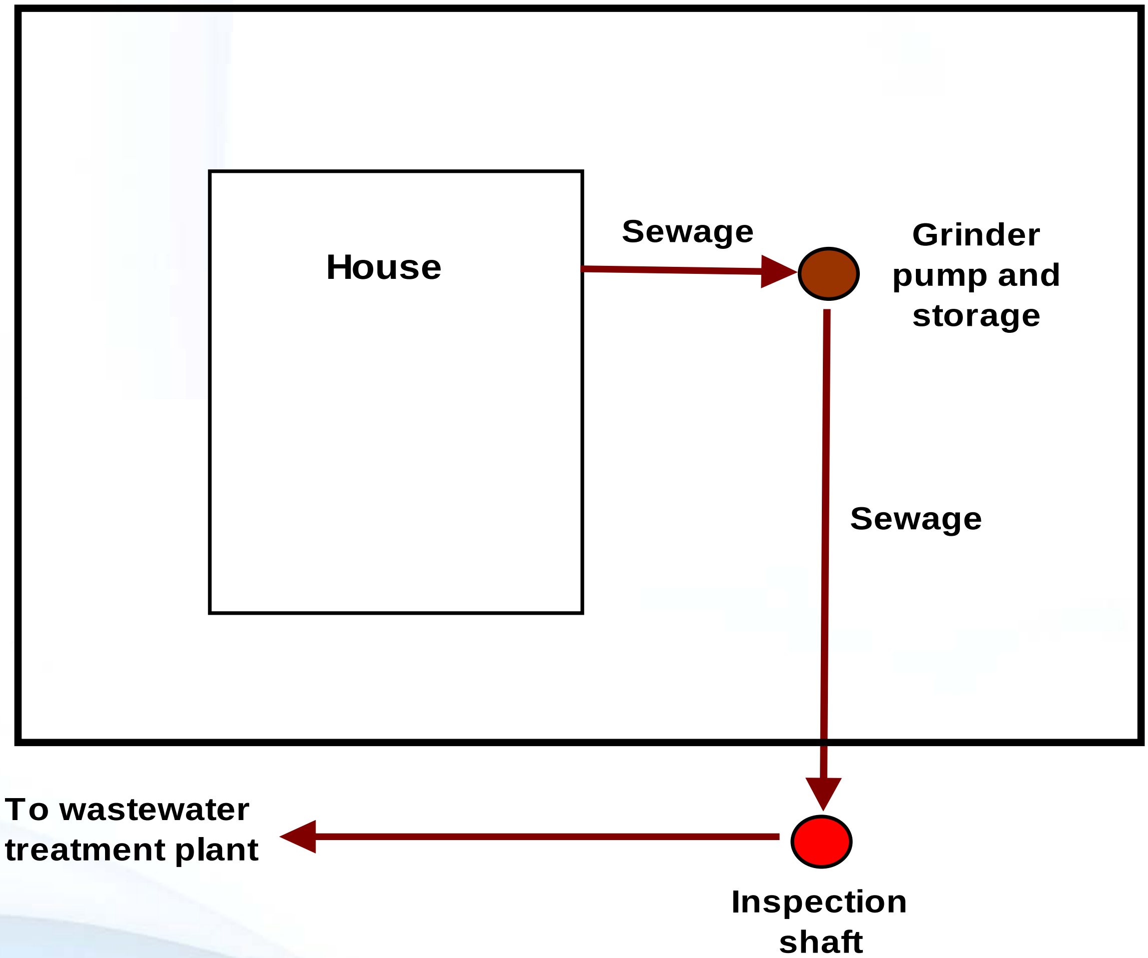

Figure 3.4: Schematic of the pressure sewer scheme utilised in Option 6

Figure 3.4 reveals that all wastewater generated from a property is directed to the grinder pump and storage. When the volume in the storage reaches a preset level, a switch activates the grinder pump. The pump operates until the level of effluent in the storage is reduced to a minimum depth. All onsite systems transfer sewage into a pressure sewer collection system generally located in the street. Sewage is then transferred to a wastewater treatment plant. The existing septic tank must be de-commissioned or removed.

3.7 Option 7 – Reticulated sewage schemes (RSS)

Option 7 involves the installation of a traditional reticulated sewage network in each rural town and transfer of sewage to the nearest wastewater treatment plant or installation of a wastewater treatment plant in each town.

4 Scenarios

A range of scenarios were established to test the response of the Options to foreseeable future threats and opportunities. The Scenarios applied to each of the Options for water cycle management throughout North East Victoria examined in this study are discussed in Table 4.1.

Table 4.1: Summary of Scenarios

Scenario	Description
Low Emissions Climate Change (LE)	The lower bounds of IPCC/CSIRO Climate Change projections of a (0.025°C) incremental change in average maximum temperature.
High Emissions Climate Change (HE)	Upper bounds of IPCC/CSIRO Climate Change projections of a (0.05°C) incremental change average maximum in temperature.
Low Population Growth (0%)	Annual average population growth remaining static (0%) across North East Victoria from 2011 to 2050.
High Population Growth (2%)	Annual average population growth of 2% across North East Victoria from 2011 to 2050.
Economic Structural Change (EC)	Structural change in the economy results from a change in agricultural activity in the region. This results in reduced commercial and industrial water demand.
Reduced water allocations (40%)	Water allocations throughout the Murray Darling Basin are reduced by 40%.

4.1 Scenarios 1 and 2: Climate Change

Scenarios 1 and 2 represent the lower and upper bounds of the current high emissions scenario from the Intergovernmental Panel on Climate Change (IPCC). A summary of the latest results from the IPCC models provided by the Bureau of Meteorology (BOM) for 2050 is presented in Figure 4.1.

2050 A1Fi

		Surface Temperature - Annual (° C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Rainfall - Annual (% change)	Much Drier < -15.00			Likelihood: 1 of 24 models (4%)	Likelihood: 1 of 24 models (4%)
	Drier -15.00 to -5.00		Likelihood: 1 of 24 models (4%)	Likelihood: 9 of 24 models (37%)	Likelihood: 1 of 24 models (4%)
	Little Change -5.00 to 5.00		Likelihood: 1 of 24 models (4%)	Likelihood: 8 of 24 models (33%)	Likelihood: 1 of 24 models (4%)
	Wetter 5.00 to 15.00			Likelihood: 1 of 24 models (4%)	
	Much Wetter > 15.00				

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Proportion (%) of models for selected variables

- No models
- < 10% of models
- 10% - 33% of models
- 33% - 66% of models
- 66% - 90% of models
- > 90% of models

Figure 4.1: A summary of climate models from the IPCC analysis of the high emissions assumptions

Figure 4.1 shows that the majority of global climate models predict increase in average temperatures ranging from 1.5°C to 3°C for the region. Similarly it appears to be equally likely for little change in rainfall and dryer rainfall conditions. The previous estimates of the impacts of climate change by the Department of Sustainability and Environment (DSE) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) are presented in Table 4.1.[22]

Table 4.1: Summary of the impacts of climate change for North East Victoria

Criteria	2030	2070	
		Low	High
Change in average temperature (°C)	0.6 to 1.2	1.0 to 2.1	2.0 to 4.0
Change in annual rainfall (%)	-9 to +2	-14 to +2	-25 to +5
Change in potential evaporation (%)	+1 to +5	+2 to +8	+4 to +16
Change in annual stream flow (%)	-20 to -25	-5 to -50	-5 to -50

Table 4.1 shows that previous estimates of climate change in the North East of Victoria predicted large changes in average temperatures and potential evaporation with moderate changes in rainfall. In accordance with the latest IPCC summary (Figure 4.1) the low emissions scenario (LE) was analysed as a 0.025°C incremental change in average maximum temperature and the high emissions scenario was analysed as 0.05°C incremental change average maximum in temperature.

[22] DSE (2008). Climate change in the North East region. Department of Sustainability and Environment.

4.2 Scenario 3: Low Population Growth (0%)

Scenario 3 is characterised by lower than expected population growth that remains static (0% annual average growth) from 2011 to 2050.

4.3 Scenario 4: High Population Growth (2%)

Scenario 4 is characterised by higher than expected average annual population growth of 2% from 2011to 2050.

4.4 Scenario 5: Economic Structural Change (EC)

Scenario 5 represents structural change in the economy of the North East region resulting in reduced Commercial and industrial water demand. Reduction in agricultural activity throughout the region will have significant impact in the economies of towns throughout the region.

4.5 Scenario 6: Reductions in water allocations (WA)

Scenario 6 represents a 40% reduction in water allocations throughout the Murray Darling Basin.

5 Methods

This study employed an integrated systems approach to analysing the performance of integrated water cycle management Options for North East Victoria. The Options were determined to generate understanding of the response of the water cycle systems throughout North East Victoria to alternative strategies. This unique analysis is dependent on detailed inputs, such as demographic profiles, and linked systems that accounts for water supply, sewerage, stormwater and environmental considerations. This section outlines the key assumptions and methods used in this analysis.

In addition, a parallel investigation was undertaken to understand the opinions and experience of stakeholders throughout the region. Stakeholders provided analysis of many aspects of the North East region from multiple perspectives, input to the systems analysis, review and interpretation of systems outcomes, and input to the final report.

It is important construct the systems analysis from the basic elements (the lot scale inputs) that drive system behaviours and account for first principles transactions within the system to allow simulation of spatial performance of the system. Biophysical systems in the North East region were constructed using three basic components:

- Sources - Regional and local water sources, catchments and waterways
- Flux – transport and treatment of water, sewage and stormwater throughout the region
- Sinks – Stormwater runoff and wastewater disposal to waterways

This fundamental concept is outlined in Figure 5.1.

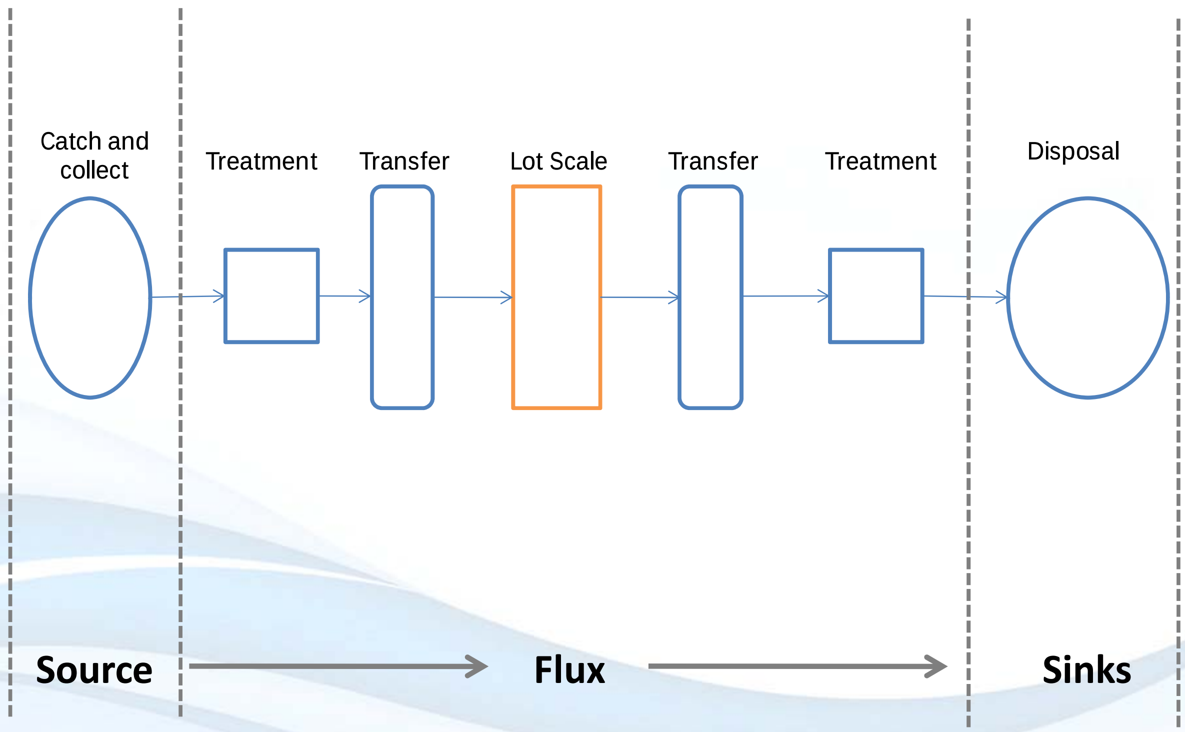

Figure 5.1: The principles underpinning any water system – Sources, Fluxes and Sinks

Figure 5.1 shows that the foundation principles used as the basis of the systems analysis in this project – the system is driven by demands at the lot scale (including water, sewage, stormwater and environmental demands or discharges) that require movement of water (Fluxes) from a range of sources and disposal of water (such as sewage and stormwater) to a range of sinks.

The framework for analysis of the North East Victorian system was compiled from the lot scale to regional scale is presented in Figure 5.2.

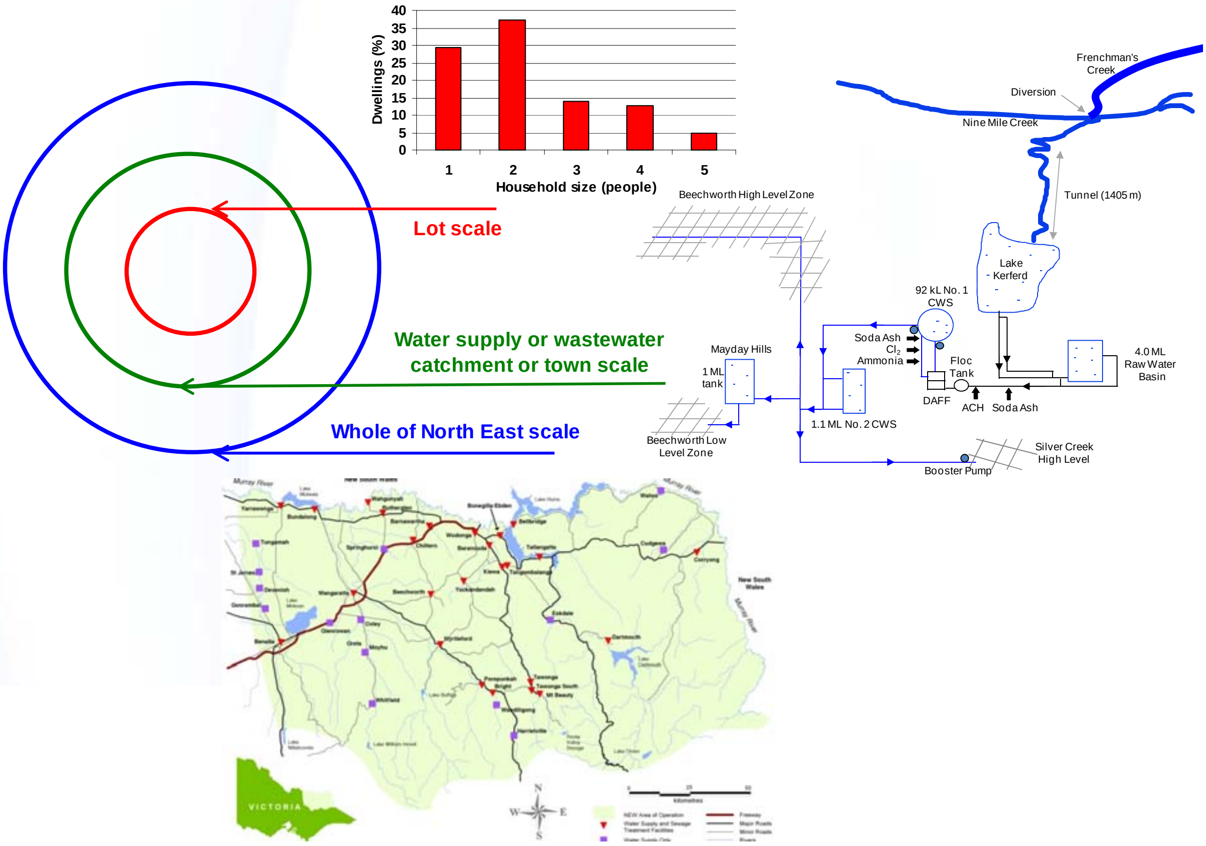

Figure 5.2: Three linked spatial scales used in the analysis and in calibration

Figure 5.2 highlights the elements that were incorporated at different scales in the analysis. This includes water use and demographics at the lot scale, distribution infrastructure and information at the sub-regional or town scale, and regional behaviours or infrastructure such as water extractions from and discharges of sewage to wastewater treatment plants. This process can be described as analysis of systems within systems across multiple scales. Our unique biophysical and scale transition framework links the dynamics of the systems with inputs across scales and time.

The analysis is anchored by a regional framework of key trunk infrastructure, demand nodes, discharge points, waterways and regional sources of water in the WATHNET systems model. Major water distribution, stormwater, sewage, demographic, climate and topographic zones are combined in this framework. This process compiles inputs from a wide range of commonly utilised analysis tools, including for local water demands and water balances (such as PURRS) and hydrology. Key simulation inputs to this framework include:

- Demographic data from the Australia Bureau of Statistics and State Government departments

- Climate data from the Bureau of Meteorology and streamflow data from the Victorian Data Warehouse
- Water and sewage flows sourced from North East Water
- Local and cluster scale inputs simulated in the PURRS model at 6 minute timesteps using long climate records.
- Urban areas and small rural towns analysed using a range of models including PURRS and MUSIC. These smaller scale systems are also analysed in more detailed WATHNET models.
- The biophysical and scale transition model compiles inputs from PURRS into the zones based on statistical local areas and calibrates to observed data from water and sewage catchments.
- The Wathnet model was used to collate and simulate all inputs across the entire region

This framework incorporates the movement of water throughout the region and connectivity to the water supply headworks system. Similarly, this framework includes the movement of sewage throughout the region and connectivity with discharge points or reuse systems. It includes stormwater catchments, conveyance systems and urban streams as shown in Figure 5.3.

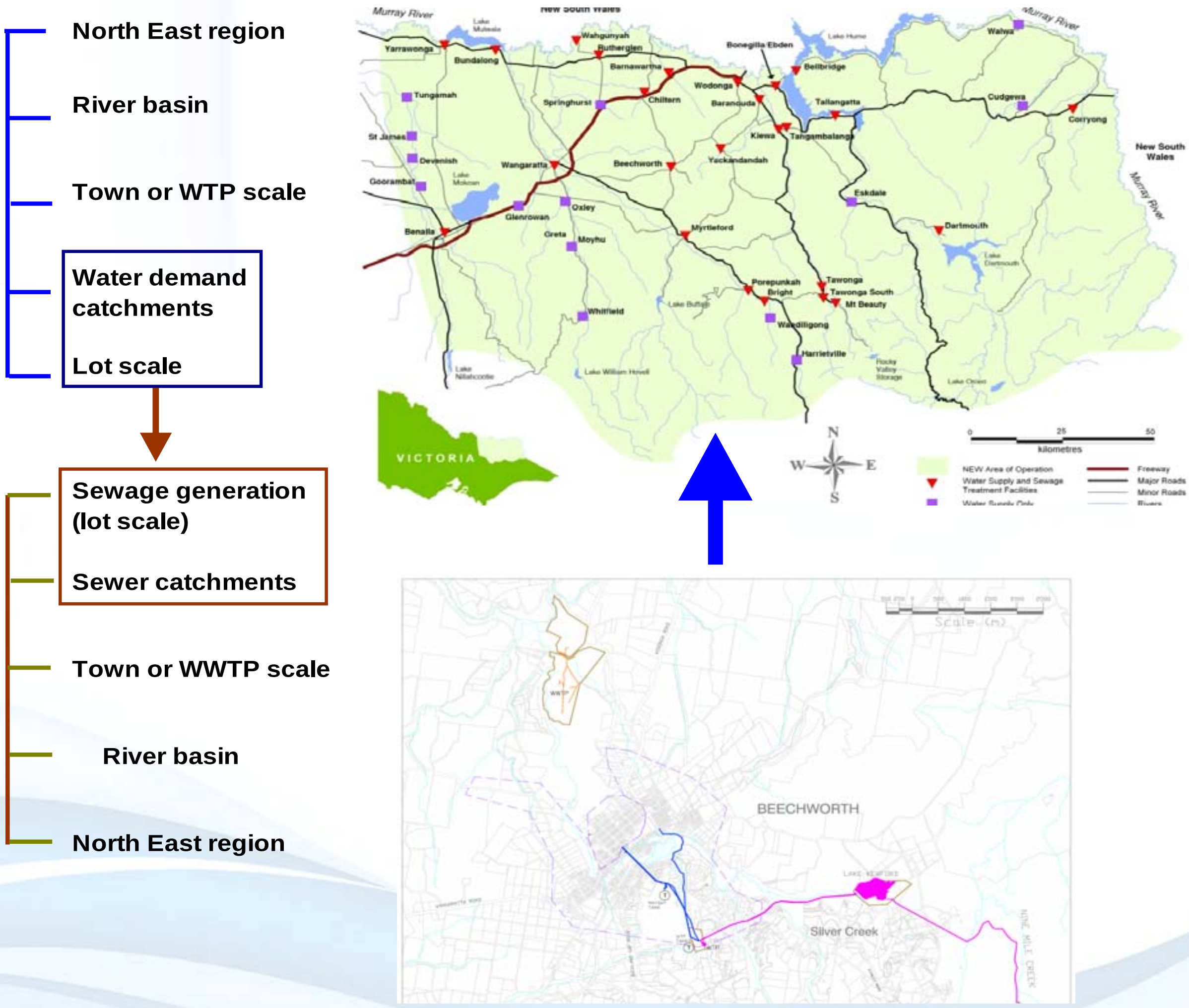

Figure 5.3: The linked nature of water and wastewater systems employed in this analysis

Importantly, the framework shown in Figure 5.3 is driven by long sequences of spatially consistent input data that captures the spatial and temporal variation in climate (rainfall, temperature and frequency of rainfall), demographics, water demands and water management strategies across the North East region. This ensures that the impact of the considerable spatial variation and connectivity across the region is robustly incorporated in the framework leading to accurate understanding of internal and external augmentation requirements. Clearly the region does not respond “on average” and this process captures the dynamics of feedback loops from sources to sinks throughout the region.

For example, this framework provides comprehensive systems understanding of the dynamics of sewage discharges, including interaction with stormwater systems, to sewage treatment plants and the impact of reusing treated effluent from the contributing sewage catchments. It will allow an understanding for the changes in sewage flows, demands for recycled water and requirement for reuse infrastructure throughout North East Victoria with the consequent changes in distribution of water from external sources (such as rivers and groundwater) throughout the region. This allows understanding of the changed energy profiles, the extent of reuse required and the operating costs of any strategy. In addition, this connectivity allows understanding of the regional water security and resilience to climate change provided by an alternative Options – a proportion of North East Victoria’s water security will be provided by internal sources.

Wherever possible the analysis incorporates first principles information and sequences of inputs rather than averages. Smaller scale inputs to the regional framework involve more detailed analysis of selected towns, commercial, industrial and agricultural areas. This analysis includes the dynamic inputs of local infrastructure and building form to the regional framework.

Details of the analysis, extractions from the data and modelling process have been provided throughout this Section to assist with understanding the systems processes used in this study. Household water consumption for the period 2005 to 2006 was selected in this study as the representing base water consumption for the region during a period relatively free of water restrictions. These water demands were then modified by a range of processes including adoption of water efficient appliances in some houses, connection to wastewater reuse systems and changes in demographics (see Section 5.6). The year used for the economic analysis is the 2009/10 financial period due to the availability of information.

