Independent research and consulting

Systems Analysis of Water Cycle Systems

Economic analysis of Options and Scenarios for the Living Ballarat project

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About the authors

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Acknowledgements

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Disclaimer

This report was written under the jurisdiction and management of the Office of Living Victoria. Nevertheless, any unintended errors or potential misinterpretations of the data presented herein are only the authors' and we would welcome further dialogue around alternative interpretations of our research.

Contents

Executive summary

The Living Ballarat project was initiated by the Victorian Government as a demonstration of a new approach to integrated water cycle management (IWCM) for regional cities and towns. This project included collaboration between local stakeholders and the Office of Living Victoria in the development of a whole of water cycle management framework for the Ballarat region. A Project Control Board (PCB) provided oversight and local governance for the development, delivery and implementation of the Ballarat IWCM Framework. A local Strategy Development Team (SDT) with membership from multiple agencies and leadership from the Office of Living Victoria's Chief Scientist provided the PCB with systems analysis of the water cycle across the region.

The Ballarat region chosen for this investigation includes 144 State Suburbs, 7 local government areas and significant river basins managed by 5 Catchment Management Authorities. Central Highlands Water provides urban water supplies to 15 water districts and reticulated sewerage services to 10 districts within the region. The region is also dependent on groundwater resources and bulk water allocations from the Moorabool, Campaspe, Goulburn, Loddon and Yarrowee River catchments. These shared regional water resources are also subject to management by Southern Rural Water, Goulburn Murray Water and the Murray Darling Basin Authority.

This report has focused on the economic behaviour of the Ballarat water district in the context of the performance of the entire region for Business as Usual (BAU), for Scenarios that may challenge the future performance of the System (such as Climate Change and High population Growth) and Options for future management (including building, precinct and regional scale strategies). A Systems Framework of the Ballarat region was developed as part of the Living Ballarat Project to assist in understanding the whole of water cycle challenges and opportunities across the region.

This investigation does not seek to define the best or preferred strategy for the Living Ballarat region. The purpose of this report is to provide insights into the behaviour of the water cycle system throughout the Living Ballarat region and the likely economic response of the regional system to different Scenarios and Options.

The Dynamic Economic Framework utilised in this analysis is a linked component of the Systems Framework that combines all available costs for the whole of water cycle across the region to produce a range of economic futures. The economic analysis of the entire system (Systems Economics) utilised in this investigation is based on cash flows of costs throughout the water cycle system.

Whilst the Economic Framework allows rapid assessment of almost all inputs, this report has presented the results for the inputs provided in Section 2 using a real discount rate of 5%. The results presented in this report should be considered in conjunction with the previous reports, namely "*Systems analysis of water cycle systems – analysis of base case scenarios for the Ballarat region*" and "*Summary of the performance of options and key insights*".

The Systems Framework of the Living Ballarat project is complete. This framework includes high population growth and climate change scenarios. The Systems Framework was built up from local scale land uses from across the region and includes whole of water cycle processes at local, suburb, town and regional scales. This structure captures the spatial, temporal and behavioural variations of the water cycle across the region.

The framework has been developed to a state where it can be reliably and robustly applied to detailed and targeted 'what if' analyses, including assessments of future water security and economics under a range of climatic and population growth scenarios, and future alternative strategies. The spatial and temporal detail within the Systems Framework allowed understanding, reproduction and testing of the complex interactions between waterways, reservoirs, operations, water demands, water restrictions and financial impacts.

This report includes hind casting of the economic analysis across the historical period from 2002 to 2012 that includes known financial information about the costs of the water and wastewater systems in the region. This process was used to verify and calibrate the inputs to and processes within the economic framework. In general, the hind casting process was able to verify the efficacy of the systems economics. This version of the report also includes a sensitivity analysis that responds to workshops held at the Office of Living Victoria and tests the most significant drivers of economic behaviour revealed by this investigation. Finally, this report is accompanied by supporting web-enabled software that allows the reader to further investigate the investment processes for water cycle management in the Living Ballarat region.

Key Insights from this investigation are summarised as follows:

1. The whole of System finances and economics of the Living Ballarat region are highly sensitive to variation in physical and financial parameters throughout the scales (temporal and spatial) within and external to the regional. Only a small proportion of regional costs are fixed or invariant from a systems economic perspective.

2. The systems analysis has produced a richness of results and information that are available for additional analysis. Only a fraction of the information and results are presented in this report.

3. The analysis using the economic framework has utilised real data from Central Highlands Water, City of Ballarat and a wide range of published reports by the National Water Commission, The Essential Services Commission and others.

4. Analysis of the entire water cycle, including linked or dependent regional systems, counting all costs and use of a planning horizon that is consistent with the behaviour of infrastructure reveals the highly sensitive and variable nature of the System's economics.

5. There is substantial value within the Living Ballarat Options that indicate that the project can provide outstanding value to the State of Victoria. The most significant future economic costs are to society for declining waterway values and flooding, and the water authority for water supply and wastewater management.

6. The Ballarat water district is challenged by a range of potential Scenarios. Changes to operating rules, reliance on regional bulk water sources, increases in regional irrigation demands, climate change and high population growth has substantial economic impacts on the Ballarat water district.

7. The Systems Economics Frameworks utilised in this investigation are based on input output economics (cash flows), whole of system costs and whole of water cycle costs. The analysis is not based on valuations of infrastructure. This analysis is different to economic or financial analysis used to satisfy various regulatory assessments.

8. A fully dynamic economic model is now available for Living Ballarat that can allow gaming in seconds. This capability should allow unprecedented value for testing assumptions and a wide range of perceptions in a workshop forum.

9. Importantly, a Systems Economics framework has been created for Living Ballarat that allows testing of the majority of "contentious inputs" from the most objective perspective possible – this is a first for the water industry and it is recommended that OLV and the PCB utilise this powerful capability to understand the potential of the region.

10. Local or building scale strategies improve the overall viability of the water cycle in the region by reductions in water demands, wastewater discharges, stormwater runoff, pollutant loads to waterways and reliance on bulk water source resulting in diminished impacts on waterways. This creates reduced costs for water supply, wastewater and stormwater management with increased costs to citizens for building scale solutions.

11. Precinct scale strategies such as wastewater reuse and stormwater harvesting improve the overall viability of the water cycle in the region. The wastewater reuse strategy produces moderate benefits that are derived from reduced water demands and wastewater discharges with associated diminished impacts on waterways.

12. However, the most significant benefits are derived from the stormwater harvesting for potable use (perhaps via managed aquifer storage processes) and for the multiple scale integrated water cycle management (IWCM) strategy.

13. This analysis has incorporated all available financial data and economic information in a whole of systems economic framework. Certainty about the analysis can be further improved by inclusion of additional information and knowledge about inputs and processes. For example, the valuation of nitrogen sourced from Melbourne Water dominates the costs of pollution.

14. A significant proportion of the economic benefits revealed from this investigation are derived by smoothing the investment cycle for regional infrastructure by use of local and precinct strategies that impact as smaller increments of costs.

15. Some of the economic benefits derived from the systems analysis are dependent on understanding and acceptance of the improved and synergistic performance created by various local and precinct scale strategies.

The Scenarios used to test the performance of the Ballarat water district are summarised in Table E1 and an overview of the performance of Scenarios is provided in Table E2.

Table E1: Overview of Scenarios

Scenario	Description
Base Case (BAU)	The Base Case is defined as continuing with current water cycle management processes and behaviours that are subject to the trajectory of current climate processes
BAU NoGW	Ground water resources are only used during droughts
Bulk	Water supply is not sourced from the Moorabool and Yarrowee Catchments
Bulk 2Irr	Water supply is not sourced from the Moorabool and Yarrowee Catchment with a 100% increase in regional irrigation demands
Climate Change (CC)	High emissions climate change as defined by the fifth report by the IPCC as a rate of increase in average temperature of 0.05°C/annum
High Growth (HG)	High population growth as defined by the Victoria in Future 2012 (VIF 2012) forecast population for 2051 achieved at 2041.
High Growth with Climate Change (HGCC)	High population growth as defined by forecast population for 2051 achieved at 2041 with high emissions climate change as defined by a rate of increase in average temperature of 0.05°C/annum.

Table E2: Impact of Scenarios on performance of the water cycle in the Ballarat Water District

Scenario	Net Present Cost ($m) versus reduction in costs (%)				
	Water	Wastewater	Stormwater	Waterways	Alternative measures
BAU	734 (0)	707 (0)	315 (0)	7497 (0)	89 (0)
NOGW	877 (+19.5)	707 (0)	315 (0)	7497 (0)	92 (0)
Bulk	893 (+21.7)	707 (0)	315 (0)	7497 (0)	92 (0)
Bulk_2Irr	886 (+20.8)	707 (0)	315 (0)	7497 (0)	92 (0)
CC	776 (+5.8)	744 (+5.2)	305 (-3)	7412 (-1.1)	92 (0)
HG	820 (+11.8)	811 (+14.6)	357 (+13.2)	8085 (+7.8)	98 (+10.1)
HGCC	845 (+15.3)	814 (+15.6)	354 (+ 12.4)	8,136 (+8.5)	96 (+9.6)

16. The majority of future costs of water cycle management accrue to the Water Authority and to Society as defined by impacts on waterways and flood risks. The costs of providing reticulated water and sewerage services, flood risks and impacts on waterways are the dominant economics costs for the Ballarat Water District. The total net present costs of water cycle management to 2051 for the BAU option is $4,108 m. Jurisdictional NPCs for all scenarios are presented in Table E3.

Table E3: Jurisdictional NPCs for all scenarios

Jurisdiction	Net Present Cost ($m)						
	BAU	**NoGW**	**Bulk**	**Bulk2Irr**	**CC**	**HG**	**HGCC**
Water authority	1,374	1,519	1,527	1,527	1,450	1,541	1,567
Local Government	80	80	80	80	68	90	79
Developers	181	181	181	181	180	227	220
Citizens	51	51	51	51	53	58	115
Society	2,423	2,423	2,423	2,423	2,708	2,983	2,987
Total	**4,108**	**4,254**	**4,261**	**4,261**	**4,459**	**4,898**	**4,968**

17. Only using groundwater resources for drought relief results in a requirement to augment water security infrastructure and an overall 3.6% ($146 m) increase in costs that accrue to the water authority.

18. A greater reliance on external water supplies from the Goulburn, Campaspe and Loddon catchments by not extracting water supply to meet urban water demands from the Moorabool and Yarrowee Catchments generates an overall 3.7% ($153 m) increase in costs that accrue to the water authority.

19. A greater reliance on external water supplies from the Goulburn, Campaspe and Loddon catchments by not extracting water supply to meet urban water demands from the Moorabool and Yarrowee Catchments with 100% increases in regional irrigation demands generates a 3.7% ($148 m) increase in costs that accrue to the water authority.

20. The impact of high emissions climate change generates an overall 8.6% ($351 m) increase in costs that accrue to the water authority, developers and society. Reductions in costs to local government are generated by reduced costs for managing stormwater quality and the diminished costs to Society are created by reduced pollutant loads.

21. Accelerated population growth with 2051 population achieved in 2041 creates an overall 19.2% ($790 m) increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, developers and society. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, and greater impacts on waterways created by additional urban growth.

22. A combination of accelerated population growth and high emissions climate change generates a 19.5% ($803 m) increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, the water authority and society. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, greater impacts on waterways created by additional urban growth and reduced availability of water resources.

23. A sensitivity analysis revealed that changes in costs of rainwater harvesting and water efficient appliances displayed a similar impact on all of the Scenarios. Increases in costs to operate

water and wastewater services generated greater impacts on the Scenarios with greater dependence on bulk water sources with limited local use of groundwater resources. Reductions in the costs of pollutants discharging to waterways provided that greatest reductions in costs for the high growth Scenarios.

The details of the alternative Options are summarised in Table E4 and an overview of the performance of the Options are provided in Table E5. The jurisdictional distribution of NPCs for each Option is presented in Table E6.

Table E4: Summary of the Alternative Options

Option	Description
BC1	Rainwater harvesting and highest level of water efficiency adopted in all new and substantially renovated buildings
BC2	Rainwater harvesting and highest level of water efficiency adopted in all new and substantially renovated buildings. Include 5 m^3 of vegetated stormwater management for each new and substantially renovated building (this could be street trees, bio-retention, landscaping of similar)
IWCM	Rainwater harvesting for non-drinking indoor uses and highest level of water efficiency adopted in all new buildings. Wastewater reuse via a third pipe network for toilet, outdoor and open space uses.
SWH	Stormwater harvesting from all impervious surfaces, stored and treated to supplement water supply for all new buildings. The highest available level of water efficient appliances and water efficient gardens.
WWR	Wastewater reuse via a third pipe network for toilet, outdoor and open space uses at all new buildings. The highest available level of water efficient appliances and water efficient gardens.

Table E5: Impact of Options on performance of the water cycle in the Ballarat Water District

Scenario	Net Present Cost ($m) versus reduction in costs (%)				
	Water	Wastewater	Stormwater	Waterways	Alternative measures
BAU	734 (0)	707 (0)	315 (0)	7497 (0)	89 (0)
BC1	694 (-5.5)	668 (-5.6)	305 (-3.1)	6,945 (-7.4)	135 (+50.7)
BC2	694 (-5.5)	668 (-5.6)	332 (+5.5)	6,724 (-10.3)	163 (+82.9)
IWCM	627 (-14.5)	652 (-7.9)	307 (-2.4)	6,184 (-17.3)	186 (+107.9)
SWH	580 (-20.9)	676 (-4.6)	315 (0)	6,635 (-11.5)	106 (+18.5)
WWR	712 (-3)	651 (-8)	315 (0)	7,046 (-6)	137 (+53)

Table E6: Jurisdictional NPCs for all options

Jurisdiction	Net Present Cost ($m)					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
Water authority	1,374	1,301	1,301	1,244	1,204	1,319
Local Government	80	75	86	84	80	80
Developers	181	182	207	201	181	202
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**4,108**	**3,716**	**3,568**	**2,593**	**3,238**	**3,407**

24. Inclusion of building scale strategies for water efficiency and rainwater harvesting for all new and renovated buildings generates an overall 11.1% ($458 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

25. Inclusion of building scale strategies for water efficiency, rainwater harvesting and street scale stormwater management for all new and renovated buildings creates an overall 16.1% ($661 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

26. An Integrated Water Cycle Management (IWCM) strategy that includes reuse of wastewater, rainwater harvesting and water efficient buildings provides an overall 36.9% ($1,515 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

27. Stormwater harvested from regional stormwater management storages in new urban areas and treated to potable standards for injection into water distribution infrastructure generates an overall 21.2% ($870 m) reduction in costs that accrue to local government, the water authority, developers and society. The Water Authority and society are proportionally higher beneficiaries and citizens experience slightly higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

28. Wastewater Reuse using existing or modular treatment plants and distribution via a third pipe network for toilet, outdoor and open space uses at all new buildings provided an overall 17.1% ($701 m) reduction in costs that accrue to local government, the water authority, developers

and society. The Water Authority and society are proportionally higher beneficiaries with citizens and developers experiencing slightly higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

29. An investigation into the sensitivity of the Options to changes in costs demonstrated that the relative value of Options were mostly insensitive to the selected changes in costs. The IWCM, SWH and WWR Options show consistent high value for the Ballarat region. However, a substantial reduction in the costs of pollutants discharging to waterways creates a significant change in the viability and economic ranking of the BC2, IWCM and WWR Options.

30. Reductions in pollutants loads discharging to waterways via stormwater runoff and wastewater discharges is a significant contributor to the value of the IWCM Option that includes wastewater reuse and rainwater harvesting, to the WWR Options that includes wastewater reuse and to the BC2 Option that includes streetscape stormwater management measures.

1 Introduction

The Living Ballarat project was initiated by the Victorian Government as a demonstration of a contemporary and robust approach to integrated water cycle management (IWCM) analysis and planning techniques for region cities and towns. This project represents collaboration between local stakeholders and the Office of Living Victoria in the development of a whole of water cycle management framework for the Ballarat region.

This report is focused on the economic behaviour of the Ballarat water district in the context of the performance of the entire region for Business as Usual (BAU), for Scenarios that may challenge the future performance of the System (such as Climate Change and High Population Growth) and Options for future management (including building, precinct and regional scale strategies). A Systems Framework of the Ballarat region was developed as part of the Living Ballarat Project to assist in understanding the whole of water cycle challenges and opportunities across the region.

The Dynamic Economic Framework utilised in this analysis is a linked component of the Systems Framework that combines the all available costs for the whole of water cycle across the region to produce a range of economic futures. The economic analysis of the entire system (Systems Economics) utilised in this investigation is based on cash flows of costs throughout the water cycle system. This investigation does not include the value of assets and the costs of asset depreciation.

The results presented in this report should be considered in conjunction with the previous reports namely "*Systems analysis of water cycle systems – analysis of base case scenarios for the Ballarat region*" and "*Summary of the performance of options and key insights*". [1,2] The Scenarios and Options that are evaluated in this report are summarised in Tables 1.1 and 1.2 respectively.

Table 1.1: Overview of Scenarios

Scenario	Description
Base Case (BAU)	The Base Case is defined as continuing with current water cycle management processes and behaviours that are subject to the trajectory of current climate processes
BAU NoGW	Ground water resources are only used during droughts
Bulk	Water supply is not sourced from the Moorabool and Yarrowee Catchments
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[1] Coombes P.J., (2014). Systems analysis of water cycle systems. Analysis of base case scenarios for the Ballarat region. Report by OLV's Chief Scientist for the Living Ballarat Project Control Board.
[2] Coombes P.J., (2014). Summary of the performance of Options and Key Insights. Summary report by OLV's Chief Scientist to the Living Ballarat Project Control Board.

Table 1.2: Summary of the Alternative Options

Option	Description
BC1	Rainwater harvesting and highest level of water efficiency adopted in all new and substantially renovated buildings
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IWCM	Rainwater harvesting for non-drinking indoor uses and highest level of water efficiency adopted in all new buildings. Wastewater reuse via a third pipe network for toilet, outdoor and open space uses.
SWH	Stormwater harvesting from all impervious surfaces, stored and treated to supplement water supply for all new buildings. The highest available level of water efficient appliances and water efficient gardens.
WWR	Wastewater reuse via a third pipe network for toilet, outdoor and open space uses at all new buildings. The highest available level of water efficient appliances and water efficient gardens.

The systems analysis employed in this investigation has produced a richness of results and information that are available for additional analysis at a later time. Only a fraction of the information and results are presented in this report.

The analysis using the economic framework has utilised a wide range of data and information, including from the following sources:

- Central Highlands Water,
- City of Ballarat,
- National Water Commission,
- The Essential Services Commission,
- The Water Services Association of Australia,
- Melbourne Water Corporation,
- Office of Living Victoria,
- Catchment Management Authorities, and
- A wide range of scientific and economic publications.

This edition of the economic systems analysis across the Ballarat district also included hind casting of the analysis for the historical period from 2002 to 2012 to verify the reliability of the analysis. A sensitivity analysis of key parameters was also undertaken and the results are included in this version of the report. Finally, this report is supported by a web-based interactive analysis that can be accessed at www.systemsframework.com. User names and passwords for the web-based analysis will be assigned upon request to Urban Water Cycle Solutions at thecoombes@bigpond.com.

2 Summary of Methods, Data and Verification

2.1 Overview

The Economic Framework developed as part of the Living Ballarat study is a linked component of all previous numerical analyses provided to support the Living Ballarat project. The Economic Framework draws on a range of data and outputs from all of the Frameworks utilised throughout earlier stages of the investigation, including the local scale, transition, town scale and network Frameworks: all contribute to the economic assessment presented in this report. Importantly, these Frameworks, and the data they provide to the Economic Framework, collectively encompass relevant water cycle processes that operate at the full range of spatial and temporal scales, ranging for example, from multi-second time steps associated with the hydraulics of rainwater harvesting first flush devices up to multi-annual timescales associated with population growth and climate change. Behavioural, climatological and infrastructure changes over these timescales all contribute in varied ways to the development and execution of the Economic Framework, and as such, its outputs should be seen as an integration of all processes and their respective impacts on the regional Ballarat water cycle.

Figure 2.1 presents a conceptual diagram of the interactions between a range of Frameworks, and with the Economic Framework and its operation in this study. Individual inputs to the economic model are presented thereafter in this Section.

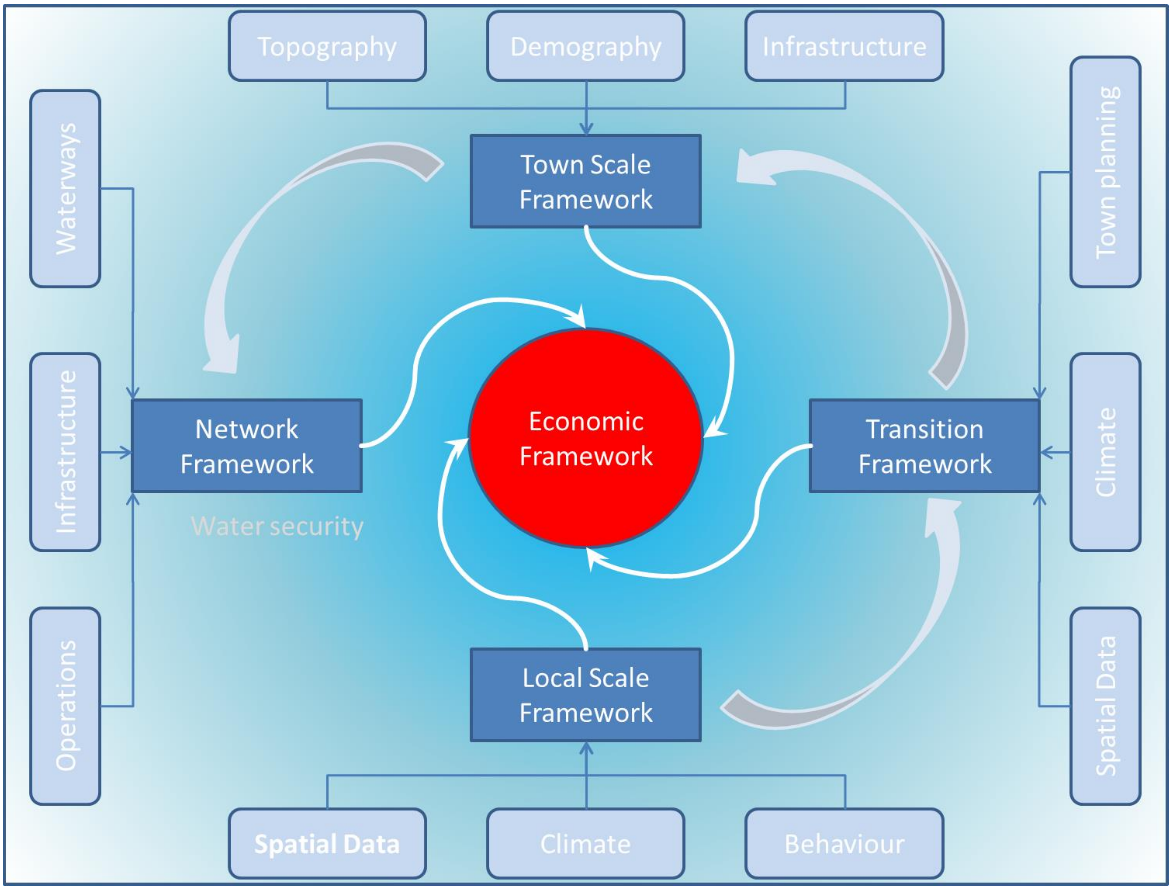

Figure 2.1: A conceptual overview of the interactions within the Systems Framework

The methods applied in the economic framework and verification of these processes using hind casting are described below. Where numerical assumptions are presented (for example the average land area of a commercial property or any rate costs), it should be noted that the economic framework has been designed and constructed in a flexible manner so as to allow for these assumptions to be tested as required. Re-executing the economic framework for all options and scenarios takes a matter of seconds, thus facilitating the rapid and robust assessment of impacts that any assumptions presented herein may have on resulting economic outputs. It is the intent that this gaming style process is applied to assist with the ongoing implementation of planning processes for the Ballarat region.

2.2 Assumptions and hind casting for water and wastewater services

Hind casting is a process of simulating the behaviour of water cycles and associated financial processes throughout a historical period with known information. This Section provides an overview of the hind casting of financial processes for the Ballarat region that was enabled by the availability of historical information about the water and wastewater infrastructure. See the report by Coombes et al. (2014) for details of hind casting of biophysical systems associated with the Ballarat region[3].

Financial hind casting compares the outputs from the Systems Framework to observed financial behaviours. This process was employed to validate the efficacy of the Systems Framework to reproduce historical financial behaviours and to calibrate the behaviour of the Framework. The calibration process ensures that the predicted costs are consistent with the observed costs for the entire hindcasting period from 2002 to 2012. In addition, the hindcasting process aims to reproduce the patterns of expendature wherever possible. The elements of the total operating costs for water and wastewater services included the following:

- Treatment of water and wastewater;
- Distribution of water and wastewater throughout district scale water cycle networks;
- Supply of bulk water to district scale water cycle networks;
- Supply of ground water to district scale water cycle networks;
- Supply of treated wastewater; and
- Corporate overheads.

The observed operating costs for the Ballarat water and wastewater district where derived from:

- the annual reports published by Central Highlands Water (CHW),
- Urban National Performance Reports published by the National Water Commission[4], and
- Asset management data provided by Central Highlands Water that highlighted the operating costs for the 2011-12 financial year.

The CHW annual reports, Urban National Perforance Reports and CHW's asset management data provided similar results for total operating costs for the 2011-12 financial year. The asset management data revealed that a 72.5% proportion of total operating costs for CHW can be

[3] Coombes P.J., M.E. Barry and Q. Gay (2014). Systems analysis of water cycle systems. Analysis of base case scenarios for the Ballarat region. Report by the Chief Scientist at the Office of Living Victoria. Version 4a.
[4] NWC (2014). Urban National Performance Reports 2012-13 Part B. Report and spreadsheet by the National Water Commission. Australian Government.

attributed to the Ballarat water and sewage district. The total water and wastewater operating costs in the Ballarat district are 41.8% and 30.7% of CHW's total operating costs, respectively.

These values were used to determine the proportion of total operating costs from CHW annual reports that attribute to the Ballarat district throughout the period 2002 to 2012. In addition, the ratio of bulk water use in the Ballarat district to the total bulk water use for the entire CHW jurisdiction was used to apportion bulk water costs to the Ballarat district.

The operating costs of water and wastewater infrastructure include treatment, pumping, maintenance and corporate costs. The average operating costs of all local and district scale water infrastructure are presented in Table 2.1. Note that these costs do not include the operation of bulk water infrastructure and payment for bulk water allocations.

Table 2.1: Operating costs of water infrastructure

Location	**Operating costs ($/ML)**
Ballarat	964
Ballan	318
Creswick	372
Skipton	313

The nominated costs in Table 2.1 are applied as a function of water demands in each nominated spatial area that are added to the general operating costs of the Ballarat district which includes water treatment. The average operating costs of all local and district scale wastewater infrastructure derived from Central Highlands Water records are presented in Table 2.2.

Table 2.2: Operating costs of wastewater infrastructure

Location	**Operating Costs ($/ML)**
Ballarat North	1,118
Ballarat South	543
Ballan	534
Cardigan Village	407
Creswick	395
Skipton	2,069

The nominated costs in Table 2.2 are applied as a function of sewerage discharges in each nominated spatial area.