5.1 Selection of zones

The North East region has been divided into 45 zones for regional analysis (see Figure 5.4) using the following data:

- Boundaries, demographics and socio-economics from ABS “State Suburbs” and “Statistical Local Areas”.
- River basins
- Local government boundaries
- Water and sewage districts from NERWA
- Climate data from the BOM

The zones presented in Figure 5.4 are also described in Table 5.1.

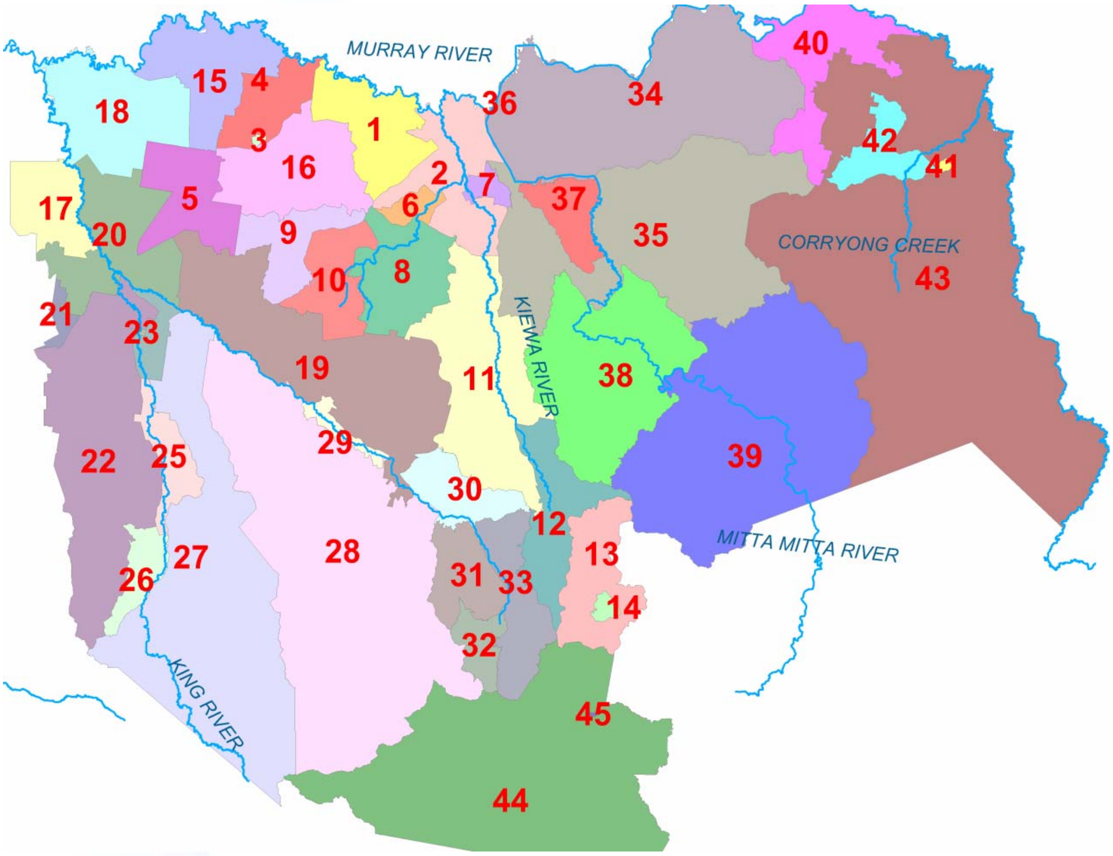

Figure 5.4: Zones used to analyse water cycle management in the North East region

Table 5.1: Description of zones used in the analysis

Zone	Number	Zone	Number	Zone	Number
Wodonga City	1	Indigo Valley	16	Wandiligong	31
Wodonga East	2	Killawarra	17	Harrietville	32
Chiltern	3	Ovens Murray	18	Freeburgh	33
Barnawartha	4	Ovens North	19	Hume East	34
Springhurst	5	Wangaratta	20	Hume South	35
Staghorn Flat	6	Glenrowan	21	Bellbridge	36
Huon	7	King West	22	Tallangatta	37
Yackandandah	8	Oxley	23	Eskdale	38
Beechworth	9	Milawa	24	Dartmouth	39
Stanley	10	Moyhu	25	Walwa	40
Middle Kiewa	11	Whitfield	26	Corryong	41
Mount Beauty	12	King East	27	Cudgewa	42
Bogong	13	Ovens South	28	Upper Murray	43
Falls Creek	14	Myrtleford	29	Hotham Heights	44
Rutherglen	15	Bright	30	Dinner Plain	45

Water use and demographic considerations

A combination of average household water use, demographic and climate data was utilised to develop water use profiles for a variety of household sizes (one to five people) and types (detached, semi detached and units) in each zone. Long daily records of temperature and rainfall at each location were combined with pluviograph (6 minute) rainfall records to create synthetic pluviograph records of suitable length for robust simulation of Options in the PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator) model. A diurnal pattern was employed to disaggregate household water use into sub-daily time steps. The use of long climate records and sub-daily time steps was required for reliable simulation of rainwater and stormwater harvesting scenarios.

The sequences of water use and sewage discharges for each location were calibrated using the selected climate information in the PURRS model and water use records from North East Water. A range of scenarios was simulated using PURRS that account for different household sizes, types of dwellings and alternative water management strategies. These results are used to determine responses to a range of drivers including alternative strategies, impacts on stormwater, sewage and mains water systems, and economics at each location.

Annual water use data was provided for the water districts throughout North East Victoria by North East Water. However, the usefulness of this data for understanding household water use behaviour is limited because this data is derived from rolling quarterly metering programs with variable periods and each area has different demographic and socioeconomic components. Annual water use measurements from commercial, industrial and other sectors provided by North East Water was also utilised in this analysis.

The Australian Bureau of Statistics (ABS) provides information about household size and distribution of dwelling types for each zone. This data provides an opportunity to unlock the characteristics of water use for each household type and for various household sizes within a given area.

5.2 Selection of towns

The small rural towns included in this investigation are presented in Table 5.2.

Table 5.2: Towns included in this investigation

Town	Mains Water	Town	Mains Water	Town	Mains Water
Bethanga	No	Harrietville	Yes	Tawonga	Yes
Bonegilla	Yes	Hamilton Park	No*	Tarawingee	No
Bogong Village	No	Mitta Mitta	No	Tintaldra	No
Cudgewa	Yes	Moyhu	Yes	Towong	No
Eldorado	No	Peechelba	Yes*	Wandiligong	Yes
Eskdale	Yes	Ovens	No	Whorouly	No
Everton	No	Springhurst	Yes		
Freeburg	No	Stanley	No		

* This area has a limited local water supply scheme.

5.3 Climate

The performance of alternative water use strategies is primarily dependent on climate processes at a given location. Water demands are also influenced by the local climate variables rainfall and temperature which are subject to considerable temporal and spatial variation across the region. This Section presents the spatial variation of climate processes across the North East Victoria.

Selection of rainfall and temperature Records

Reliable analysis of the performance of alternative water systems is dependent on the use of realistic water demand and local rainfall sequences. The physical processes involved in rainwater and stormwater harvesting including collection of roof runoff and rainwater supply to households can only be accurately simulated using sub-daily time steps and the longest available rainfall records.

Daily rainfall and temperature records containing greater than 30 years of data that also include the recent drought were obtained from the Bureau of Meteorology for locations throughout North East Victoria. In addition, pluviograph (6 minute) rainfall records containing greater than 10 years of data were obtained from the Bureau of meteorology for the region. More than 72 daily rainfall and 35 pluviograph records were identified and some of these records were used to derive long synthetic pluviograph records at each location.

Development of long term pluviograph rainfall records

Synthetic pluviograph (6 minute) rainfall records were derived at locations with long daily rainfall records using a non-parametric nearest neighbourhood scheme.[23] At a given site with a daily rainfall record, data from pluviograph rainfall records with different time periods in surrounding areas can be utilised to disaggregate daily rainfall into a synthetic pluviograph rainfall record. A diagram of the concept is shown in Figure 5.5.

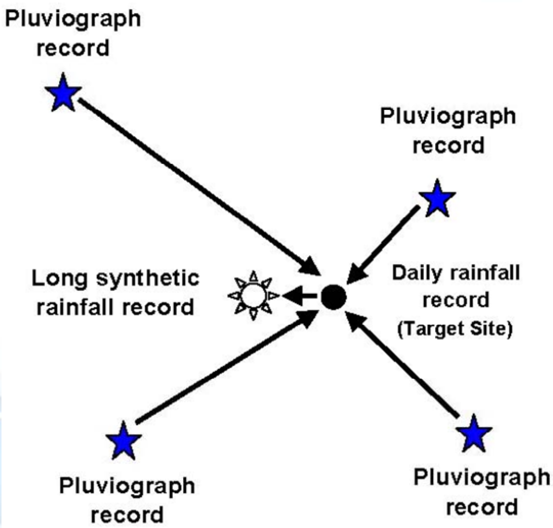

Figure 5.5: Diagram of the non-parametric nearest neighbourhood scheme for development of synthetic pluviograph records

[23] Coombes P.J., 2004. Development of Synthetic Pluviograph Rainfall Using a Non-parametric Nearest Neighbourhood Scheme. WSUD2004 conference. Adelaide.

The non-parametric scheme utilises climate and seasonal parameters (daily rainfall depth, month, count of days since last rain event) at the daily rainfall and nearby pluviograph rainfall sites to select a day of pluviograph rainfall from the most appropriate nearby pluviograph record. For each day in the daily rainfall record a day of pluviograph rainfall record is chosen using climate and seasonal parameters, and a ranking scheme. The nearby pluviograph records can be ranked on the basis of proximity to the location of the daily rainfall record and similarity of annual rainfall depths, topography and distance from the coast. This allows disaggregation of the daily rainfall records into a series of storm events and dry periods that constitute a continuous synthetic pluviograph rainfall record.

This process ensures that the synthetic continuous rainfall record will have similar rainfall patterns to the chosen site whilst the total daily rainfall depths in the synthetic rainfall record are conditioned on the daily rainfall record. In the non-parametric nearest neighbourhood scheme a rank is used to prioritise the search process for a continuous rainfall pattern that best matches the climate characteristics of the daily rainfall record on any given day.

Example from the Wodonga zone

A synthetic pluviograph rainfall record with a length of 116 years and average annual rainfall depth of 711 mm was constructed for the Wodonga area using daily rainfall from Wodonga with pluviograph rainfall from Hume, Rutherglen, Ovens River and Wangaratta. These pluviograph records were chosen as the closest available long records to the site and to account for the spatial influence of weather events on the area.

Rainfall

Average annual rainfall at each of the zones used in this study is presented in Figure 5.6 to highlight the spatial distribution of rainfall throughout the region.

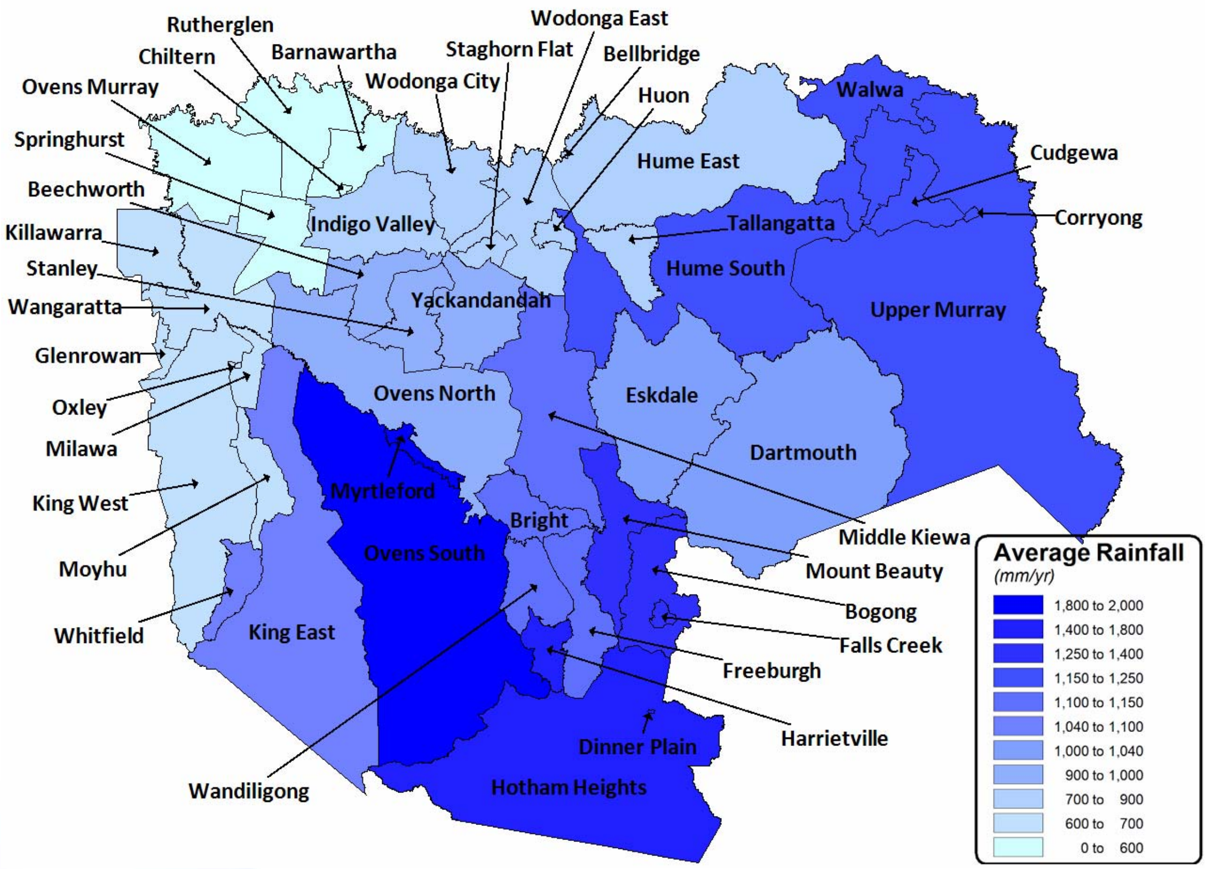

Figure 5.6. Spatial distribution of average annual rainfall across the North East Victoria

Figure 5.6 shows considerable variation in average annual rainfall across the region with the highest rainfall of 1,818 mm experienced at Bright and Ovens South zones with the lowest rainfall of 582 mm occurring in the Killawarra and Ovens Murray zones. Use of the actual rainfall records at each location throughout the North East Victoria will provide a more reliable analysis of alternatives strategies and generate more robust water demand profiles.

The daily rainfall observations from the Bureau of Meteorology (BOM) used to derived rainfall records for each LGA are shown in Table 5.3 and the pluviograph records used to create continuous rainfall records are presented in Table 5.4.

Table 5.3: Rainfall records used for each zone in the North East region

LGA	BOM Station(s) used	Start (Year)	End (Year)	Length (years)	Rainfall (mm/yr)
Barnawartha	Chiltern (82010)	1/01/1986	31/12/2010	125	690
Beechworth	Beechworth (82001)	1/01/1880	31/12/2010	131	996
Bellbridge	Hume Reservoir (72023)	1/01/1922	31/12/2010	89	694
Bogong	Harrietville (83012)	1/01/1904	31/12/2010	107	1402
Bright	Mount Buffalo (83073)	1/01/1911	31/12/2010	100	1818
Chiltern	Chiltern (82010)	1/01/1886	31/12/2010	125	690
Corryong	Nariel Creek (82035)	1/01/1885	31/12/2010	124	1038
Cudgewa	Nariel Creek (82035)	1/01/1885	31/12/2010	124	1038
Dartmouth	Callaghan Creek (82008)	1/01/1912	31/12/2010	99	1020
Dinner Plain	Omeo Shannon Vale (83035)	1/01/1958	31/12/2010	52	901
Eskdale	Callaghan Creek (82008)	1/01/1912	31/12/2010	99	1020
Falls Creek	Omeo Shannon Vale (83035)	1/01/1958	31/12/2010	52	901
Freeburgh	Harrietville (83012)	1/01/1904	31/12/2010	107	1402
Glenrowan	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Harrietville	Harrietville (83012)	1/01/1904	31/12/2010	107	1402
Hotham Heights	Omeo Shannon Vale (83035)	1/01/1958	31/12/2010	52	901
Hume East	Tallangatta DCNR (82045)	1/01/1901	31/12/2010	110	813
Hume South	Tallangatta DCNR (82045)	1/01/1901	31/12/2010	110	813
Huon	Tangambalanga (82046)	1/01/1895	31/12/2010	116	773
Indigo Valley	Yackandandah (82058)	1/01/1897	31/12/2010	114	946
Killawarra	Boorhaman (82006)	1/01/1909	31/12/2010	102	582
King East	Carboor (82009)	1/01/1911	31/12/2010	100	915
King West	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Middle Kiewa	Kergunyah South (82022)	1/01/1887	31/12/2010	124	909
Milawa	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Mount Beauty	Harrietville (83012)	1/01/1904	31/12/2010	107	1402
Moyhu	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Myrtleford	Carboor (82009)	1/01/1911	31/12/2010	100	915
Ovens Murray	Boorhaman (82006)	1/01/1909	31/12/2010	102	582
Ovens North	Beechworth (82001)	1/01/1880	31/12/2010	131	996
Ovens South	Mount Buffalo (83073)	1/01/1911	31/12/2010	131	1818
Oxley	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Rutherglen	Springhurst (82041)	1/01/1901	31/12/2010	110	606
Springhurst	Springhurst (82041)	1/01/1901	31/12/2010	110	606
Staghorn Flat	Tangambalanga (82046)	1/01/1895	31/12/2010	116	773
Stanley	Beechworth (82001)	1/01/1880	31/12/2010	131	996
Tallangatta	Tallangatta DCNR (82045)	1/01/1901	31/12/2010	110	813
Upper Murray	Walwa (82052)	1/01/1895	31/12/2010	116	818
Walwa	Walwa (82052)	1/01/1895	31/12/2010	116	818
Wandiligong	Harrietville (83012)	1/01/1904	31/12/2010	107	1402
Wangaratta	Milawa Brown Bros (82029)	1/01/1903	31/12/2010	108	653
Whitfield	Whitfield (83031)	1/01/1904	31/12/2010	107	1096
Wodonga City	Wodonga (82056)	1/01/1899	31/12/2010	116	711
Wodonga East	Tangambalanga (82046)	1/01/1895	31/12/2010	116	773
Yackandandah	Yackandandah (82058)	1/01/1897	31/12/2010	114	946

Table 5.4: Pluviograph rainfall records used to derive continuous rainfall for each zone

LGA	Pluviograph Site 1	Pluviograph Site 2	Pluviograph Site 3	Pluviograph Site 4
Barnawartha	Rutherglen (82039)	Hume (72023)	Ovens River (82121)	Wangaratta (82138)
Beechworth	Ovens River (82121)	Rutherglen (82039)	Wangaratta (82138)	Hume (72023)
Bellbridge	Hume (72023)	Rutherglen (82039)	Dartmouth (82076)	Ovens River (82121)
Bogong	Bright (83067)	Dartmouth (82076)	Omeo (83025)	Benambra (83003)
Bright	Bright (83067)	Edi Upper (83083)	Whitfield (83031)	Dartmouth (82076)
Chiltern	Rutherglen (82039)	Ovens River (82121)	Hume (72023)	Wangaratta (82138)
Corryong	Corryong (82011)	Khancoban (72060)	Tooma (72163)	Valentines (72112)
Cudgewa	Corryong (82011)	Khancoban (72060)	Dartmouth (82076)	Tooma (72163)
Dartmouth	Dartmouth (82076)	Benambra (83003)	Corryong (82011)	Bright (83067)
Dinner Plain	Omeo (83025)	Bright (83067)	Crooked River (84125)	Benambra (83003)
Eskdale	Dartmouth (82076)	Bright (83067)	Hume (72023)	Corryong (82011)
Falls Creek	Bright (83067)	Omeo (83025)	Dartmouth (82076)	Benambra (83003)
Freeburgh	Bright (83067)	Dartmouth (82076)	Edi Upper (83083)	Whitfield (83031)
Glenrowan	Wangaratta (82138)	Ovens River (82121)	Whitfield (83031)	Edi Upper (83083)
Harrietville	Bright (83067)	Omeo (83025)	Crooked River (84125)	Dartmouth (82076)
Hotham Heights	Omeo (83025)	Bright (83067)	Crooked River (84125)	Benambra (83003)
Hume East	Hume(72023)	Dartmouth (82076)	Corryong (82011)	Rutherglen (82039)
Hume South	Hume (72023)	Dartmouth (82076)	Bright (83067)	Corryong (82011)
Huon	Hume (72023)	Rutherglen (82039)	Dartmouth (82076)	Bright (83067)
Indigo Valley	Rutherglen (82039)	Hume (72023)	Ovens River (82121)	Wangaratta (82138)
Killawarra	Ovens River (82121)	Wangaratta (82138)	Rutherglen (82039)	Dookie (81013)
King East	Edi Upper (83083)	Whitfield (83031)	Rutherglen (82039)	W Hovell Res (83074)
King West	Whitfield (83031)	Wangaratta (82138)	Edi Upper (83083)	Ovens River (82121)
Middle Kiewa	Bright (83067)	Hume (72023)	Dartmouth (82076)	Edi Upper (83083)
Milawa	Wangaratta (82138)	Ovens River (82121)	Edi Upper (83083)	Whitfield (83031)
Mount Beauty	Bright (83067)	Dartmouth (82076)	Omeo (83025)	Benambra (83003)
Moyhu	Wangaratta (82138)	Whitfield (83031)	Edi Upper (83083)	Ovens River (82121)
Myrtleford	Bright (83067)	EDI UPPER (83083)	Whitfield (83031)	Wangaratta (82138)
Ovens Murray	Rutherglen (82039)	Ovens River (82121)	Wangaratta (82138)	Dookie (81013)
Ovens North	Ovens River (82121)	Wangaratta (82138)	Edi Upper (83083)	Bright (83067)
Ovens South	Bright (83067)	Edi Upper (83083)	Whitfield (83031)	W Hovell Res (83074)
Oxley	Wangaratta (82138)	Ovens River (82121)	Edi Upper (83083)	Whitfield (83031)
Rutherglen	Rutherglen (82039)	Ovens River (82121)	Wangaratta (82138)	Hume (72023)
Springhurst	Rutherglen (82039)	Ovens River (82121)	Wangaratta (82138)	Hume (72023)
Staghorn Flat	Hume (72023)	Rutherglen (82039)	Ovens River (82121)	Bright (83067)
Stanley	Ovens River (82121)	Rutherglen (82039)	Wangaratta (82138)	Bright (83067)
Tallangatta	Hume (72023)	Dartmouth (82076)	Bright (83067)	Rutherglen (82039)
Upper Murray	Corryong (82011)	Khancoban (72060)	Tooma (Eudlo) (72163)	Tooma (72099)
Walwa	Corryong (82011)	Tooma (Eudlo) (72163)	Tooma (72099)	Khancoban (72060)
Wandiligong	Bright (83067)	Edi Upper (83083)	Whitfield (83031)	Dartmouth (82076)
Wangaratta	Ovens River (82121)	Wangaratta (82138)	Rutherngien (82039)	Edi Upper (83083)
Whitfield	Whitfield (83031)	Edi Upper (83083)	W Hovell Res (83074)	Lima South (82107)
Wodonga City	Hume (72023)	Rutherglen (82039)	Ovens River (82121)	Wangaratta (82138)
Wodonga East	Hume (72023)	Rutherglen (82039)	Ovens River (82121)	Bright (83067)
Yackandandah	Hume (72023)	Rutherglen (82039)	Ovens River (82121)	Bright (83067)

Seasonal distribution of rainfall

The seasonal distribution of rainfall at selected locations is presented in Figure 5.7.

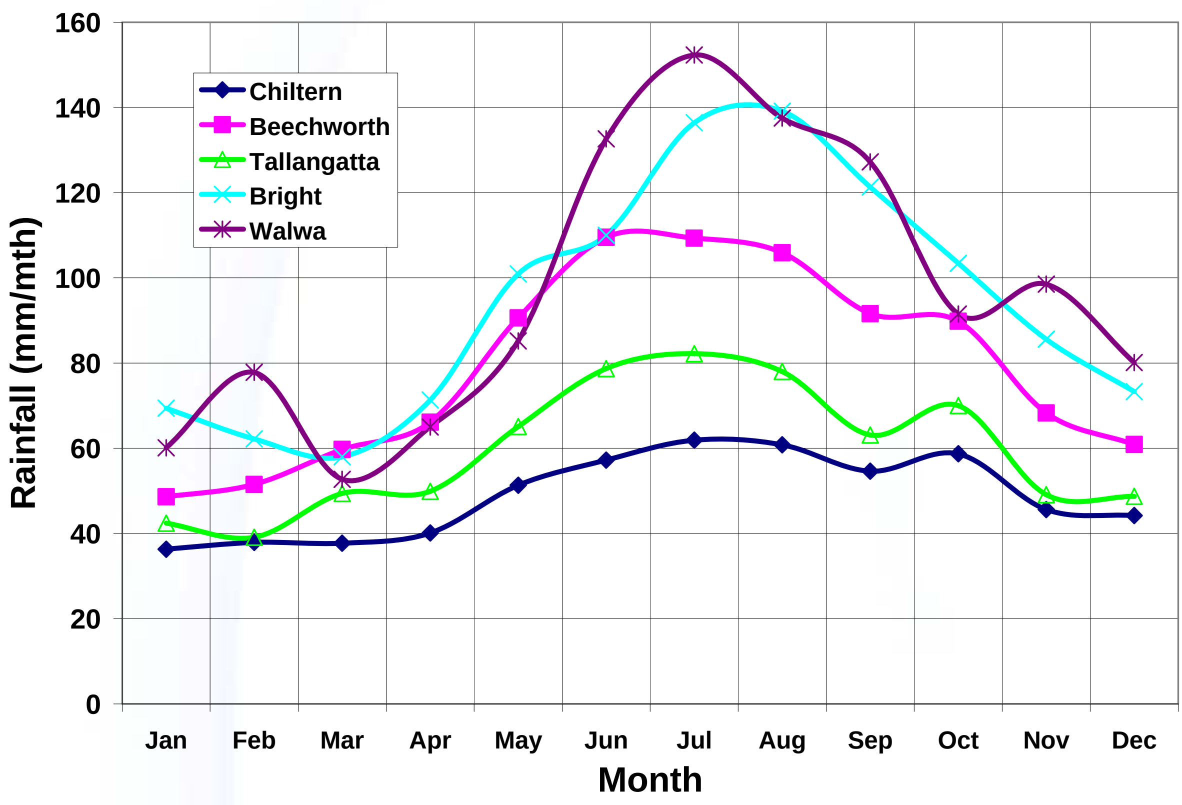

Figure 5.7: Mean monthly rainfall at selected locations across North East Victoria

Figure 5.7 reveals that the region is subject to higher rainfall during the Winter. The dominance of Winter rainfall in the seasonal distribution is more significant in areas with higher rainfall and elevations such as Walwa, Bright and Beechworth.

Average annual rain days

The frequency of rain events is an important indicator of water demands and the potential of strategies that include rainwater and stormwater harvesting. Average annual number of days with rainfall at each of the zones used in this study is shown in Figure 5.8.

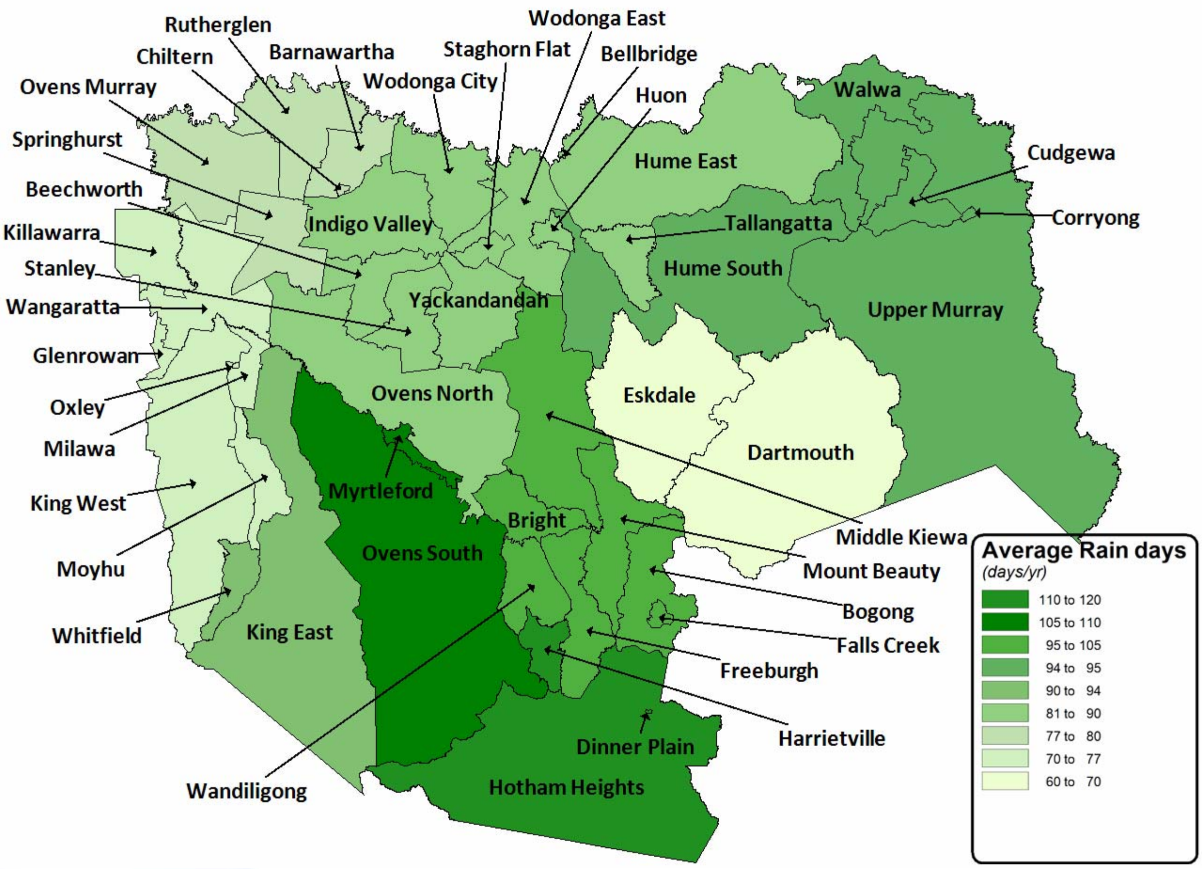

Figure 5.8: Spatial distribution of the frequency of rainfall across North East Victoria

Figure 5.8 shows considerable variation in the frequency of rainfall across the region with the highest number of annual rain days (110) occurring at Harrietville, Hotham Heights and Dinner Plains with the lowest number of rain days (61) occurring at Eskdale and Dartmouth.

A majority of the region is subject to relatively high number of average annual rain days with only a small proportion of the region experiencing less than 70 average annual rain days. The frequency of rain days across North East Victoria ranges from rainfall occurring, on average, every 3 to 6 days. The seasonal variation in the frequency of rainfall is presented in Figure 5.9.

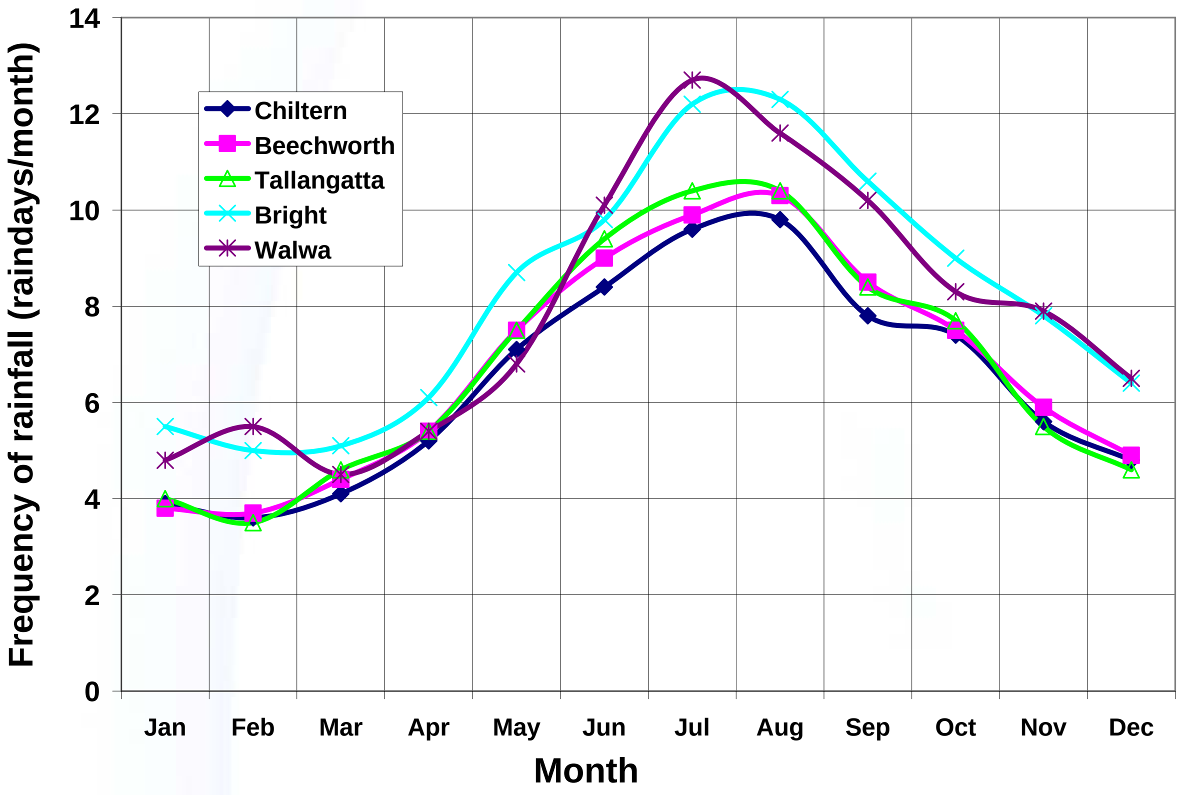

Figure 5.9: Seasonal variation in frequency of rainfall at selected locations

Figure 5.9 shows that the region is subject to higher frequencies of rainfall during the Winter seasons. Lower frequencies of rainfall are experienced during the Summer season. The difference in frequency of rainfall is more pronounced at the Walwa and Bright locations that are subject to higher rainfall.

Average annual maximum temperature

Daily maximum temperature is seen to influence water use behaviour, in particular outdoor water use, and is, therefore, an important indicator of the potential yields from rainwater tanks, stormwater harvesting and wastewater reuse. Average annual maximum temperatures at each of the zones used in this study are shown in Figure 5.10.

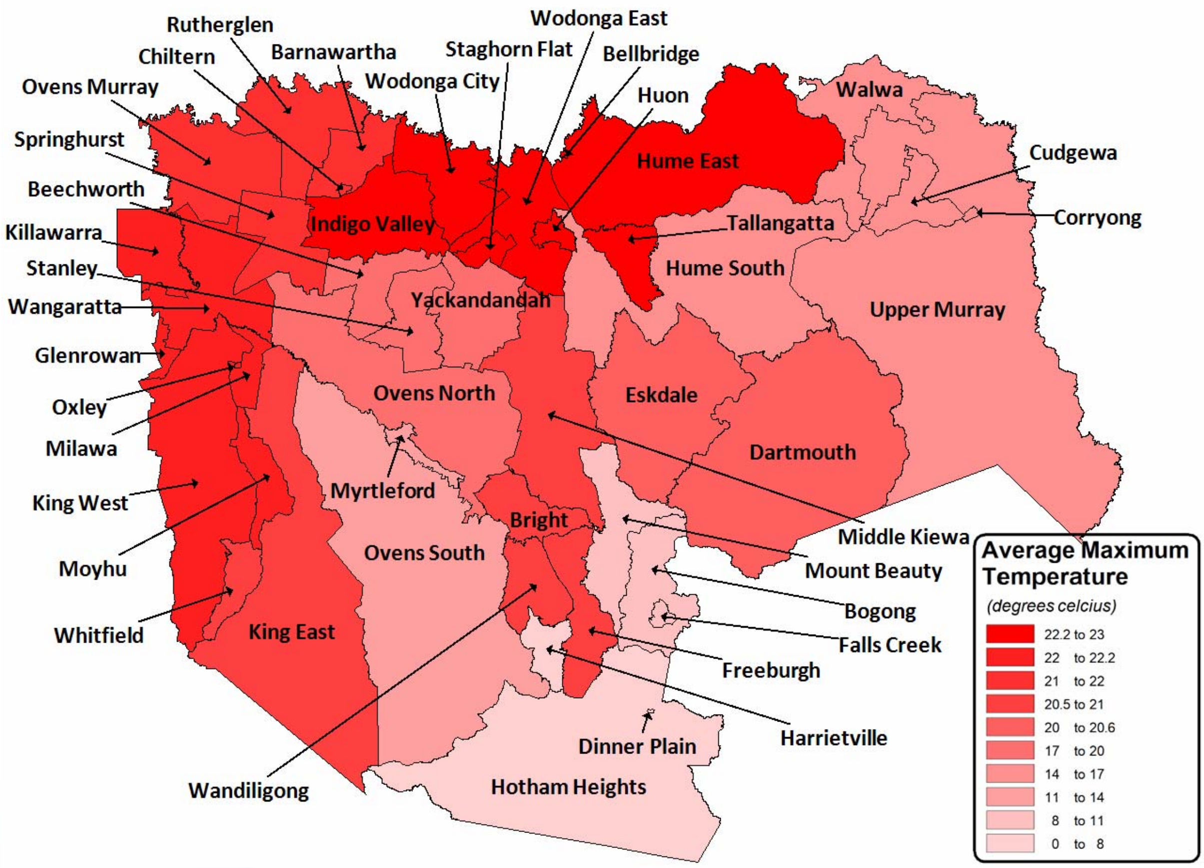

Figure 5.10: Spatial distribution of average annual maximum temperatures across North East Victoria

Figure 5.10 shows a wide variation in average annual maximum temperatures across the region with the highest annual average maximum temperature (22.2°C) occurring in the areas with lower elevations with the lowest annual average maximum temperature (7.9°C) occurring in the areas with higher elevations.

Mean monthly maximum temperature

The seasonal variation in average maximum temperatures at selected locations is presented in Figure 5.11.

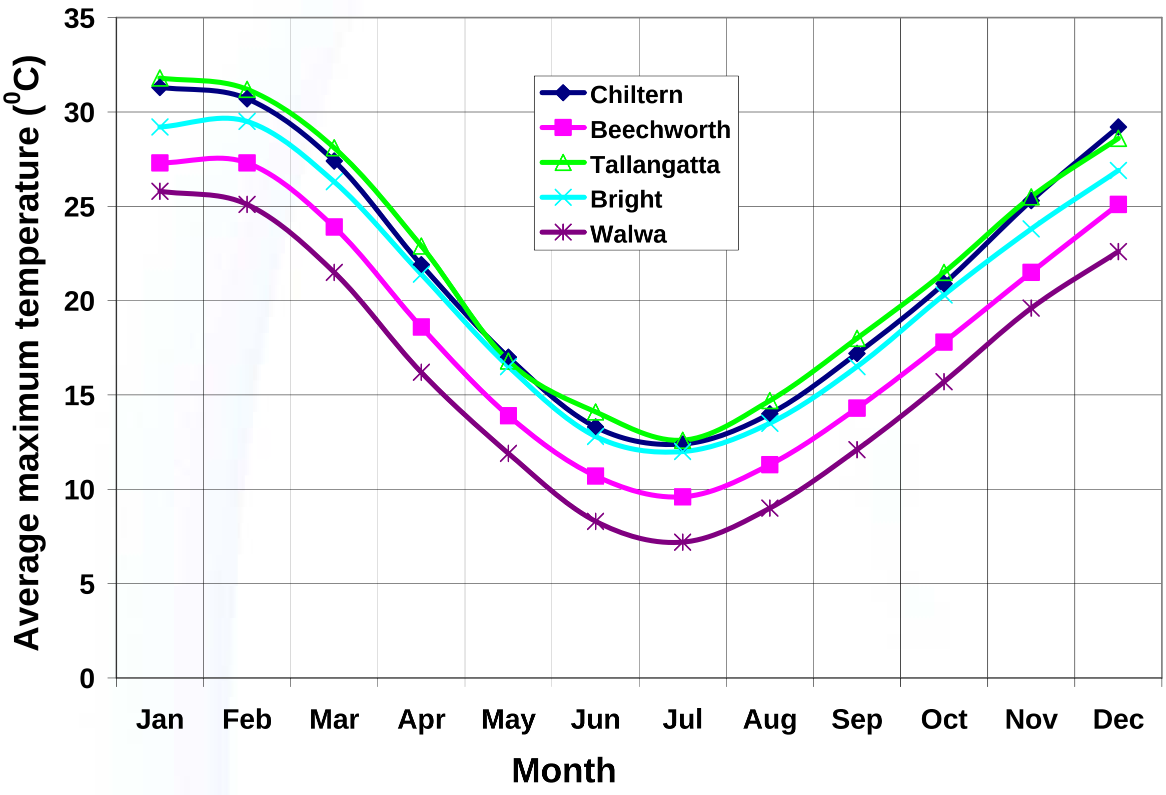

Figure 5.11: The seasonal distribution of average maximum temperatures at selected locations

Figure 5.11 shows that the seasonal distribution of temperature is similar for all locations with generally lower average temperatures in the Beechworth and Walwa zones. The distribution of average daily maximum temperatures displays greater spatial variation during the Summer season.

5.4 Demographics

A robust understanding of demographic behaviours is an important element of analysis of water resources strategies. We have utilised a range of accepted publications to derive a population profile for North East Victoria for the period 2010 to 2050. The profile is based on the number of dwellings present in each LGA over the given time period. Past demographic growth from 1996 to 2006 and current demographic growth for each LGA was derived using ABS 3218.2[24] series of publications.

The growth projections published by Department of Planning and Community Development (DPCD) in the Victoria in the Future 2011.[25] The spatial distribution of household income for the North East region is presented in Figure 5.12.

[24] Australian Bureau of Statistics, 3218.0 - Regional Population Growth, Australia, 2008-09, http://www.abs.gov.au/AUSSTATS
[25] Department of Planning and Community Development (2011). Victoria in the Future 2011.

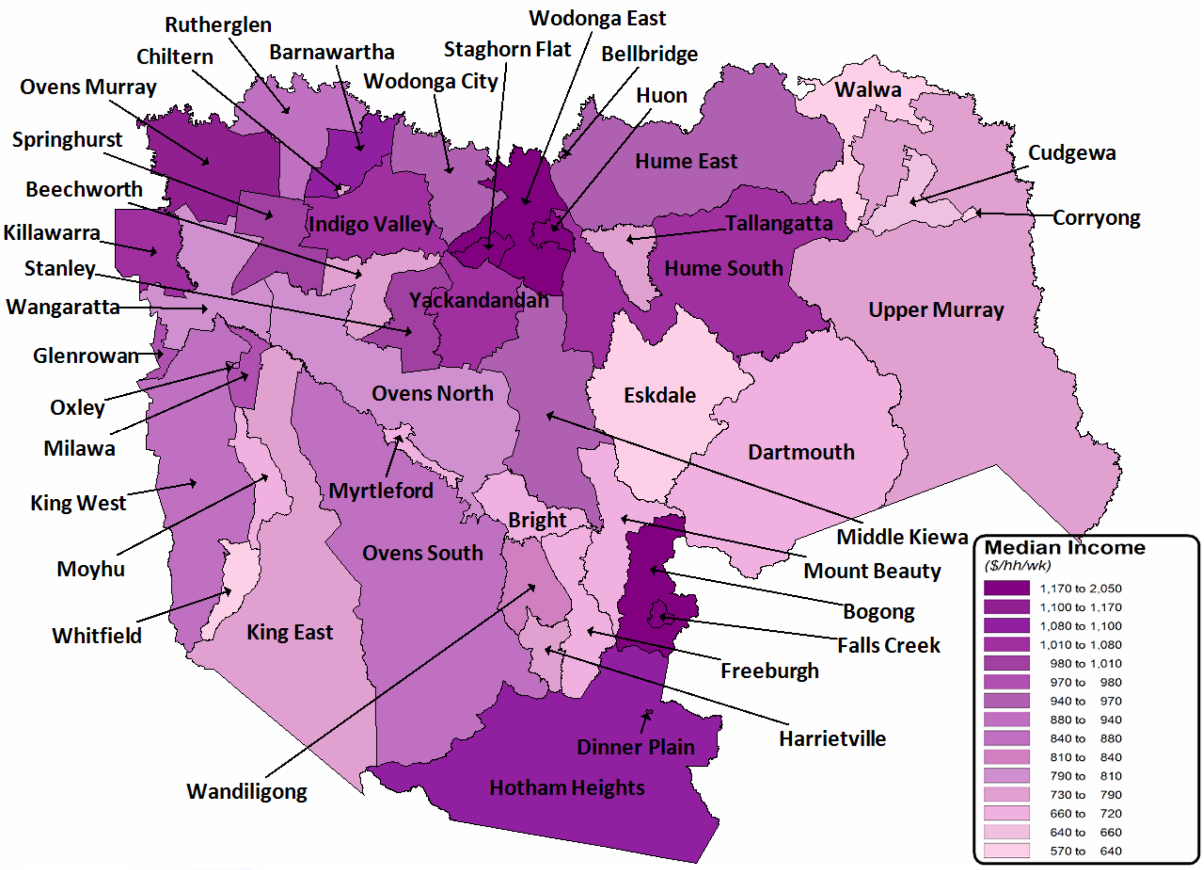

Figure 5.12: Spatial distributions of median household income across North East Victoria

Figure 5.12 shows that the region is subject to significant spatial variation in household income and that the areas with the lowest incomes (Eskdale, Whitfield, Corryong and Walwa) do not have traditional reticulated water or sewage services. The areas of North East Victoria with the highest household income include the established rural cities (Wodonga) and the high country resort areas (Falls Creek and Bogong).

The demographic information presented in this section was compiled to create the demographic growth profile used in the systems analysis of the Greater Sydney region as shown in Table 5.9.

The renovation or redevelopment rate was derived from ABS 8731.0 series "Building Approvals". The values of new dwellings and renovated (or redeveloped) dwellings reported in this document were used to derive the renovation rates for use in this study as a fixed proportion for each LGA of the overall total cost of a new dwelling.