The security of water supplies to Ballarat water district is also dependent on bulk water resources that can be extracted from a range of catchments as shown in Table 2.3.

Table 2.3: Bulk water allocations from external catchments

Catchment	Security	Volume (ML/year)
Goulburn	high	8,723
Campaspe	low	11,419
Murray	high	70
Lower Broken Creek	high	145
Murray	high	825
Loddon (Crosgrave and Newlyn)	high	500

The Goulburn, Murray and Broken Creek allocations are accessed via the Colbinabbin pump station in the Goldfield pipeline connection and the Campaspe allocation is accessed from Lake Eppalock.

The operating costs derived from Central Highlands Water data and bulk water charges provided by Goulburn Murray Water were combined as shown in Table 2.4 for use in the Systems Economic Framework.

Table 2.4: Costs for bulk water sources

Source	Operating cost ($/ML)	Resource Cost ($/ML)	Allocation cost ($/ML)
Goulburn and Campaspe	1,600	7.64 and 12.16	9.85 and 4.83
Moorabool Reservoir	1,068	-	-
Lal Lal Reservoir	1,428	-	-
Cosgrave and Newlyn Reservoirs	1,416	32.46	4.83
Ground water	92	-	-

A comparison between observed total operating costs and the total operating costs predicted by the Systems Economic Framework for the Ballarat water and sewage district is presented in Figure 2.1.

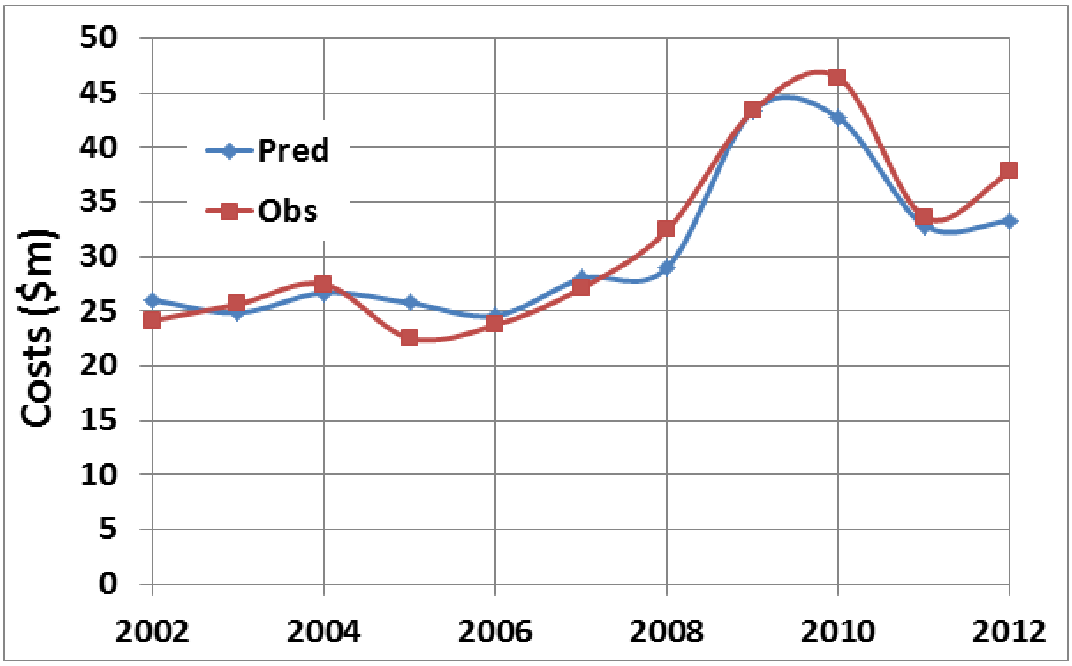

Figure 2.1: Total operating costs for water and wastewater services

Figure 2.1 demonstrates that Systems Framework has reproduced the patterns and magnitudes of total operating costs for the Ballarat water and sewage district. The reliability of the prediction with respect to time is provided by the Pearson Correlation of 0.95 and the co-efficient of determination (R^2) of 0.91. These results indicate that the Systems Framework provided a high level of accuracy for generating total operating costs.

The bulk water expenses for the Ballarat district include the costs to source and transfer water from a regional water storages (see Table 3.4) to the Ballarat district. The predicted and observed bulk water costs for the Ballarat district are presented in Figure 2.2.

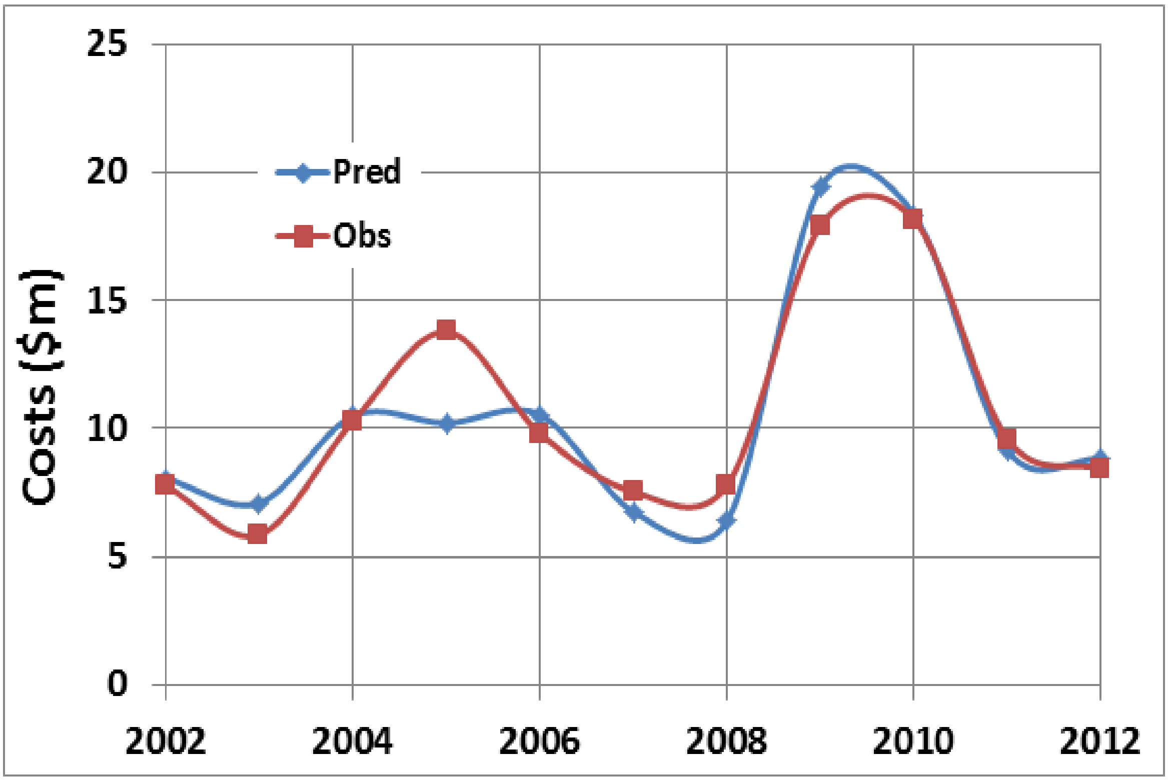

Figure 2.2: Bulk water costs for the Ballarat district

Figure 2.2 show that the Systems Framework has accurately reproduced that regime of bulk water costs for the 2002 to 2012 period. This strong result is also confirmed by a Pearson Correlation of 0.95 and a Co-efficient of Determination of 0.89.

The costs to replace existing water and wastewater infrastructure (renewal costs) are usually included in capital costs in CHW annual reports and National Benchmarking Reports. Asset management data and Water Plan submissions from CHW were used to derive historical renewal costs. The renewal costs of water and wastewater infrastructure were assumed to be spatially unchanging across the system, as presented in Table 2.5.

Table 2.5: Costs for distribution scale water and wastewater renewal

Water Stream	Renewal Costs ($/ML)
Water	193
Wastewater	316

Renewal costs were set to be functions of total water supply (in ML) and wastewater generation in the Systems Framework as follows:

$$WaterRenewal_t = WaterRenewalCost \times TotalSupply_i$$
$$WastewaterRenewal_t = WasteWaterRenewalCost \times TotalWastewater_i \quad (1)$$

The values in Table 2.5 and Equation 1 are used in the Systems Framework to evaluate the renewal costs of water and wastewater infrastructure. The predicted and observed renewal costs for the Ballarat district are presented in Figure 2.3.

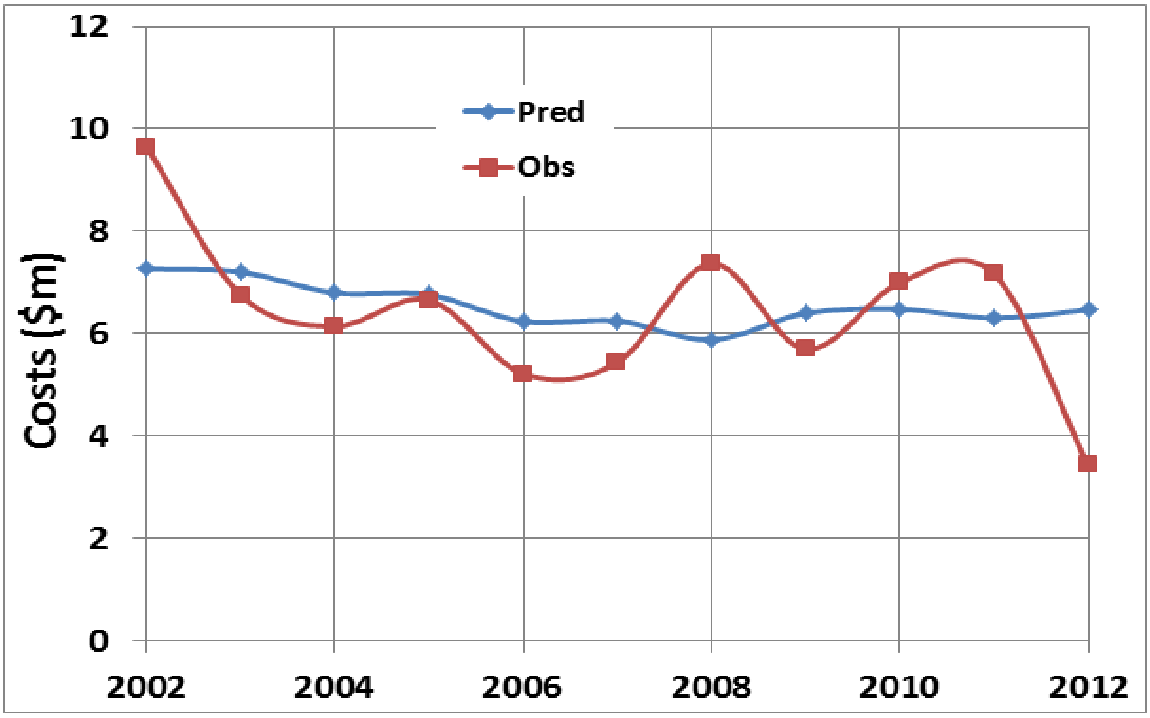

Figure 2.3: Renewal costs for water and wastewater infrastructure

Figure 2.3 reveals that the Systems Framework was able to estimate the total magnitude and trend of renewal costs for the period from 2002 to 2012. The Pearson Correlation of 0.77 indicates a good prediction of the overall trends in renewal costs.

However, the Co-efficient of Determination of 0.13 shows a limited prediction of the variability of renewal costs that was strongly influenced by the high first value and the low final value in the observed data. Nevertheless, the magnitude of renewal costs for the hind casting period was successfully predicted.

Intermediate scale infrastructure was defined as infrastructure that is not at a local (gifted assets that are installed at the street scale in land subdivisions) or bulk "headworks" scale and is typically referred to also as trunk infrastructure. Forensic analysis of historical expenditure patterns of CHW, as published in annual reports and provided by CHW data, was utilised to determine the costs and timing for installation and operation for intermediate or trunk scale water infrastructure.

Observed capital costs of water and wastewater trunk infrastructure to supply new growth was derived from CHW's asset management data and annual reports. District scale capital costs of trunk infrastructure were determined as the value of total capital investments less the combined value of gifted assets and water security infrastructure.

The expenditure patterns revealed that this infrastructure is installed to service new urban precincts and for associated augmentation of existing trunk infrastructure at larger time intervals than local infrastructure, in response to new urban growth areas. The Systems Framework was employed to estimate that the trigger for augmentation of trunk infrastructure. The installation costs of trunk water infrastructure are presented in Table 2.6.

Table 2.6: Costs for intermediate scale water infrastructure

Location	**Capital Costs ($/100 ML/annum)**
Ballarat	1,955,170
Ballan	1,404,924
Creswick	566,402

Table 2.6 shows that the timing of costs (Capital) for installing new trunk water infrastructure is approximated as 100 ML intervals of new water demands generated by new properties. Average annual water demands in any year were found to be the basis of peak demands used to design and provide trunk water infrastructure to service new urban growth areas.

The cost of trunk water infrastructure (TrunkWaterCost) required in any year (t) is a function of the cumulative new water demands (NewDem) for new growth areas and the costs (WaterCost) from Table 2.6 as shown in Equation 2:

$$NewDem_t = \sum_{i=1}^{t} \left(\frac{TotalDemand_i}{Total\ properties_i}\right) NewProperties_i$$

$$TrunkWaterCost_t = \left\{ \begin{matrix} 0, \ NewDem_t < 100 \\ \frac{NewDem_t \times WaterCost}{100}, \ NewDem_t \geq 100 \end{matrix} \right\} \quad (2)$$

Equation 2 indicates that when the sum of increased water demand expected from new properties is greater than 100 ML the capacity of existing trunk infrastructure is exceeded for a given growth area and the costs to provide new trunk water infrastructure are applied. Then the summation of new demand is reset to zero and the process continues.

The costs of providing trunk infrastructure are applied in a cumulative manner across the system. For example, new growth in (say) Ballan or Creswick may also require upgrades of infrastructure within the Ballarat system to service this growth.

The predicted and observed costs of trunk water infrastructure for the Ballarat district are presented in Figure 2.4.

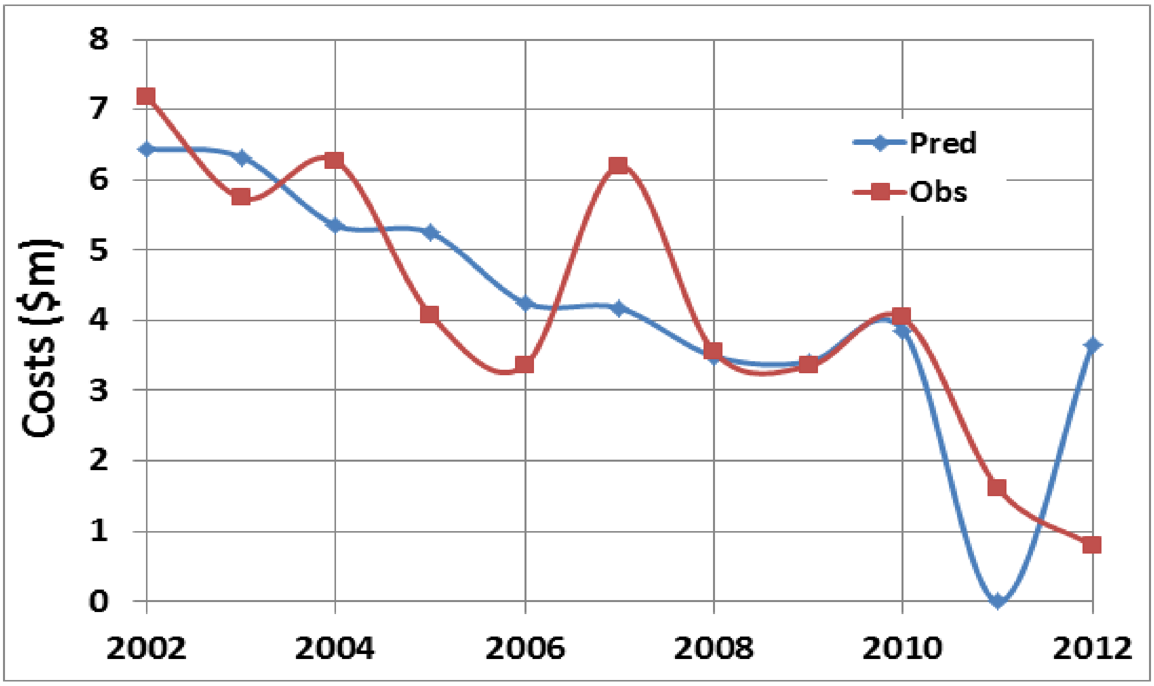

Figure 2.4: Capital costs (not gifted assets or security infrastructure) for district water infrastructure

Figure 2.4 reveals that Systems Framework was able to reproduce the magnitude and the overall trend of capital expenditure for trunk water infrastructure. A Pearsons Correlation of 0.74 and Co-efficient of Determination of 0.53 indicates that a good prediction of the regimes of capital expenditure for trunk water infrastructure.

The installation costs of trunk wastewater infrastructure derived from CHW records are presented in Table 2.7.

Table 2.7: Costs for intermediate scale wastewater infrastructure

Location	**Capital Costs ($/100 ML/annum)**
Ballarat North	5,129,144
Ballarat South	7,148,880
Ballan	2,063,850
Cardigan Village	9,872,567
Creswick	7,339,982
Skipton	4,121,173

Table 2.7 shows that the timing of costs (Capital) for installing new trunk wastewater infrastructure is approximated as 100 ML intervals of new wastewater discharges generated by new properties. Average annual wastewater discharges in any year were found to be the basis of peak demands used to design and provide trunk wastewater infrastructure to service new urban growth areas.

The cost of trunk wastewater infrastructure (TrunkWWCost) required in any year (t) is a function of the cumulative wastewater discharges (NewWW) for new growth areas and the costs (WWCost) from Table 2.7 as shown in Equation 3:

$$NewWW_t = \sum_{i=1}^{t} \left(\frac{TotalWW_i}{Total\ properties_i}\right) NewProperties_i$$

$$TrunkWWCost_t = \begin{Bmatrix} 0, \ NewWW_t < 100 \\ \frac{NewWW_t \times WWCost}{100}, \ NewWW_t \geq 100 \end{Bmatrix} \quad (3)$$

Equation 3 shows that when the sum of increased wastewater discharges expected from new properties is greater than 100 ML the capacity of existing trunk infrastructure is exceeded for a given growth area and the costs to provide new trunk wastewater infrastructure are applied. Then the summation of new wastewater discharges is reset to zero and the process continues. The costs of providing trunk wastewater infrastructure are applied for each wastewater catchment in the system.

The predicted and observed costs of trunk wastewater infrastructure for the Ballarat district are presented in Figure 2.5.

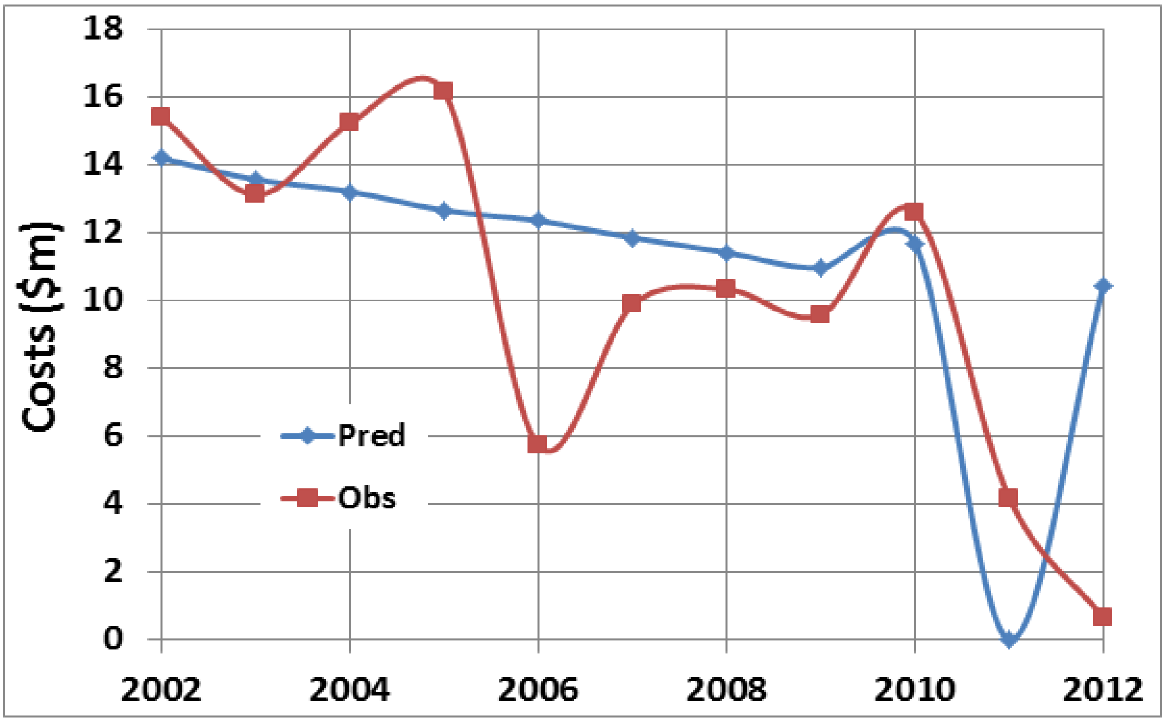

Figure 2.5: Capital costs (not gifted assets) for district wastewater infrastructure

Figure 2.5 demonstrates that the Systems Framework has reproduced the trends and magnitudes of expenditures on trunk wastewater infrastructure for the entire hind period. The Pearsons Correlation of 0.58 and a Co-efficient of Determination of 0.27 indicate a good reproduction of trends in expenses with limited capacity to capture the variable regimes of the costs. Nevertheless, the analysis was able to reproduce the total magnitude of trunk water expenses for the period 2002 to 2012.

A comparison between the total costs of observed and predicted expenses for water and wastewater services is presented in Figure 2.6.

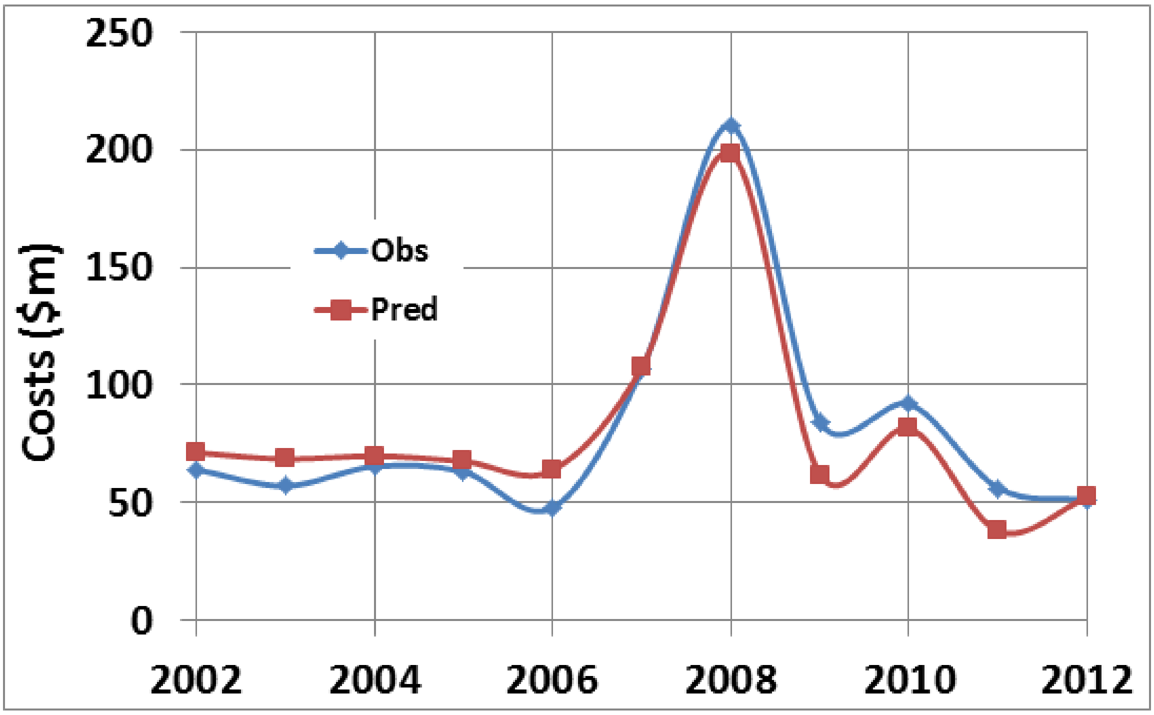

Figure 2.6: Total costs for water and wastewater services (excluding gifted infrastructure)

Figure 2.6 demonstrates the Systems Framework was able to successfully reproduce the trends and magnitudes of total expenses for water and wastewater infrastructure for the period 2002 to 2012. A Pearsons Correlation of 0.96 and a Co-efficient of Determination of 0.97 confirm an excellent prediction of the total costs for water and wastewater services.

The Systems Framework has successfully reproduced the magnitude and patterns of historical water and wastewater expenditures throughout the Ballarat district. These results indicate that the Systems Framework can reliably simulate the expected future impacts of Scenarios and Options on the financial and economic viability of water cycle management in the Ballarat district. However, it will be important to include sensitivity analysis of key parameters in analysis of future states to overcome any potential uncertainty about predicted futures created by variability and inconsistency of some sources of financial input data.

2.3 Additional Methods and Inputs

This section includes additional methods and inputs that were not subject to hind casting due to limited availability of historical information. The average costs of providing local scale infrastructure derived from tenders for construction of housing estates in the Ballarat region are presented in Table 2.8.

Table 2.8: Costs for local reticulated infrastructure and stormwater management

Criteria	**Costs ($/property)**
Water	2,282
Wastewater	5,484
Stormwater	6,931

Table 2.8 shows the average costs per property for local water, sewage and stormwater reticulation. The costs of local stormwater infrastructure include stormwater detention to manage local flooding and treatment for acceptable stormwater quality. The analysis also incorporates an equivalent average land area of property of 1,250 m^2 that is derived from detached housing that includes half of the road frontage that is used to equate stormwater runoff to additional non-residential properties.

The economic analysis translates the infrastructure costs for each property into variable costs for water demands or wastewater discharges or urban stormwater runoff for each new property in any year (t) as shown in the following equations 4, 5 and 6:

$$LocalWaterCost = \left(\frac{TotalDemand_t}{Total\ properties_t}\right) NewProperties_t \times WaterCost$$

(4)

$$LocalWastewaterCost = \left(\frac{TotalWastewater_t}{Total\ properties_t}\right) NewProperties_t \times WastewaterCost$$

(5)

$$LocalStormwaterCost = \left(\frac{TotalUrbanRunoff_t}{Total\ properties_t}\right) NewProperties_t \times StormwaterCost$$

(6)

Equations 4 to 6 were incorporated in the systems economic framework to account for installation of local scale infrastructure. The economic analysis recognises that new properties will require services via local infrastructure regardless of the status of regional water demands, stormwater runoff or sewerage discharges. This requirement for local infrastructure is based on the expected average annual water demands of new properties in a given year. Note that peak factors used to design infrastructure are derived from average demands.

The economic analysis also includes the option to include additional stormwater management on properties, within street scapes and in parks. It is envisaged that these additional measures include strategic landscaping (designed to retain and filter stormwater runoff), bioretention facilities and a range of vegetated measures that disconnect impervious (hard) surfaces from direct connection to drainage infrastructure. This approach is cognisant that the entire road corridor is traditional utilised to convey urban stormwater. The installation, maintenance and replacement costs of street scape measures was determined to be \$300/m^2, \$45/ML of captured stormwater runoff and \$300/m^2. The design life of these measures was assumed to be 15 years.

The costs of stormwater management were derived from three sources of City of Ballarat's 2012/13 actual expenditure and annual asset replacement costs:

1. City Services Drainage Operations Budget
2. City Services Street Cleansing, Trails and Waterways Operations Budget
3. Assets Database Projections for Critical averaged Asset Repair and Replacement Expenditure for next 30 years.

In addition, the costs of regional scale stormwater management infrastructure were derived from Melbourne Water's western Development Services Schemes for use in this analysis. The inclusion of regional scale stormwater infrastructure accounts for regional scale flood and water quality management infrastructure that usually driven by multiple agency processes and funding, and responses to regional events such as the 2010 and 2011 floods.

Whilst the urban development process provides for local stormwater management infrastructure in response to the development timelines, these additional regional infrastructure responses are infrequently required to mitigate whole of catchment or regional impacts. A trigger of an increase in average annual stormwater flows of 1000 ML was utilised in the Systems Framework to capture the infrequent nature of these regional infrastructure strategies.

Previous investigations combined the results of all available flood investigations with multiple layers of big data (including flood layers provided by the Department of Environment and Primary Industries and City of Ballarat) to reveal that currently 1,740 buildings and 2,551 properties in urban areas are potentially subject to flooding from 100 year ARI storm events.[5] The estimated flood damage results are presented in Figure 2.7 for median, minimum and maximum costs.

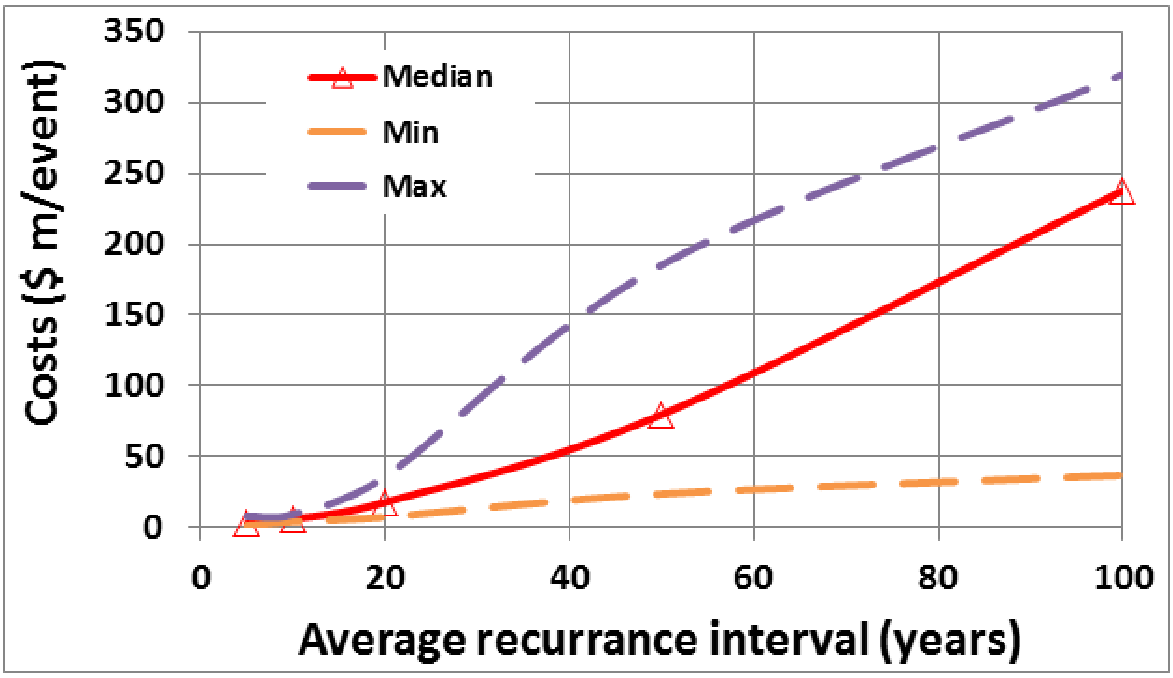

Figure 2.7: Flood damage curve for City of Ballarat (known flood risks)

Figure 2.7 revealed that costs of flood events in the City of Ballarat jurisdiction range from $2.5 m (minimum of $0 m to maximum $7.8 m) for 5 year ARI events to $237 m (minimum of $27 m to maximum of $319 m). The probable maximum flood (PMF) may yield total damage costs ranging from $46 m to $673 m.

Note that the flood damage curve is based on known flood risks from the area (much is unknown) and the traditional estimates of flood damage using this Rapid Assessment Method (loss – probability curve method) is usually significantly less than actual insurance cost observations. However, the damage costs have been inferred from published flood studies in surrounding locations which limits the certainty of actual local costs. Nevertheless, the likely economic results are summarised in Table 2.9.

[5] Coombes P.J. (2014). Insights into flood risks in the City of Ballarat jurisdiction. Briefing Note provided by OLV's Chief Scientist.

Table 2.9: Economic results for flood risks in City of Ballarat jurisdiction

Criteria	Costs ($ m)		
	Median	**Minimum**	**Maximum**
Average annual damage	8	2.1	15.4
Net present costs	134	35	259

The median value of expected average annual damage from flooding was included in the economic framework. The installation, operating and flood damage costs of stormwater infrastructure that are included in the economic framework are presented in Table 2.10.

Table 2.10: Costs for intermediate scale stormwater infrastructure

Criteria	Value	Rate
Operations	$2,349,906/annum	$150/ML
Renewals	$758,861/annum	$48.60/ML
Trunk infrastructure	$25,855/Ha	$8,505,000/1,000ML
Average Annual Damage - base value	-	$8,000,000/annum

Table 2.10 shows that the timing of costs (Capital) for installing new regional stormwater infrastructure is approximated as 1,000 ML intervals of new urban stormwater runoff. Note that the costs for subdivision scale stormwater infrastructure provided by urban developers are counted in Table 2.8. The regional scale stormwater infrastructure supplements the performance of the local infrastructure for management of flooding and stormwater quality.

Average annual stormwater runoff in any year was found to be the basis of peak demands used to design and provide trunk water infrastructure to service new urban growth areas. The cost of trunk stormwater infrastructure (TrunkSWCost) required in any year (t) is a function of the cumulative new stormwater runoff (NewSW) for new growth areas and the costs (SWCost) from Table 2.10 as shown in Equation 7:

$$NewSW_t = \sum_{i=1}^{t} \left(\frac{TotalSW_i}{Total\ properties_i} \right) NewProperties_i$$

$$TrunkSWCost_t = \begin{Bmatrix} 0,\ NewSW_t < 1000 \\ \frac{NewSW_t \times SWCost}{1000},\ NewSW_t \geq 1000 \end{Bmatrix} \quad (7)$$

Equation 7 shows that when the sum of increased stormwater runoff from new properties is greater than 1,000 ML the capacity of existing trunk infrastructure is exceeded for a given growth area and the costs to provide new trunk stormwater infrastructure are applied. Then the summation of new stormwater discharges is reset to zero and the process continues. The costs of providing trunk stormwater infrastructure are applied for each stormwater catchment in the system.

The Framework also accounts for the costs associated with the generation and environmental delivery of pollutants through the stormwater network and waterways. Total pollutant loads (as opposed to concentrations) of nitrogen, phosphorus and suspended sediments were considered in the analysis, with these loads having being previously computed throughout the Systems Framework as the product of urban stormwater runoff volumes and event mean concentrations (EMCs) for each pollutant. Costs and EMCs are presented in Table 2.11.

Table 2.11: Costs and EMCs for associated with stormwater pollution

Pollutant	EMC (kg/ML)	Cost ($/kg)
Nitrogen	10	2,250
Phosphorus	0.2	268
Suspended Sediment	15	30

The total costs associated with unmitigated delivery of these pollutants to the environment were computed in the Systems Framework as presented in Equation 8:

$$TotalCost_t = EMC \times UrbanStormwaterRunoff_t \times Cost \quad (8)$$

The Economic Framework also simulated the costs of implementing water saving measures and alternative water sources, including capital, operating and renewal costs associated with distributed rainwater harvesting, adoption of water efficient appliances, stormwater harvesting and wastewater reuse. Where appropriate, these costs were separated into residential and non-residential category, and in the case of rainwater harvesting, individual system components (i.e. pumps and tanks). Costs are presented in Tables 2.12 to 2.15 below.

Table 2.12: Costs associated with rainwater harvesting

Component	Cost	Cost unit
Capital cost (residential)	3,500	$/building
Capital cost (non-residential)	14,500	$/1,000 m^2 roof area
Operating	160	$/ML
Renewal - pump	650	$/building or 1,000 m^2 roof area
Renewal – tank (residential)	2,000	$/building
Renewal – tank (non-residential)	5,000	$/1,000 m^2 roof area
Growth	1	Fraction of future dwellings to install water saving measures
Renovation rate	0.5	Fraction of renovated dwellings installing water saving measures

The values for installation and operation of rainwater harvesting systems were derived from rainwater industry data and peer reviewed publications (such as for the Queensland Auditor General).[6]

[6] Coombes P.J. (2012). Effectiveness of rainwater harvesting in South East Queensland. Urban Water Cycle Solutions. Report for the Rainwater Harvesting Association of Australian submitted to the Qld State Government Cabinet.

Table 2.13: Costs associated with water efficient appliances

Component	Cost	Cost unit
Capital cost	500	$/equivalent residential building
Operating	0	$/ML
Renewal	500	$/equivalent residential building
Growth	1	Fraction of future dwellings to install water saving measures
Renovation rate	0.5	Fraction of renovated dwellings installing water saving measures

The costs associated with water efficient appliances were derived from the product surveys completed by the Office of the Chief Scientist at the Office of Living Victoria.[7]

Table 2.14: Costs associated with stormwater harvesting

Component	Cost	Cost unit
Capital cost	43,128	$/ML of new demand/annum
Operating	650	$/ML
Renewal	268	$/ML
Growth	1	Fraction of future dwellings to install water saving measures
Renovation rate	0	Fraction of renovated dwellings installing water saving measures

The costs associated with stormwater harvesting schemes were derived from recent publically available information about projects such the Fitzroy Gardens, Darling Street East Melbourne and Royal Park stormwater harvesting projects within the City of Melbourne jurisdiction.

Table 2.15: Costs associated with wastewater reuse

Component	Cost	Cost unit
Capital cost (system)	53,420	$/ML of new demand/annum
Capital cost (third pipe)	2,500	$/building
Operating (future install)	2,200	$/ML
Renewal (future install)	834	$/ML
Operating (existing)	2,509	$/ML
Renewal (existing)	834	$/ML
Growth	1	Fraction of future dwellings to install water saving measures
Renovation rate	0	Fraction of renovated dwellings installing water saving measures

The costs associated with wastewater reuse projects were derived from the Ballarat North wastewater reuse facility and reports published by the authors.

Operating costs associated with the information in the above Tables were calculated using respective total volumes of water from alternative sources (either existing in the case of wastewater reuse, or future, or both) as follows:

$$OperatingCost_t = RateCost \times TotalWaterVolume \quad (9)$$

[7] Office of the Chief Scientist (2013). Price point survey of water efficient appliances. OLV Chief Scientist. Government of Victoria.

The (capital) costs of installing rainwater harvesting and water efficient appliances were computed as a function of new and renovated properties each year as follows (for residential and non-residential properties):

$$CapitalCost_t = YearlyGrowth \times Fractionof\ AdoptingProperties \times CapitalCost \qquad (10)$$

Installation costs associated with stormwater harvesting and wastewater reuse were computed as the product of total savings gained from each measure within a given year, and their respective rate costs presented in Tables 2.14 and 2.15 above. In the case of wastewater reuse, additional annual capital costs were computed as the annual growth in residential and non-residential properties multiplied by the unit cost of third pipe networks in Table 2.15.

Renewal costs for all savings measures and alternative water sources were computed with reference to two user specified renewal years (see tabulations below) and the useful life of the asset (Renew). In the period prior to the first renewal year, no renovation costs are incurred. Between the first and second renewal years, rainwater harvesting pumps and water efficient appliances are renewed as a function of past uptake of measures at residential and non-residential buildings, as follows (respectively):

$$RWTRenewalCost_t = UptakeRate_{t-renew}\ Annual\ Growth_{t-renew} \times Pump\ CapitalCost \qquad (11)$$

$$WEARenewalCost_t = Annual\ Growth_{t-renew} \times UptakeRate_{\ t-renew} \times WEA\ CapitalCost \qquad (12)$$

After the second renewal year, stormwater harvesting and wastewater reuse costs are computed by multiplying the corresponding water savings in a given year by the unit cost of renewal. Rainwater harvesting renewal costs beyond the second renewal period are assumed to be associated with replacement of rainwater tanks and are computed in a manner analogous to equation (11).

Finally, and as mentioned throughout the above method descriptions, a series of user defined parameters were required to complete the analysis. The majority of these are simply unit conversions factors and the like (i.e. have no methodological significance beyond unit accounting), however key parameters are listed blow in Table 2.16, with supporting explanation.

Table 2.16: User defined parameters

Parameter	**Typical Value**	**Description**
Augmentation year	2052	Year in which bulk water augmentation is to occur
First renewal year	2025	The first year after simulation start that triggers savings measure renewal
Second renewal year	2040	The second year after simulation start that triggers savings measure renewal
Discount rate	5%	Used for NPC calculations (can be varied)
Global renovation rate	0.9%	Assumed property renovation rate

Augmentation of the water security system was assumed to occur when the frequency of water restrictions reaches unacceptable levels. At this point, a capital expenditure of $106m was incurred for duplication of the Goldfields pipeline to source additional water from the Goulburn Catchments, and for all following years an additional cost of $723/ML (over and above prior costs) was applied to water sourced via this augmentation in the calculation of operating costs.

3 Results

The Systems Framework of the water cycle was utilised to investigate the performance of business as usual (BAU), Scenarios and Options for water cycle management across the Living Ballarat region.[8,9] The results presented in this report should be considered in conjunction with the previous reports.

A dynamic Economic Framework is a linked component within the Systems Framework that combines the all available costs for the whole of water cycle across the region to produce a range of economic futures. The economic analysis of the entire system (Systems Economics) utilised in this investigation is based on cash flows of costs throughout the water cycle system.

Whilst the Economic Framework allows rapid assessment of almost all inputs, this report presents the results for the inputs provided in Section 2 using a real discount rate of 5%. The comparative results for the simulations of BAU, Scenarios and Options are provided in this section.

A set of detailed cash flows and net present costs (NPC) are provided for water, wastewater and stormwater services, and for waterway pollution. In addition, these results are combined by jurisdiction into economic futures for the Water Authority, Local Government, Developer, Citizen and Society. Note that the Society jurisdiction includes changes in the costs of flood risks and waterway health since 2010.

3.1 BAU

The result of the simulations of cash flows for providing water services is presented in Figure 3.1.

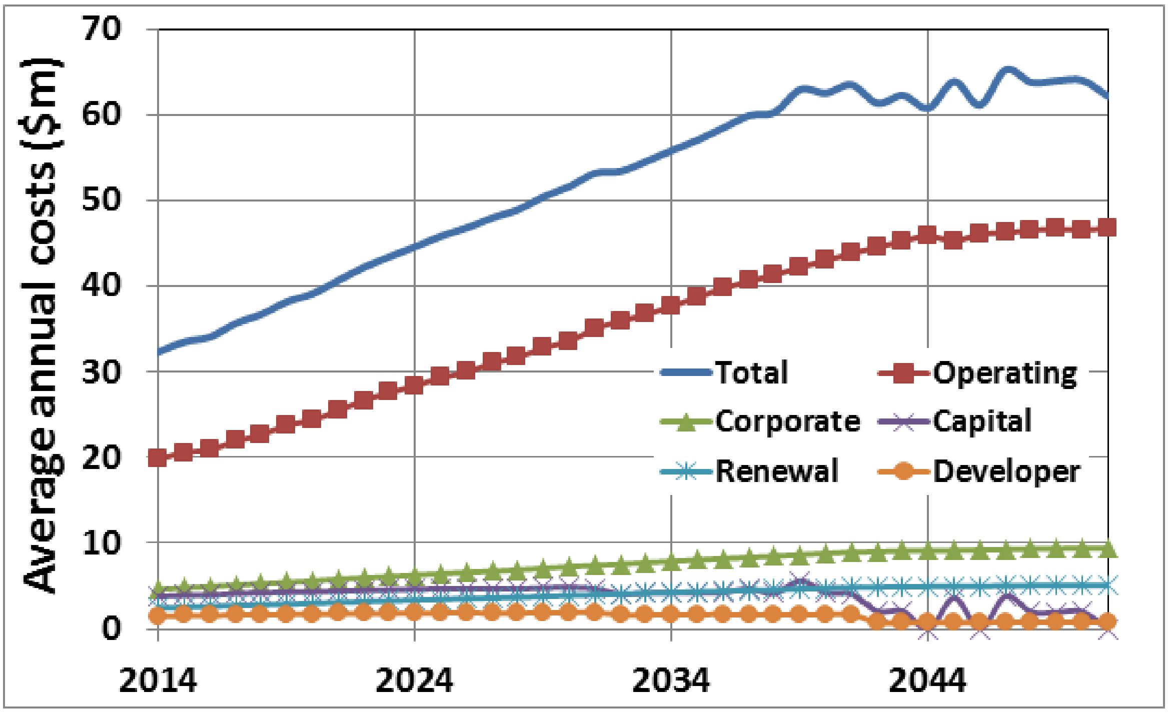

Figure 3.1: Average annual cost of water services

[8] Coombes P.J., (2014). Systems analysis of water cycle systems. Analysis of base case scenarios for the Ballarat region. Report by OLV's Chief Scientist for the Living Ballarat Project Control Board.
[9] Coombes P.J., (2014). Summary of the performance of Options and Key Insights. Summary report by OLV's Chief Scientist to the Living Ballarat Project Control Board.

Figure 3.1 reveals that the costs of servicing the Ballarat water district increase over time in response to population growth. The costs of local infrastructure provided by developers, renewal of water infrastructure and corporate overheads at the water authority are subject to moderate increases over time. Note that the costs incurred by developers is seen to decline after 2040 in response to decreasing population growth included in published planning strategies. In contrast, the operating costs of water supply and distribution infrastructure is subject to strong growth over time, and increasing urban development drives the periodic requirement for new trunk water infrastructure. The net present costs to 2051 for provision of water services are provided in Table 3.1.

Table 3.1: Net present costs to 2051 for water services

Criteria	NPC ($m)
Total	734
Operating	474
Corporate	109
Capital	63
Renewal	58
Developer	29

Table 3.1 highlights that the costs of operating water supply, distribution and treatment infrastructure are the most significant future costs of providing water services in the Ballarat Water district. The majority of these future cost accrue to the Water Authority. The timeline of costs of providing wastewater services are presented in Figure 3.2.

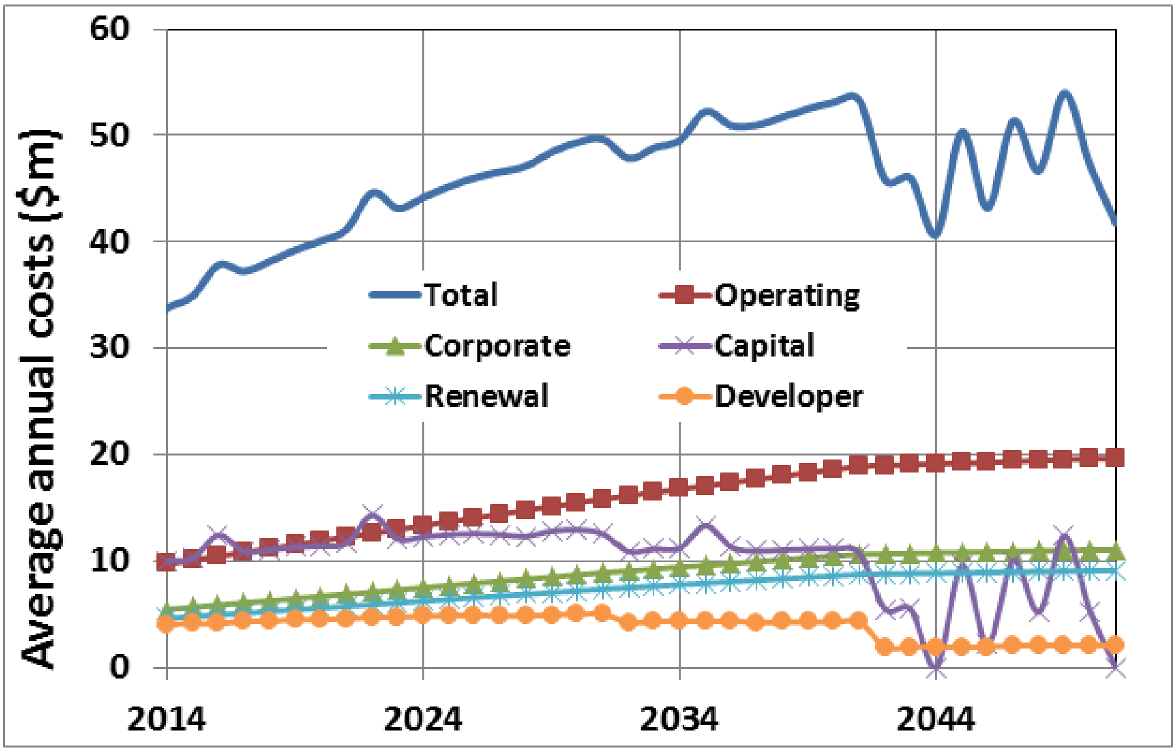

Figure 3.2: Average annual costs of wastewater services

Figure 3.2 shows that the majority of costs for provision of wastewater services accrue to the Water Authority and the costs increase with population growth. In particular, the costs of operating the wastewater network are seen to cumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. Note that the economic analysis assumed that all new developments will be serviced by reticulated infrastructure. The net present costs to 2051 for provision of wastewater services are provided in Table 3.2.

Table 3.2: Net present costs of wastewater management

Criteria	NPC ($m)
Total	707
Operating	227
Corporate	128
Developer	76
Capital	170
Renewal	107

Table 3.2 reveals that the operating, renewal and corporate costs are significant proportions of the total future costs of providing wastewater services.

The timeline of future costs of stormwater management and flood risks are presented in Figure 3.3.

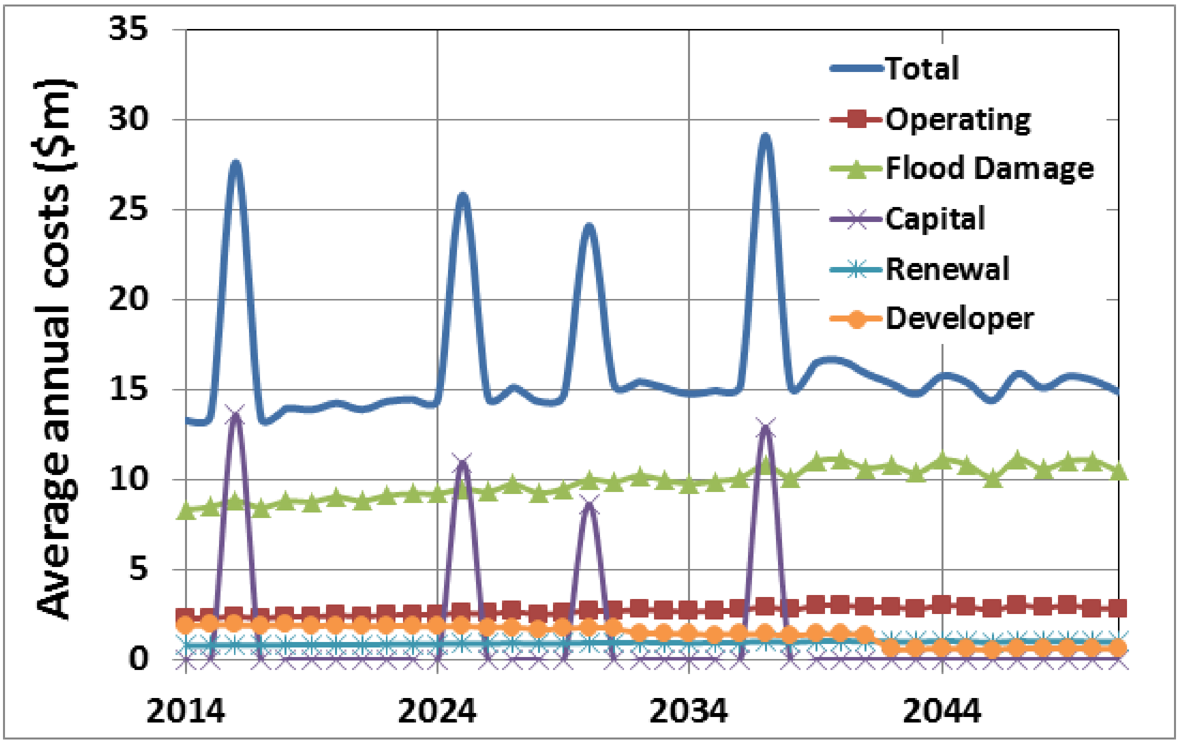

Figure 3.3: Average annual stormwater costs

Figure 3.3 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management. The cost of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decreases over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon.

The net present costs to 2051 for stormwater management and flooding are provided in Table 3.3.

Table 3.3: Net Present costs of stormwater management and flooding

Criteria	NPC ($m)
Total	315
Operating	44
Developer	75
Capital	21
Renewal	15
Flooding	160

Table 3.3 shows that the costs of flood risks, for provision of local infrastructure by developers and operations and maintenance by local government are a substantial proportion of costs of stormwater management. The timeline of future costs of pollutant loads in waterways are presented in Figure 3.4.