It is important to note that the cost of a single average new dwelling has not been used for all of North East Victoria – the spatial costs of new dwellings that are vastly different in each zone were used in this study. The determination of the renovation or redevelopment rate for each zone is shown in Table 5.10.

Table 5.10 shows the renovation or redevelopment rate in each zone for renovations that incur expenses of greater than 10% of the value of an average dwelling and for renovations that are equal or greater than the cost of an average dwelling. The 10% renovation rate indicates the proportion of dwellings subject to partial renovation (such as a kitchen, a bathroom or a new extension) whereas the 100% renovation rate indicates the proportion of dwellings that are substantially redeveloped.

Table 5.9: Growth residential dwellings for each LGA in North East Victoria

Year	Population in each Local Government Area				
	Alpine	Indigo	Towong	Wangaratta	Wodonga
2010	12866	16111	6343	28938	36432
2011	12874	16144	6347	29002	36982
2016	13023	16635	6402	29585	39933
2021	13214	17187	6437	30295	43037
2026	13424	17738	6491	30987	45955
2031	13617	18210	6552	31556	48435
2036	13733	18565	6612	31950	50266
2041	13833	18870	6629	32260	51630
2046	13955	19199	6663	32628	52979
2051	14074	19528	6694	33012	54387

Table 5.10: Determination of the renovation rate at each LGA

SLA	Renovation rate (%) as a proportion of average dwelling value	
	100 % of Avg. value	10 % of Avg. value
Alpine (East)	0.52	5.25
Alpine (West)	0.24	2.41
Indigo (Part A)	0.54	5.41
Indigo (Part B)	0.23	2.34
Towong (Part A)	0.20	1.97
Towong (Part B)	0.14	1.38
Wangaratta (Central)	0.22	2.23
Wangaratta (North)	0.32	3.24
Wangaratta (South)	0.18	1.83
Wodonga	0.18	1.78

The values shown in Table 5.9 were used to define the development rate for each LGA throughout North East Victoria and the values in Table 5.10 were used to determine the rate of inclusion of alterative water management strategies in existing areas.

5.5 Water demands

The indoor water demand at each property is an integral element of the amount of sullage or sewerage generated. The performance of alternative water cycle management strategies is primarily dependent on the spatial distribution of water demands and climate process throughout a region. This section outlines the development of residential and non-residential water demands.

A summary of water demands within each town for the 2004-05 year is provided in Table 5.11 as sourced from the 2007 Water Supply Demand Strategy.[26] Note that these water demands from the period prior to significant regional water restrictions were used in this study to establish accurate baseline water demand behaviours for the region. These water demands are then modified in the systems analysis in response to adoption of water efficient appliances and behaviours, and by regional water restrictions.

Table 5.11: Distribution of water demands in towns with reticulated water supplies across North East Victoria

Town	Residential demand (kL/hh/yr)	Water demands (ML/yr)				
		Residential	Commerce	Industry	Other	Total
Barnawartha	356	77	8	0	13	97
Beechworth	313	386	182	1	153	700
Bellbridge	313	50	4	0	9	62
Bright	242	374	180	0	339	890
Chiltern	282	137	26	1	71	230
Corryong	309	196	92	11	73	370
Dartmouth	133	10	9	0	16	35
Eskdale	116	6	1	0	1	8
Glenrowan	287	37	21	0	26	84
Harrietville	218	36	25	0	9	71
Mount Beauty	213	242	85	0	133	460
Moyhu	327	30	8	0	8	46
Myrtleford	275	201	363	211	138	910
Oxley	360	41	1	0	19	61
Springhurst	268	20	3	0	8	31
Tallangatta	290	121	56	0	47	220
Wahgunyah	412	516	125	128	115	880
Walwa	294	14	11	0	10	34
Wangaratta	318	1118	2273	619	915	4900
Whitfield	255	11	7	0	18	37
Wodonga	308	3908	1358	784	1073	7100
Yackandandah	311	92	50	0	23	160

Table 5.11 also provides the average annual household water demands from each town. Note that the water demands for Eskdale were derived from the current draft Water Supply Demand Strategy for the region.[27]

Residential water demands

[26] North East Water (2007). Water Supply Demand Strategy.
[27] North East Water (2011). 2010 Water Supply Demand Strategy.

The use of average water demands and average household sizes to simulate the performance of alternative water management strategies produces considerable error.[28] Table 5.11 shows that the annual average household water demands are subject to considerable variation across the region with the highest demands experienced at Wahgunyah and the lowest demands observed at Eskdale. This variation is influenced by a range of factors including the distribution of dwelling types, household sizes, climate and income.

The performance of alternative water cycle management strategies or, indeed, any other water management strategy is primarily dependent on water use behaviour in each household and building. Water use behaviour is also influenced by household size and dwelling type. Information about average household water use for each month, distribution of household sizes and dwelling types were available for each State Suburb and Statistical Local Areas (SLA) from the Australian Bureau of Statistics.

Average water demands at any location are dependent on the distribution of household sizes (Figure 5.13) and dwelling types (Figure 5.14). As shown in Figure 5.13, for example, the distribution of household sizes is different for each type of dwelling and does not take the form of a normal distribution. Note that the distribution of household sizes is skewed toward smaller households for units and semi detached dwellings, and shows a more even distribution for detached housing.

As a consequence of the skewed distributions of household sizes and different types of dwellings, average water demands for an area cannot represent the water demands of an average household. Importantly, this type of average assumption cannot distinguish between the behaviour of different households and the performance of decentralised water management strategies in each of the households.

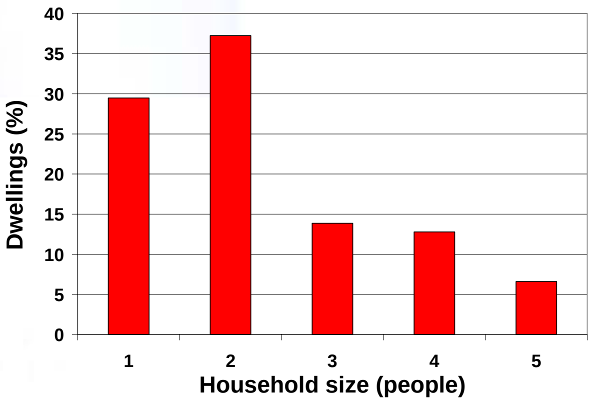

Figure 5.13: Distribution of household sizes at Beechworth

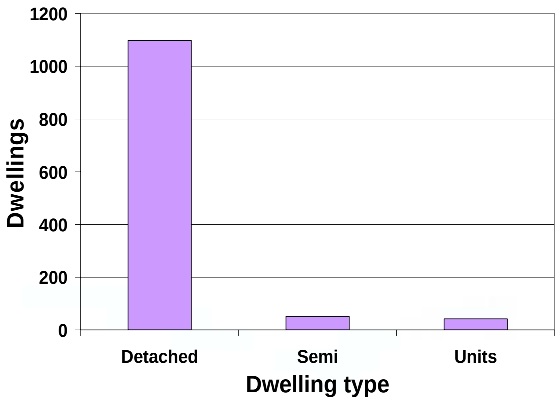

Figure 5.14: Distribution of housing types at Beechworth

As shown in Figure 5.14, for example, the dwelling stock in each area comprises a range of different dwelling types. Each dwelling type will also generate different behaviours that will influence the characteristics of household water use. For example, a detached house may allow the opportunity for significant outdoor water use whilst a unit dwelling is unlikely to provide opportunities for outdoor use.

The distributions of household sizes and dwelling types for an area provides an opportunity to disaggregate average water demand for an area into the likely water demands in each household. This task also requires an estimate of the proportion of water demand that is used outdoors.

[28] Coombes P.J. and M.E. Barry (2007). The effect of selection of time steps and average assumptions on the continuous simulation of rainwater harvesting strategies. Journal of Water Science and Technology. London.

Selection of the "base" water demand year

The availability of water use data that is disaggregated to the household scale is limited to recently available information. It is preferable that the base water demands used in analysis of water supply scenarios be derived for periods that were not subject to regional water restrictions. However, this was not possible for this study. During the 2004/05 period the region was subject to lower levels water restrictions.

In our calibration to the chosen period of "base water use" it was assumed that the lower levels of "water restrictions" were reasonable way to improve household scale water management and these changes in water using behaviours would be maintained in the future. Household water consumption for the period 2004/05 was selected in this study as the representing base water consumption for North East Victoria. Note that adoption of additional strategies including connection to wastewater reuse systems and other water efficiency programs were used to modify the base water demands in accordance with a range of time based growth in strategies. These impacts were included by simulation of a wide range of different water use strategies in different households and combining the different water use sequences for each zone.

The impacts of regional water restrictions were included in the simulations of water use for each zone after generation of the combined sequences of water use for each zone.

The PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator) Model

A schematic of the basic processes in the PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator) model is shown in Figure 5.15. The rainfall input to the model can be from pluviograph rainfall data, the DRIP (Disaggregated Rectangular Intensity Pulse) event rainfall model or a synthetic pluviograph rainfall generator[29]. The synthetic pluviograph rainfall generator can be used to create a rainfall pluviograph record from daily rainfall in locations where incomplete or no pluviograph data is available. A more complete description of the PURRS model is provided in the literature[30].

The PURRS model was utilised to generate lot and precinct scale responses including behaviour and climate driven water demands, adoption of water efficient appliances, sewage discharges and stormwater runoff that were spatially incorporated in the wider spatial systems framework. This analysis also includes a wide range of spatial processes including water efficient buildings, rainwater harvesting, local wastewater reuse and stormwater harvesting.

[30] Coombes P.J., 2006. Integrated Water Cycle Modeling Using PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator). Urban Water Cycle Solutions.

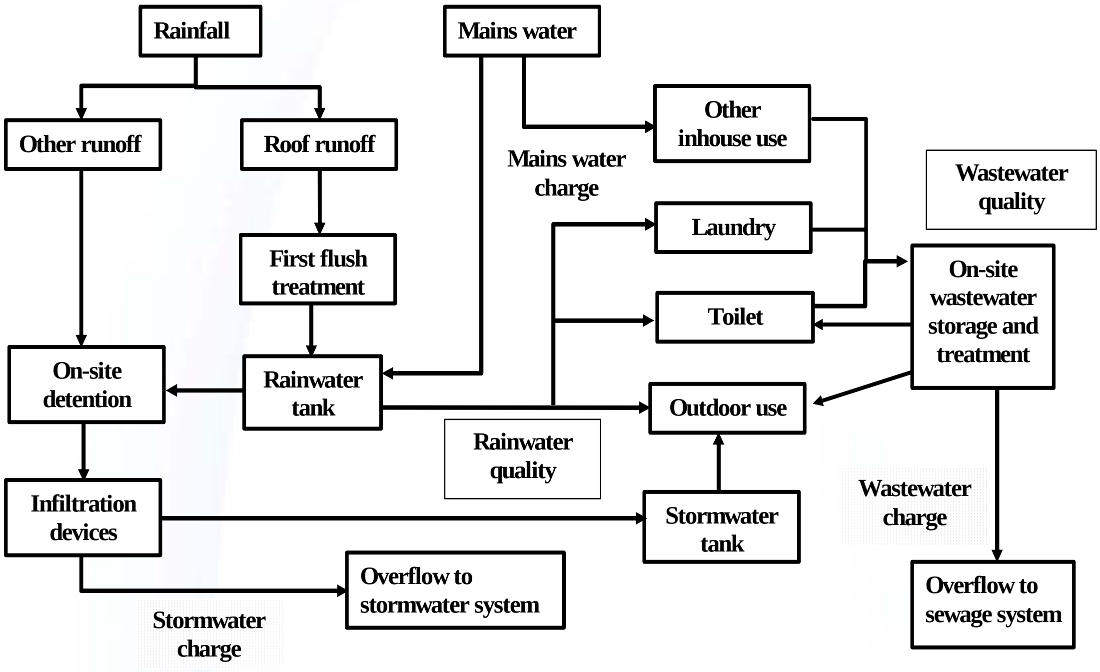

Figure 5.15: Example schematic of the basic processes in the PURRS water balance model

Figure 5.15 shows one of the many combinations of water cycle solutions that can be utilised within the PURRS simulation framework.

Considering outdoor water use

The variability of outdoor water use for various household types in different climate zones is not usually measured. In a rare study of household water use, Coombes[31] analysed indoor and outdoor water use in 192 houses across 5 climate zones and 12 years in the Hunter region of New South Wales and derived a relationship for estimating monthly average daily outdoor use:

$$OutdoorUse = 7.53M - 11.3AveR - 0.025Inc - 0.816Rdays + 24.44G + 19.08AveT - 251 \quad (5.1)$$

where M is a seasonal index with values from 1 to 6 (January and December = 1; June and July = 6), Inc is the average income of people in the household, AveR is average monthly daily rainfall, G is annual population growth, Rdays is the number of rain days in each month and AveT is the average monthly daily maximum temperature.

This research provides some insight into the behavioural drivers of outdoor water demand. Outdoor water use was found to be independent of household size and garden area but was strongly correlated with climatic variables, measures of dryness, seasonal and socioeconomic variables. Importantly, the research revealed that the magnitude and sequence of outdoor water use is variable.

Climate and demographic information from each zone was used in Equation 5.1 to provide an initial estimate of average daily outdoor water use. Importantly, Equation 5.1 also provides information about the likely temporal pattern of outdoor water use.

[31] Donovan I. and P.J. Coombes, (1998; 1999 and 2001). WSUD discussion paper, Practice Notes and Water Smart Planning Provisions. The Hunter Regional Organisation of Councils. NSW. Australia.

Outdoor water use is not a constant proportion of household water use throughout a year. As such the use of average proportions of outdoor water use in analysis of decentralised water management strategies will not provide a reliable understanding of the performance of measures at the household scale and, indeed, across the region. Equation 5.1 has been utilised to estimate the average proportions and the temporal patterns of outdoor water use for input to the water demand algorithms employed in the PURRS water balance model for this study.

It is should be noted that the water demand algorithms used in the PURRS model allow for climate generated daily and diurnal variation of water demands that use information from equation 5.1 as conditioning variables. The magnitude of the monthly outdoor water uses estimated using Equation 5.1 are then calibrated to measured local values provided by the North East Water to ensure that the annual average volumes of outdoor water uses are consistent with local behaviour. It is clear that there is limited knowledge of the magnitude and patterns of outdoor water demand. More comprehensive monitoring programmes are required to allow understanding of outdoor water use.

The Outdoor Water Use Model

Domestic outdoor water use such as garden watering, car washing and filling of swimming pools is seen to be a recreational pastime that is dependent on human behaviour. Outdoor water use behaviour is significantly modified by human reaction to daily temperature, days without rainfall and rainfall depth. The probability of outdoor water use is expected to increase as the length of a period without rainfall increases and the volume of water used is a function of temperature and normal water use patterns (the monthly average daily demand defined by Equation 5.1). People are more likely to use water outside of the house when it is hot and dry, and in accordance with habits.

Garden watering, particularly vegetable gardens can be a seasonal use and will depend on geographic location, cultural authenticity, and socio economic factors.

During a day with rainfall there is a smaller probability of water use and the volume of water used is dependent on the rainfall depth. There is a chance of outdoor water use when people perceive rainfall depth to be insignificant and, conversely, when rainfall depth is perceived to be large there will be no outdoor water use. When that rainfall depth is sufficiently high, people may not use water outside of the house for a number of days. These behavioural considerations have been formalised into a probabilistic framework[32] that drives the daily simulation of outdoor water use. This climatic behavioural simulation approach is used in the PURRS model.

Considering indoor water use

Knowledge of the magnitudes of indoor water uses for a different household sizes across a variety of demographic and socioeconomic profiles is also limited. This investigation also utilised relationships from a comprehensive long term study of household water uses[33] to estimate monthly daily average indoor water use inDem for a variety of household sizes in different regions:

$$inDem = 27.79 + 145.69P - 0.42M - 10.58AveR + 6.7Rdays - 0.16Inc - 12.28G + 0.49AveT \qquad (5.2)$$

[32] Coombes P. J., G. Kuczera and J.D. Kalma, 2000. A behavioural model for prediction of exhouse water demand, 3rd International Hydrology and Water Resource Symposium, 793-798, Perth, Australia.

[33] Coombes P.J., (2002). Rainwater tanks revisited – new opportunities of integrated water cycle management. PhD Thesis. The University of Newcastle. NSW. Australia.

where P is the number of occupants in a dwelling.

Indoor water use was found to be strongly dependent of household size and also demonstrated some correlation with climatic variables, measures of dryness, seasonal and socioeconomic variables. The research also revealed that the magnitude and sequence of indoor water use was also variable. Indoor water demand from different household sizes was estimated using Equation 5.2.

The estimated water demands using equation 5.2 reveal that the magnitude of indoor water demands is strongly dependent on household size and displays some seasonal variation. In addition, the relationship between household size and indoor water demands is not linear. These phenomena are consistent with the observations from recent research into household water use.[5,6,34,35.]

Equation 5.2 was used to estimate the magnitude of indoor water demands for different household sizes throughout North East Victoria for use in the PURRS water balance model. The indoor water demands estimated using Equation 5.2 were then calibrated using locally available measured water demands provided by SWC to ensure that simulations of indoor water demands are consistent with local behaviour.

The water use algorithms were then calibrated to observed water use in dwellings throughout the region. Note that the observations of residential water use were derived from rolling metering programs that do not directly measure sequences of water use.

It is important to highlight that there are limited measurements available to determine the magnitudes and patterns of indoor water uses in different sized households. Urban metering, monitoring and measurement practices need to be modified to improve understanding of household water use behaviours. Nevertheless, the likely water demands for each household in a given area can be approximated using the available observed data and some informed assumptions based on the equations presented in this report. Distributions of household size and dwelling types for each SLA were obtained from the ABS, and the average household water demands were provided by North East Water. This information can be used to disaggregate average water demands for an area into the likely water demands in each household.

The indoor water use values derived using Equation 5.2 for different household sizes and outdoor water use were combined with climate data in the water balance model PURRS. The performance of each different household was simulated. The simulated values for average annual indoor use for each household size are utilised to adjust the input values for indoor use so that the combined simulations equate to the previously calculated value for average indoor use. Similarly, the outdoor water use inputs to the model are adjusted to ensure that simulated long term average values for outdoor use equal the previously calculated values for average outdoor use.

It is important to note that the water demand algorithms in the PURRS model allow for climate generated daily and diurnal variation of water demands that use information from equations 5.1 and 5.2 as conditioning variables. The PURRS demand algorithms allow for daily and diurnal variation of water use whilst maintaining the expected long term volumes of water use.

Indoor water end uses

Simulation of daily indoor uses in the PURRS model are based on the values estimated using Equation 5.2,

[34] Cui L., M. Thyer., P.J. Coombes and G. Kuczera, 2007. A hidden state Markov model for identifying the long term dynamics of indoor household water uses. Rainwater and Urban Design 2007 Conference. Sydney Australia.
[35] Thyer M., M. Hardy., P.J. Coombes and C. Patterson, 2007. The impacts of end use dynamics on urban water system design criteria. Rainwater and Urban Design 2007 Conference. Sydney Australia.

diurnal patterns and a distribution of household indoor water uses into kitchen, laundry, toilet, bathroom and hot water uses. In this study the distribution of indoor water uses from the Yarra Valley Water area reported by Roberts[36] were modified for use in PURRS as shown in Figure 5.15.

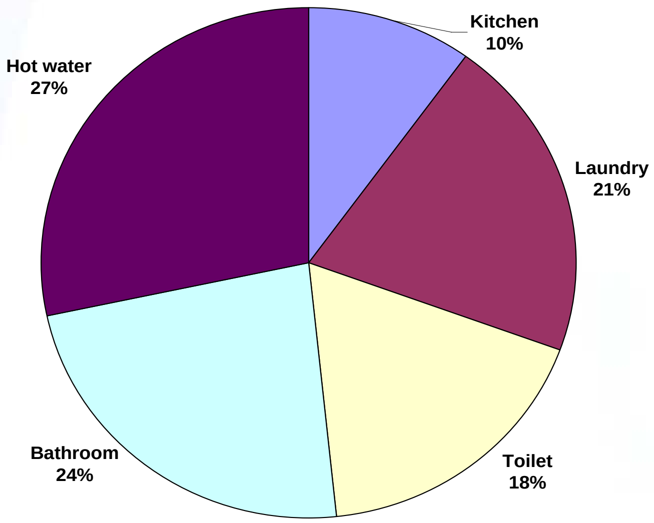

Figure 5.15: Distribution of household indoor water uses

The water use algorithms were also used to generate sewage discharges from each household and non-residential building throughout the region.

The proportion of indoor use via hot water services was determined to allow understanding of strategies that utilise the water quality improvement characteristics of domestic hot water services and to fully understand the potential to reduce the energy use for heating water by use of water efficient appliances. The water use algorithms were also used to generate sewage discharges from each household and non-residential building throughout North East Victoria.

The simulation of the performance of each dwelling cluster was assumed to include half of the road frontage to the allotment to account for stormwater runoff from the urban area. Dimensions of the dwelling clusters used in the simulations are presented in Table 5.12.

Table 5.14: dimensions of residential clusters used in the analysis

Dwelling type	Lot area (m^2)	Roof area (m^2)	Impervious area (%)	Outdoor use factor	Number of dwellings
Detached (BAU)	700	100	70	1.0	1
Semi detached (BAU)	500	100	70	0.1	1
Units (BAU)	2,000	600	90	0.05	10
Detached (small towns)	2,000	250	70	1.0	1
Semi detached (small towns)	1,000	120	70	0.1	1
Other (small towns)	2,000	600	90	0.05	10

Table 5.14 shows that individual detached and semi detached dwellings, and clusters of ten units were analysed. The roof areas of dwellings that were included in alternative water strategies within towns with

[36] Roberts P., 2006. End use research in Melbourne suburbs. Water. Australian Water Association. 51-55.

reticulated water services were set at a maximum value to account for limitations on rainwater harvesting strategies. The stormwater harvesting strategies in the alternative strategies collects stormwater from all impervious surfaces. Note that the outdoor use factor accounts for the proportion of outdoor use at a detached dwelling that can be expected for other types of dwellings.

Non-residential water demands

This investigation has also included non-residential water demands from each of the zones. The proportions of water demands from residential, commercial, industrial and other sectors for North East Victoria is shown in Table 5.11.

Non-residential water demands are a significant proportion of the total urban water demand in the North East Victoria. The non-residential water demands from each zone that were included in this investigation are shown in Table 5.11 that shows that annual volumes of non-residential demands vary considerably across the region. In addition, urban water systems throughout the region are subject to relatively high losses.

Non-residential water demands were also simulated using the PURRS model that also accounted for alternative strategies for the non-residential sector. Water use information was collated with summaries of business categories (such as the Census of Land Use and Employment) and information about numbers of connections from SWC to estimate the land use and numbers of non-residential connections in each zone. Non-residential water demands were assumed to increase at the same rate as growth in total residential connection in each zone.

5.6 The transition framework

A transition framework was used to generate daily water cycle responses for each zone as shown in Figure 5.16.

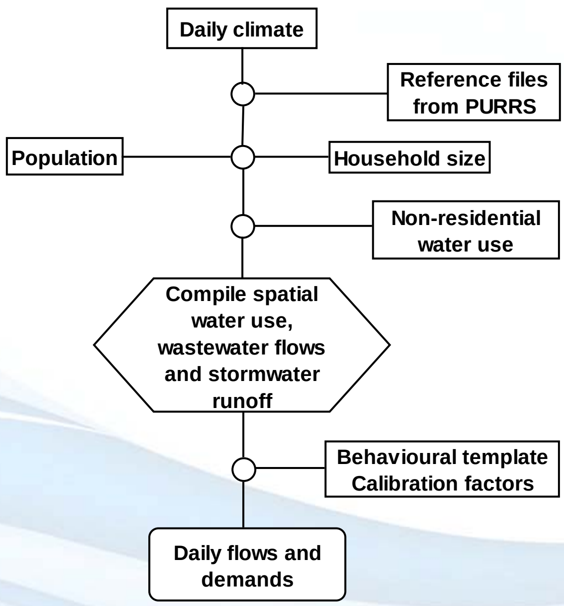

Figure 5.16: The transition framework

Sequences of daily water balance results from the PURRS model were compiled using seasonal information and historical climate data including daily rain depths, cumulative days without rainfall and average daily maximum ambient air temperature to create resource files of water demand, wastewater generation and stormwater runoff. The method of non-parametric aggregation[38] was utilised to generate daily water use, generation of wastewater and stormwater runoff for each dwelling type in each zone using the historical resource files and climate replicates generated for the simulation of the regional system.

At each time step climate variables from the regional model are used to find matching climate variables and coincident daily water use, sewage generation and stormwater runoff results for each dwelling from the resource files. These results are combined with population, non-residential water use and demographic data at each time step to estimate total indoor and outdoor use, sewage flows and stormwater runoff for each zone. The sequences of data from the PURRS simulations are combined in the transition framework using the framework presented in Figure 5.17. Daily sequences of water cycle information; such as water demands, wastewater discharges and stormwater runoff; are combined for different household sizes, different dwelling types and a combination of different water cycle management Options for each strategy in the Transition Model.

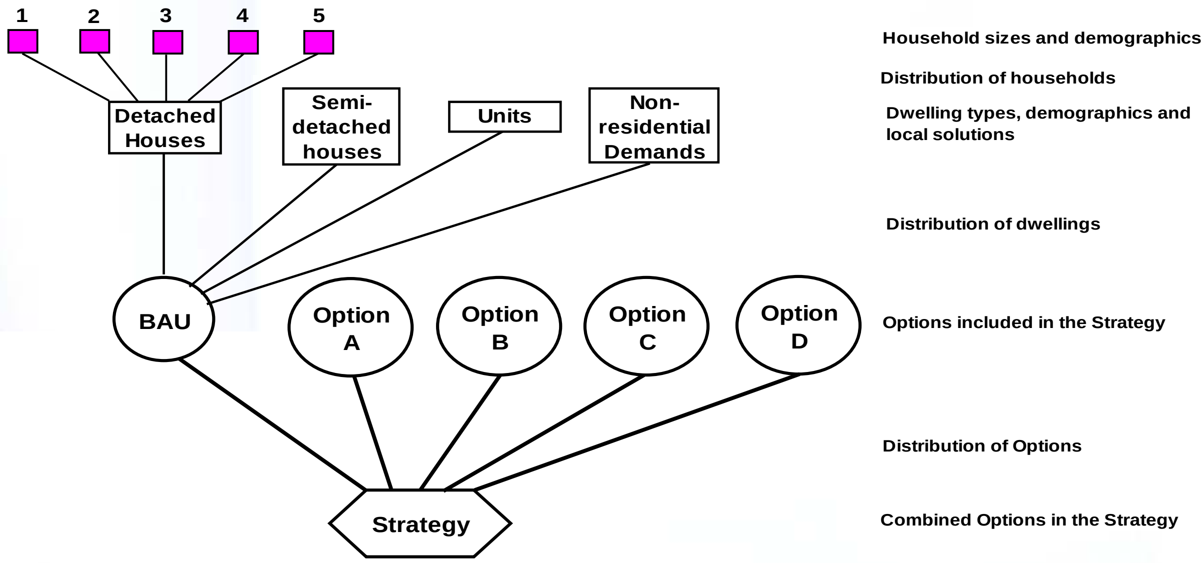

Figure 5.17: Structure for combining different household sizes, dwelling types and water cycle management Options in the Transition Model

The climate variables in the regional systems model were derived using the synthetic climate series generated using historical climate sequences. Importantly the climate replicates are temporally and spatially consistent with the rainfall and stream flows in the water supply catchments.

5.7 Regional systems

The WATHNET network linear program for water supply headworks simulation was utilised to analyse the combined water, sewage, wastewater reuse and waterway networks for each town, water district and river basin. A wide range of spatial information generated by the lot scale analysis was combined in the scale transition framework for use in the systems analysis. The movement of water, sewerage, recycled water

[38] Coombes P.J., G. Kuczera, J.D. Kalma and J.R. Argue. An evaluation of the benefits of source control measures at the regional scale. Urban Water. 4(4). London, UK. 2002.

and stormwater throughout North East Victoria was simulated over a 40 year period using 100 replicates of climate sequences. This allowed analysis of peak flows in trunk infrastructure, assessment for regional sewerage discharges, stormwater runoff and water demands.

The schematics of the trunk water distribution, demand nodes and water supply headworks networks used in this study were provided by North East Water, the North East Catchment Management Authority and Goulburn Murray Water. This information was combined with the author's previous studies and data from the region to construct the major water flow paths employed in the systems analysis. In addition, extensive forensic examination of public documents was untaken to clarify a range of issues and confirm the efficacy of the information used in this analysis. Details of the districts and towns with reticulated water services are provided in Table 5.15. Note that this investigation also includes towns that do not have reticulated water and sewage services.

Table 5.15: Water supply districts in the North East Region of Victoria

District	Towns	Water sources
Alpine	Bright and Wandiligong	Ovens River and Bakers Gully Creek
	Harrietville	Simmons Creek and Ovens River
	Mt Beauty, Tawonga and Tawonga South	West Kiewa River and Simmonds Creek
	Myrtleford	Buffalo Creek
	Porepunkah	Buckland River and Bright
Central	Barnawartha	Murray River (Wodonga Creek)
	Chiltern	Murray River (Wodonga Creek)
	Glenrowan	Ovens River (from Wangaratta)
	Springhurst	Murray River (Wodonga Creek)
King	Moyhu	King River
	Oxley	King River
	Whitfield	Musk Gully Creek * soon to be King River
Mitta Mitta	Eskdale	Mitta Mitta River
	Dartmouth	Mitta Mita River and Lake Tabor
	Tallangatta	Mitta Mitta River and Lake Hume
Murray	Bundalong	Murray River
	Rutherglen and Wahgunyah	Murray River
	Wodonga, Baranduda, Kiewa and Tangambalanga	Murray River (Wodonga Creek)
Ovens	Wangaratta	Ovens River and groundwater bores
Sub-Alpine	Beechworth	Nine Mile Creek, Frenchmans Creek and Lake Kerferd
	Yackandandah	Nine Mile Creek
Upper Murray	Bellbridge	Murray River and Lake Hume
	Corryong and Cudgewa	Nariel Creek
	Walwa	Murray River

Details of the districts and towns with reticulated wastewater services are provided in Table 5.16.

Table 5.16: North East Water wastewater systems

Wastewater System	Towns Serviced	Discharge Point
Baranduda	Baranduda, Kiewa, Tangambalanga, Killara, Bonegilla (Army barracks)	Wodonga wastewater system
Barnawartha	Barnawartha	On-site irrigation
Beechworth	Beechworth	Spring Creek and On-site irrigation
Bellbridge	Bellbridge	Agricultural irrigation
Bright - Porepunkah	Bright, Porepunkah	Ovens River and golf course irrigation
Chiltern	Chiltern	On-site irrigation
Corryong	Corryong	On-site irrigation
Dartmouth	Dartmouth	Mitta Mitta River
Mt. Beauty	Mt. Beauty, Tawonga South, Tawonga (Bogong Hotel area only)	Kiewa River
Myrtleford	Myrtleford	Ovens River
Rutherglen - Wahgunyah	Rutherglen, Wahgunyah	Agricultural and public open space irrigation
Tallangatta	Tallangatta	Agricultural irrigation
* Walwa (Hybrid STED)	Walwa	Sub-surface irrigation sports ground.
Wangaratta	Wangaratta	On-site, agricultural and public open space irrigation
Wangaratta (Trade Waste Plant)	Wangaratta (Bruck Textiles and Nuplex)	Fifteen Mile Creek
Wodonga	Wodonga	Murray River and industrial reuse and public open space irrigation
Yackandandah	Yackandandah	On-site irrigation

* This scheme is largely complete and operating. It is subject to final inspections and handovers

5.8 Economic considerations

When considering the economics of the system it is important to account for the economic transfers within the system. Broadly, they can be described as economic costs and benefits. There are a number of levels of expenses and revenues, or benefits within a system.

From an economic perspective, there are costs involved in the regional and retail provision of water and wastewater services. There are also associated costs with the impact on the environment of activities such as disposal of wastewater in waterways and oceans, or the impact of constructing a new dam or desalination plant. On the other side of the ledger are a series of economic benefits from the provision of water services. These include the provision of utility and amenity to individuals and society though the provision of water and wastewater services. Benefits are also derived by returning water to certain environments and ecosystems. It is important to holistically consider all of these economic costs and benefits.

Our economic analysis evaluated the detailed transactions involved in the transfer of services from the bulk water supplier to water retailer and North East Victoria with consequent charges (revenue earned) for these services. In addition, the economic analysis considers the impacts of stormwater runoff and sewage discharges to water quality in waterways, and on urban flooding.

It is important to consider both the economic and financial aspects of the provision of services when undertaking a systems analysis of the provision of water services. The economic analysis includes the revenue earned by North East Water from developer, fixed and variable charges to connected properties in each zone for water and wastewater services.

Delivery of these services has been defined as extension, renewal, transfer and treatment costs of operating the water and wastewater systems. The foundation elements of these expenses and revenues are imbedded in the dynamic analysis of the spatial economics for water and wastewater services as shown in Figures 5.18 and 5.19 respectively.

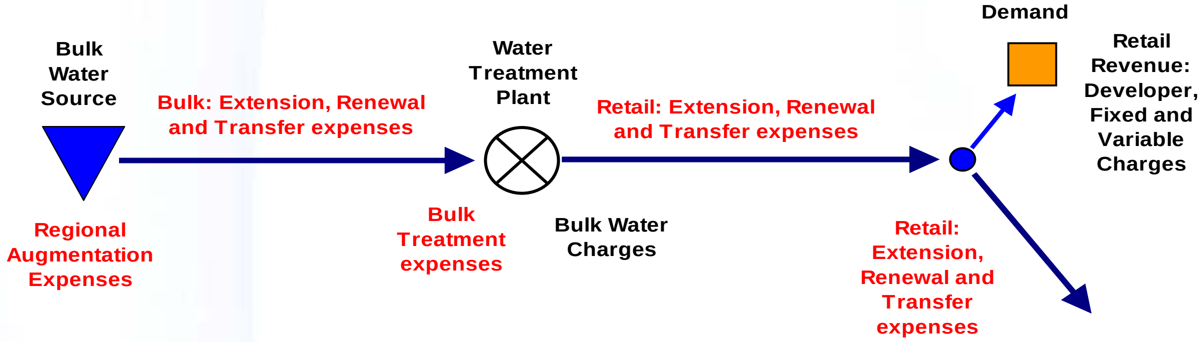

Figure 5.18: Foundation elements for water systems in the dynamic economic analysis

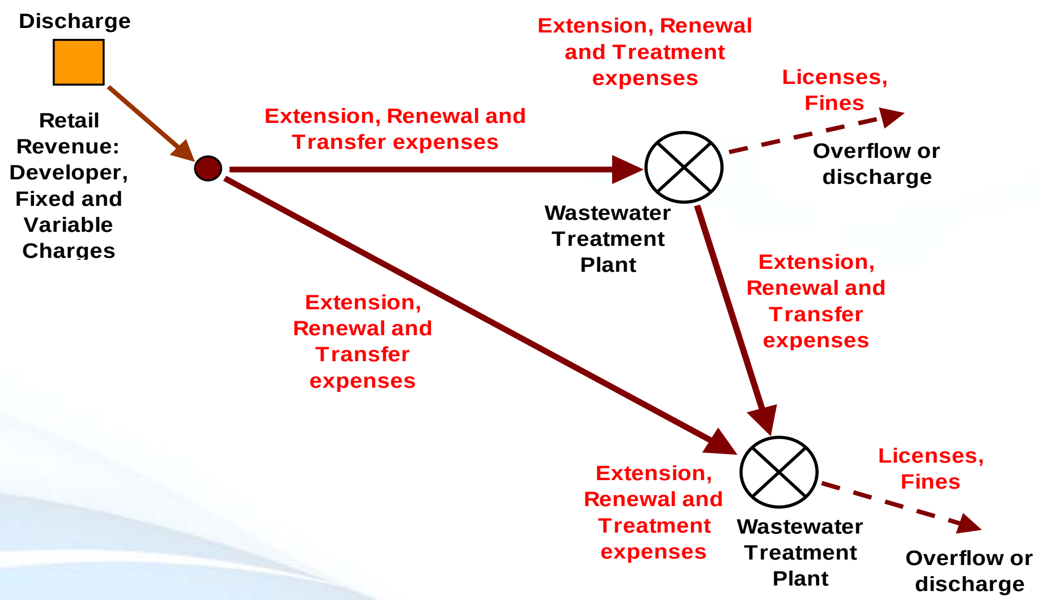

Figure 5.19: Foundation elements for wastewater systems in the dynamic economic analysis

Figures 5.13 and 5.14 demonstrate that extension, renewal and transfer costs are included in the spatial systems analysis for each of the basic transfer elements in the network. Transfer of water from one location to another requires the use of infrastructure and a range of associated resources that are included using this methodology.

Note that the costs associated with transfer of additional flows in the sewage networks generated by infiltration of stormwater are also included in this method. Moreover, the financial impacts of alternative water strategies that may have some reliance on the existing centralized network are also counted in this method – failure to supply sufficient water from (say) a stormwater harvesting system at a given spatial location will require additional water supply from the centralized system which may generate a requirement to augment the central systems and incur extension costs.

Extensions, renewals, transfer and treatment costs have been derived for each area from local information wherever possible as follows:

- **Extensions** – The cost to augment infrastructure to meet each additional unit of demand
- **Renewal** – The annual cost of renewing (or replacing) existing infrastructure for each unit of demand
- **Transfer** – The local costs to transfer water and sewage throughout the system
- **Treatment** – The local costs to treat water and sewage throughout the system

The economic analysis also includes bulk water charges levied by the Goulburn Murray Water, dividends payed to the Victoria Government (determined to be 13% of gross revenue), Company taxation (defined as 30% of profit), augmentation of wastewater treatment capacity and management of biosolids.

In addition, provision of these services includes the costs of augmentation of local and regional water supplies. Throughout the analysis financial values are their real value. Long time sequences of financial transactions presented in the Methods section for illustrative purposes are the nominal value.

Key data sources and assumptions underpinning the economic analysis

A number of data sources have been used in the development of this economic analysis as follows:

- “water price review 2009-10 to 2012-13” and supporting documentation published by the Victorian Essential Services Commission (ESC)
- “2009-10 National Performance Report - Urban water utilities” published by the Water Services Association of Australia
- “North East Water Annual Report 2010-11” published by North East Water
- Confidential data provided by North East Water
- Interviews conducted with key persons in the wider field of the potential introduction of alternative water services in Victorian country towns, November - December 2012.

Information from the 2010-11 financial year has been used wherever possible in the development of the economic analysis. Alternatively, information from the 2009-10 year has been used and calibrated to enable comparative analysis. Key assumptions are listed below in Table 5.17.

Table 5.17: Assumptions underpinning economic analysis

Category	Criteria
CPI	2.5%
Base year	2010
Discount rate	9%

5.9 Constituents in wastewater

A range of wastewater quality indicators were also used to analyse the performance of the Options including Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Nitrogen (TN). The median concentrations of each indicator were derived using sampling results from 20 wastewater treatment plants as shown in Table 5.18.

Table 5.18: Base concentrations of key indicators

Indicator	Concentration (t/GL)
BOD	247
TSS	294
TDS	429
TN	44

The values for the key indicators shown in Table 5.18 were used to analyse the changes in constituent loads discharging to existing wastewater plants and waterways.

5.10 Greenhouse gas emissions

The potential for climate change will have significant impacts on human and natural systems. There is a need to adapt our cities to be resilient in response to climate change and to reduce emissions of greenhouse gasses to mitigate further changes in climate regimes. This study has evaluated energy uses of key water cycle infrastructure to assess the impacts of each Option on greenhouse gas emissions. The translation factor of 1.26 kg CO_2 for each kWh of energy use for Victoria published by the Department of Climate Change was utilised in this analysis.[39]

Our analysis includes the spatial energy characteristics of sourcing, transporting and disposing of water and sewage throughout North East Victoria. Information about the energy use of various elements of the Options were utilised from a wide range of sources for use in this investigation including: Benchmarking report published by the National Water Commission, data provided North East Water, research publications and the annual reports.

The energy balance for the region was combined with a range of published results for different elements of the water cycle to generate energy use for the range of elements evaluated in this study as presented in Table 5.19.

[39] Department of Climate Change (2009). National Greenhouse Account Factors

Table 5.19: Energy use of various elements of the water cycle options

Item	Energy use (kwH/ML)
Water treatment (average)	259
Water distribution (average)	257
Wastewater treatment (average)	432
Wastewater distribution (average)	65
Membrane Bioreactors	750
Rainwater and stormwater harvesting distribution	900
Treatment of rainwater and stormwater	500
Distribution of treated wastewater	250
Water efficient appliances	-9.9

The values for energy use from Table 5.19 were used in the systems analysis to provide understanding of the greenhouse gas emissions associated with the different Options for water cycle management in North East Victoria. The energy use of the precinct scale MBR plants was estimated to be 750 kWh/ML and the energy required to distribute the treated wastewater was 250 kWh/ML.[40,41] Note that the energy use of MBR plants in Europe and Singapore range from 550 kWh/ML to 900 kWh/ML.

Importantly, the economic and energy efficiency of MBR systems are subject to ongoing improvements.[42] It is often claimed that MBR systems use more energy due to a requirement for air scouring of membranes. However, the energy efficiency of MBR plants is actually a function of overall plant design, operation and downtime.[43] The common practice of designing and establishing MBR plants in the same schematic as traditional wastewater treatment plants (such as IDAL) is a key driver for inefficiencies – MBR plants must be designed, established and optimised as MBR plants to achieve high levels of economic and energy efficiency.

Installation of water efficient clothes washers is expected to reduce energy use by 3.5 kWh/ML of water saved.[44] Energy savings from water efficient showers and dishwashers was estimated to be 6.4 kWh/ML.

[40] Coombes P.J., A. Cullen and K. Bethke (2011). Toward sustainable cities – Integrated water cycle management (IWCM) at an existing principal activity centre at Doncaster Hill. 33rd Hydrology and Water Resources Symposium. Engineers Australia.
[41] Wallis-Lage C.L., and S.D. Levesque (2009). Cost Effective and Energy Effiecent MBR systems. SIS09.
[42] General Electric (2011). GE's next generation MBR wastewater treatment system slashes energy use, boosts productivity.
[43] Livingston D., and K. Zhang (2011). Energy efficiency of MBR. Water and Wastes Digest.
[44] PMSIEC (2007). Water for Our Cities: building resilience in a climate of uncertainty. Section by Coombes on household energy use. Report by the Prime Minister's Science, Innovation and Engineering Council working group. The Australian Government. Canberra.

6 Results and Discussion

The results of the systems analysis of climate, demographic and water cycles throughout North East Victoria are presented in this Section. An explanation of climate processes and the potential of water cycle management Options to manage sullage and sewage at allotment and town scales are provided for selected small rural towns throughout North East Victoria. This unique systems analysis has provided a wealth of information about the behaviour of the North East region that will continue to inform discussion for some time. An overview of the key insights and discussions generated by the analysis are provided in this Section.

In addition, this Section provides an overview of the insights, discussions and recommendations resulting from a range of interviews with stakeholders and parallel investigation of issues relating to provision of services to small rural towns.

6.1 Barriers as perceived by key experts

A series of interviews has been conducted with key persons in the wider field of the potential introduction of alternative water services in Victorian country towns. Three interrelated issues areas emerged as key concerns and perceived barriers:

- Lack of knowledge about the technical and practical options in the available alternative systems.
- A perceived reluctance of future users to accept alternative solutions
- The institutional settings (local government and water authorities) do not encourage the introduction of alternative systems but tend to embrace wherever possible conventional (reticulation and wastewater treatment plants).

All three issues reflect the reluctance of government institutions to enter a field of onsite wastewater services which traditionally had been largely left in the hands of individual homeowners and a relatively loose framework of planning rules and instruments. The resulting high levels of onsite systems that fail to meet expected standards are largely the outcome of years of neglect by government in promoting an awareness of standards and risks within those areas where onsite systems provide essential wastewater services. Victoria and Australia share this experience with a number of countries within the European Community and the USA. Ireland provides the most spectacular example.

The Victorian institutional settings do not encourage water authorities or local government to set up arrangements which could provide quality control of existing and new systems. This process also does not allow fit for purpose local systems which overcome the problems associated with systems, including:

- localized common treatment,
- joint infiltration beds,
- separation of grey and black water in onsite systems,
- rainwater capture on public land,
- a higher degree of water security during drought periods.

In order to achieve such an integrated approach to provision of water services a new organizational or structural model will be needed which can provide expert advice and management for example to also match infiltration methods better with locally prevailing soil types. Though the actual installation and management of small scale local systems can be provided within contracts by the private sector or local town based consortiums, there may be a need for the overall management supervision by the regional water authority.

This low cost, fit for purpose and responsive to local conditions approach in catering for local needs will require a new organizational unit within regional water authorities or the state bureaucracy. Staffing of such an organisational unit will be quite distinct from currently established areas as the management of integrated water services will require a set of professional areas of expertise that are well beyond the traditional profile of water authorities. The development of a delivery organisation for a new business of provision of alternative water services could well be part of a new business unit of a respective regional authority. The Victorian Auditor-General highlighted this issue in 2006 when challenging the regional water industry's lack of commitment to competition.

Salisbury Council is South Australia is a good example of a local government catering for local needs, re-appraising its business model and core business. Salisbury Council has set up an extensive storm water treatment and harvesting project, initially to service its own civic needs, but now with nearly 600 customers. This is in competition to the water provided by the local water authority.

Competition should include examining opportunities for further developing business. The Auditor General blamed the lack of competitive elements in the establishment of Victorian water institutions and the expert respondents to this study expressed similar views.

The Auditor General also commented that a lack of availability of new technology was a constraint on the efficiency and effectiveness of the regional water corporations, 'NMUs are often too small to allocate significant resources to developing new technology. Joint funding of research and investigations in regard to the utilisation of new technology could overcome this constraint'.[45]

The findings of the AECOM[46] review in regard to operational and management skills in small organizations influenced their views that local government might not be the vehicle because of size and the structure of their workforce.

Respondents suggested that water authorities should be encouraged to provide these alternative services through a new business unit. Alternative services would need the formal recognition as a 'business' within the organization. Water authorities need to offer recognition and careers separate from the traditional areas in reticulated water and sewerage. In order to provide a competitive element it was suggested that new business units could operate on state wide basis thus providing for competition among the government authorities.

The development of a new business focus within a water corporation may also create an environment in which third parties would be willing to enter the market and offer similar or alternative service packages to the householder.