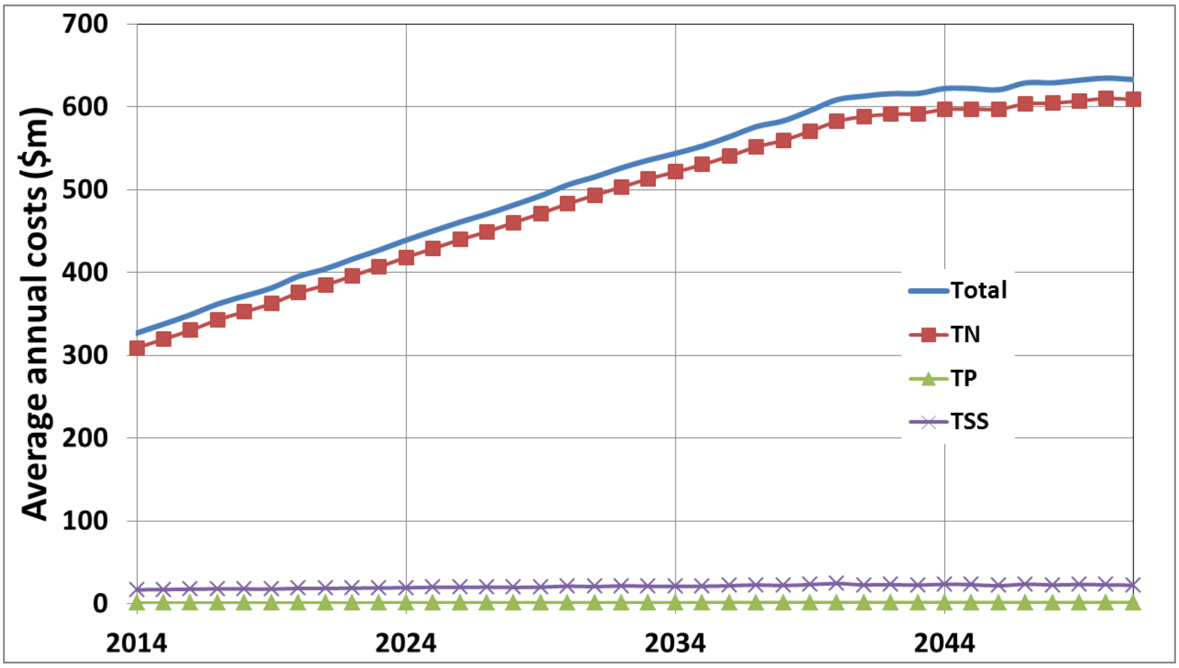

Figure 3.4: Costs of cumulative pollutant loads in waterways

Figure 3.4 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments. These costs are used as the basis of comparison across Scenarios and Options. The substantial increases in the costs of nitrogen loads are attributed to the relatively high costs assigned to nitrogen in the valuation by

Melbourne Water Corporation and to increases in discharges of wastewater effluent to waterways in response to population growth.

The net present costs to 2051 of the total pollutant loads are provided in Table 3.4.

Table 3.4: Net present costs of pollutant loads

Criteria	NPC ($m)
Total	7,497
Total nitrogen	7,140
Total phosphorus	20
Total suspended solids	337

Table 3.4 reveals that the costs of total loads of nitrogen dominate the pollutant costs. The timeline of future costs of water efficiency and alternative water sources are presented in Figure 3.5.

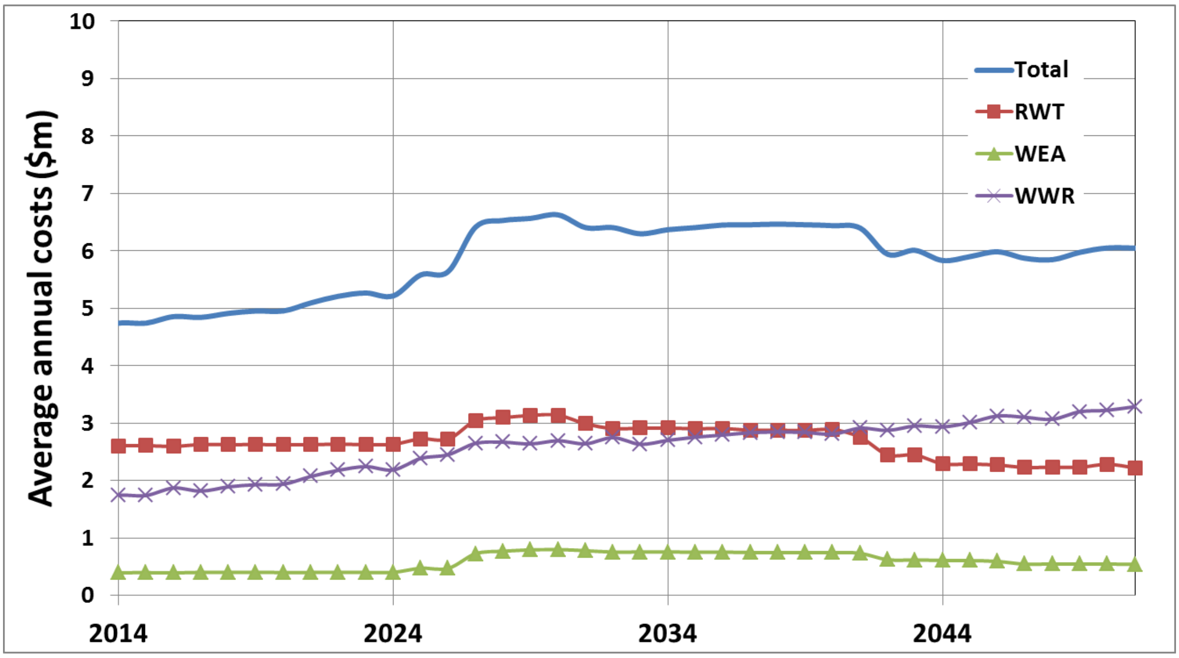

Figure 3.5: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse

Figure 3.5 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies. The decline in the annual costs of wastewater reuse is generated by diminished demands for treated wastewater created by increasing water efficiency and rainwater harvesting.

The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.5.

Table 3.5: Net present costs of water saving measures

Criteria	NPC ($m)
Total	89
Rainwater harvesting	42
Water efficient appliances	8
Wastewater reuse	39

Table 3.5 highlights that the costs of rainwater harvesting and wastewater reuse are a substantial proportion of the total costs of water saving measures. The timeline of future costs to 2051 of water cycle management by jurisdiction are presented in Figure 3.6. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

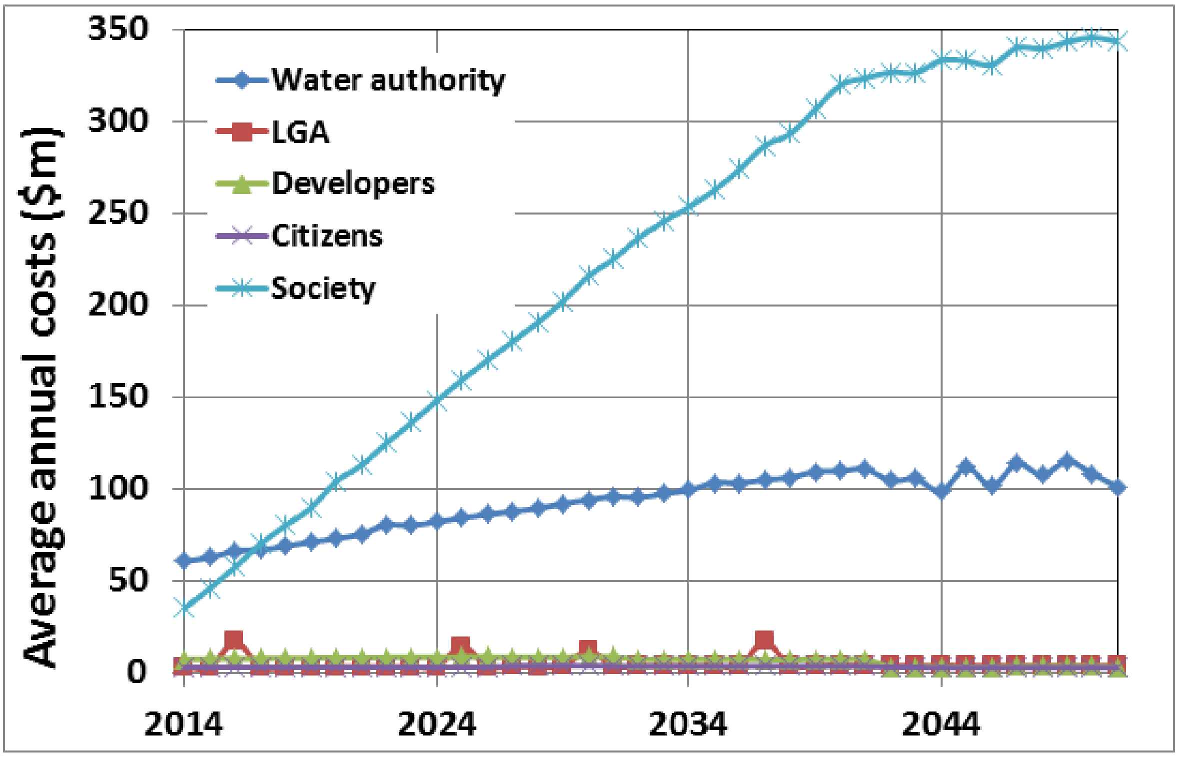

Figure 3.6: Average annual costs versus jurisdiction

Figure 3.6 demonstrates that the future costs of water cycle management are dominated Water Authority and Society costs that are also subject to substantial increases in response to population growth.

The net present costs that accrue to each jurisdiction are presented in Table 3.6

Table 3.6: Net present costs that accrue to each jurisdiction for BAU

Jurisdiction	NPC ($m)
Water authority	1,374
Local Government	80
Developers	181
Citizens	51
Society	2,423
Total	4,108

Table 3.6 shows that a majority of future costs of water cycle management accrue the Water Authority and Society. The costs of providing reticulated water and sewerage services, flood risks and impacts on waterways are the dominant economics costs for the Ballarat Water District. The total net present costs of water cycle management to 2051 for the BAU option is $4,108 m.

3.2 BAU_NOGW

The BAU_NOGW Option is operation of the water supply systems for the Ballarat water district so that ground water resources at Ballarat West and Bungaree are only used for drought relief. This Option is expected to generate a Net Present Value of -$146 m that results in an increase in costs that accrue to the water authority. The cash flows for providing water services in the BAU_NOGW Option are presented in Figure 3.7.

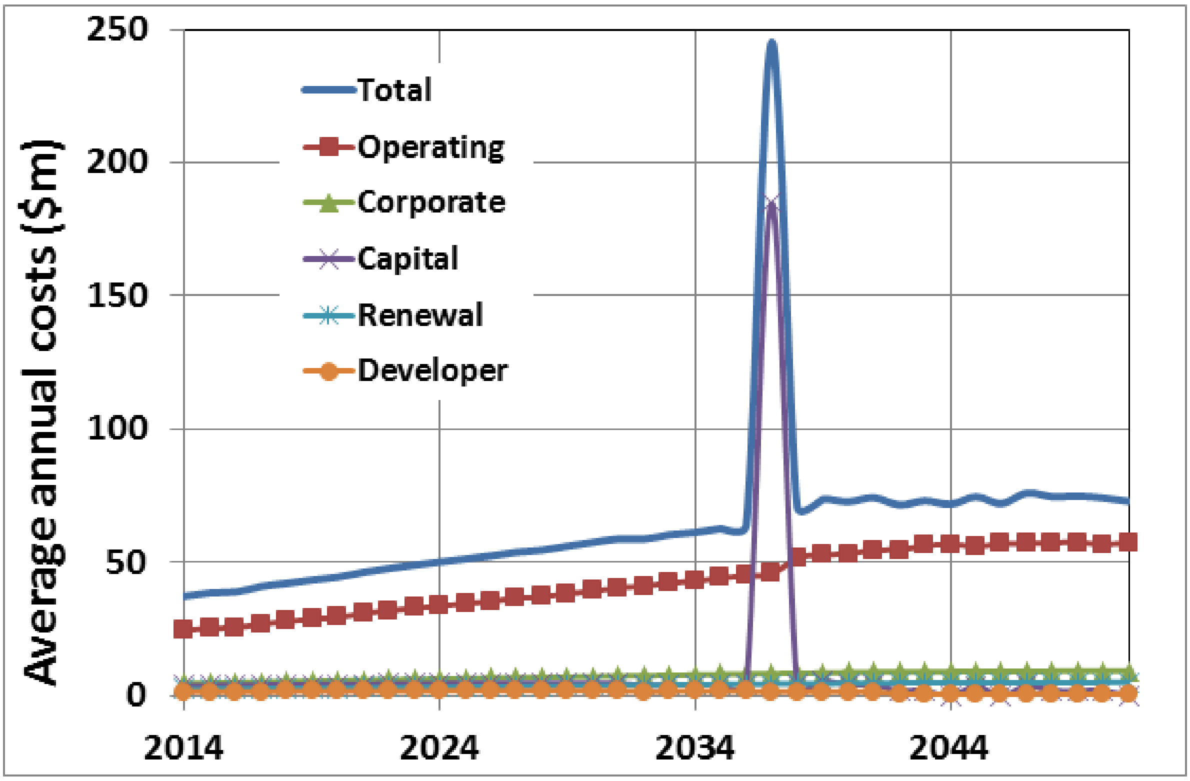

Figure 3.7: Average annual water costs for the BAU_NOGW Option

Figure 3.7 highlights that the limited use of ground water resources results in a requirement to augment regional water security that generates increased capital and operating expenses. Note that the augmentation solution utilised on this BAU analysis is duplication of the Goldfields pipeline and purchase of additional water licenses from willing sellers in the Goulburn River catchments. The net present costs to 2051 for provision of water services in the BAU_NOGW Option are provided in Table 3.7.

Table 3.7: Net present costs to 2051 for water supply in the BAU_NOGW Option

Criteria	NPC ($m)	Change from BAU (%)
Total	877	+ 19.5
Operating	568	+ 19.9
Corporate	110	+ 1.3
Capital	110	+ 74.1
Renewal	59	+ 1.4
Developer	29	0

Table 3.7 shows that the BAU_NOGW Option generates substantial increases in capital and operating costs that are associated with installation and operation of a duplicated Goldfields pipeline. The timelines of costs for reticulated wastewater services for the BAU_NOGW Option are presented in Figure 3.8.

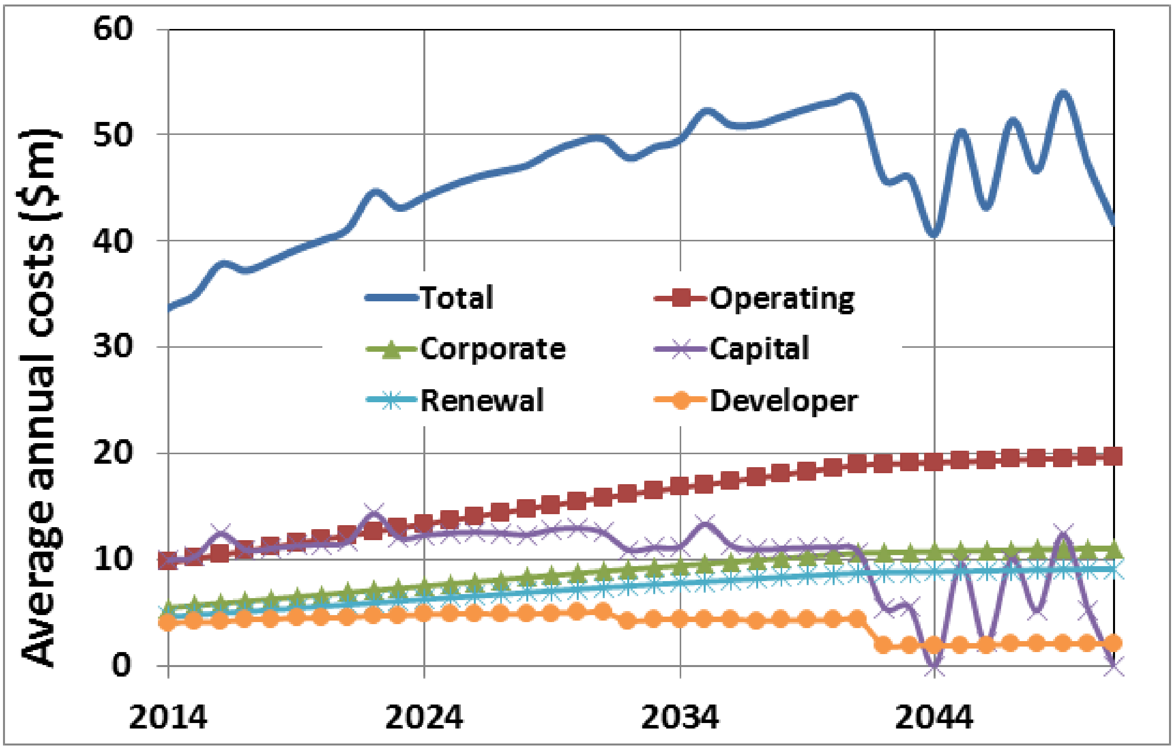

Figure 3.8: Average annual wastewater costs for the BAU_NOGW Option

Figure 3.8 shows that the majority of costs for provision of wastewater services in the BAU_NOGW Option accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to cumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. Note that the economic analysis assumed that all new developments will be serviced by reticulated infrastructure. The net present costs to 2051 for provision of wastewater services are provided in Table 3.8.

Table 3.8: Net present costs of wastewater management in the BAU_NOGW Option

Criteria	NPC ($m)	Change from BAU (%)
Total	707	0
Operating	227	0
Corporate	128	0
Developer	76	0
Capital	170	0
Renewal	107	0

Table 3.8 shows that the costs of reticulated wastewater services in the BAU_NOGW Option are similar to the BAU Option. The timelines of costs for stormwater management and flooding are presented in Figure 3.9.

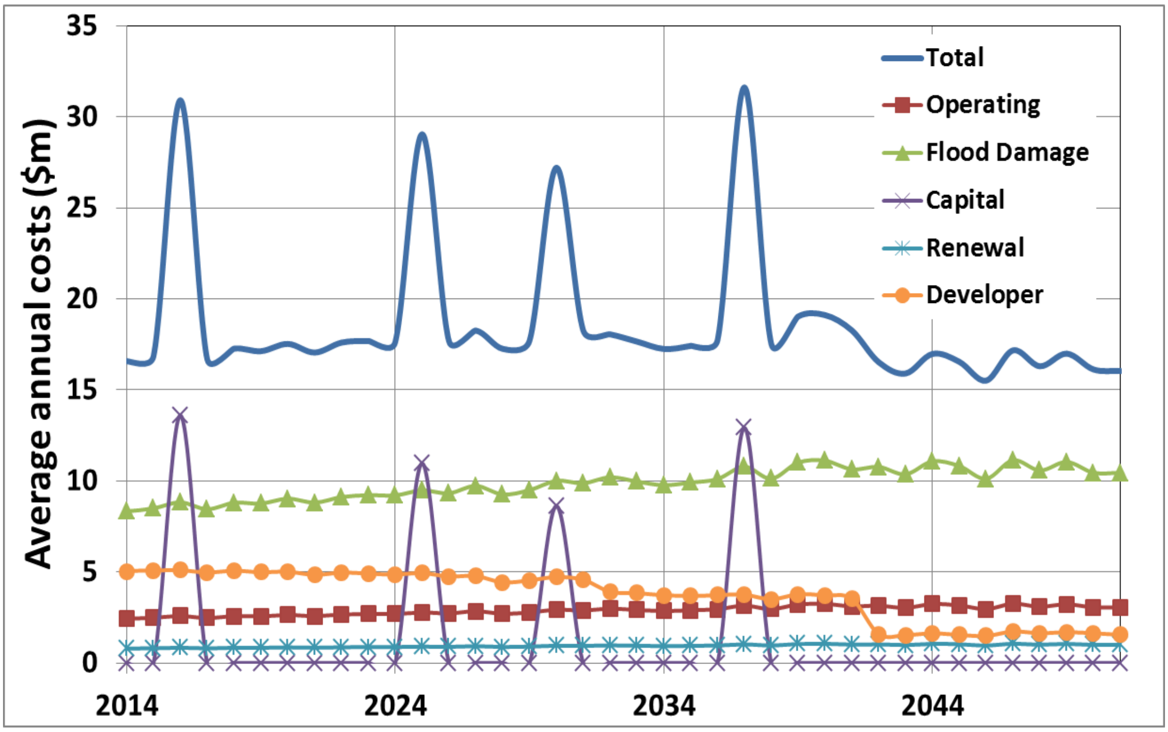

Figure 3.9: Average annual stormwater costs for the BAU_NOGW Option

Figure 3.9 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the BAU_NOGW Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon.

The net present costs to 2051 for stormwater management and flooding in the BAU_NOGW Option are provided in Table 3.9.

Table 3.9: Net Present Costs of stormwater management and flooding in the BAU_NOGW Option

Criteria	NPC ($m)	Change from BAU (%)
Total	315	0
Operating	44	0
Developer	75	0
Capital	21	0
Renewal	15	0
Flooding	160	0

Table 3.9 shows that the costs of stormwater management and flood risks in the BAU_NOGW are similar to the BAU Option. The timelines for annual costs of the total pollutant loads in the BAU_NOGW Option are provided in Figure 3.10.

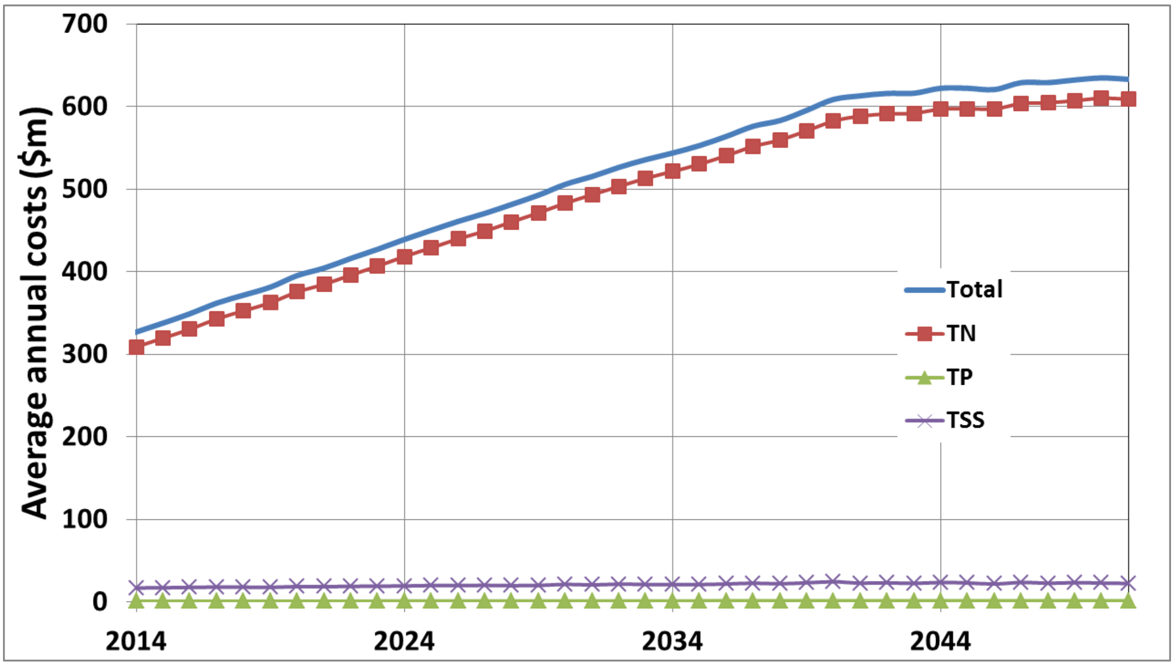

Figure 3.10: Costs of total pollutant loads in the BAU_NOGW Option

Figure 3.10 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the BAU_NOGW Option.

The net present costs to 2051 of the total pollutant loads in the BAU_NOGW Option are provided in Table 3.10.

Table 3.10: Net present costs of pollutant loads

Criteria	NPC ($m)	Change from BAU (%)
Total	7,497	0
Total nitrogen	7,140	0
Total phosphorus	20	0
Total suspended solids	337	0

Table 3.10 reveals that the costs of pollutant loads in the BAU_NOGW Option are similar to the BAU Option. The timeline of future costs of water efficiency and alternative water sources in the BAU_NOGW Option are presented in Figure 3.11.

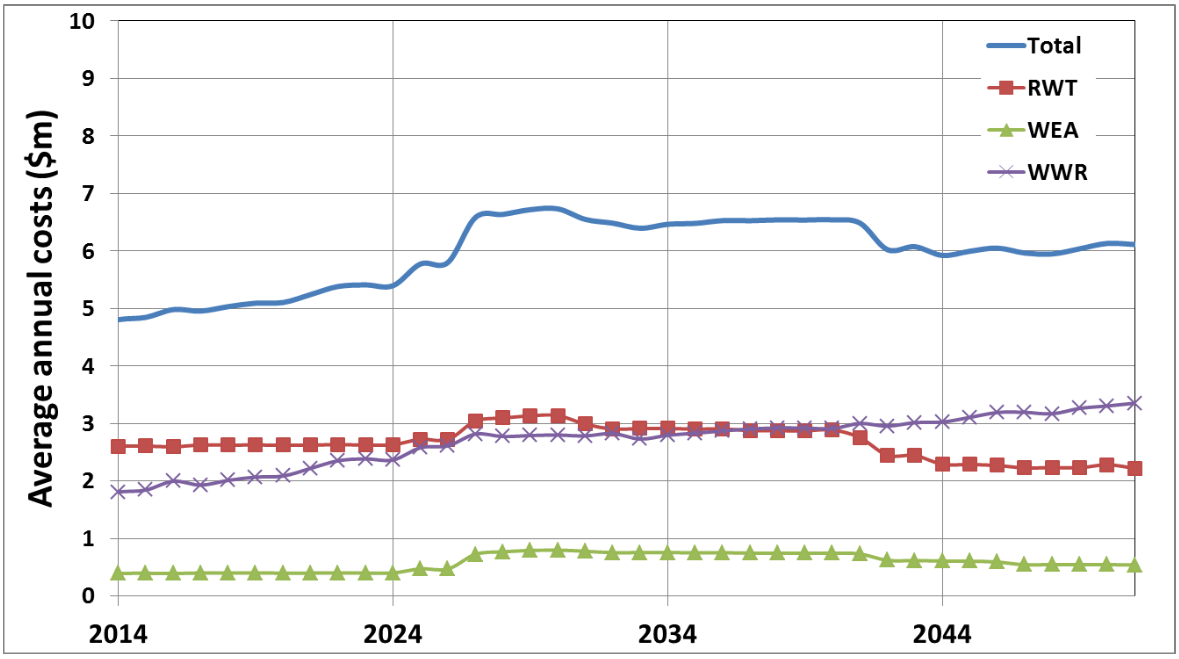

Figure 3.11: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the BAU_NOGW Option

Figure 3.11 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the BAU_NOGW Option. The decline in the annual costs of wastewater reuse is generated by diminished demands for treated wastewater created by increasing water efficiency and rainwater harvesting.

The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.11.