[45] Auditor-General Victoria (2006) Protecting Our Environment and Community from Failing Septic Tanks,
[46] AECOM (2010) Review of Regional Water Quality and Security prepared for Infrastructure Australia

6.2 Assumed restrictions to new services.

The Victorian non-metropolitan water corporations, in contrast to other States, are not local government entities but are stand alone corporations that provide water services within their respective designated regions.

The Victorian Government has issued statements of obligations or statement of services (SoS) for each of the water corporations, which outlines the key duties in regard to the supply of water services. Basically the obligations refer to those water services which are already supplied by the corporation and those services which are in the planning stage.

The statement of obligations does not impose a requirement to service smaller country towns and settlements but leaves the extension of services or the provision of new services largely at the discretion of the corporation. This situation is widely seen as recognition of the status quo that water authorities limited their activities to those services and locations in which they are already active and do not actively pursue new activities out of the traditional range. This restraint, however, is more in the nature of a self-imposed restriction than a necessary by product of the actual framework for the operations of water authorities.

However, the statement of obligations imposes a number of sustainability considerations on the corporation which relate to the use of water in a sustainable manner as well as responding to regional needs. In addition there is special reference to the need for innovation. The authority is obliged to prepare a water plan for its area which is to reflect the obligations as well as the way the organisation addresses the future needs within its area of responsibility. Obviously the range of obligations includes efficiency in its operations and clearly formulated frameworks for sound financial management.

However, the SoS cannot be seen as a major barrier to the extension of water services into areas that previously had not been services by the authority or into technical areas which did not form part of the established service pattern. This implies that there is no obligatory barrier imposed that might prevent a water authority's involvement in decentralised wastewater treatment or in the supply of drinking water from decentralized systems such as networks of rainwater tanks.

It might appear to be surprising that water corporations in non-metropolitan Victoria have been so reluctant in becoming involved in the water services problem of smaller country towns and larger rural settlements, given the obvious problems which exist in the three areas of drinking water supply, wastewater management and finally mitigation of stormwater runoff. All three areas have been the subject of intensive work over decades in metropolitan Melbourne and the major regional cities but these experiences appear to have little or no impact on smaller country towns.

In the past drinking water, waste water treatment and stormwater have been considered separately and not as a one resource approach. The statement of obligations could be an opportunity for future Government leadership and direction to allow more sustainable outcomes for the entire community. These could become key performance objectives for Water Authorities.

6.3 The culture of established methods and practices

The Victorian experience with the introduction of alternative water services resulted in a very low take up rate by councils and water authorities.

Our interviews with key decision makers have shed some light on this phenomenon. Practically all persons interviewed emphasized the culture of low risk that prevails in local government and regional water authorities alike.

But a separate argument seemed to be as important as the 'no change cultural' argument. Respondents were of the opinion that there is a lack of any organizational structure to support innovative water services projects and a commonly held opinion that this might well be another temporarily fashionable argument which after a short period would fade away. Consequently there is no organizational advantage in embracing novel approaches. This is exacerbated by the fact that the public may be in possession of even more limited information than local government officials or employees of water authorities. Respondents speculated that alternative water services are seen as a kind of hobby activity while real substantial services rely on pipes and major capital works.

Demonstrated ongoing leadership in this area will be required at both governmental and community level.

Experiences on the public debate in a number of small towns on the relative merits of alternative services and traditional sewerage schemes point to a general preference by local residents for traditional services. This has been accentuated by the respective water authorities supporting traditional reticulated services for the projects and providing the majority of capital costs.

Respondents highlighted that alternative services had few local champions when water authorities advocated reticulated services. Given that the high capital cost were largely born by the water authorities the true cost of providing these services to small communities were not part of local debates.

A Victorian example is Birregurra. In November 2011, Barwon Water indicated a cost of $12 million for the Birregurra scheme,[47] which is nearly double the original estimated cost. Birregurra is a small town of 300 dwellings and the scheme will provide opportunity for further development of the town. The residents of Birregurra will contribute $800 for each residential allotment to the capital cost of the offsite project costs and then the full amount of their own onsite connection costs. The customer base of Barwon Water will service the capital borrowings for the project via increased tariffs. The residents of Birregurra are unlikely to have considered the full cost of the project in supporting the preferred option proposed by Barwon Water.

Local residents do not commonly have access to detailed information about costs and performance of alternative methods and often follow the advice of local government and water authorities that advocate for reticulated services.

6.4 Lack of appropriate business models for innovation

There has been no known attempt by regional water corporations to develop business models for provision of appropriate alternative sewerage and water security services to small towns in Victoria.

There are no or very weak incentives to water corporations to provide innovative low cost solutions to country towns. In fact greater incentives are presently provided for the provision of reticulated systems and for seeking cross subsidisation to service borrowings. Tariff increases are mostly accepted by Government and the Essential Service Commission without challenge where there has been a Government commitment to providing services such as the Country Town Water Supply and Sewerage Program.

[47] Barwon Water (November 2011) *Birregurra Sewerage Scheme*

The Victorian Competition and Efficiency Commission[48] recently indicated that the productivity and innovation of the urban water industry could be improved by, amongst other things, reforming the water sector to encourage greater competition led innovation and productivity growth. A closer analysis of recent statements and the determination leave the impression that 'innovative' schemes would be supported.

6.5 Interaction between application of planning rules and provision of water services

Although there seems to be no serious problems in the interplay between council planning determinations and the specific requirements of fit for purpose alternative water service schemes, a wide scale introduction of alternative services might well create tensions.

Given the need for training of staff and a public awareness campaign, a joint handbook of best practice should be developed jointly by DSE and the Department of Planning and Community Development (DPCD) in consultation with local government.

There is a requirement for site specific development of alternative schemes and the establishment of on-going comprehensive management programs. It will be necessary to carefully develop tools for local government which allow councils to be a partner in developing new systems for country towns. Issues such as proper siting, design, construction, maintenance, the use of public lands, development of cluster systems and ongoing monitoring will require a high degree of interaction between the provider of water services and local government.

In the United States and within the European Union there has been concern that while large urban centralized systems have been effectively managed and monitored, small rural decentralised wastewater systems are often not subject to management or monitoring. The European Commission recently drew attention to this very problem in the conflict with the Irish Republic.

6.6 Inadequate Training

The expert respondents pointed to the barrier of knowledge and expertise about alternative systems within the Victorian regional water authorities. The report noted the astoundingly limited knowledge of the wide range of available wastewater systems. This problem is aggravated by the lack of training courses offered by tertiary institutions about alterative systems.

Standard engineering courses pay little attention to alternative systems. As a consequence of this neglect it will be necessary to set up training courses for staff that will eventually have to deal with the systematic implementation of alternative systems. A comprehensive program to service small country towns with alternative systems that takes advantage of the substantial cost and maintenance discrepancy between reticulated traditional systems and fit for purpose alternative systems will require considerable knowledge.

The dimension of a future training requirement for a regional water authority staff cannot be underestimated. Perhaps this is easier to understand when we consider the problems country water authorities are still having in supplying water services with standard quality. A recent study by AECOM[49] for

[48] Victorian Competition and Efficiency Commission (2011), Securing Victoria's Future Prosperity: A Reform Agenda- Draft Report

[49] AECOM (2010) Review of Regional Water Quality and Security prepared for Infrastructure Australia

the Commonwealth Department of Infrastructure showed major deficiencies in the application of water quality standard especially within smaller water service providers in Queensland and NSW.

The report describes the level of skills and training of the work force as key elements for quality improvements in the operations of water services in country areas. The combination of low skills, the lack of an appropriate career structure as well as the underdeveloped nature of supervisory systems with underdeveloped reporting systems and data collections are seen as major impediments to the delivery of better quality water services. Although Victoria has been singled out for some praise for its quality of service, the general picture emerging from the report is less is than flattering for the water industry.

The lesson to be drawn from the report rests in the need to create training for staff. Training will have to start from a low knowledge and awareness base. The water industry has been running small drinking water systems for more than a century and today we find that some basics are still not being applied. Any new system will require training and probably some level of professional certification at early stages.

6.7 Stakeholder discussions and workshops

This investigation also included discussions with a large number of stakeholders, including residents in towns, and workshops convened by the North East Greenhouse Alliance. An overview of key issues raised in these discussions is incorporated with review of public documents in this Section.

Public and environmental health issues of septic systems

Most reports on country towns claim that onsite septic systems present “health and environmental’ risks. The performance of septic systems can be occasionally problematic. However, correctly implemented onsite systems often provide adequate services. An assumption that onsite septic systems create widespread or even common environment or health problems is misleading.

Assumptions about the failure of onsite septic systems need to be modified by clarification of the definition of failure that also accounts for the severity of the consequences of an apparent failure. For example, a perception of failure of an onsite system is created when the system is not operating as designed or creates odour or runoff of effluent or sullage from the property. Representatives from local government maintain that a complaint about a system from (say) a neighbour is a failure of the system.

Is infrequent odour or runoff containing effluent from a property a health risk or an amenity problem? These issues are commonly reported as health problems. However, there does not appear to be any deaths or notifications from medical practitioners reporting illness as a consequence of onsite septic systems. However, discussions have noted that in a broader sense odours can impact health and there is also social wellbeing to consider. It is also a concern that poorly defined discussions about apparent failure of onsite systems can prevent allocation of funding. Claims of major public health problems can be met with disbelief in the absence of clear evidence. Correct and unambiguous definition of failure of onsite systems will allow identification the actual problems in any area and the provision of cost effective solutions.

Maintenance and Enforcement

There is uncertainly about the frequency of maintenance of septic systems and diligence of householders to ensure the sludge was periodically removed from septic systems. Clearly an absence of an adequate regime of periodic maintenance which is predominantly removing sludge from Septic tanks contributes to overflows from onsite systems which could be defined as a failure.

It is, therefore, an important to determine who pumps out the septic systems and who decides when this action is required. Onsite systems are not managed by a water authority or local government and reliant on infrequent management interventions by individuals. It was commonly perceived by those in the local and state government that individuals will assume someone else will deal with the management of their onsite systems.

Who will, can or does enforce maintenance of onsite systems?

This question has generated considerable ongoing debate. A common response was to introduce a levy that paid someone else to manage onsite systems as a service to householders. This type of approach has been facilitated by local government in New South Wales.

It has been ten years since Indigo Shire Council established a municipal wastewater plan. The strategy was adopted by council but has never been implemented. Council stated that they cannot levy additional costs on citizens during a drought. In addition, allocating funds to ensure compliance has proved to be difficult in a political environment. This issue was perceived to be similar to swimming pools – councils can't check for compliance with fencing because these actions require additional resources.

However, these discussions highlight that councils already have the necessary jurisdiction over land uses and to collect rates from properties. Local government should include management of onsite systems in the rates levied on properties. It is proposed that Council's may not be actually checking onsite systems but require residents to provide evidence as part of their rates assessment that their onsite system has been inspected by an accredited professional.

However, it was commonly believed that householders would ignore requirements for periodic inspections or maintenance if these requirements are not enforced by penalties. Councils are reluctant to establish centralized management processes because it is perceived that ratepayers do no want to pay for these services. A centralized inspection service will require fees to pay for inspections and the inspections will find issues that need to be resolved with additional expense.

It is noteworthy that citizens are required to keep vehicles roadworthy (especially when a vehicle is sold). Why are septic systems different? This issue is especially relevant for the transfer of ownership of a house that could generate checks to ensure that septic systems are properly maintained.

Discussions have also highlighted important legacy issues that were created by historical design process and attitudes. Many properties include onsite systems that were historically acceptable that are shown to be inadequate by more recent standards and understanding. It is common for the owners of these systems to resist any requirement to upgrade older existing system – "I bought it this way, why should I have to change?"

For example, owners of a large number of properties in Barnawartha refused to connect to new reticulated sewage system. This resulted in considerable debate between North East Water and council about who should enforce connection to the reticulated sewage system. Ultimately no one enforced connection to the system. After six years more than 200 properties are still not connected to the reticulated sewage systems. This was perceived to create significant problems during the recent floods. North East Water don't want to be an enforcement agency and prefer that local councils require property owners to connect to traditional reticulated sewage infrastructure.

What powers do councils have?

Environmental Protection Act states that owners of properties must comply with various conditions relating to discharges from properties. It was perceived that some councils bravely enforce these conditions but most do not.

It was generally acknowledged that the State government needed to implement legislation that allowed councils to act to ensure adequate management of onsite systems. Local government management of onsite septic systems is facilitated by legislation in New South Wales. Do local government require additional powers or do these powers already exist and are not employed?

Local government does have jurisdiction over use of land, including private land. These powers apply to new developments but cannot apply to existing areas. These planning powers also apply for redevelopments. Nevertheless, it is believed that it is too difficult for councils to apply the Health Act even though this Act was potential source of power for enforcement for adequate onsite systems. Councils are (or at least feel) limited in their ability to respond to enforcement of adequate standards for onsite systems. It was commonly stated that local government needs explicit EPA rules or state government legislation.

Bypassing onsite systems

The owners of some properties bypassed their septic systems and discharge effluent directly to waterways. There clearly needs to be consequences of bypassing an onsite system and polluting a waterway. The small size of allotments was perceived to be an issue that results in bypassing of septic systems. However, it was apparent that older systems may have always discharged directly to waterways.

Actions that pollute waterways should evoke a response from the EPA. It was agreed by most stakeholders that many of the relevant organizations deflected or avoided responsibility for actions.

Greywater reuse

The use of greywater was raised as an issue and it was agreed that greywater will require some form of treatment to avoid impacts on waterways and soil profiles. The ongoing use of greywater was likely to increase the salinity of soils due to fillers used in most detergents. Salt fillers and phosphates in detergents can be problematic. It was noted that some countries, such as Canada, have banned the use of fillers in detergents and bathroom products.

The use of greywater on private property was perceived to be an important issue by local government. Some people insist on using greywater for outside uses because they can’t afford the charges levied by North East Water. Nevertheless it was agreed that is difficult to eliminate or regulate use of greywater on private property.

Knowledge and capability

Lack of understanding and knowledge about the design and performance of alternative strategies for management of sewage was an agreed barrier. There are many low cost alternative options but almost no awareness of these opportunities. This problem begins at University for most professionals because these institutions only provide information about traditional reticulated systems.

The designs of small systems are often completed by consultants that utilize junior staff (who have limited knowledge of alternative systems) as a consequence of the low cost nature of the projects which creates a bias towards traditional systems. Many opportunities are also missed due to generalisations in the Australian Standards and design codes.

Land Capability Assessments

Land capability assessments are now used for approving new onsite systems. These assessments are theoretically better than Australian standard. These assessments are often completed by independent certifiers. It was believed that third party certification of onsite systems can be problematic. These assessment services are provided at low cost – therefore often produce quick and often inadequate outcomes. Should councils be approving onsite systems?

Other issues

Some properties discharged sullage to street drainage systems that creates problems with odour in urban settlements. Many onsite systems were developed using older design standards and different perceptions about adequate performance. How do council's respond to a proposal from a council officer suggesting works at a few locations to normalise the behaviour of the town's system, rather than looking at townscale reticulation as a solution? It was believed that such a recommendation was unlikely to be adopted

There are isolated problems with existing properties on small lots or near rivers that generate perplexing issues for local government – "What do you do, tell people move out of the house?"

It was claimed that private certifiers are approving upgrades of onsite systems that don't comply because the alternatives are unworkable. It was agreed that this was a common problem throughout Australia. Indeed, the following sequence of outcomes was seen to apply to the region:

- People don't want to pay to maintain or to upgrade onsite systems
- Thus the isolated local problems cannot be solved, so just put in reticulated sewage system provided by North East Water.
- As a result only a few towns get serviced in state government budget and lower cost alternative solutions are not implemented.
- Many towns with relatively minor problems do not receive any assistance because they are in the midst of do nothing and highly expensive traditional reticulated sewage systems.

The high costs attributed to otherwise low cost alternative schemes in business cases by NEW, DSE and some consultants were seen to be excessive. For example, the estimated cost of $1.6 million for a small STED scheme at Eskdale as reported by NEW was questioned. It was apparent that only costs assigned by DSE or NEW were accepted. The also appeared to be a conflict of interest in the appointment of consultants to recommend alternative options as smaller projects are perceived to generate lower fees.

This issue impacts on the decision making process for lower cost alternatives. It was agreed that councils need more realistic prices before they can act to support alternatives. However, there also needed to be agreement on who would operate such systems, should any or all of the following provide these services:

- North East Water?
- Local government?

- Local Communities?
- State government?
- Private consortiums?

It was a common perception that there was limited desire from North East Water and most councils to operate smaller alternative sewage systems. In addition, each small town in the region has very different characteristics. However, there is a common element in each town of clusters of smaller properties along main streets which require management.

6.8 Climate

This study utilised the longest available daily rainfall records that include the recent drought for each zone within the region. Considerable spatial variation of average annual rainfall depths ranging from 582 mm to 1,818 mm were observed for North East Victoria. This is a significant result that highlights that rainfall regimes cannot be described by average or generalisations.

Analysis of the rainfall sequences at each location revealed a high variability of annual rainfall across the region and the relative reliability of rainfall – annual rainfall depths range from 263 mm to over 3,321 mm and annual rainfall depths of less than 300 mm are rare. Importantly, these areas have not experienced a year without rainfall and the rainfall sequences display cycles of higher and lower rainfall as demonstrated in Figure 6.1.

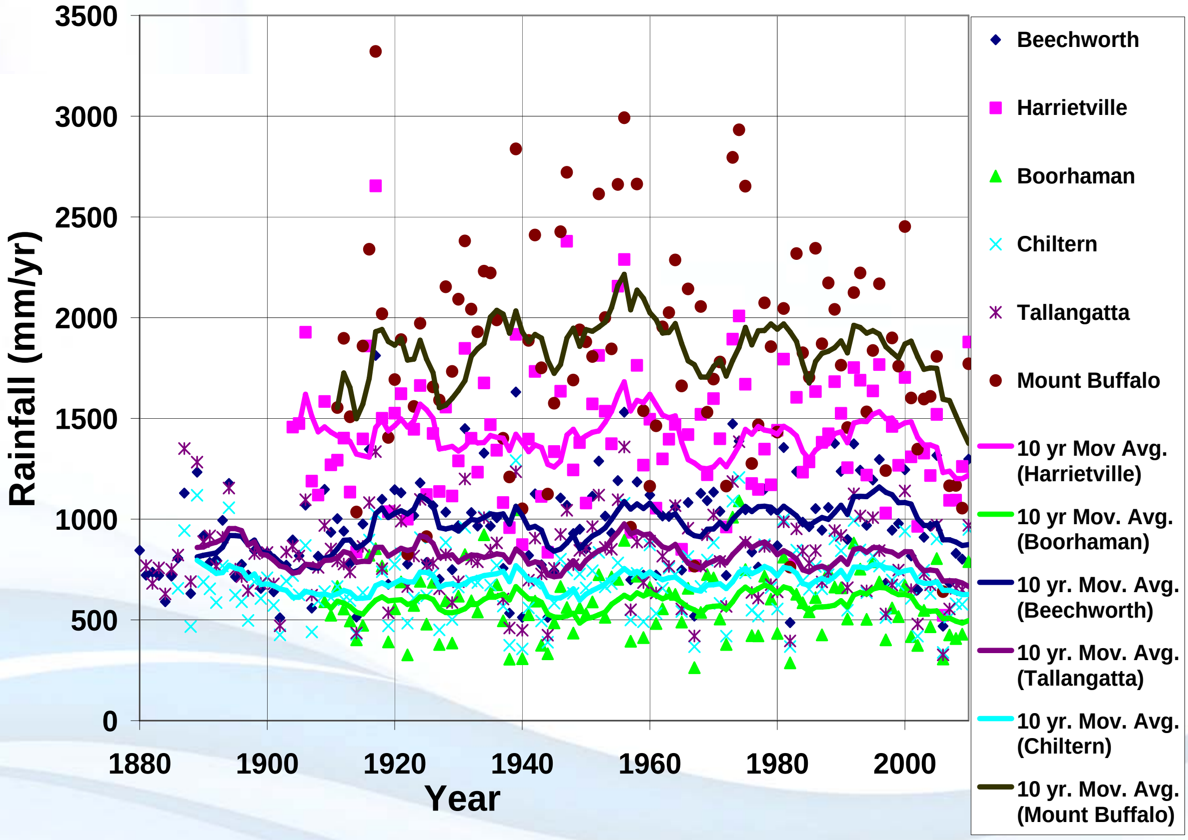

Figure 6.1: Selected rainfall sequences within Metropolitan Melbourne

Figure 6.1 reveals that annual rainfall is highly variable over time and throughout North East Victoria. It is also clear that the region has not been subject to a “step change” in rainfall regimes. The rainfall regime for the region can best be described as cyclic patterns of wet and dry periods throughout recorded history. The rainfall records within the region display a range of long term trends of decline (Mount Buffalo and Harrietville) and increases in annual rainfall depths (Tallangatta), and some locations are not subject to changes in annual rainfall depths (Chiltern, Boorhaman and Beechworth).

The areas with high annual rainfall depths are subject to long term decline in rainfall and areas with relatively lower annual rainfall do not show any significant change in annual rainfall. It is noteworthy that Tallangatta is subject to a long term trend of increased rainfall. Clearly the behaviour of rainfall throughout North East Victoria cannot be described in general terms and rainfall throughout the region cannot be represented by a single rain gauge (such as Hume Reservoir).

The patterns of rainfall within entire rainfall records were examined to understand the impact on annual rainfall depths created by the recent drought by comparing the average rainfall from entire records to rainfall during the recent drought (the period from 2000 to 2010). In addition, evidence of a step change in annual rainfall depths was sought by comparing the average annual rain depth of the entire records to the average annual rain depths in the period after 1950 (the period 1950 to 2010). In addition the average rainfall depths from the period prior to 1950 were compared to the average rainfall depths of the period after 1950. The results of this investigation are provided in Table 6.1 for rainfall records within the North East region.

Table 6.1: Change in annual rainfall throughout North East Victoria

Criteria	Max (%)	Min (%)	Avg (%)
Recent drought (2000 to 2010)	-19.5	-4.8	-10.3
Change (post 1950 versus entire record)	+6	-1.8	+1.7
Change (post 1950 versus prior 1950)	+11.9	-1.8	+3.9

Table 6.1 reveals that rainfall within North East Victoria displayed a highly variable response to the recent drought ranging from a small decrease in annual rainfall to a significant decrease. Nevertheless, the average response to the recent drought was a 10.3% decrease in rainfall. However, there was no evidence that rainfall would cease at any location throughout North East Victoria.

It is noteworthy that daily maximum temperatures observed at the Rutherglen Research gauge increased by 4% (0.9°C) during the recent drought.

It is also revealed in Table 6.1 that there was no evidence of a step change to reduced rainfall throughout the region. However, there was a clear trend to increased rainfall throughout the region in comparison to pre 1950 rainfall and entire rainfall records. In addition, daily maximum temperatures in the period after 1950 were observed to decrease by 1% in comparison to pre 1950 temperatures.

The lengths of rainfall records used in this study were sufficient to capture the natural variation and extremes in rainfall at each location. Use of this data allows robust understanding of the performance of existing systems and alternative strategies. There is sufficient depth of annual rainfall, even during low rainfall years, for significant rainwater and stormwater yields at all locations throughout North East Victoria.