Table 3.11: Net present costs of water saving measures in the BAU_NOGW Option

Criteria	NPC ($m)	Change from BAU (%)
Total	92	0
Rainwater harvesting	45	0
Water efficient appliances	8	0
Wastewater reuse	39	0

Table 3.11 shows that the costs of water efficiency and alternative water supplies in the BAU_NOGW Option are similar to the BAU Option. The timeline of future costs to 2051 of water cycle management by jurisdiction for the BAU_NOGW Option are presented in Figure 3.12. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

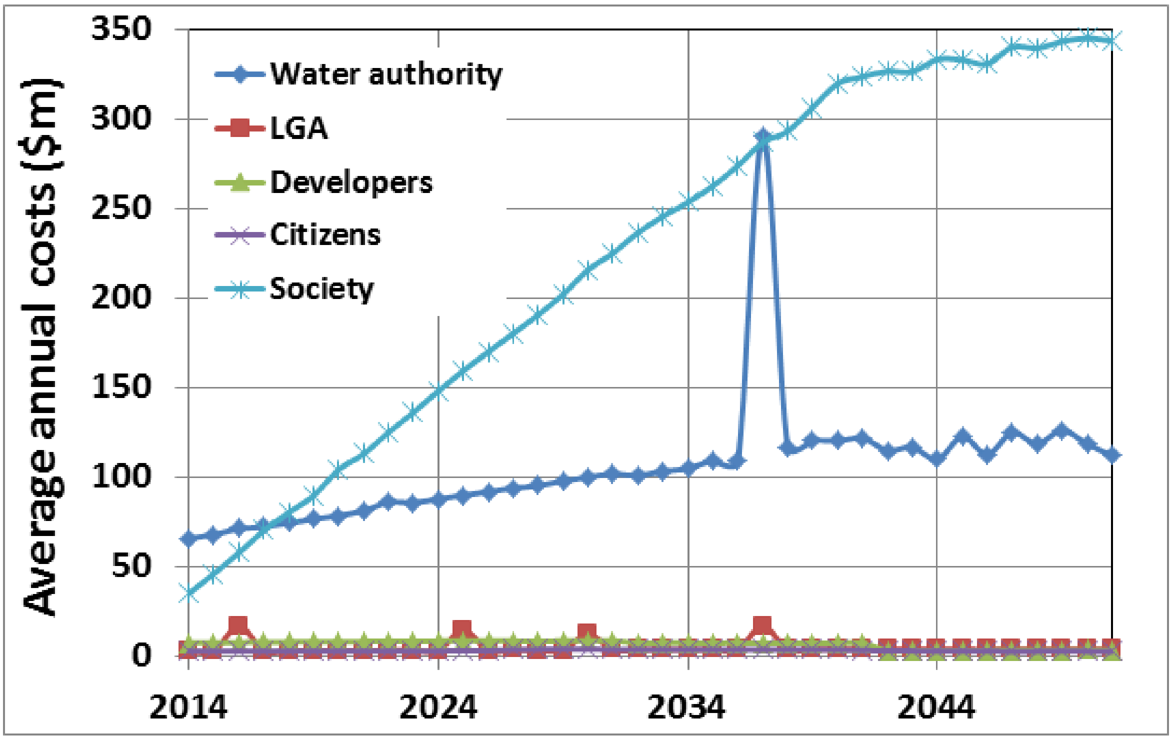

Figure 3.12: Average annual costs versus jurisdiction for the BAU_NOGW Option

Figure 3.12 demonstrates that the future costs of water cycle management in the BAU_NOGW Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure and a requirement to augment the security of the water supply.

The net present costs that accrue to each jurisdiction in the BAU_NOGW Option are presented in Table 3.12.

Table 3.12: Net present costs that accrue to each jurisdiction in the BAU_NOGW Option

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,519	+ 10.6
Local Government	80	0
Developers	181	0
Citizens	51	0
Society	2,423	0
Total	4,254	+ 3.6

Table 3.12 reveals that the BAU_NOGW Option generates a 3.6% increase in costs that accrue to the water authority. This represents a net present value of -$146 m.

3.3 Bulk

The Bulk Option investigates the impacts of not extracting water supply to meet urban water demands from the Moorabool and Yarrowee Catchments. As a consequence, this Option has a greater reliance on external water supplies from the Goulburn, Campaspe and Loddon catchments. This Option is expected to generate a Net Present Cost of $166 m that results in an increase in costs that accrue to the water authority for bulk water supply. The cash flows for providing water services in the BAU_BULK Option are presented in Figure 3.13.

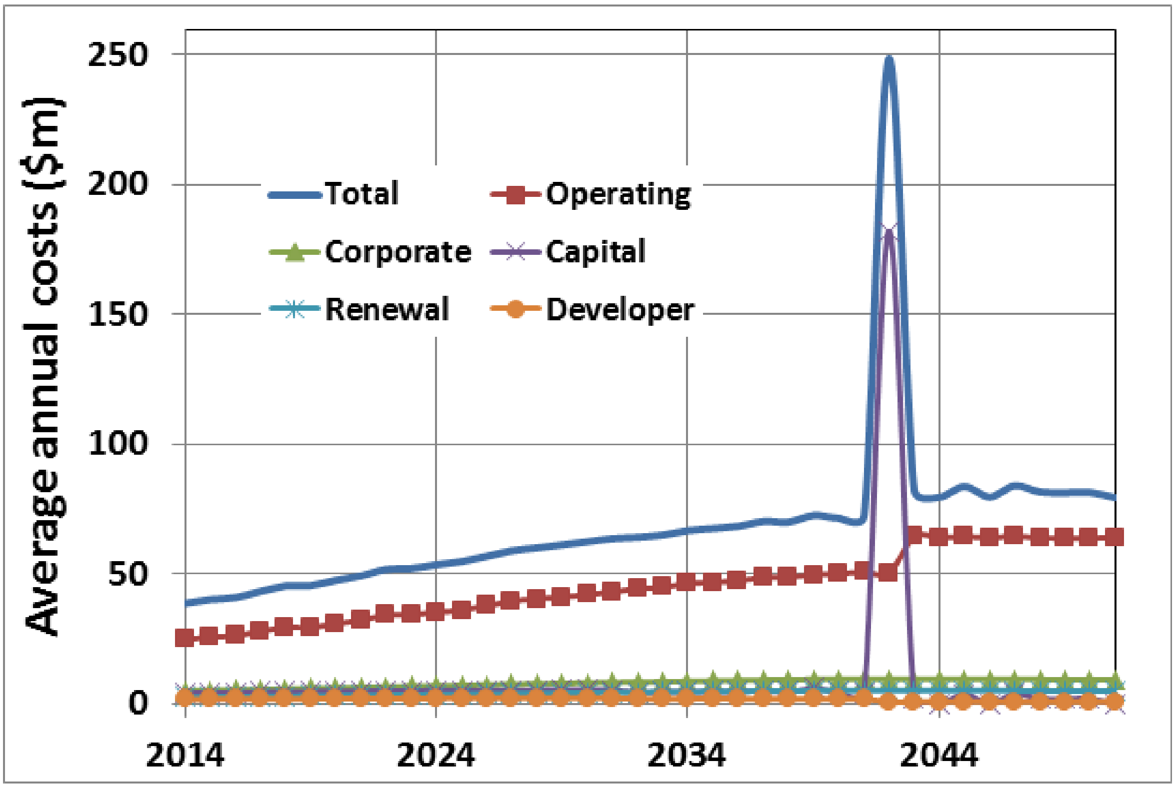

Figure 3.13: Average annual water costs in the BAU_BULK Option

Figure 3.13 highlights that reliance on bulk water supplies from external catchments in the BAU_BULK Option generate a requirement to augment regional water security that generates increased capital and operating expenses. Note that the augmentation solution utilised on this BAU analysis is duplication of the Goldfields pipeline and purchase of additional water licenses from willing sellers in the Goulburn River catchments. The net present costs to 2051 for provision of water services in the BAU_NOGW Option are provided in Table 3.13.

Table 3.13: Net present costs to 2051 for water supply in the BAU_BULK Option

Criteria	NPC ($m)	Change from BAU (%)
Total	893	+ 21.7
Operating	582	+ 22.9
Corporate	118	+ 8.4
Capital	106	+ 67.3
Renewal	58	0
Developer	29	0

Table 3.13 reveals that the BAU_BULK Option generates substantial increases in operating and capital costs in comparison to the BAU Option. The timelines of costs for reticulated wastewater services from the BAU_BULK Option are presented in Figure 3.14.

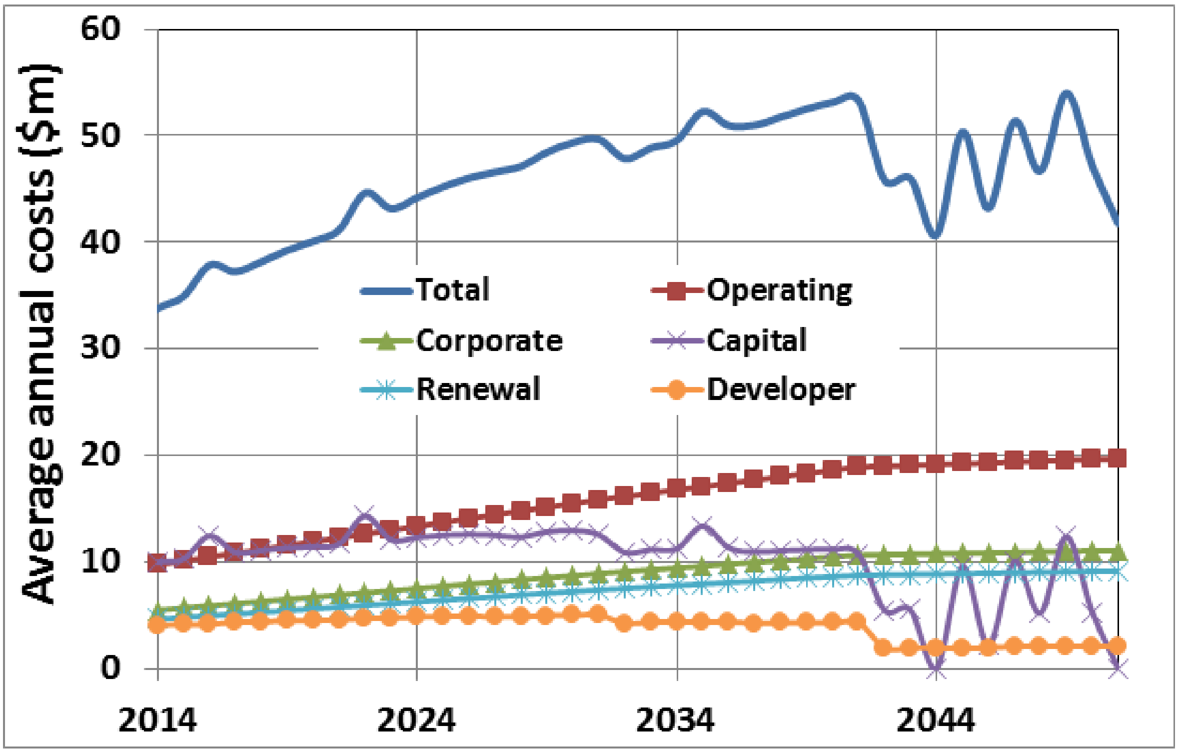

Figure 3.14: Average annual wastewater costs from the BAU_BULK Option

Figure 3.14 shows that the majority of costs for provision of wastewater services in the BAU_BULK Option accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to cumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the BAU_BULK Option are provided in Table 3.14.

Table 3.14: Net present costs of wastewater management for the BULK Option

Criteria	NPC ($m)	Change from BAU (%)
Total	707	0
Operating	227	0
Corporate	128	0
Developer	76	0
Capital	170	0
Renewal	107	0

Table 3.14 shows that BAU_BULK Option generates similar costs for wastewater management as the BAU Option. The timelines of costs for stormwater management and flood risks for the BAU_BULK Option are presented in Figure 3.15.

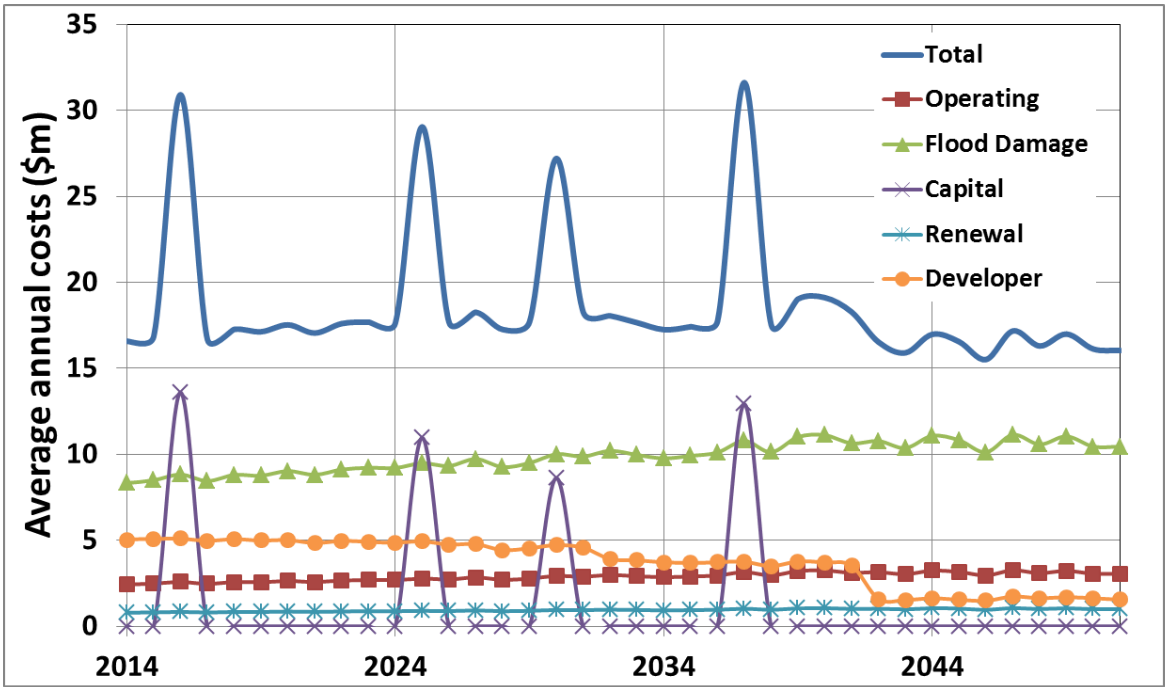

Figure 3.15: Average annual stormwater costs for the BAU_BULK Option

Figure 3.15 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the BAU_BULK Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon.

The net present costs to 2051 for stormwater management and flooding in the BAU_BULK Option are provided in Table 3.15.

Table 3.15: Net Present Costs of stormwater management and flooding in the BAU_BULK Option

Criteria	NPC ($m)	Change from BAU (%)
Total	315	0
Operating	44	0
Developer	75	0
Capital	21	0
Renewal	15	0
Flooding	160	0

Table 3.15 reveals that the BAU_BULK Option experiences similar costs for stormwater management and flooding as the BAU Option. The timelines for annual costs of the total pollutant loads in the BAU_NOGW Option are provided in Figure 3.16.

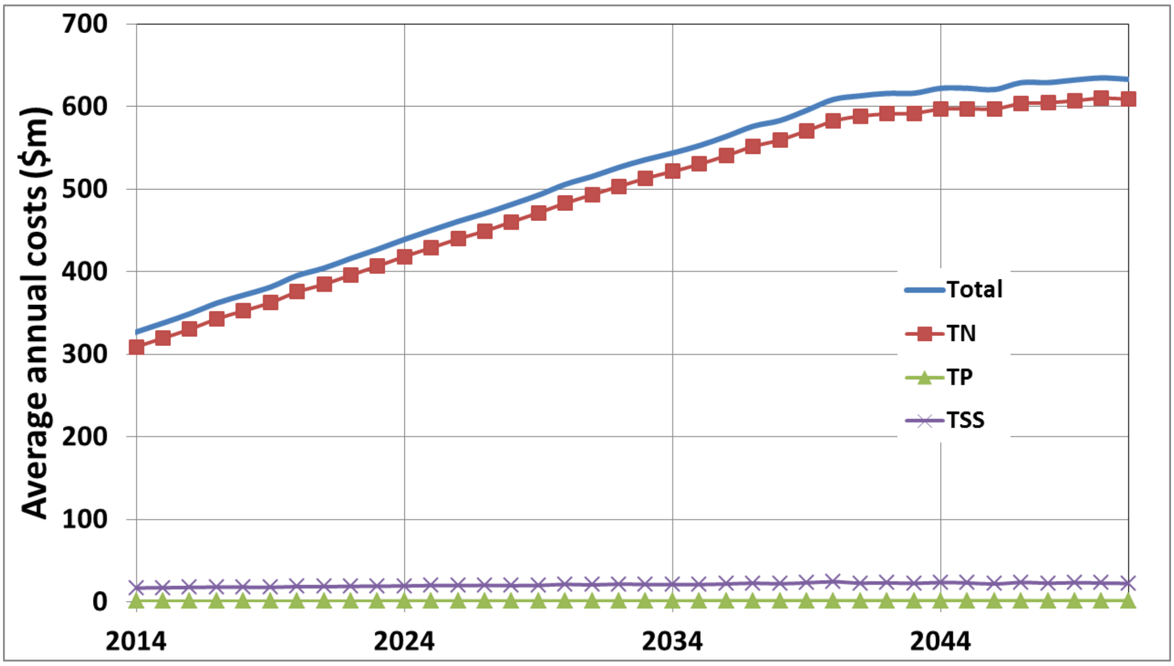

Figure 3.16: Costs of total pollutant loads in the BAU_BULK Option

Figure 3.16 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the BAU_BULK Option.

The net present costs to 2051 of the total pollutant loads in the BAU_BULK Option are provided in Table 3.16.

Table 3.16: Net present costs of pollutant loads in the BAU_BULK Option

Criteria	NPC ($m)	Change from BAU (%)
Total	7,497	0
Total nitrogen	7,140	0
Total phosphorus	20	0
Total suspended solids	337	0

Table 3.16 reveals that the costs of pollutant loads in the BAU_BULK Option are similar to the BAU Option. The timeline of future costs of water efficiency and alternative water sources in the BAU_BULK Option are presented in Figure 3.17.

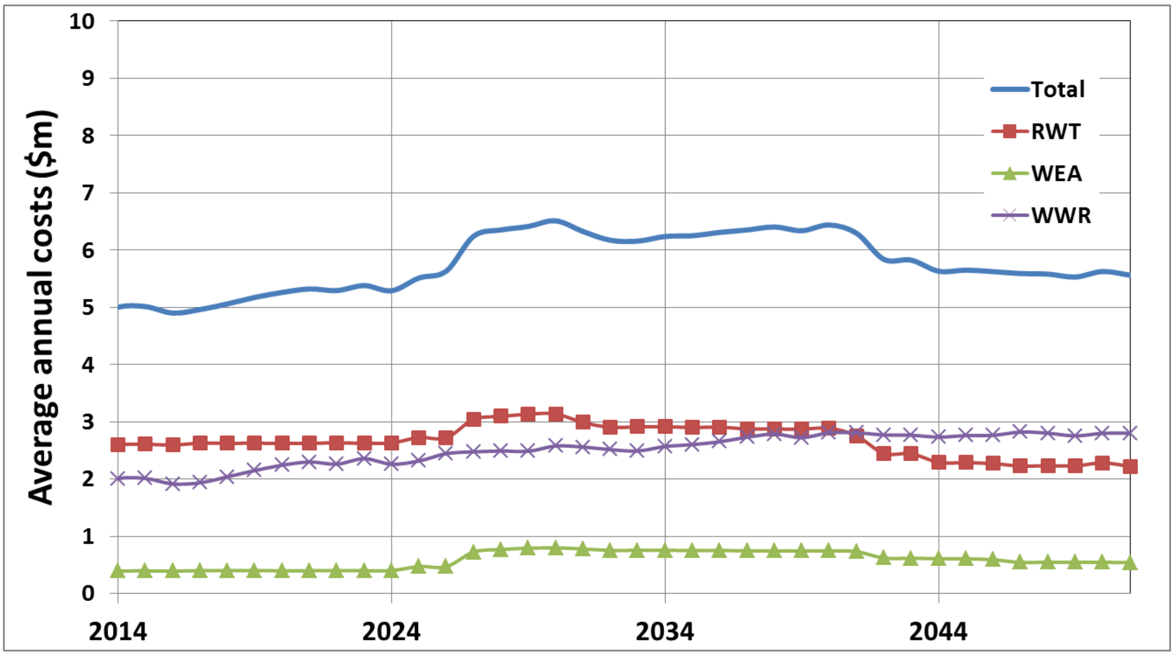

Figure 3.17: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the BAU_BULK Option

Figure 3.17 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the BAU_BULK Option. The decline in the annual costs of wastewater reuse is generated by diminished demands for treated wastewater created by increasing water efficiency and rainwater harvesting. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.17.

Table 3.17: Net present costs of water saving measures in the BAU_BULK Option

Criteria	NPC ($m)	Change from BAU (%)
Total	92	0
Rainwater harvesting	45	0
Water efficient appliances	8	0
Wastewater reuse	39	0

Table 3.17 shows that the BAU_BULK Option produces similar costs for water efficiency and alternative water supply at the BAU Option. The timeline of future costs to 2051 of water cycle management by jurisdiction for the BAU_BULK Option are presented in Figure 3.18. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

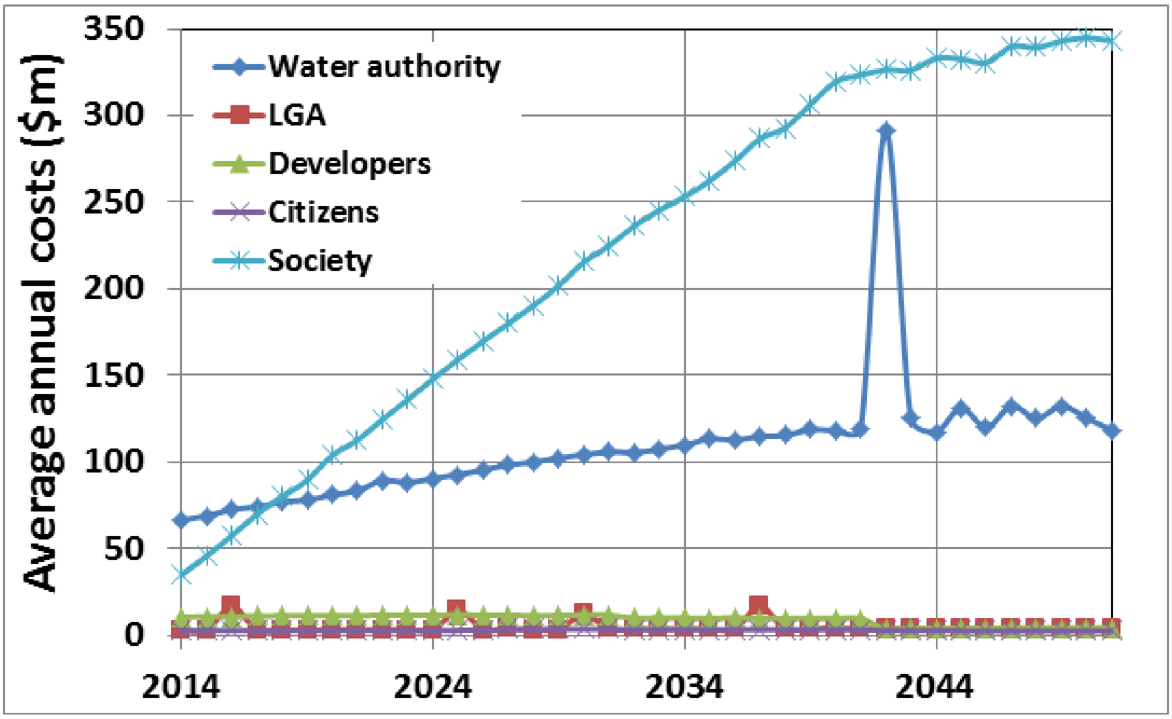

Figure 3.18: Average annual costs versus jurisdiction in the BAU_BULK Option

Figure 3.18 demonstrates that the future costs of water cycle management in the BAU_BULK Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure and a requirement to augment the security of the water supply.

The net present costs that accrue to each jurisdiction in the BAU_BULK Option are presented in Table 3.18.

Table 3.18: Net present costs that accrue to each jurisdiction

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,539	+ 12
Local Government	80	0
Developers	181	0
Citizens	51	0
Society	2,423	0
Total	4,274	+ 4

Table 3.18 reveals that the BAU_BULK Option generates a 4% increase in costs that accrue to the water authority. This represents a net present value of -$166 m.

3.4 Bulk2Irr

The Bulk2Irr Option examines the impact of not sourcing water from the Moorabool and Yarrowee Catchments to meet urban water demands and a 100% increase in regional irrigation demands. This Option is expected to generate a Net Present Value of -$153 m that results in an increase in costs that accrue to the water authority for bulk water supply. The timelines of costs for the Bulk2Irr Option are presented in Figure 3.19.

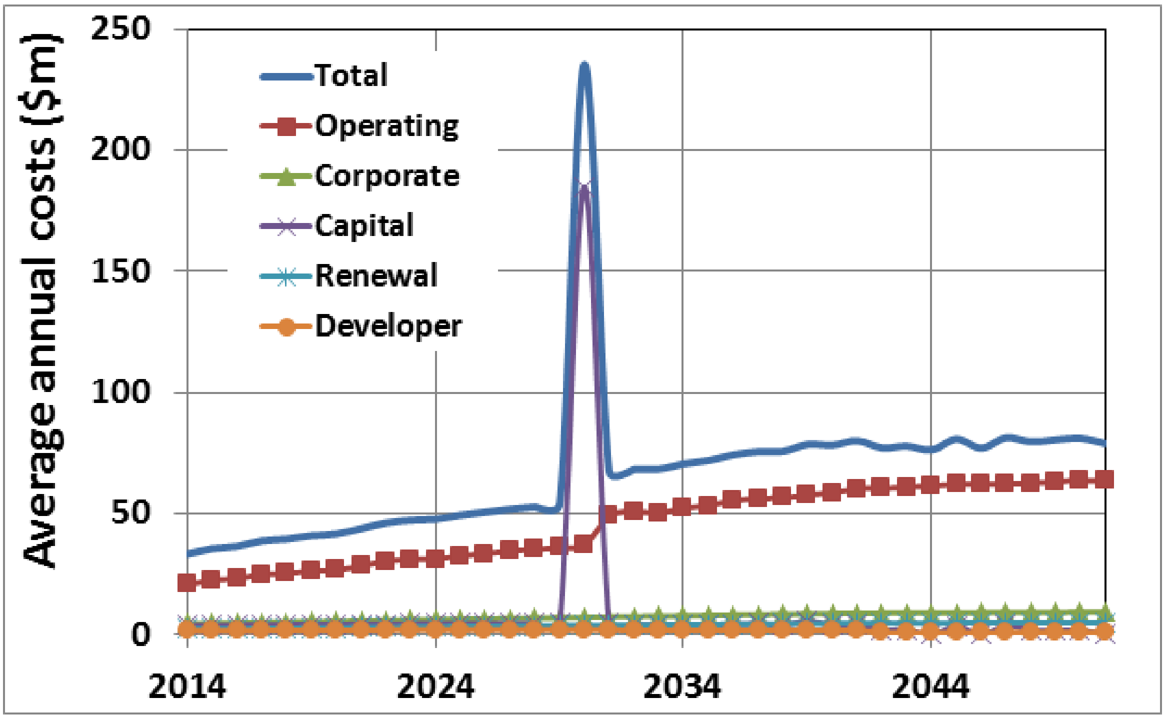

Figure 3.19: Average annual water costs in the Bulk2Irr Option

Figure 3.19 highlights that reliance on bulk water supplies from external catchments in the Bulk2Irr Option generate a requirement to augment regional water security that generates increased capital and operating expenses. Note that the augmentation solution utilised on this analysis is duplication of the Goldfields pipeline and purchase of additional water licenses from willing sellers in the Goulburn River catchments. The net present costs to 2051 for provision of water services in the Bulk2Irr Option are provided in Table 3.19.