The region is subject to a wide variation of the frequency of rainfall in a year as defined by the number of days with rainfall greater than 1 mm and a relatively even distribution of rainfall across seasons. The region experiences an average of 87 rain days in any year. The frequency of rain days across North East Victoria ranges from rainfall occurring every 3 to 6 days. The rainfall regimes are eminently suitable for highly efficient rainwater and stormwater harvesting strategies.

6.9 Streamflow

Streamflows in the river catchments is presented in Figure 6.2 and is mostly characterised by significantly higher streamflow during the period 1950 to 1970 and cyclic patterns of lower and higher streamflow throughout the records.

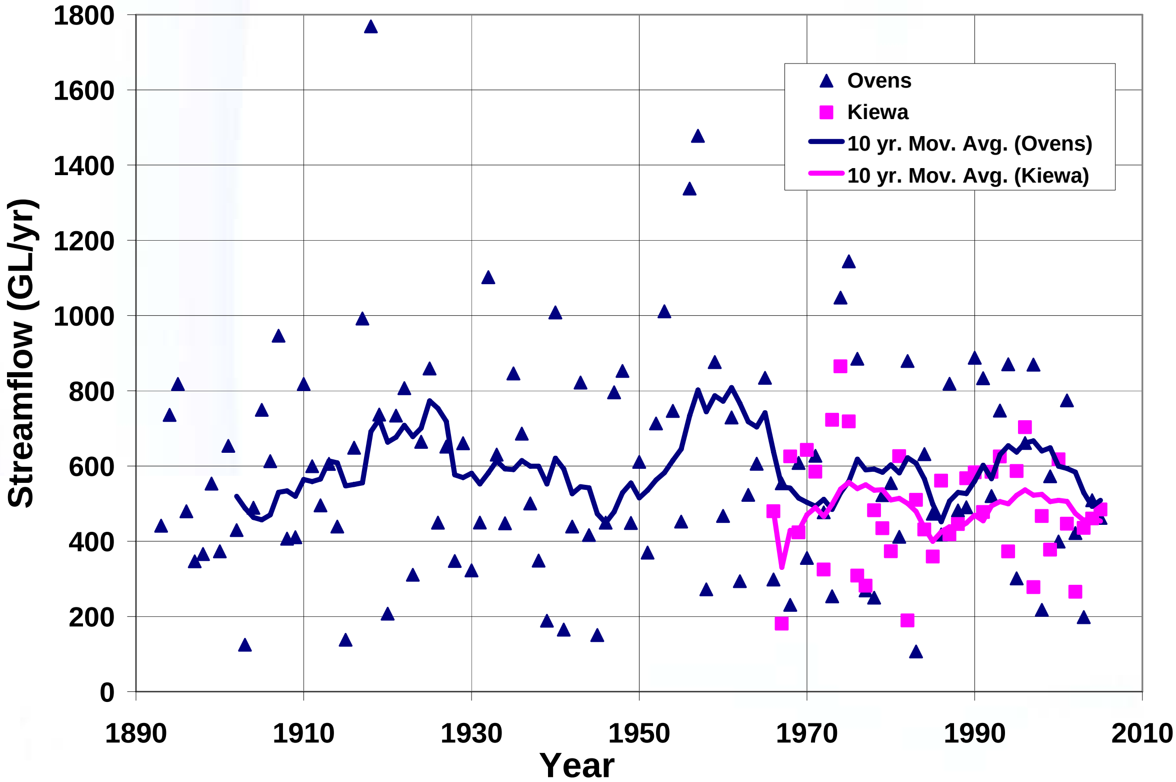

Figure 6.2: Sequences of streamflow from river basins in the North East Victoria

Figure 6.2 reveals that the water supply catchments are subject to highly variable annual streamflows that includes cyclic patterns of wet and dry periods.

The streamflow records do display considerable variation in annual flows but do not reveal evidence of a step change in the regime of streamflows. These streamflow records were used to assist with determination of the hydrology of the water supply catchments.

The streamflow within entire records were examined to understand the impacts created by the recent drought by comparing the average streamflow from entire records to streamflow during the recent drought (the period from 2000 to 2008). In addition, evidence of a step change in annual streamflow was sought by comparing the average annual streamflows of the entire records to the average annual streamflows in the period after 1950 (the period from 1950 to 2008). Average streamflow from the period prior to 1950 were compared to the average streamflow of the period after 1950. The results of this investigation are provided in Table 6.2 for streamflows within the water supply catchments.

Table 6.2: Change in annual streamflow in the water supply catchments

Criteria	Max (%)	Min (%)	Avg (%)
Recent drought (2000 to 2008)	-37.9	-16.5	-25.6
Change (post 1950 versus entire record)	+2.6	-1.2	+0.8
Change (post 1950 versus prior 1950)	+5.3	-2.3	+1.7

Table 6.2 reveals that significant decreases in streamflow were experienced within the water supply catchments during the recent drought. The average response to the recent drought was a 25.6% decrease in annual streamflow.

It is also revealed in Table 6.2 that there was no evidence of a significant step change to reduced streamflow throughout the water supply catchments. Indeed, there was a trend to increased streamflow throughout the water supply catchments in comparison to pre 1950 regimes.

Clearly the streamflow regimes have returned to "normal" or pre 1950 patterns throughout the water supply catchments supplying North East Victoria. Importantly, during periods of droughts small reductions in rainfall generate large reductions in runoff into rivers because increasing temperature regimes produce large losses in water supply catchments due to evapotranspiration.

6.10 Residential water demand

Metered quarterly water use from households, distribution of household sizes and dwelling types, average weekly income, average age and a range of climate parameters from each location were utilised to derive the lot scale water demands employed in this study.

Importantly, household water use was found to be dependent on climate and demographic parameters that vary widely across the region. The spatial variation of household water use across North East Victoria is influenced by income, minimum and maximum temperatures, rainfall depths and frequency of rainfall.

The range of spatial variation of parameters influencing water use indicates that the use of global averages to represent water demands for the North East region will produce misleading understanding of water planning, analysis of alternative water sources and water conservation strategies. Importantly, household sizes and dwelling types are not normally distributed or spatially consistent throughout the region which renders the use of averages unreliable. The pattern of these distributions is also highly variable across North East Victoria.

This study has revealed a paucity of knowledge about household water use behaviour throughout North East Victoria. Current and historical metering programs do not provide sufficient information to allow a robust understanding of the highly variable water use behaviour throughout the region. There is only limited information available to understand the drivers for indoor and outdoor water use. The ongoing focus on averaging or generalising water use generates a limited understanding.

6.11 Climate Change

The impact of the climate change scenarios on the North East in 2050 is presented in Table 6.3.

Table 6.3: Impact of the climate change scenarios for North East Victoria by 2050

Change in criteria	LE	HE
Average maximum temperature (°C)	0.85	2.05
Potential evaporation (%)	4	9
Annual average rainfall (%)	-?9	-?18
Streamflow (%)	-?25	-?45

Table 6.3 shows that the climate change scenarios generate moderate reductions in average annual rainfall and large reductions in streamflow in rivers by 2050. This result indicates that the availability of regional water resources will be dramatically diminished by 2050.

6.12 Lot scale results

The actual performance of onsite systems is revealed by continuous simulation of water balances and biophysical systems over long time periods. The impact of water efficient buildings and onsite reuse of wastewater for toilet and outdoor uses at selected towns is presented in Table 6.4. Note that the WEA Option does not include water efficient gardens.

Table 6.4: Impact of water efficient buildings and onsite wastewater reuse on small rural towns

Town	Water savings (%)		Effluent reduction (%)	
	WEA	Reuse	WEA	Reuse
Bellbridge	17	54.2	25.1	79.9
Eskdale	18.9	59.7	24.9	78.7
Harrietville	24.7	50	24.9	50.4
Walwa	21.1	57.1	24.9	67.1
Whitfield	18.1	57.1	25	78.8

Table 6.4 highlights that the WEA and onsite reuse Options provide substantial reductions in demands for potable water and of excess effluent. In this investigation, excess effluent is defined as the daily volume of effluent discharging to an adsorption facility or from the site. Importantly, the onsite reuse Option has more than halved water demands and eliminated the majority of effluent discharging to an absorption trench.

Continuous simulation using long sequences of local climate and climate dependent water demands to assess the performance of the various onsite strategies including BAU, WEA, OTR and OSIB. These onsite strategies were designed in accordance with the Australian Standard AS NZS 1547-2000 [50] to include absorption trenches based on a conservative design loading rate (DLR) of 5 mm/day. The conservative assumption about DLR that is consistent with a medium to heavy clay soil was made in the absence of details of local soil types. This consistent assumption about the DLR allows understanding of the impact of climate and water demands on the performance of onsite systems throughout the region.

The impact of the use of water efficient appliances (WEA) is compared to current practice (BAU) in Table 6.5 for the region. Note that the Option WEA (0.67) refers to the WEA Option with a third reduction in the area of the absorption trenches, Freq is the annual count of overflows and Ave Vol is average volume of overflows.

Table 6.5: Impact of water efficient buildings (WEA) on the performance of onsite systems

Town	BAU		WEA		WEA (0.67)	
	Freq.	Ave. Vol.	Freq.	Ave. Vol	Freq.	Ave. Vol.
Bogong	14	0.07	0	0	63	0.07
Bonegilla	0	0	0	0	0	0
Cudgewa	2	0.07	0	0	62	0.19
Eskdale	0	0	0	0	0	0
Freeburgh	0	0	0	0	0	0
Glenrowan	0	0	0	0	0	0
Harrietville	0	0	0	0	0	0
Hume East	0	0	0	0	0	0
Milawa	0	0	0	0	0	0
Mitta Mitta	0	0	0	0	0	0
Ovens North	0	0	0	0	0	0
Ovens South	1	0.07	0	0	25	0.06
Oxley	0	0	0	0	0	0
Springhurst	0	0	0	0	0	0
Stanley	0	0	0	0	0	0
Tawonga	3	0.24	0	0	51	0.20
Upper Murray	0	0	0	0	0	0
Walwa	4	0.26	0	0	110	0.13
Wandiligong	0	0	0	0	0	0
Whitfield	0	0	0	0	0	0

Table 6.5 reveals that the BAU Option is adequate for the majority of areas. Only the Bogong, Cudgewa, Ovens South, Tawonga and Walwa produce overflows from the absorption trenches from sites at rates of up to 14 times each year. The average volumes of overflows range from 0.07 m^3 to 0.26 m^3. Whilst these potential overflows represent "failure" of the septic systems the volumes of overflows are small in

[50] Standards Australia, 2000. AS NZS 1547-2000 Onsite domestic wastewater management.

comparison to the volumes of stormwater runoff. Nevertheless, the areas, except Walwa, that generate potential failures are subject to high rainfall, large water demands and low outdoor water use. Walwa is subject to moderate rainfall, higher outdoor water use and the highest water demands. The use of water efficient appliances (WEA) eliminates these potential failures and allows reduction of the area of absorption trenches (WEA 0.67) for most towns.

Importantly, this analysis has assumed correct installation and management of onsite systems – additional influences on performance are discussed elsewhere in this report and in the Case Studies.

The impact of onsite reuse for irrigation and toilets (OTR) is compared to current practice (BAU) in Table 6.6. Note that the Option OTR (0.5) and OTR (0.33) refers to the OTR Option with half and a third of area of the absorption trenches respectively.

Table 6.6: Impact of wastewater reuse (OTR) on the performance of onsite systems

Town	BAU		OTR (0.5)		OTR (0.33)	
	Freq.	Ave. Vol.	Freq.	Ave. Vol	Freq.	Ave. Vol.
Bogong	14	0.07	0	0	113	0.05
Bonegilla	0	0	0	0	0	0
Cudgewa	2	0.07	0	0	36	0.11
Eskdale	0	0	0	0	0	0
Freeburgh	0	0	0	0	0	0
Glenrowan	0	0	0	0	0	0
Harrietville	0	0	0	0	1	0.02
Hume East	0	0	0	0	0	0
Milawa	0	0	0	0	0	0
Mitta Mitta	0	0	0	0	0	0
Ovens North	0	0	0	0	1	0.02
Ovens South	1	0.07	0	0	82	0.13
Oxley	0	0	0	0	0	0
Springhurst	0	0	0	0	0	0
Stanley	0	0	0	0	0	0
Tawonga	3	0.24	1	0.03	240	0.09
Upper Murray	0	0	0	0	1	0.02
Walwa	4	0.26	0	0	44	0.11
Wandilgong	0	0	0	0	0	0
Whitfield	0	0	0	0	0	0

Table 6.6 demonstrates that onsite reuse of treated wastewater for toilet and irrigation uses improves the performance of onsite septic systems. This strategy reduces the requirement for absorption trenches by half and requires less than a third of the area of absorption trenches for many areas. The ability to further reduce the areas of absorption trenches is limited by the low demands for outdoor water use in areas with

higher and more frequent rainfall. Note that this Option will require onsite treatment systems that produce water of sufficient quality for flushing toilets.

The impact of sub-surface irrigation of an area of 200 m^2 using greywater (OSIB) is compared to current practice (BAU) in Table 6.7. Note that the Option OSIB (0.33) and OTR (0.33 + WEA) refers to the OSIB Option with a third of area of the absorption trenches and with water efficient appliances (WEA) respectively.

Table 6.7: Impact of sub-surface irrigation using greywater on the performance of onsite systems

Town	BAU		OSIB (0.33)		OSIB (0.33 + WEA)	
	Freq.	Ave. Vol.	Freq.	Ave. Vol	Freq.	Ave. Vol.
Bogong	14	0.07	5	0.02	0	0
Bonegilla	0	0	4	0.02	0	0
Cudgewa	2	0.07	14	0.05	7	0.02
Eskdale	0	0	0	0	0	0
Freeburgh	0	0	0	0	0	0
Glenrowan	0	0	0	0	0	0
Harrietville	0	0	0	0	0	0
Hume East	0	0	4	0.02	0	0
Milawa	0	0	0	0	0	0
Mitta Mitta	0	0	0	0	0	0
Ovens North	0	0	8	0.03	0	0
Ovens South	1	0.07	10	0.36	0	0
Oxley	0	0	6	0.04	0	0
Springhurst	0	0	0	0	0	0
Stanley	0	0	5	0.03	0	0
Tawonga	3	0.24	17	0.04	6	0.02
Upper Murray	0	0	0	0	0	0
Walwa	4	0.26	12	0.06	7	0.02
Wandiligong	0	0	0	0	0	0
Whitfield	0	0	6	0.02	0	0

All overflows in Table 6.7 refer to surcharges of grey water from the soil profiles used for sub-surface irrigation. These surcharges from the soil profiles were almost eliminated by the use of water efficient appliances. Only a third of the area of absorption trenches was required for a septic system that only received effluent from toilets. The soil profile and vegetation will provide significant treatment of the greywater prior to surcharge. Nevertheless, this greywater strategy will be subject to careful selection of bathroom and laundry detergents to protect the soil profiles from salts, nutrients and fats. In addition, the strategy is dependent on establishment of gardens to allow evapotranspiration of greywater.

It is noteworthy that use of long term continuous simulation at sub-daily time steps allows understanding of interaction between soil processes, diurnal patterns of water demands and rainfall regimes on the performance of onsite wastewater systems.

6.12 Town scale case studies

The town scale Options STEDS, OPS and RSS were evaluated using three different towns that currently do not have traditional reticulated sewage services. These towns of Eskdale, Moyhu and Stanley have been subject to various concerns about overflows from septic tanks and discharge of sullage to drainage networks.

This analysis has included site inspections, discussions with a wide range of stakeholders and informal requests for quotations from many of the local suppliers and service providers. Site inspections of 20 towns without traditional sewage services reveal that each town commonly included clusters of smaller lots that were perceived to be generating concerns.

In situations where the clusters of smaller lots contained older housing it was noted that some onsite systems to manage septic and sullage were inconsistent with the more robust modern standards of management. The design of the town scale Options responded to need to manage clusters of higher density housing and to allow future clusters of higher density housing.

Each of the STEDS (Septic Tank Effluent Disposal Scheme) schemes were designed as low cost systems using small diameter gravity conduits installed at minimum depth using efficient “Ditch Witch” technology and local plumbers. Importantly, these schemes are based on simple and easy to understand technologies and strategies that are also flexible. These networks are designed to work with the natural terrain at each site and to eliminate requirement for onsite disposal of effluent. The gravity networks utilised 100 mm diameter sewer grade PVC conduits and the rising mains utilised small diameter (63 mm) high pressure poly pipe.

Prefabricated pump wells with storage of 3,000 litres each were also utilised. Effluent is ultimately collected at a package wastewater treatment that is designed to produce Class A treated wastewater. Our investigations have revealed that both electroflocculation and small scale membrane bioreactors (MBR) will produce similar results for the same capital costs. These solutions produce higher quality water and occupy a smaller land area.

The OPS (Onsite Pressure Systems) schemes were designed to replace septic tanks with packages of sewage grinder pumps in storage wells at each site. These onsite grinder pumps discharges sewage in a small diameter collection system to a package wastewater treatment plant.

The RSS (Reticulated Sewage Schemes) were designed in accordance with the strategies published by NEW and DSE. Plumbing in houses is disconnected from septic schemes, septic tanks are removed and all wastewater discharges via gravity to a reticulated network of pipes, pump stations and rising mains. The reticulated network ultimately discharges sewage to lagoon based wastewater treatment plants.

This analysis assumes that all works on public and private land are completed by the entity building the schemes and all costs accrue to that entity. This implies that the entity building the schemes must be able to work closely with householders in each town to refine the strategies to best suit local conditions. It was assumed for each Option that a survey would locate all septic tanks and create easements as required. The surveyor would collaborate with a plumber to locate all outlets (and inlets) to existing septic systems. In addition, all septic tanks were pumped out during the early stages of each project. Conceptual designs were created to minimise disruption of local amenity and infrastructure in each town.

Remote sensing techniques using images derived from satellites were combined with field inspections, aerial photographs, cadastre and contour information to generate a digital terrain model of each site. This information was used to select routes for conduits that collect sewage or effluent from each house that are reliant on gravity, for rising mains and for the location of wastewater treatment plants. The same information was then used to assess all three Options.

Eskdale

Eskdale is an old gold mining township situated on the banks of the Little Snowy Creek on the escarpment adjacent to the Mitta River floodplain. After the demise of the gold mining activity the town was reliant on a butter factory and sawmill. Both industries closed many years ago. A legacy from the two major employers was clusters of houses adjacent to these work locations that were previous occupied by employees. The township had two private water supply schemes until very recently and these schemes were the legacy of the former employers. Both these schemes drew water from the Little Snowy Creek. These water supplies were subject to contamination that resulted in ongoing “boil water notices” from 1999.

The water supply problems in the township led to the creation of a Neighbourhood Environmental Improvement Project (NEIP). This co-operative scheme included farmers from the rural areas upstream of the town, townsfolk, the Shire of Towong and various government agencies including the EPA, Department of Health and the North East CMA. The NEIP provided extensive water quality monitoring and community involvement in understanding of water resources at Eskdale.

Water supply from Little Snowy Creek was exhausted during the recent drought and water supply is now drawn from the Mitta River approximately 800 metres north west of the township. This project was a co-operative joint project between the Shire of Towong and North East Water. North East Water are responsible for the operation of new water supply scheme.

The provision of a reticulated sewerage scheme at Eskdale was one of 50 projects included in the Country Towns Water Supply and Sewerage Scheme that was an initiative of the 2004/05 Victorian state budget. This project was allocated to North East Water (NEW). The project was subject to limited progress up to 2010. North East Water have completed a “Business Plan” assessment of options that determined that traditional and an alternative STEDS scheme would be not be an economic proposition for NEW based on the various assumptions about costs and their business model.

North East Water has been in negotiation with the Shire of Towong for over 12 months about providing a solution for both Eskdale and Bethanga.

The Shire of Towong is very supportive of the need for viable solutions for the town. However the Shire is financially unable to take over the construction and management of a sewerage scheme. The conceptual design solutions that were used to assess each Option are presented in Figures 6.4 and 6.5 for 68 properties. Note that each Option utilised a wastewater treatment plant located adjacent to the sporting oval. The terrain at Eskdale allows gravity collection of sewage or effluent within the town and transfer via a rising main to the wastewater treatment plant. The strategy also includes emergency storage with capacity to capture sewage generated by the entire town on a single day to account for the potential for failures in the electricity supply.

Figure 6.3: Schematic of wastewater strategy for Eskdale

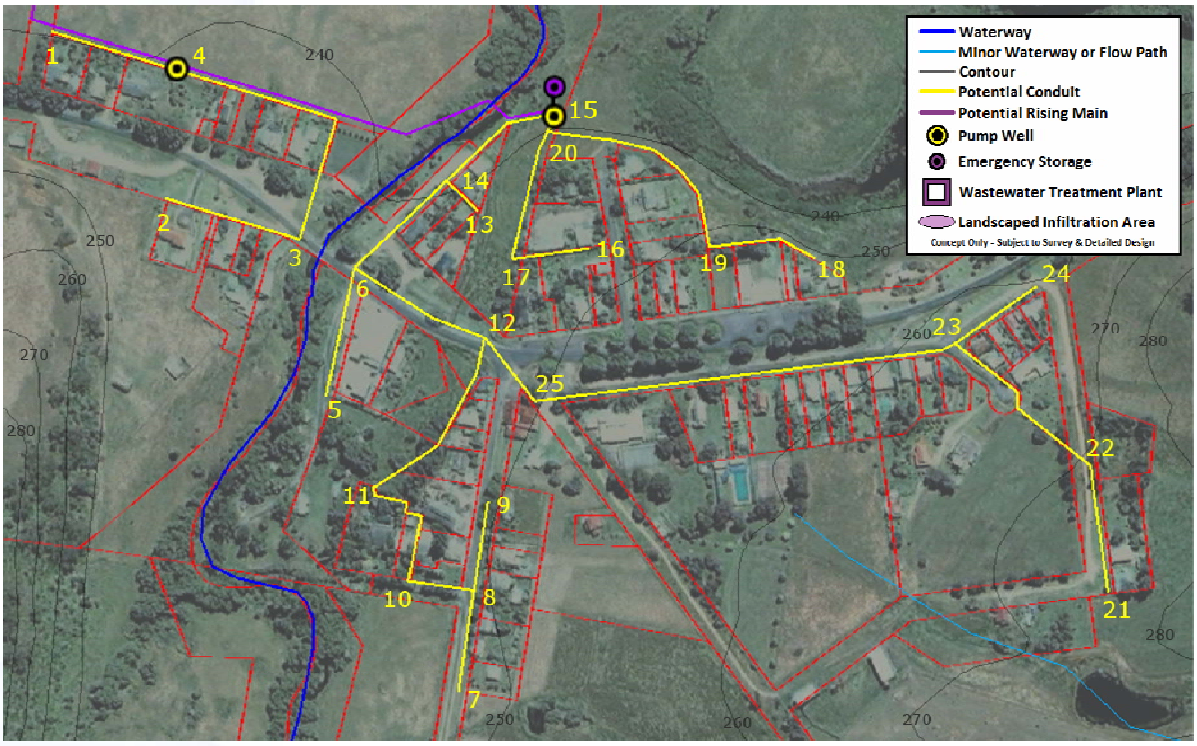

Figure 6.4: Closer view of the schematic of wastewater strategy for Eskdale

Figure 6.3 also highlights that the land area surrounding the sporting oval will also include a landscaped infiltration area that will allow infiltration and evapotranspiration of any excess treated wastewater. The strategy includes reuse of treated wastewater to irrigation the grounds in the oval precinct and for toilet flushing in the amenities. Note that the landscaped area was designed to provide sub-surface storage and surface storage in shallow billabongs to facilitate maximum losses of effluent.

The capital and operating costs of each Option are presented in Table 6.8 and in more detail in Appendix A.

Table 6.8: Summary of capital and operation costs of the Options for Eskdale

Option	Costs ($)	
	CAPEX	OPEX
STEDS	539,430	7,360
OPS	1,286,250	20,990
RSS	1,139,380	12,810

Table 6.8 reveals that the STEDS Option generates the lowest capital and operating costs. This outcome is a result of using readily available simple technologies and installation of conduits at minimum depth using “Ditch Witch” machines that allow rapid trenching. Treatment lower volumes of effluent (12.9 kL/day) also provide reduced costs in comparison to treating higher volumes of sewage (15.2 kL/day).

The OPS Option provided the highest costs that result from replacing septic tanks with grinder pumps in wells on each property. The use of multiple pumps generates a higher likelihood of the need to service the pumps. The RSS Option generates higher costs due to the deeper installation, decommissioning septic tanks and more expensive nature of traditional sewage infrastructure.

Moyhu

Moyhu is situated at a major road intersection approximately 25 km south of Wangaratta on the Wangaratta Whitfield Road. The Glenrowan Moyhu Road intersects from the west and the Moyhu Meadow Creek Road intersects from the east. The township is effectively “L” shaped with development centred on the Wangaratta Whitfield Road and Glenrowan Moyhu Road intersection.

Boggy Creek, a major tributary of the King River, crosses the Moyhu Meadow Creek Road approximately 250 metres east of the towns and the King River is situated a further 1,100 metres further east.

A significant proportion of the town’s drains either directly or indirectly into Boggy Creek. Currently stormwater, sullage and overflows from septic tanks on some properties flow along the Wangaratta Whitfield Road (Byrne Street drain) to a low point and then via a gully in a drainage easement across private freehold land into a large rural dam adjacent to the Boggy Creek. An example of the drainage system is presented in Figure 6.5.

Figure 6.5: Drainage schemes in Moyhu

The City of Wangaratta was successful in early 2011 in obtaining funding of up to $1 million in Round 3 of the Small Towns Water Quality Fund following submission of a Registration of Interest and then a Business Plan. Subsequently the City of Wangaratta has decided that provision of small town sewerage solutions is not "core business" and has suggested the transfer of this funding to North East Water.

The town has not experienced significant development in recent times and includes a hotel, a caravan park, kindergarten and Bowling Club as well as residential dwellings on both small and larger lots. North East Water provides reticulated water to the township from the King River. A Recreation Reserve including a football ground, netball and tennis courts is situated approximately 800 metres west of the town centre and this should provide a flood free area for both treatment and reuse of treated effluent. The conceptual design solutions that were used to assess each Option are presented in Figure 6.6 for 95 properties.

Figure 6.6: Schematic of wastewater strategy for Moyhu

Figure 6.6 highlights that the flat undulating terrain within Moyhu creates the need for five separate gravity systems that are combined using pump wells and rising mains. This terrain is likely to present considerable challenges to the design of traditional reticulated sewage schemes.

The strategy includes reuse of treated wastewater to irrigation the grounds in the oval precinct and for toilet flushing in the amenities. The landscaped area was designed to provide sub-surface storage and surface storage in shallow billabongs to facilitate maximum losses of effluent. The capital and operating costs of each Option are presented in Table 6.9 and in more detail in Appendix A.

Table 6.9: Summary of capital and operation costs of the Options for Moyhu

Option	Costs ($)	
	CAPEX	OPEX
STEDS	702,000	16,160
OPS	1,783,190	42,670
RSS	1,905,680	35,830

Table 6.9 demonstrates that the STEDS Option generates the lowest capital and operating costs that results from using readily available simple technologies and installation of conduits at minimum depth using methods that allow rapid trenching. Treatment lower volumes of effluent (45.6 kL/day) also provide reduced costs in comparison to treating higher volumes of sewage (54.8 kL/day).

The RSS Option was subject to the highest costs due to the deeper installation, decommissioning septic tanks, provision of manholes and more expensive nature of traditional sewage infrastructure. The OPS Option provided the higher costs that result from replacing septic tanks with grinder pumps in wells on each property. The use of multiple pumps generates a higher likelihood of the need to service the pumps that results in the highest operating costs.

Stanley

Stanley is situated approximately 10 km south of Beechworth. Stanley is a historic gold mining town located within the Nine Mile Creek Catchment which currently contributes to the water supply for the town of Yackandandah and downstream domestic users.

The town comprises clusters of dwelling located on allotments with variable areas. Some old miner's cottages are on smaller lots whilst some of the later development is on larger allotments. Development within the township is in higher density clusters along roads. In addition, large areas within the township are crown land that contains old mines, and the land surrounding creeks and waterways.

The town has been subject to limited recent development and includes a hotel and primary school. Residential dwellings exist on both small and larger lots. The "Galloping Goat" Restaurant was an icon establishment in the region and was closed approximately two years ago.

An active group of local residents were successful in reopening the post office via a community led initiative. This group were advised that the current lack of traditional sewerage infrastructure would be a major impediment to new commercial development within the township.

A recreation reserve including a historic cricket oval and tennis courts is situated close to the centre of town. This property has sufficient area for both treatment and reuse of treated effluent. The town is also surrounded by nearby commercial orchards and horticulture areas that could also utilise recycled water.

There is no formal water supply to the township but a number of dwellings draw their water from local waterways including Nine Mile Creek. The conceptual design solutions that were used to assess each Option are presented in Figure 6.7 for 50 properties.

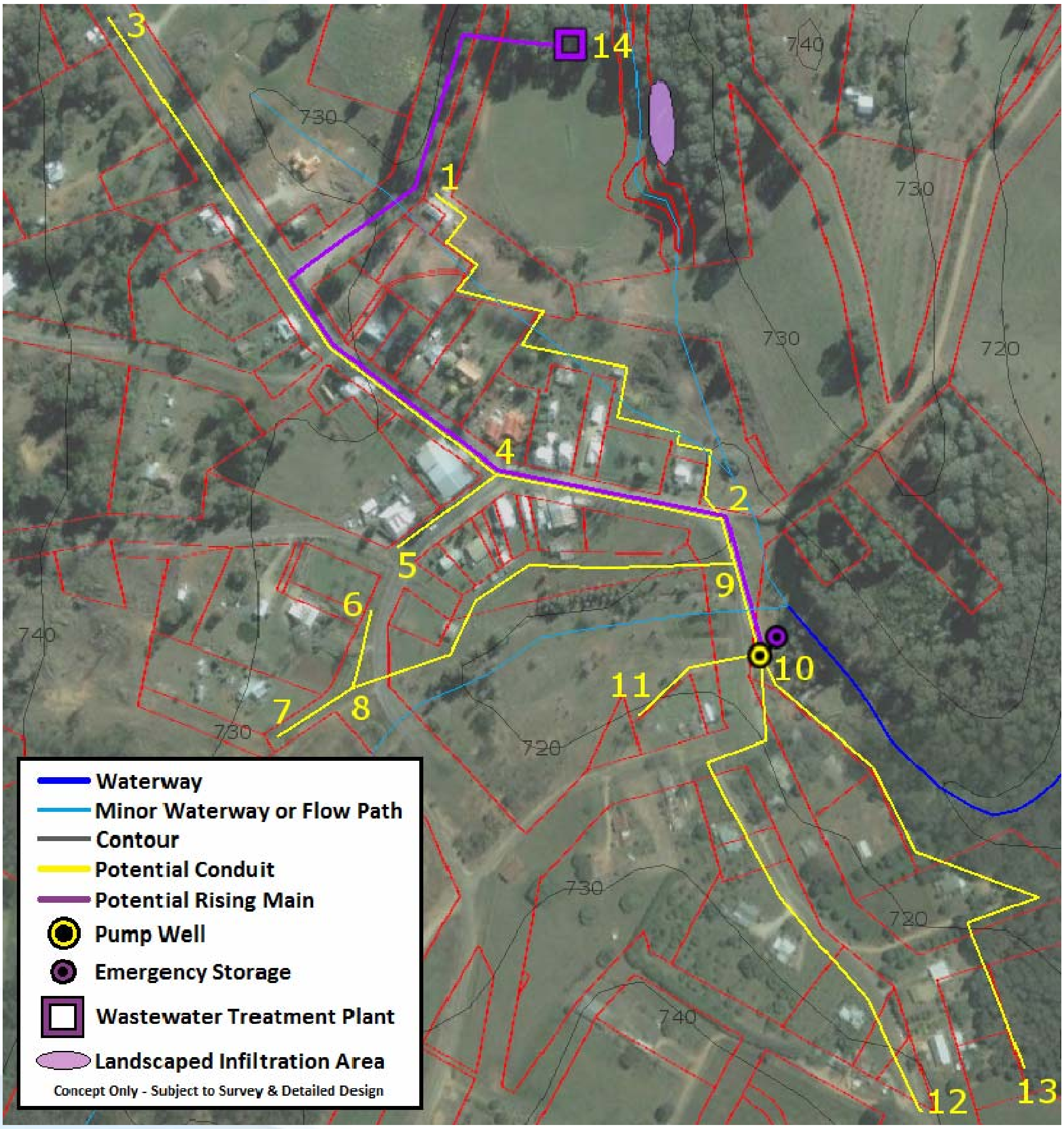

Figure 6.7: Schematic of wastewater strategy for Stanley

Figure 6.7 demonstrates that Stanley includes relatively steep and variable terrain. The town also contains clusters of lower density dwellings and buildings. Nevertheless, it was possible to establish a strategy that allows conveyance of sewage or effluent to a single location within the town. A pumping system is required to transfer wastewater from that location to a wastewater treatment plant at a nearby oval. The capital and operating costs of each Option are presented in Table 6.10 and in more detail in Appendix A.

Table 6.10: Summary of capital and operation costs of the Options for Stanley

Option	Costs ($)	
	CAPEX	OPEX
STEDS	572,500	5,770
OPS	1,114,920	24,330
RSS	970,970	17,510

Table 6.10 highlights that the STEDS Option provides the lowest capital and operating costs. The use of readily available simple technologies and installation of conduits at minimum depth using methods that allow rapid trenching allow this outcome. Treatment lower volumes of effluent (45.6 kL/day) also provide reduced costs in comparison to treating higher volumes of sewage (54.8 kL/day). In addition, the smaller scale of the installation process (Ditch Witch versus backhoe or excavator) allow for minimal disruption of existing amenity in difficult terrain.

The OPS Option provided the highest costs that result from replacing septic tanks with grinder pumps in wells on each property which will present challenges in Stanley. The use of multiple pumps generates a higher likelihood of the need to service the pumps that results in the highest operating costs. The RSS Option was subject to the higher costs due to the deeper installation, decommissioning septic tanks, provision of manholes and more expensive nature of traditional sewage infrastructure. For example, the provision of traditional sewage infrastructure is likely to require use of a backhoe or excavator that requires more and creates greater disturbance of area.

7 Conclusions

A forensic analysis has been undertaken of the existing biophysical systems that are related to North East Victoria. The analysis incorporates inputs from many disciplines, to understand the potential futures of towns in the region.

The existing sophisticated integrated systems models of the North East region developed by Dr Peter Coombes have been updated and enhanced for use in this project. These models subdivide the region into hierarchies of distributed nodes, or 'zones', that represent opportunities, constraints and feedback loops across multiple scales. A selection of indicative alternative Options; WEA, OTR, OSIB, STEDS, OPS and RSS; were compared to the business as usual (BAU) Option to understand the response of the North East Victorian system to alternative strategies. The alternative Options considered in this investigation are:

WEA – this Option includes water efficient buildings, gardens and practices.

OTR – this Option combines the WEA Option with onsite treatment and reuse of wastewater for toilet and outdoor uses.

OSIB – this Option combines the WEA Option with onsite treatment using sub-surface drip irrigation systems

STEDS – this Option combines the WEA Option with a small diameter common effluent network that discharges to a town scale wastewater treatment system

OPS – this Option combines the WEA Option with an onsite storage and grinder pump that distributes sewage via a pressurised reticulated network to a town scale wastewater treatment plant.

RSS – this Option provides a traditional reticulated sewage network and wastewater treatment plant for each small rural town.

A summary of the results of this study is presented below:

Climate

- The recent drought reduced average annual rainfall by 4.8% to 19.5% throughout North East Victoria and included a 4% (0.9°C) increase in average daily maximum temperatures.
- Increases in temperaure and evaporation with reduced rainfall in the recent drought reduced annual average streamflow in rivers by 16.5% to 37.9%.
- The recent drought may not be the worst period of low rainfall on record at many locations throughout North East Victoria and is consistent with the cycles of natural variation in rainfall.
- The rainfall records in the North East region do not reveal evidence of a step change in rainfall regimes.
- The region is subject to a high frequency of rainfall events (on average, every 3 to 6 days) and is eminently suitable for highly efficient rainwater and stormwater harvesting strategies.
- Climate change may generate reductions in annual average rainfall of 9% to 18% and diminish annual average streamflows by 25% to 45% by 2050. It is noteworthy that these scenarios produce years with very low flows in the regions rivers that is consistent with more severe droughts.

Planning and design issues

- The opportunities for provision of services to small rural towns is limited by a lack of knowledge about the technical and practical options provided by the available alternative systems.
- There is a perceived reluctance of future users to accept alternative solutions
- The institutional settings (local government and water authorities) do not encourage the introduction of alternative systems but tend to embrace wherever possible conventional system (reticulation and wastewater treatment plants).
- The highly limited and general nature of planning and design codes for small wastewater management systems is misleading and results in considerable missed opportunities for effective alternative systems.
- Design guides over-allocate wastewater discharges for onsite systems and under-estimate the capacity of sites
- The design and operation of apparently "simple" septic tanks systems are poorly understood leading to incorrect design and mismanagement.
- This report highlights the important legacy issues that were created by historical design processes and attitudes. Many properties include onsite systems that were historically acceptable that are shown to be inadequate by more recent standards and understanding.
- Publically available reports into sewage strategies for small towns tend to provide considerable over-estimation of the costs of alternative schemes and under-estimate the costs of traditional reticulated sewage schemes
- In addition, these reports also imply that any other outcome option than do nothing or traditional reticulated sewage systems will produce high costs to land owners. This results in a high level of resistance to alternatives from residents of small towns.
- A preference for traditional reticulated sewage schemes that require considerable funding by the Water Authority and Councils limits opportunities to improve the amenity and viability of small towns using lower cost alternative schemes.

Lot Scale Analysis

- Although climate change generates large reductions in average annual streamflows in rivers, the average annual yields from rainwater harvesting was insignificant ranging from 0.3% to 4.8%. In constrast reductions in stormwater runoff ranged from 13.2% to 28.7%. Local strategies were resilient to the impacts of climate change.
- Climate change also generated small increases in outdoor water use ranging from 3.9% to 7.5%.
- The use of water efficient appliances and onsite wastewater reuse for toilet flushing and irrigation can reduce the volumes of effluent discharging to absorption facilits by 85% to 91% whilst decreasing demands for potable water by 50% to 59.7%.
- Water efficiency and onsite reuse substantially diminishes the risk of offsite discharge of effluent.
- Options that improve the performance of onsite wastewater systems in small rural towns an also dramtically increase the resilience of the towns to the potential impacts of climate change.
- All of the towns examined in this study contained clusters of higher density housing that can be readily managed by smaller scale solutions such as STEDS Options

- The alternative STEDS Options can provide flexible and easily understood options for low cost management of sewage and sullage in small towns
- Modified STEDS schemes can provide significantly lower costs for management of sewage and sullage from the clusters of higher density housing in small country towns.

Community Understanding and Acceptance

- Existing and alternative systems to manage sewage and sullage are not "flush and forget" systems – institutions, individuals and the community must take responsibility for the operation and outcomes of these systems
- The recent report by the Auditor General has noted these responsibilities.
- There appears to be limited appetite for enforcement of the current codes and responsibilities
- Utilisation of alternate models for provison of alternative schemes will require community education and a clear strategy for implementation.

Amenity and Liveability

- Improvements in the management of sewerage and sullage for small towns will improve the amenity, liveability and viability of these townships.
- Alternative stratregies for management of sewage and sullage has the potential to provide more sustainable water use and create new opportunity for development.

Leadership and Legislation

- This report questions the current governance model for management of sewerage and sullage in small towns. A new Business Model is required.
- An opportunity exists for a new authority take responsibility for leadership in this area or alternatively the government can clarify its expectations vide revised Statement of Obligations for water authoritiews or legislation for Councils, Water Authorities and others.
- At a community level local champions will required to help facilitate changes in attitudes towards management of sewerage in small towns.

Appendix A

Eskdale STEDS

Capital Costs

Item	Quantity	Cost ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia gravity system	2740	11645
Installation (2 plumbers and machine)	3	22005
Fittings	68	10200
Inspection shafts	6	6600
Pump wells (prefab)	2	15000
Wet weather storage and pump	1	7500
Electrician	1	2692
63 mm rising main	1210	13620
Installation (2 plumbers and machine)	2	14670
Pump out septic tanks	68	23800
100 mm dia gravity system	68	5780
Installation (2 plumbers and machine)	6	44010
Wastewater Treatment Plant	1	180000
Irrigation system for oval	1	25000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
Total		**449522**
		449522
Contingency (10%)		44952
Design and supervision (10%)		44952
Total		**539426**

Operation costs

WWTP	1	2558
Septic Tank Pumping	1	2720
Maintenance	1	2077
Total		**7355**

Eskdale OPS

Capital costs

Item	Quantity	Cost ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia pressure system	2740	68737
Installation (2 plumbers and machine)	4	36000
Fittings	68	10200
Inspection shafts	6	6600
Electrician	7	18844
100 mm rising main	1210	28897
Installation (2 plumbers and machine)	3	27000
Connection and decommission septic tanks	68	142800
Pump out septic tanks	68	23800
Onsite Pressure System	68	374000
Installation (2 plumbers and machine)	7	63000
Wastewater Treatment Plant	1	180000
Irrigation system for oval	1	25000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
		1071878
Contingency (10%)		107188
Design and supervision (10%)		107188
Total		**1286254**

Operation costs

Operation		
WWTP	1	6054
Maintenance	1	14937
		20991

Eskdale RSS

Capital Costs

Item	Quantity	Cost
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
150 mm gravity main	2740	427440
Fittings	68	10200
Manholes	6	27000
Inspection shafts	12	13200
Electrician	1	2692
100 mm rising main	1210	102850
Connection and decommission septic tanks	68	142800
Pump out septic tanks	68	23800
Pump stations	2	100000
Wet weather storage and pump	1	7500
Irrigation system for oval	1	25000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
Total		**949482**
Contingency (10%)		94948
Design and supervision (10%)		94948
Total		**1139378**

Operation Costs

WWTP	1	6054
Maintenance	1	6759.95
		12814

Moyhu STEDS

Capital Costs

Item	Quantity	Cost ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia gravity system	2739	11641
Installation (2 plumbers and machine)	3	22005
Fittings	95	14250
Inspection shafts	3	3300
Pump wells (prefab)	5	37500
Wet weather storage and pump	3	22500
Electrician	2	5840
63 mm rising main	1907	13620
Installation (2 plumbers and machine)	2	14670
100 mm dia gravity system	95	8075
Installation (2 plumbers and machine)	7	51345
Pump out septic tanks	95	33250
Wastewater Treatment Plant	1	230000
Irrigation system for oval	1	30000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	70000
		584996
Contingency (10%)		58500
Design and supervision (10%)		58500
Total		**701995**

Operation Costs

WWTP	1	9029
Septic Tank Pumping	1	3800
Maintenance	1	3329
		16159

Moyhu OPS

Capital Costs		
Item	Quantity	Costs ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia pressure system	2739	68612
Installation (2 plumbers and machine)	3	27000
Fittings	95	14250
Inspection shafts	6	6600
Electrician	8	21536
100 mm rising main	1907	37740
Installation (2 plumbers and machine)	2	18000
Connection and decommission septic tanks	95	199500
Pump out septic tanks	95	33250
Onsite Pressure System	95	522500
Installation (2 plumbers and machine)	10	110000
Wastewater Treatment Plant	1	310000
Irrigation system for oval	1	30000
Connection to toilets at oval		2000
Landscaped infiltration area	1	70000
Total		**1485987**
Contingency (10%)		148599
Design and supervision (10%)		148599
Total		**1783185**

Operation Costs		
WWTP	1	21700
Maintenance	1	20974
Total		**42674**

Moyhu RSS

Capital Costs

Item	Quantity	Costs ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
150 mm gravity main	2739	427284
Fittings	95	14250
Manholes	13	58500
Inspection shafts	8	8800
Electrician	2	5384
100 mm rising main	1907	162095
Connection and decommission septic tanks	95	199500
Pump out septic tanks	95	33250
Pump stations	5	250000
Wastewater Treatment Plant	1	312000
Irrigation system for oval	1	30000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	70000
Total		**1588063**
Contingency (10%)		158806
Design and supervision (10%)		158806
Total		**1905676**

Operation costs

WWTP	1	21700
Maintenance	1	14130.65
Total		**35831**

Stanley STEDS

Capital Costs

Item	Quantity	Costs ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia gravity system	2691	11437
Installation (2 plumbers and machine)	3	22005
Fittings	50	10200
Inspection shafts	6	6600
Pump wells (prefab)	1	7500
Wet weather storage and pump	2	15000
Electrician	1	2692
63 mm rising main	790	8888
Installation (2 plumbers and machine)	1	7335
Pump out septic tanks	50	17500
100 mm dia gravity system	50	4250
Installation (2 plumbers and machine)	5	36675
Wastewater Treatment Plant	1	230000
Irrigation system for oval	1	30000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
Total		**477081**
Contingency (10%)		47708
Design and supervision (10%)		47708
Total		**572498**

Operation costs		
WWTP	1	1921
Septic Tank Pumping	1	1750
Maintenance	1	2094
		5765

Stanley OPS

Capital Costs

Item	Quantity	Costs ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
100 mm dia pressure system	2691	67410
Installation (2 plumbers and machine)	4	36000
Fittings	50	7500
Inspection shafts	10	6600
Electrician	5	13460
100 mm rising main	790	15634
Installation (2 plumbers and machine)	2	18000
Connection and decommission septic tanks	50	105000
Pump out septic tanks	50	17500
Onsite Pressure System	50	275000
Installation (2 plumbers and machine)	5	45000
Wastewater Treatment Plant	1	230000
Irrigation system for oval	1	25000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
		929104
Contingency (10%)		92910
Design and supervision (10%)		92910
Total		**1114924**

Operation costs

WWTP	1	12695
Maintenance	1	11636
		24330

Stanley RSS

Capital Costs

Item	Quantity	Costs ($)
Survey (locate septic tanks and levels)	1	5000
Easements	1	10000
150 mm gravity main	2691	419796
Fittings	50	7500
Manholes	6	27000
Inspection shafts	5	5500
Electrician	1	2692
100 mm rising main	790	67150
Connection and decommission septic tanks	50	105000
Pump out septic tanks	50	17500
Pump stations	1	50000
Wet weather storage and pump	2	15000
Irrigation system for oval	1	25000
Connection to toilets at oval	1	2000
Landscaped infiltration area	1	50000
		809138
Contingency (10%)		80914
Design and supervision (10%)		80914
Total		**970966**

Operation Costs

WWTP	1	12695
Maintenance	1	4817
		17512