Table 3.19: Net present costs to 2051 for water supply

Criteria	NPC ($m)	Change from BAU (%)
Total	886	+ 20.8
Operating	565	+ 19.2
Corporate	107	-1.4
Capital	128	+ 101.1
Renewal	58	-0.5
Developer	29	-1.3

Table 3.19 reveals that the Bulk2Irr Option generates substantial increases in operating and capital costs in comparison to the BAU Option. The timelines of costs for reticulated wastewater services from the Bulk2Irr Option are presented in Figure 3.20.

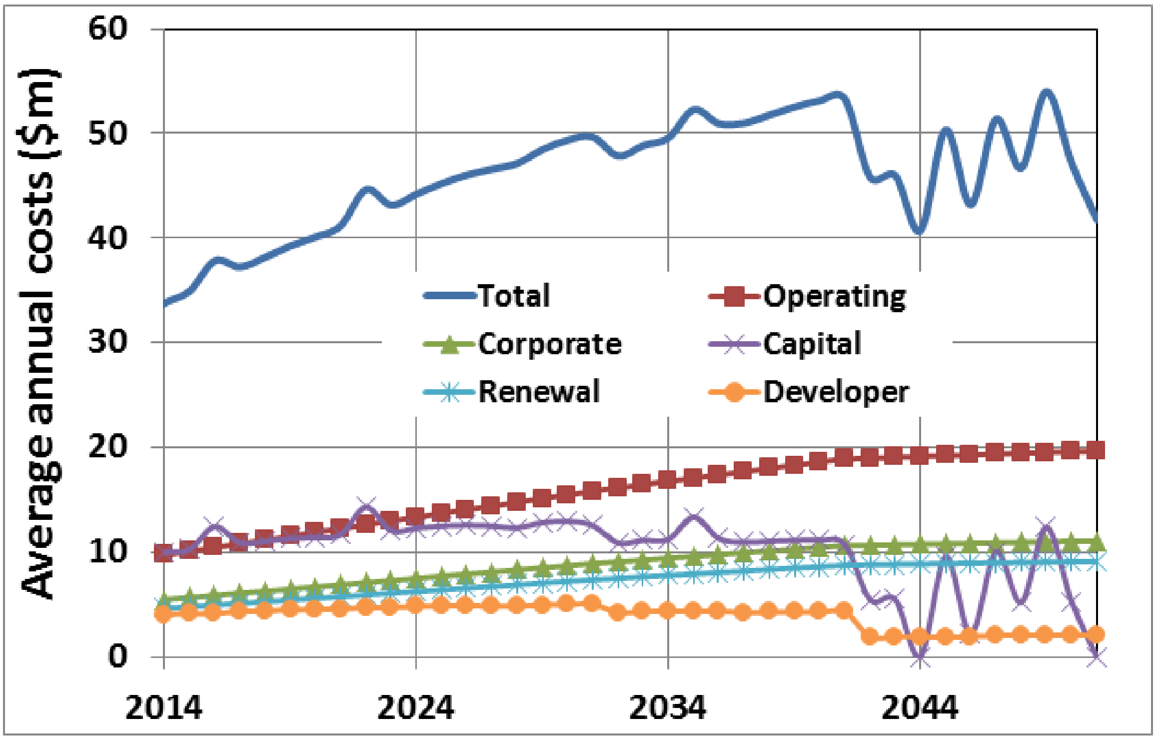

Figure 3.20: Average annual wastewater costs in the Bulk2Irr Option

Figure 3.20 shows that the majority of costs for provision of wastewater services in the BAU_BULK Option accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to cumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the BAU_BULK Option are provided in Table 3.20.

Table 3.20: Net present costs of wastewater management in the Bulk2Irr Option

Criteria	NPC ($m)	Change from BAU (%)
Total	707	0
Operating	227	0
Corporate	128	0
Developer	76	0
Capital	170	0
Renewal	107	0

Table 3.20 shows that BAU_BULK Option generates similar costs for wastewater management as the BAU Option. The timelines of costs for stormwater management and flood risks for the Bulk2Irr Option are presented in Figure 3.21.

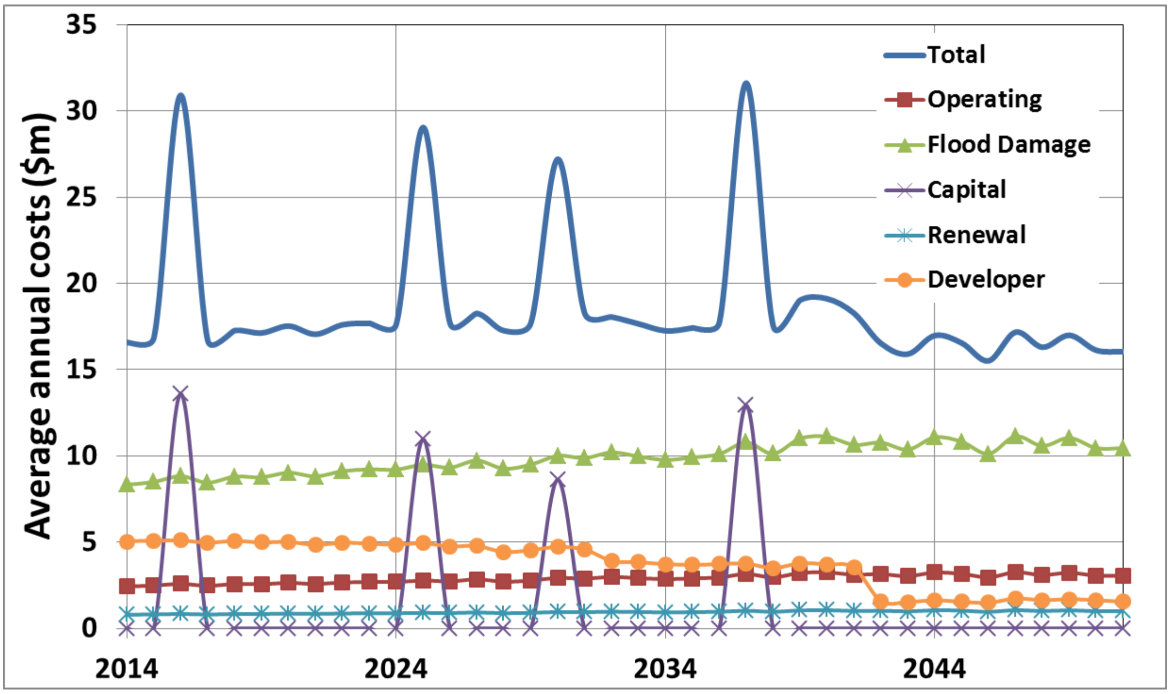

Figure 3.21: Average annual stormwater costs for the Bulk2Irr Option

Figure 3.21 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the Bulk2Irr Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon.

The net present costs to 2051 for stormwater management and flooding in the Bulk2Irr Option are provided in Table 3.22.

Table 3.22: Net Present Costs of stormwater management and flooding in the Bulk2Irr Option

Criteria	NPC ($m)	Change from BAU (%)
Total	315	0
Operating	44	0
Developer	75	0
Capital	21	0
Renewal	15	0
Flooding	160	0

Table 3.22 reveals that the Bulk2Irr Option experiences similar costs for stormwater management and flooding as the BAU Option. The timelines for annual costs of the total pollutant loads in the Bulk2Irr Option are provided in Figure 3.23.

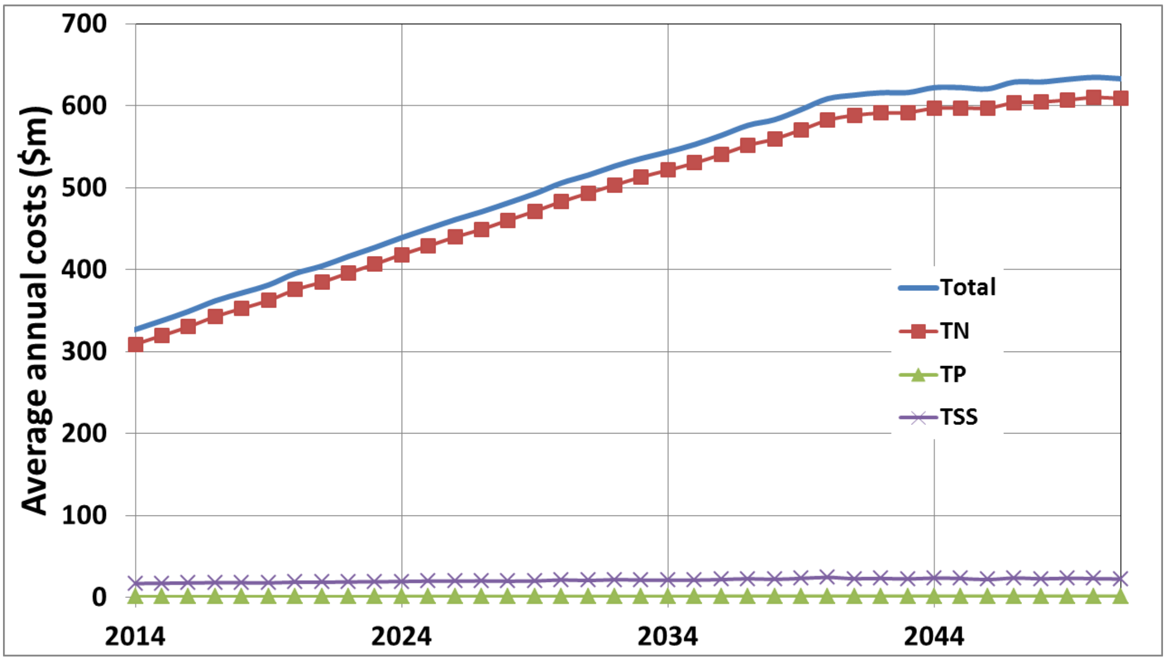

Figure 3.23: Costs of total pollutant loads in the Bulk2Irr Option

Figure 3.23 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the Bulk2Irr Option.

The net present costs to 2051 of the total pollutant loads in the Bulk2Irr Option are provided in Table 3.23.

Table 3.23: Net present costs of pollutant loads in the Bulk2Irr Option

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	7497	0
Total nitrogen	7140	0
Total phosphorus	20	0
Total suspended solids	337	0

Table 3.23 reveals that the costs of pollutant loads in the Bulk2Irr Option are similar to the BAU Option. The timeline of future costs of water efficiency and alternative water sources in the Bulk2Irr Option are presented in Figure 3.24.

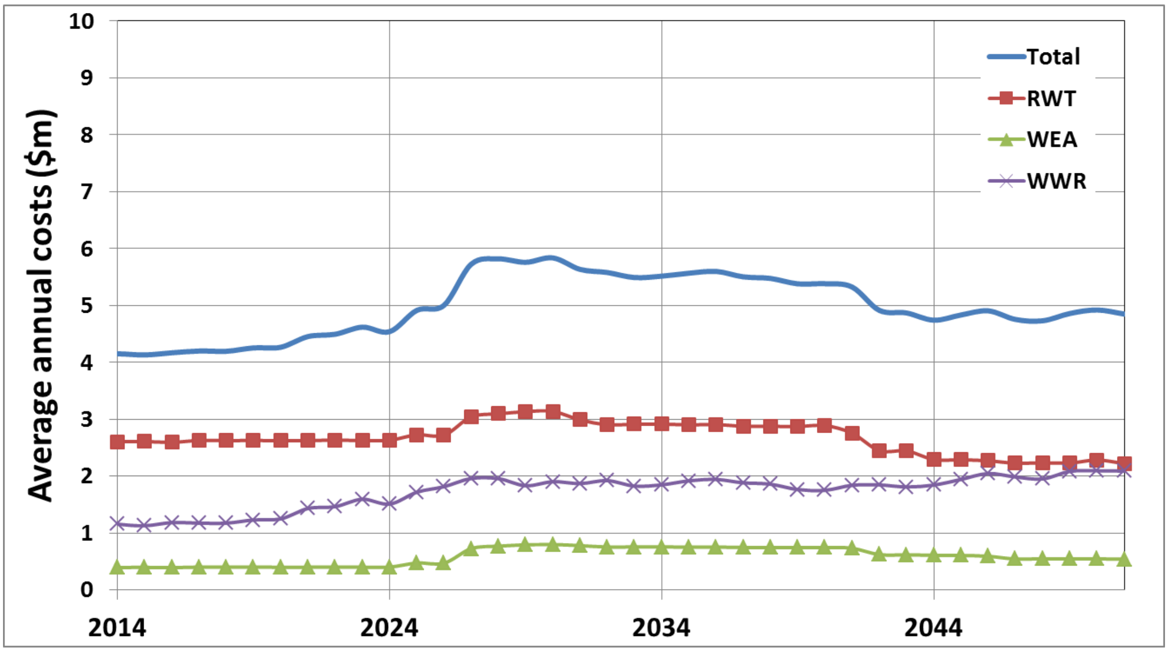

Figure 3.24: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the Bulk2Irr Option

Figure 3.24 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the Bulk2Irr Option. The decline in the annual costs of wastewater reuse is generated by diminished demands for treated wastewater created by increasing water efficiency and rainwater harvesting. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.24.

Table 3.24: Net present costs of water saving measures

Criteria	NPC ($m)	Change from BAU (%)
Total	92	0
Rainwater harvesting	45	0
Water efficient appliances	8	0
Wastewater reuse	39	0

Table 3.24 shows that the Bulk2Irr Option produces similar costs for water efficiency and alternative water supply at the BAU Option. The timeline of future costs to 2051 of water cycle management by jurisdiction for the Bulk2Irr Option are presented in Figure 3.25. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

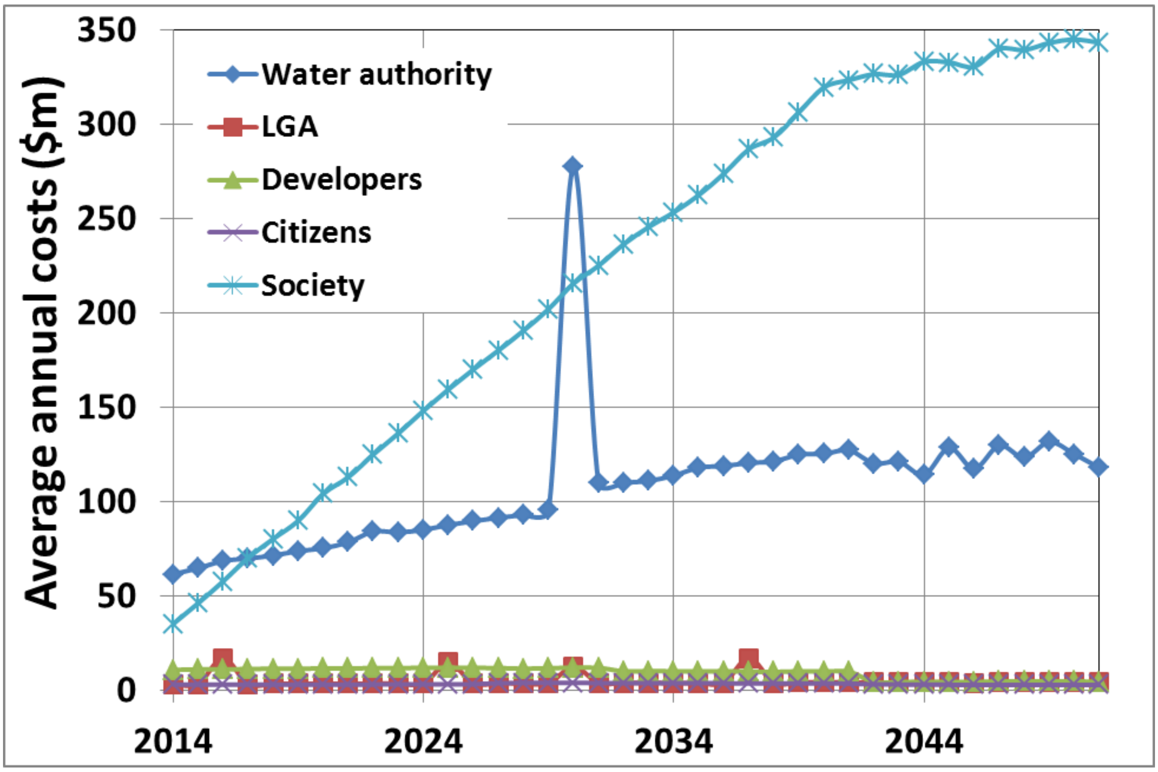

Figure 3.25: Average annual costs versus jurisdiction

Figure 3.25 demonstrates that the future costs of water cycle management in the Bulk2Irr Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure and a requirement to augment the security of the water supply.

The net present costs that accrue to each jurisdiction in the Bulk2Irr Option are presented in Table 3.25.

Table 3.25: Net present costs that accrue to each jurisdiction

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,527	+ 11.1
Local Government	80	0
Developers	174	0
Citizens	53	0
Society	2,423	0
Total	4,256	+ 3.7

Table 3.18 reveals that the BAU_2Irr Option generates a 3.7% increase in costs that accrue to the water authority. This represents a net present value of -$148 m.

3.5 Climate Change

The CC Scenario examines the impact of high emissions climate change as defined by the fifth report by the IPCC as a rate of increase in average temperature of 0.05°C/annum. This Scenario is expected to generate a Net Present Cost of $351 m that results in an increase in costs that accrue to the water authority for bulk water supply that are mitigated by reduced local government and waterway costs. The timelines of costs for the CC Scenario are presented in Figure 3.26.

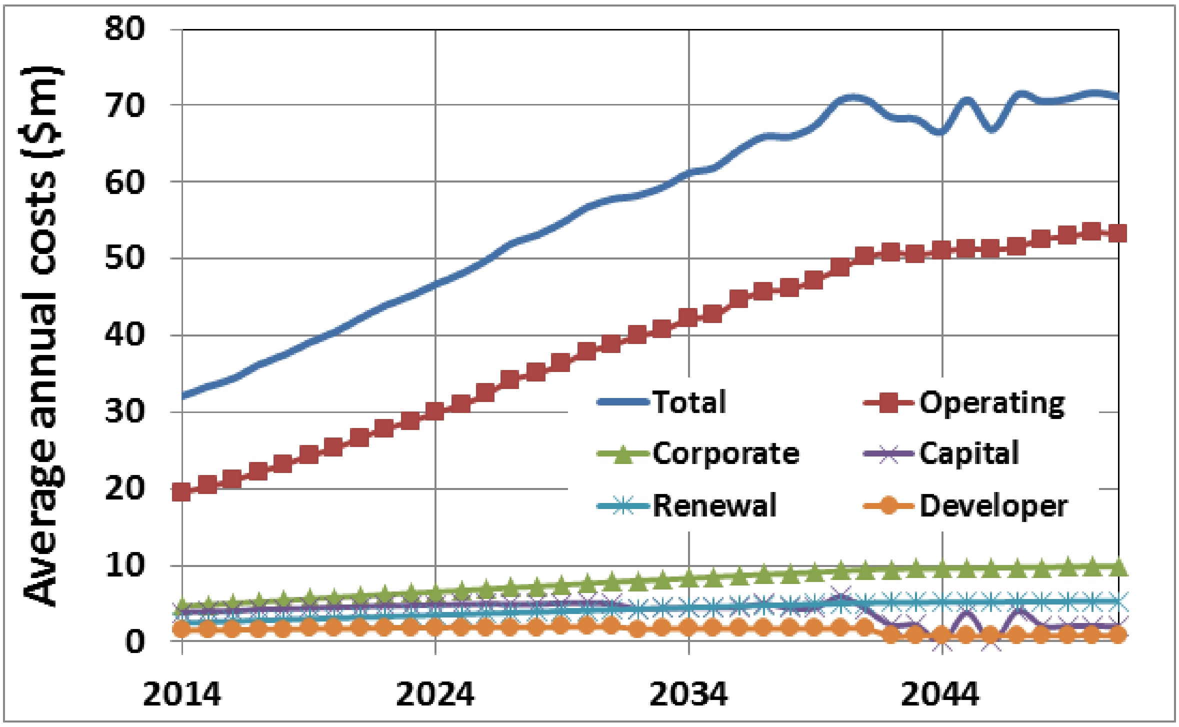

Figure 3.26: Average annual water costs from the CC Scenario.

Figure 3.26 highlights that the CC Scenario generates increased capital and operating expenses. The net present costs to 2051 for provision of water services in the CC Scenario are provided in Table 3.26.

Table 3.26: Net present costs to 2051 for water supply

Criteria	NPC ($m)	Change from BAU (%)
Total	776	+ 5.8
Operating	507	+ 7.1
Corporate	113	+ 3.5
Capital	66	+ 3.8
Renewal	60	+ 3.7
Developer	30	+ 0.8

Table 3.26 reveals that the CC Scenario increases water demands and reduces streamflows in waterways which generates significant increases in operating and capital costs in comparison to the BAU Option. Timelines of costs for reticulated wastewater services from the CC Scenario are presented in Figure 3.27.

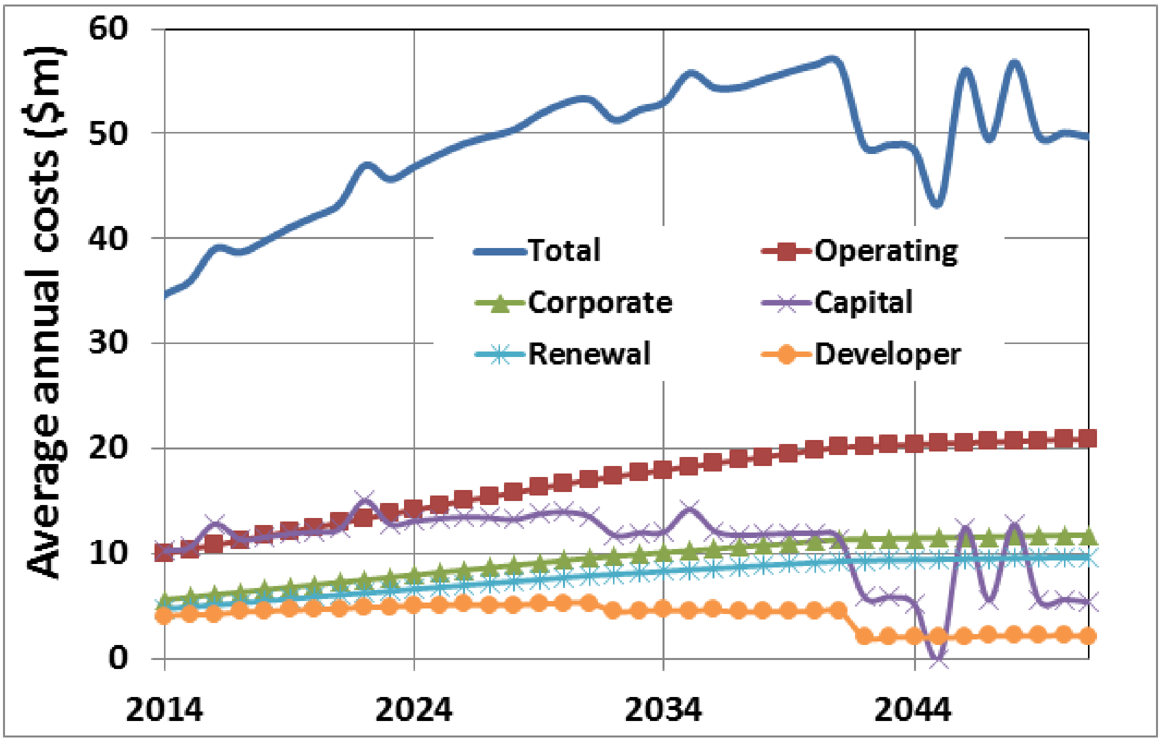

Figure 3.27: Average annual wastewater costs in the CC Scenario

Figure 3.27 shows that the majority of costs for provision of wastewater services in the CC Scenario accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to accumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the CC Scenario are provided in Table 3.27.

Table 3.27: Net present costs of wastewater management

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	744	+ 5.2
Operating	239	+ 5.3
Corporate	135	+ 5.3
Developer	79	+ 3.6
Capital	179	+ 5.9
Renewal	112	+ 5

Table 3.27 shows that CC Scenario generates higher water demands that increase the costs of wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the CC Scenario are presented in Figure 3.28.

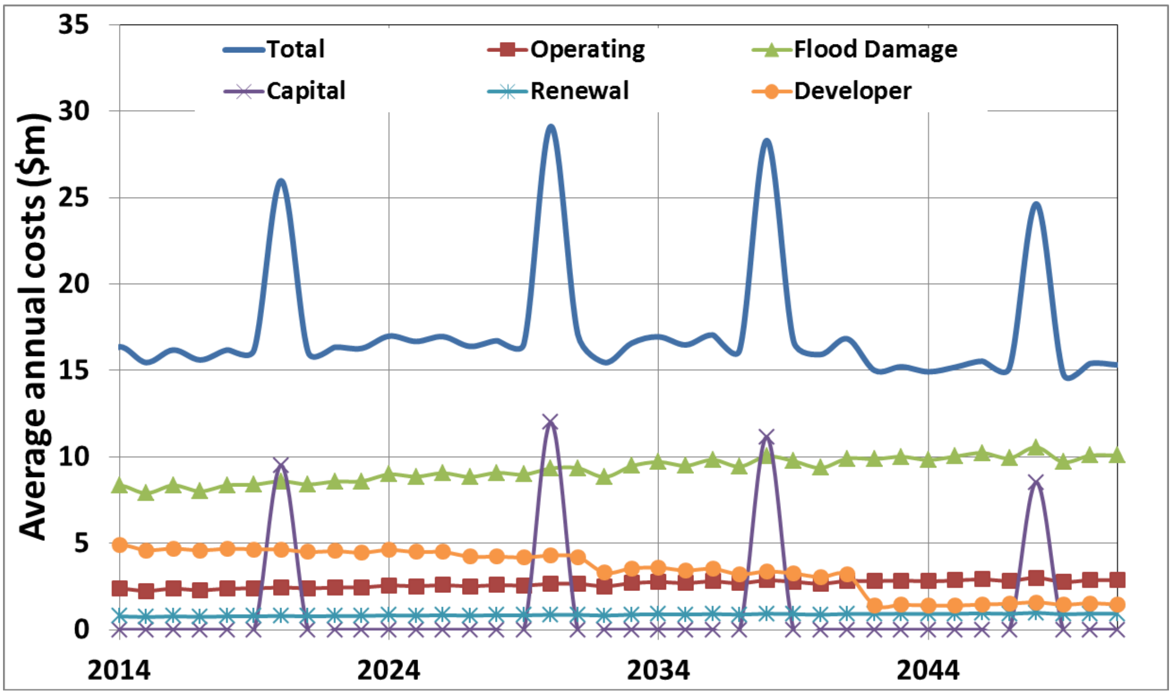

Figure 3.28: Average annual stormwater costs in CC Scenario

Figure 3.28 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the CC Scenario. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon.

The net present costs to 2051 for stormwater management and flooding in the CC Scenario are provided in Table 3.28.

Table 3.28: Net Present Costs of stormwater management and flooding in the CC Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	305	-3
Operating	40	-8
Developer	71	-5
Capital	14	-34
Renewal	14	-8
Flooding	165	+ 3

Table 3.28 reveals that the CC Scenario reduced costs for stormwater management in response to diminished stormwater runoff, and increased flooding costs generated by higher rainfall intensity.

The timelines for annual costs of the total pollutant loads in the CC Scenario are provided in Figure 3.29.

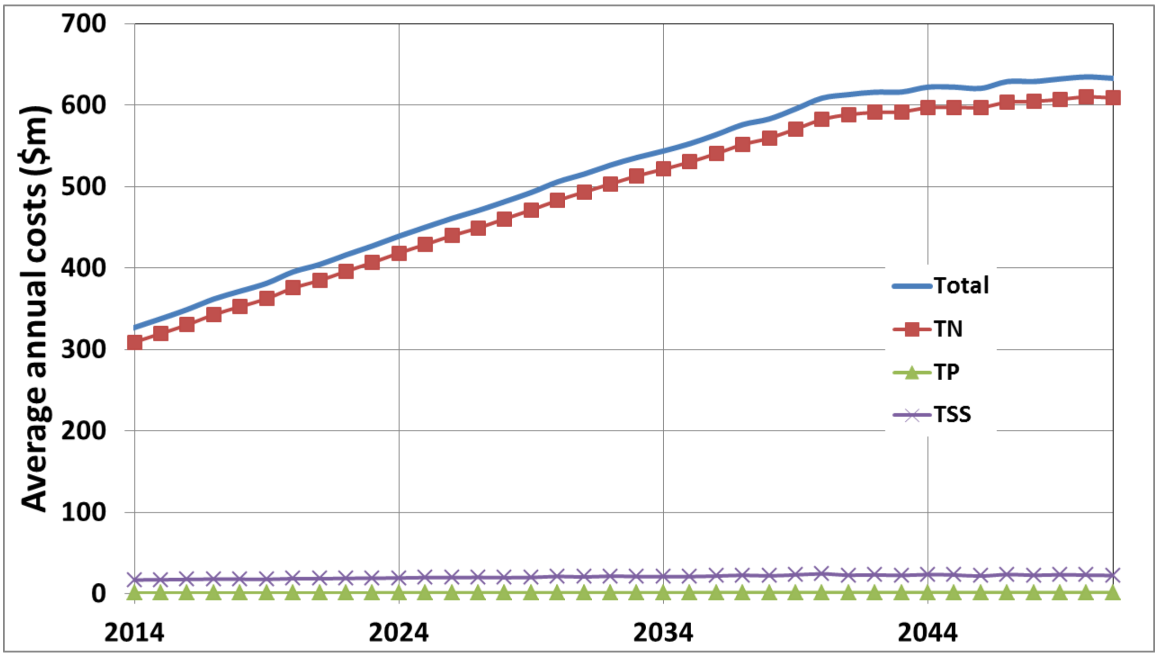

Figure 3.29: Costs of total pollutant loads in the CC Scenario

Figure 3.29 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the CC Scenario.

The net present costs to 2051 of the total pollutant loads in the CC Scenario are provided in Table 3.29.

Table 3.29: Net present costs of pollutant loads in the CC Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	7,412	-1.1
Total nitrogen	7,001	-1.9
Total phosphorus	19	-4.3
Total suspended solids	326	-3.3

Table 3.29 reveals that the costs of pollutant loads in the CC Scenario are reduced in comparison to the BAU Option due to reduced stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the CC Option are presented in Figure 3.30.

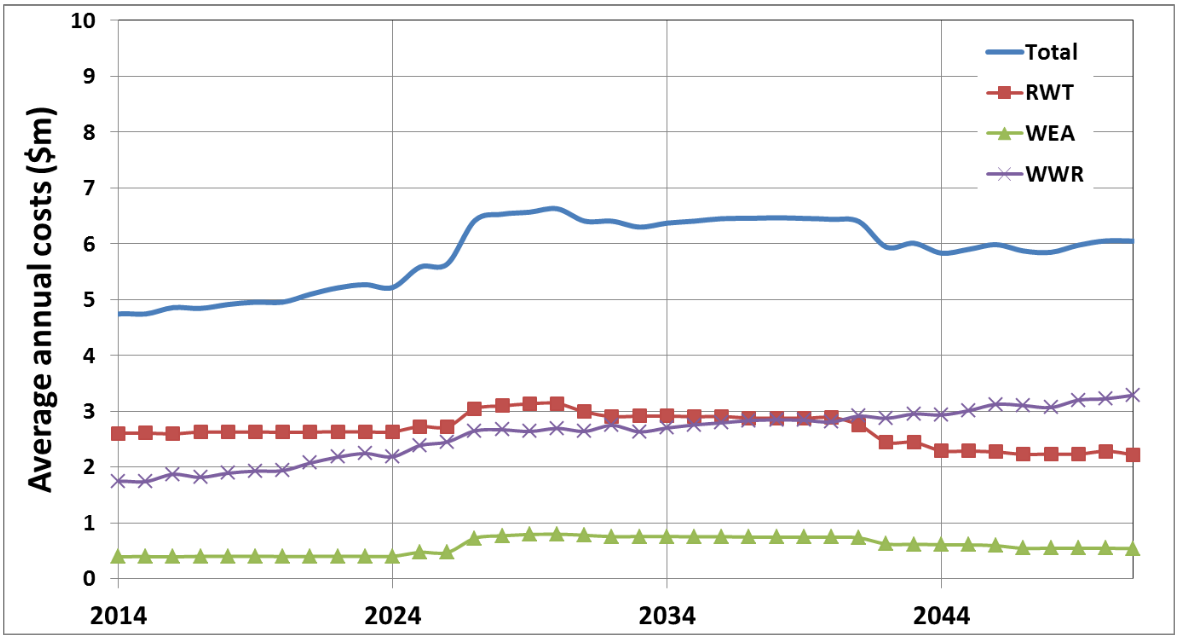

Figure 3.30: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the CC Scenario

Figure 3.30 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the CC Scenario. The decline in the annual costs of wastewater reuse is generated by diminished demands for treated wastewater created by increasing water efficiency and rainwater harvesting. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.30.

Table 3.30: Net present costs of water saving measures in the CC Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	92	0
Rainwater harvesting	45	0
Water efficient appliances	8	0
Wastewater reuse	39	0

Table 3.30 shows that the CC Scenario produces similar costs for water efficiency and alternative water supply at the BAU Option. The timeline of future costs to 2051 of water cycle management by jurisdiction for the CC Scenario are presented in Figure 3.31. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

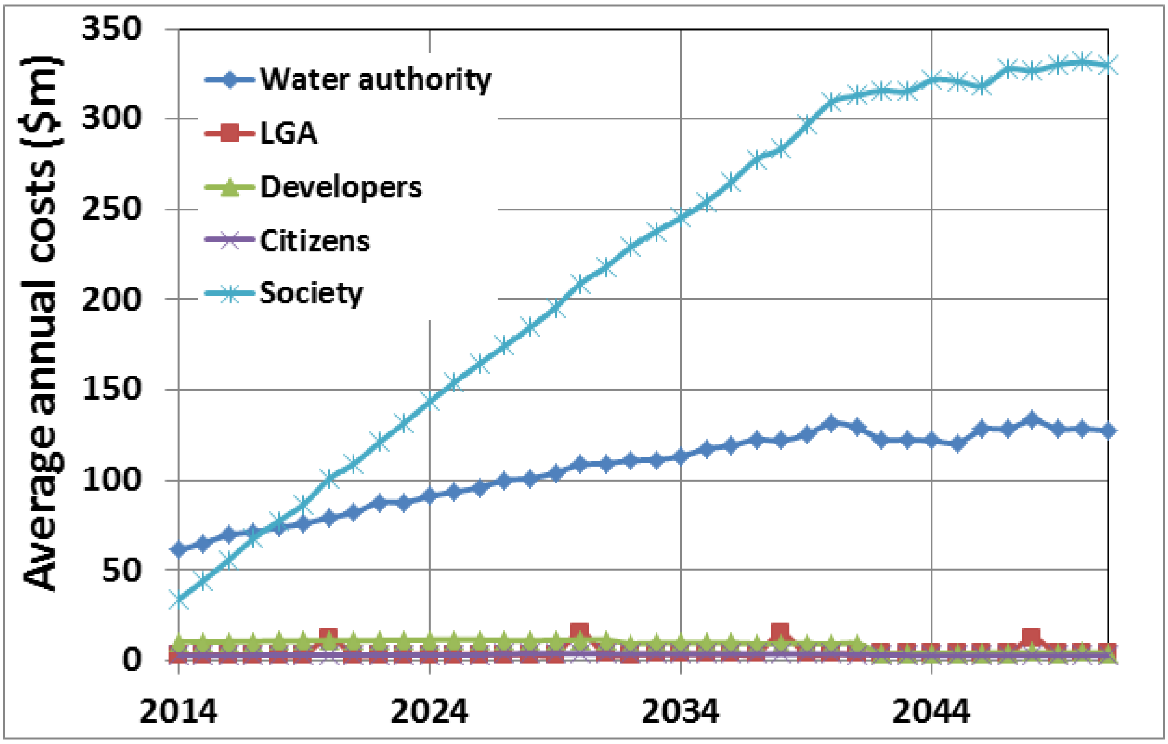

Figure 3.31: Average annual costs versus jurisdiction in the CC Scenario

Figure 3.31 demonstrates that the future costs of water cycle management in the CC Scenario are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth.

The net present costs that accrue to each jurisdiction in the CC Scenario are presented in Table 3.31.

Table 3.6: Net present costs that accrue to each jurisdiction in CC Scenario

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,450	+ 5.5
Local Government	68	-14.6
Developers	180	0
Citizens	53	+ 4.6
Society	2,708	+ 11.8
Total	4,459	+ 8.6

Table 3.18 reveals that the CC Scenario generates an 8.6% increase in total costs that accrue to developers and society. This represents a net present cost of $351 m. The reductions in costs to local government are generated by reduced costs for managing stormwater quality and the diminished costs to Society are created by reduced pollutant loads. This Scenario includes increased costs to the water authority for managing increased water demands and wastewater discharges generated by hotter days and greater peak stormwater events.

3.6 High Growth

The High Growth (HG) Scenario used in this study incorporates accelerated population growth as defined by the Victoria in Future 2012 (VIF 2012) forecast population for 2051 achieved at 2041. This Scenario is expected to generate an additional Net Present cost of $790 m for the Ballarat water district that results in an increase in costs that accrue to all jurisdictions. The timelines of costs for the HG Scenario are presented in Figure 3.32.

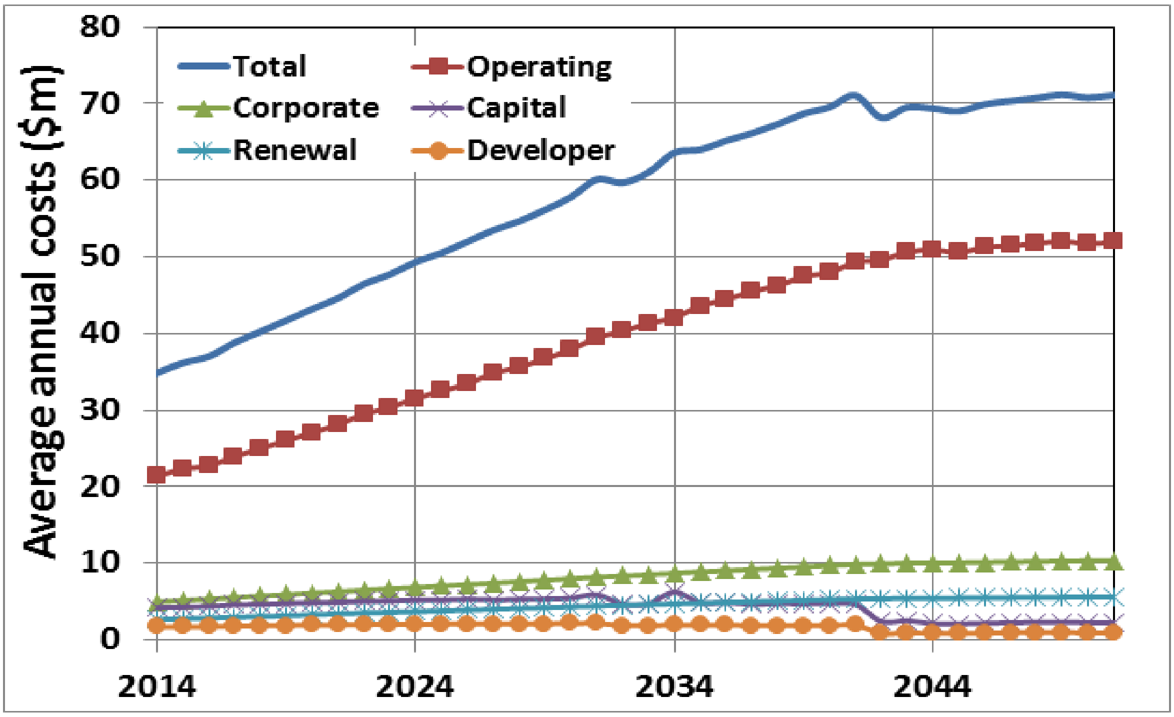

Figure 3.32: Average annual water costs from the Ballarat water district in the HG Scenario

Figure 3.32 highlights that the HG Scenario generates increased capital and operating expenses. In particular, the frequency and magnitude of capital expenditure has increased. The net present costs to 2051 for provision of water services in the HG Scenario are provided in Table 3.32.

Table 3.32: Net present costs to 2051 for water supply to the Ballarat water district in the HG Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	820	+ 11.8
Operating	523	+ 10.4
Corporate	117	+ 8
Capital	80	+ 25.7
Renewal	63	+ 8.3
Developer	37	+ 24.5

Table 3.32 reveals that the accelerated population growth in the HG Scenario generates significant increases in operating and capital costs in comparison to the BAU Option. Higher proportional increases in costs are required for local infrastructure provided by developers and for trunk or

regional infrastructure provided by the water authority. Timelines of costs for reticulated wastewater services from the HG Scenario are presented in Figure 3.33.

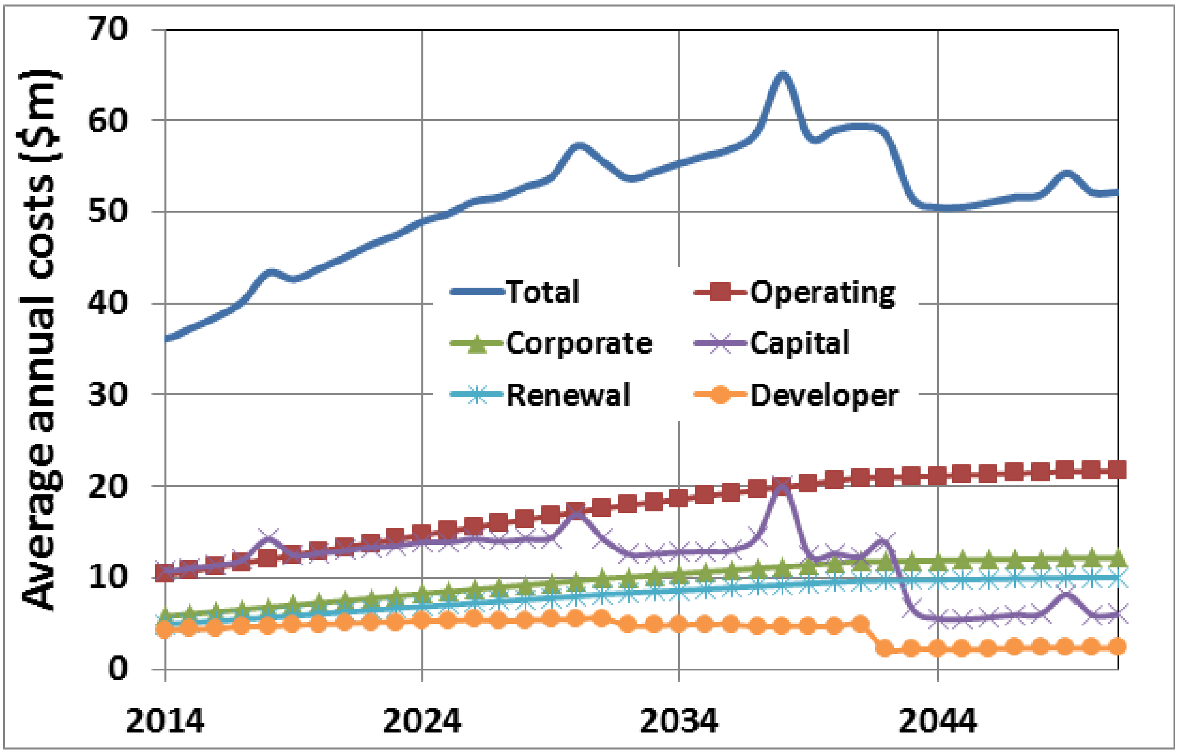

Figure 3.33: Average annual wastewater costs for the Ballarat water district in the HG Scenario

Figure 3.33 shows that the majority of costs for provision of wastewater services in the HG Scenario accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to accumulate in response to increasing population. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. Note that the accelerated population growth has increased amplitude and frequency of capital expenditure resulting in an increased "lumpiness" of spending patterns. The net present costs to 2051 for provision of wastewater services in the HG Scenario are provided in Table 3.33.

Table 3.33: Net present costs of wastewater management in the HG Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	811	+ 14.6
Operating	247	+ 8.7
Corporate	139	+ 8.7
Developer	94	+ 23.3
Capital	215	+ 27
Renewal	116	+ 8.5

Table 3.33 shows that the accelerated population growth in the HG Scenario generates greater requirement for infrastructure and higher wastewater discharges that increase the costs of

wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the CC Scenario are presented in Figure 3.34.

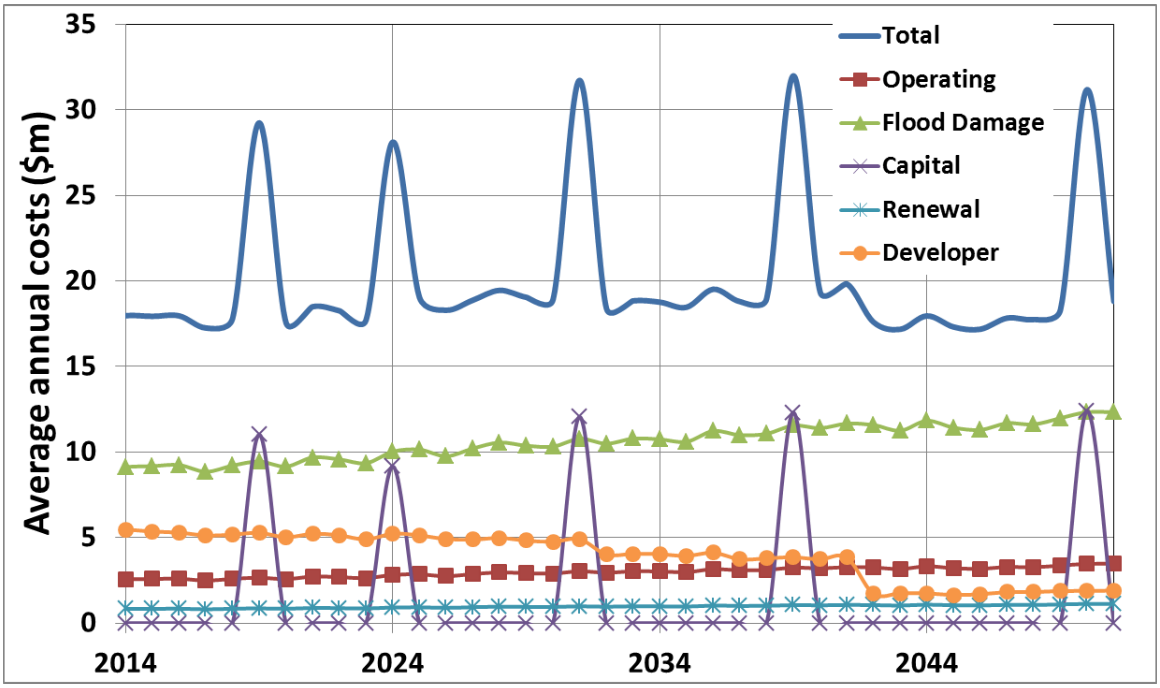

Figure 3.34: Average annual stormwater costs in the HG Scenario

Figure 3.34 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the HG Scenario. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the HG Scenario are provided in Table 3.34.

Table 3.34: Net Present Costs of stormwater management and flooding in the HG Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	357	+ 13.2
Operating	45	+ 2.3
Developer	96	+ 28.1
Capital	30	+ 43.2
Renewal	15	+ 2.3
Flooding	170	+ 6.3

Table 3.34 reveals that the accelerated population growth in the HG Scenario increased costs for stormwater management in response to increased requirement for infrastructure and higher

stormwater runoff with associated increased flood risks. The timelines for annual costs of the total pollutant loads in the HG Scenario are provided in Figure 3.35.

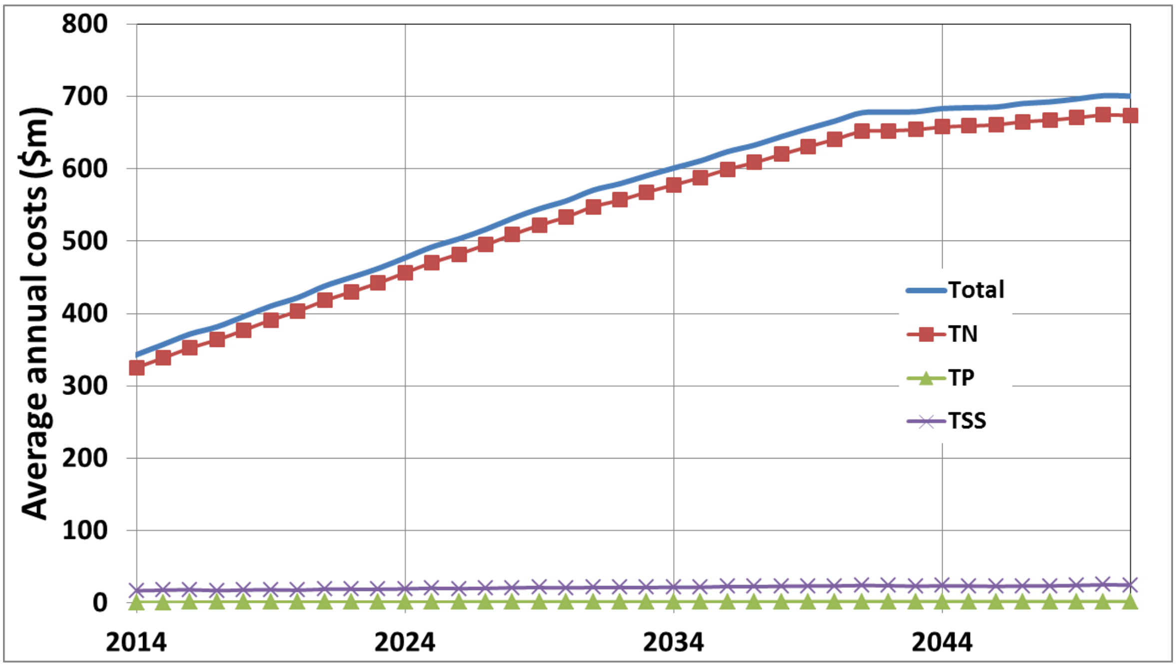

Figure 3.35: Costs of total pollutant loads in the HG Scenario

Figure 3.35 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the HG Scenario. The net present costs to 2051 of the total pollutant loads in the HG Scenario are provided in Table 3.35.

Table 3.35: Net present costs of pollutant loads in the HG Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	8,085	7.8
Total nitrogen	7,727	8.2
Total phosphorus	21	6
Total suspended solids	337	0

Table 3.35 reveals that the costs of pollutant loads in the HG Scenario are increased in comparison to the BAU Option due to increased stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the HG Scenario are presented in Figure 3.36.

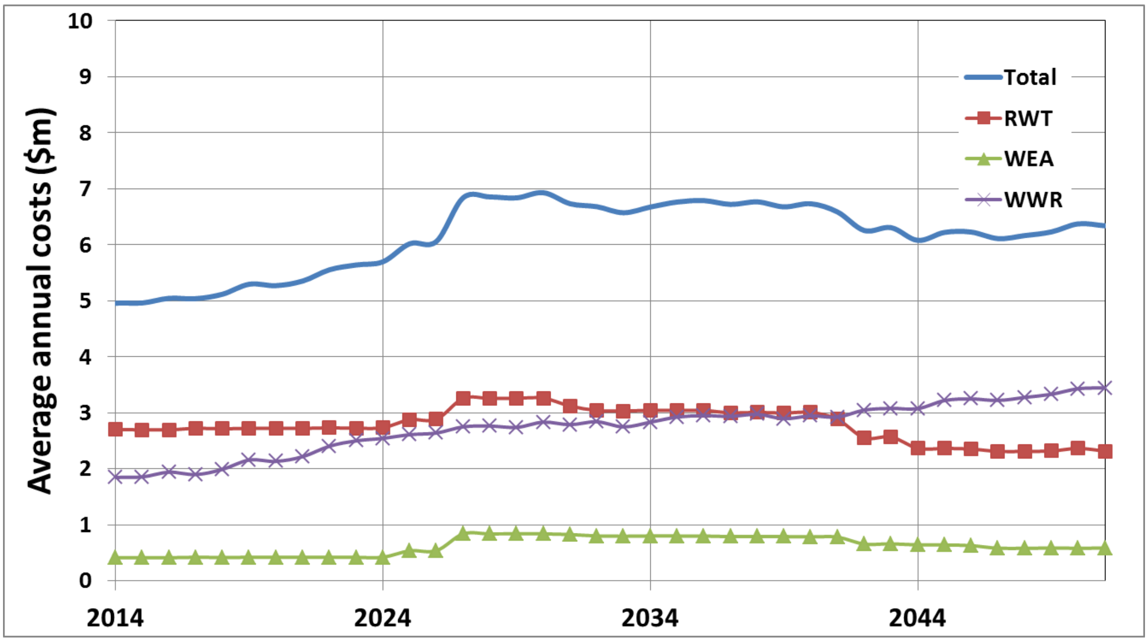

Figure 3.36: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the HG Scenario

Figure 3.36 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the HG Scenario. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.36.

Table 3.36: Net present costs of water saving measures in the HG Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	98	+ 10.1
Rainwater harvesting	48	+ 13.7
Water efficient appliances	9	+ 12.5
Wastewater reuse	41	+ 5.6

Table 3.36 shows that the HG Scenario produces greater total costs for water efficiency and alternative water supply at the BAU Option that is generated by increased numbers of properties. The timeline of future costs to 2051 of water cycle management by jurisdiction for the HG Scenario are presented in Figure 3.37. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

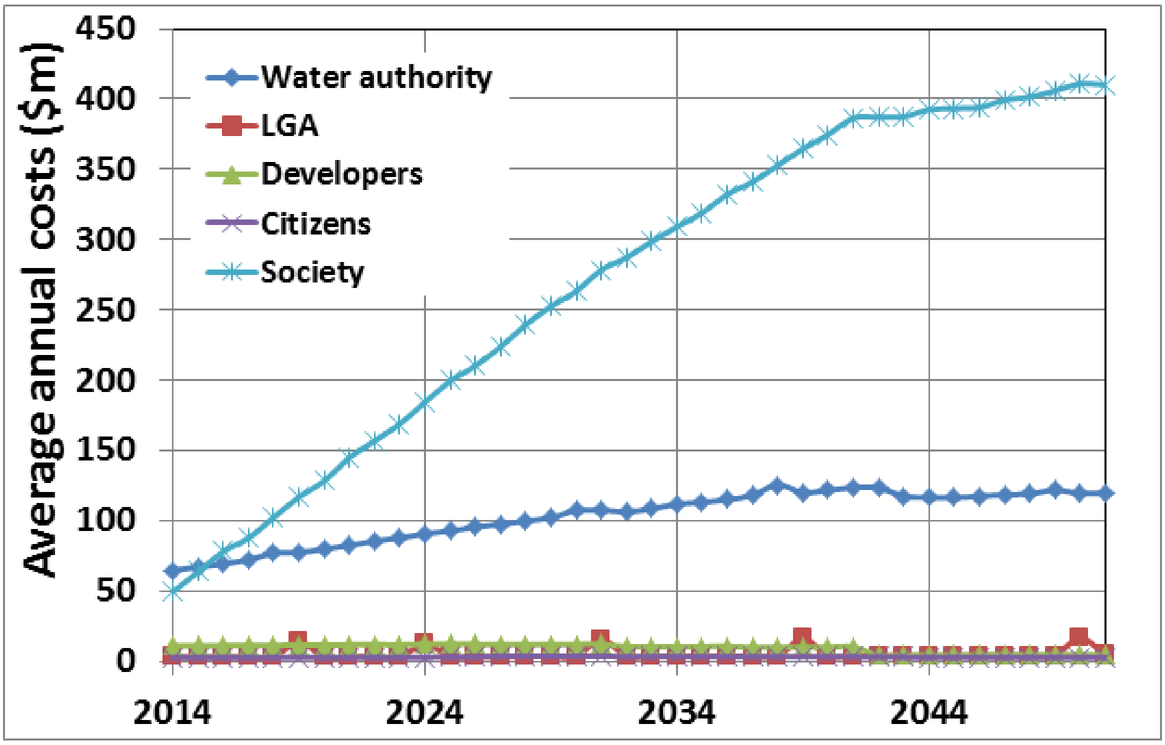

Figure 3.37: Average annual costs versus jurisdiction in the HG Scenario

Figure 3.37 demonstrates that the future costs of water cycle management in the CC Scenario are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth.

The net present costs that accrue to each jurisdiction in the HG Scenario are presented in Table 3.37.

Table 3.37: Net present costs that accrue to each jurisdiction

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,541	+ 12.2
Local Government	90	+ 13.1
Developers	227	+ 25.5
Citizens	58	+ 13.5
Society	2,983	+ 23.1
Total	4,898	+19.2

Table 3.37 reveals that the HG Scenario generates a 19.2% increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, developers and society. This represents a Net Present Cost of $790 m. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, and greater impacts on waterways created by additional urban growth.

3.7 High population Growth with Climate Change

The High population Growth and Climate Change (HGCC) Scenario examines the impact of high population growth as defined by forecast population for 2051 achieved at 2041 with high emissions climate change as defined by a rate of increase in average temperature of 0.05°C/annum. This Scenario is expected to generate a Net Present Cost of $803 m for the Ballarat water district that results in an increase in costs that accrue to all jurisdictions. The timelines of costs for the HGCC Scenario are presented in Figure 3.38.

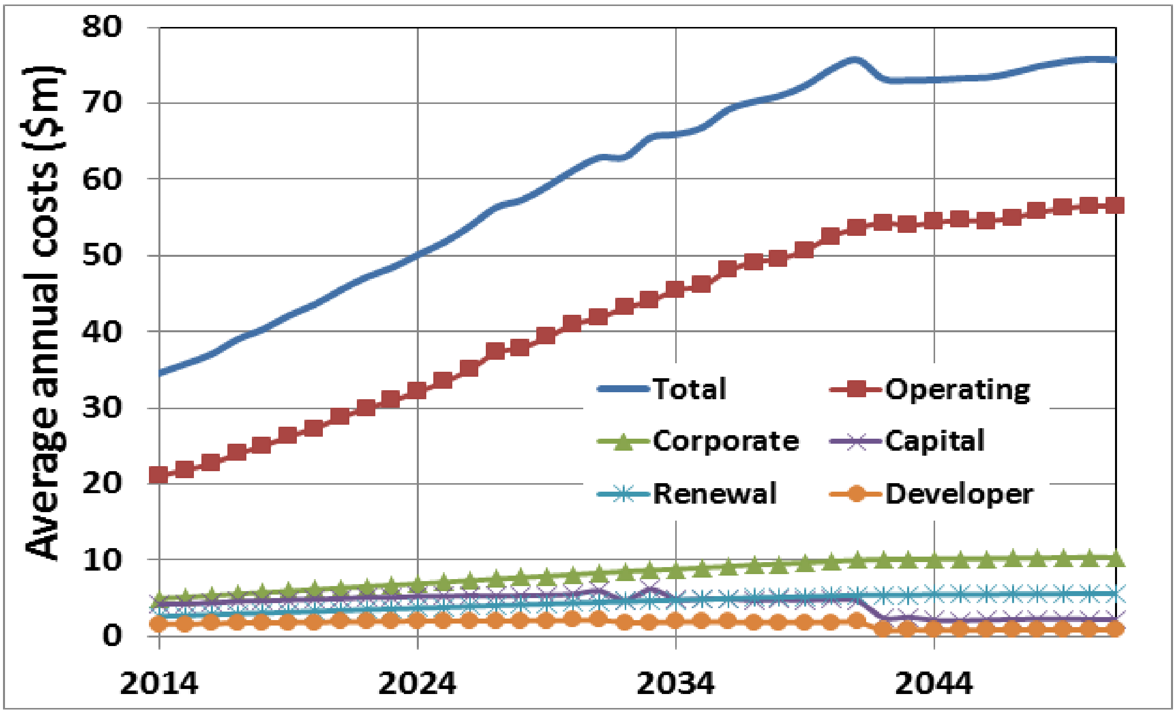

Figure 3.38: Average annual water costs in the HGCC Scenario

Figure 3.38 highlights that the HGCC Scenario generates increased capital and operating expenses. In particular, the frequency of capital expenditure for trunk or regional has increased. The net present costs to 2051 for provision of water services in the HGCC Scenario are provided in Table 3.38.

Table 3.38: Net present costs to 2051 for water supply in the HGCC Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	845	+ 15.3
Operating	545	+ 15.1
Corporate	119	+ 9.7
Capital	81	+ 27.5
Renewal	64	+ 9.9
Developer	36	+ 23.3

Table 3.38 shows that the accelerated population growth and higher water demands in the HGCC Scenario generates greater requirement for infrastructure and higher wastewater discharges that

increase the costs of wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the HGCC Scenario are presented in Figure 3.39.

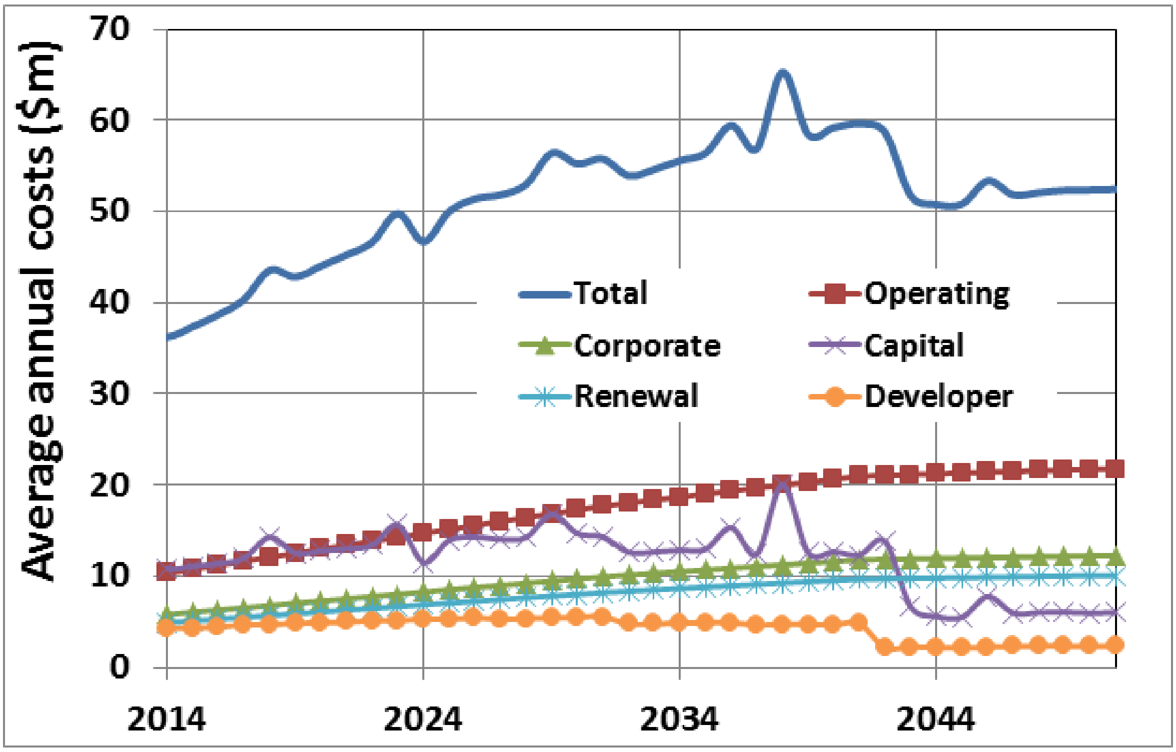

Figure 3.39: Average annual wastewater costs in the HGCC Scenario

Figure 3.39 shows that the majority of costs for provision of wastewater services in the HGCC Scenario accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. Note that the accelerated population growth has increased amplitude and frequency of capital expenditure resulting in an increased "lumpiness" of spending patterns. The net present costs to 2051 for provision of wastewater services in the HGCC Scenario are provided in Table 3.39.

Table 3.39: Net present costs of wastewater management

Criteria	NPC ($m)	Change from BAU (%)
Total	814	+ 15.1
Operating	248	+ 9.2
Corporate	140	+ 9.2
Developer	94	+ 23.3
Capital	216	+ 27.5
Renewal	116	+ 9

Table 3.39 shows that the accelerated population growth with increased water demands in the HGCC Scenario generates greater requirement for infrastructure and higher wastewater discharges that increase the costs of wastewater management in comparison to the BAU Option. The timelines

of costs for stormwater management and flood risks for the HGCC Scenario are presented in Figure 3.40.

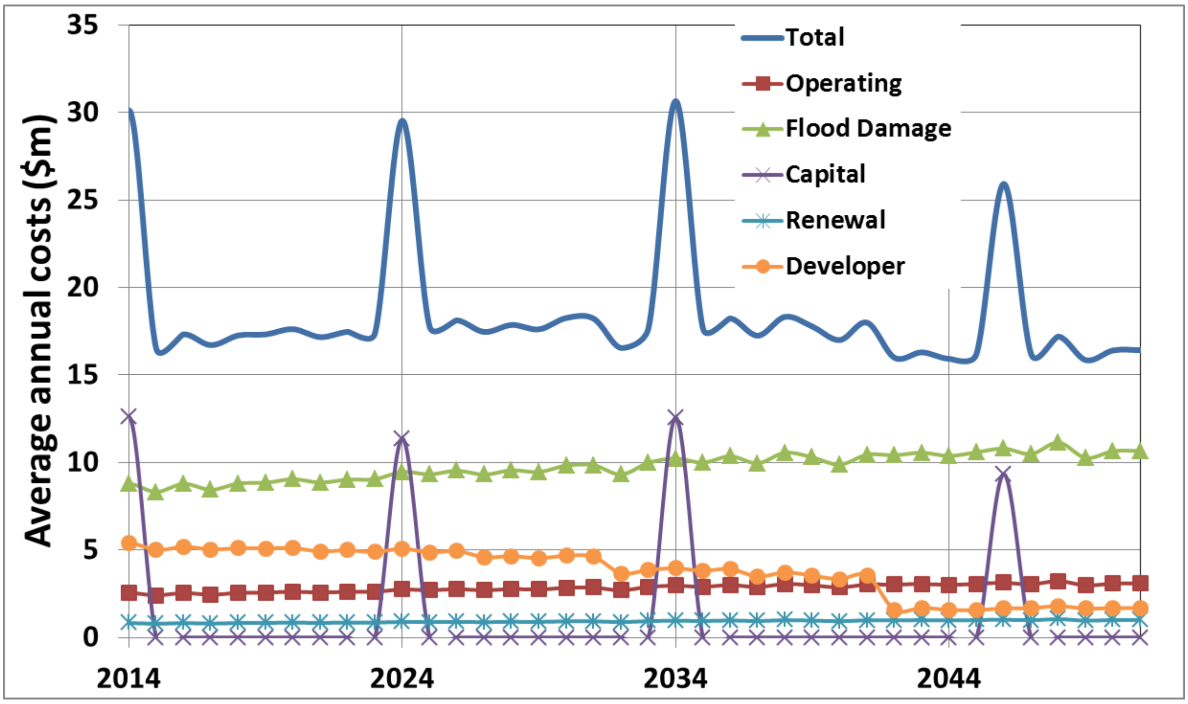

Figure 3.40: Average annual stormwater costs in the HGCC Scenario

Figure 3.40 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the HGCC Scenario. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the HGCC Scenario are provided in Table 3.40.

Table 3.40: Net Present Costs of stormwater management and flooding

Criteria	NPC ($m)	Change from BAU (%)
Total	354	+ 12.4
Operating	47	+ 7.1
Developer	90	+ 19.9
Capital	21	-2.3
Renewal	15	0
Flooding	186	+ 15.9

Table 3.40 reveals that the accelerated population growth in the HGCC Scenario increased costs for stormwater management in response to increased requirement for infrastructure and higher stormwater runoff with associated increased flood risks. The timelines for annual costs of the total pollutant loads in the HG Scenario are provided in Figure 3.41.

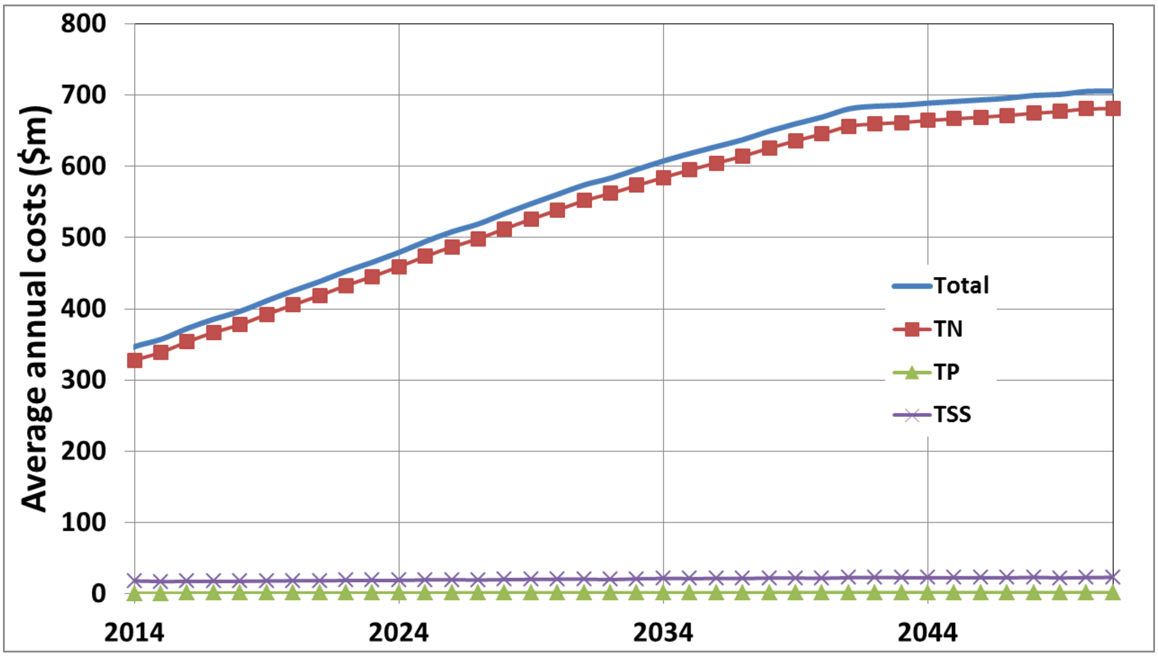

Figure 3.41: Costs of total pollutant loads in the HGCC Scenario

Figure 3.41 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the HGCC Scenario. The net present costs to 2051 of the total pollutant loads in the HGCC Scenario are provided in Table 3.41.

Table 3.41: Net present costs of pollutant loads in the HGCC Scenario

Criteria	NPC ($m)	Change from BAU (%)
Total	8136	+ 8.5
Total nitrogen	7782	+ 9
Total phosphorus	21	+ 6.5
Total suspended solids	343	+ 1.9

Table 3.41 reveals that the costs of pollutant loads in the HGCC Scenario are increased in comparison to the BAU Option due to increased stormwater runoff to waterways. Note that the lower volumes of stormwater runoff generated by climate change are overwhelmed by increased urban development for generation of pollutants. The timeline of future costs of water efficiency and alternative water sources in the HG Scenario are presented in Figure 3.42.

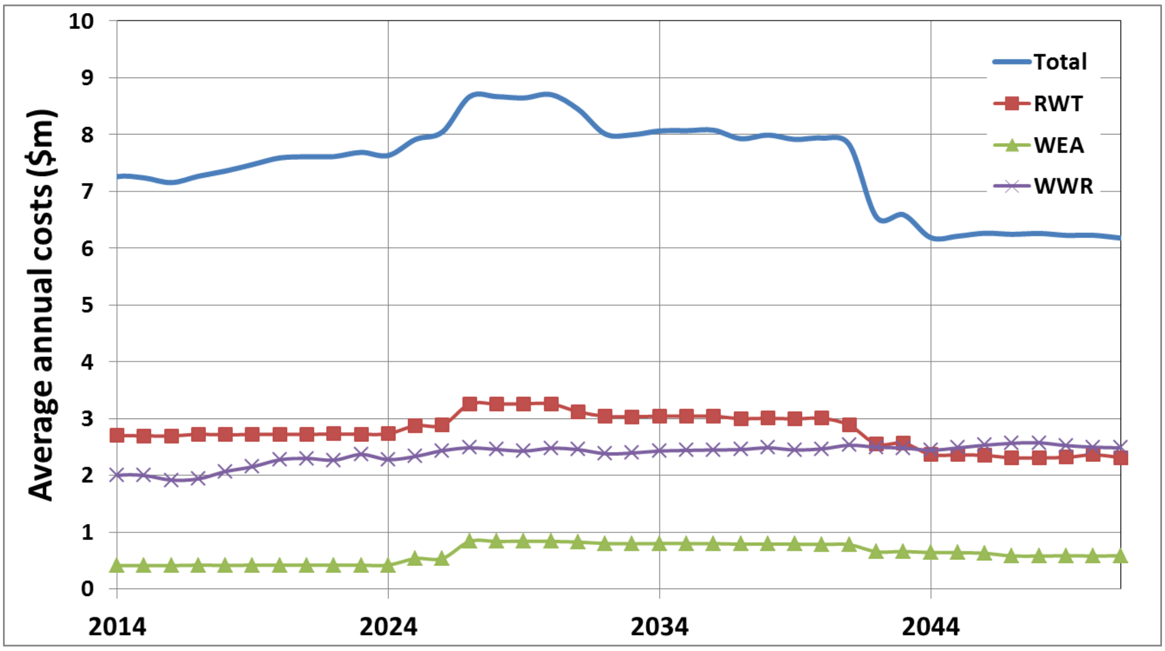

Figure 3.43: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the HGCC Scenario

Figure 3.43 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the HGCC Scenario. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.43.

Table 3.43: Net present costs of water saving measures in the HGCC Scenario

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	96	+ 6.9
Rainwater harvesting	48	+ 13.6
Water efficient appliances	9	+ 12.5
Wastewater reuse	39	0

Table 3.43 shows that the HGCC Scenario produces greater total costs for water efficiency and alternative water supply at the BAU Option that is generated by increased numbers of properties. Note that increasing water efficiency in public open spaces balances the demand for wastewater reuse. The timeline of future costs to 2051 of water cycle management by jurisdiction for the HGCC Scenario are presented in Figure 3.44. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

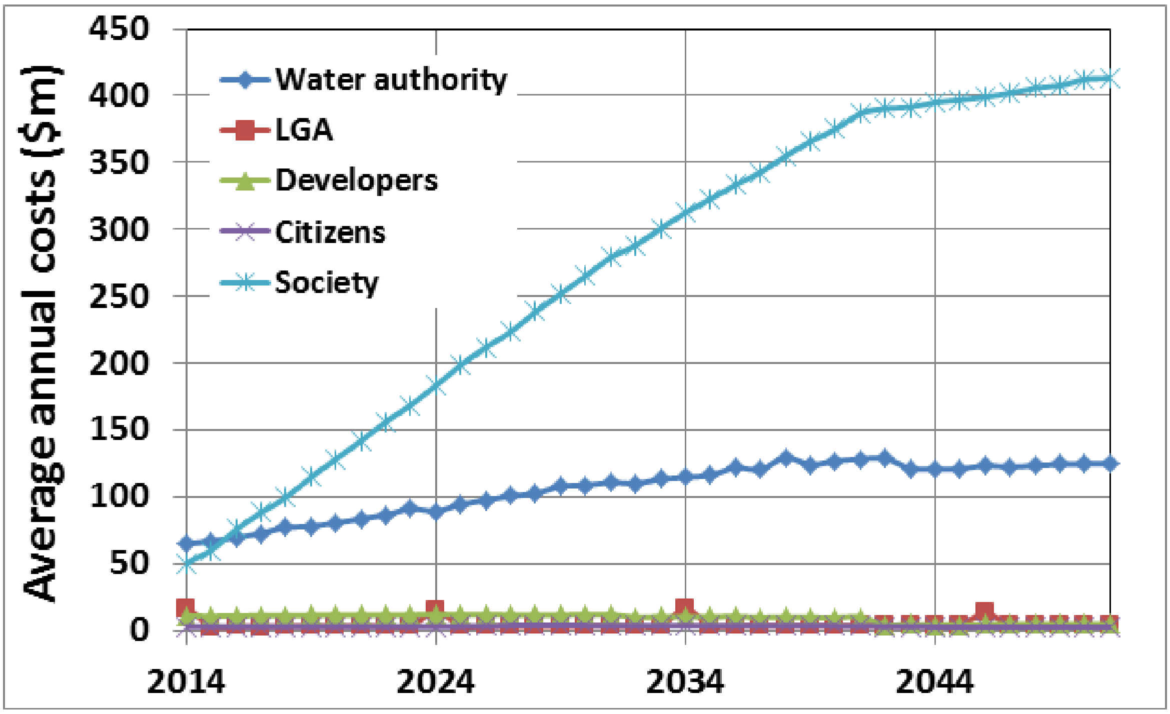

Figure 3.44: Average annual costs versus jurisdiction for the HGCC Scenario

Figure 3.44 demonstrates that the future costs of water cycle management in the HGCC Scenario are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure and a requirement to augment the security of the water supply.

The net present costs that accrue to each jurisdiction in the HGCC Scenario are presented in Table 3.44.

Table 3.44: Net present costs that accrue to each jurisdiction in the HGCC Scenario

Jurisdiction	**NPC ($m)**	**Change from BAU (%)**
Water authority	1,567	+ 14.1
Local Government	79	-1.6
Developers	220	+ 21.9
Citizens	58	+ 13.5
Society	2,987	+ 23.3
Total	4,911	+ 19.5

Table 3.44 reveals that the HGCC Scenario generates a 19.5% increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, the water authority and society. This represents a Net Present Cost of $803 m. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, greater impacts on waterways created by additional urban growth and reduced availability of water resources.

3.8 Building Controls

The Building Control (BC1) Options included rainwater harvesting and highest level of water efficiency adopted for all new and substantially renovated buildings. This Option is expected to generate a Net Present Value of $458 m for the Ballarat water district that results in decreased costs that accrue to most jurisdictions with increased costs to citizens. The timelines of costs for the BC1 Option are presented in Figure 3.45.

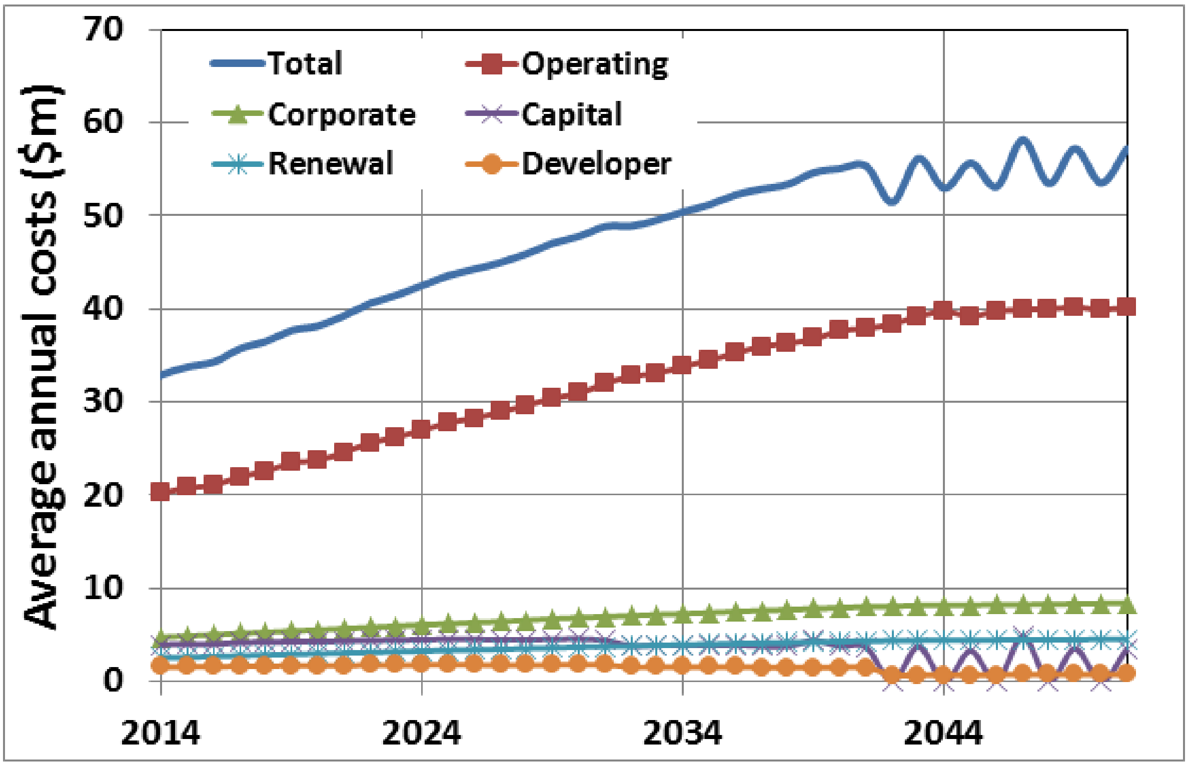

Figure 3.45: Average annual water costs for the Ballarat water district in the BC1 Option

Figure 3.45 highlights that the BC1 Option generates decreased capital and operating expenses. In particular, the frequency of capital expenditure for trunk or regional infrastructure has diminished. The net present costs to 2051 for provision of water services in the BC1 Option are provided in Table 3.45.

Table 3.45: Net present costs to 2051 for water supply

Criteria	NPC ($m)	Change from BAU (%)
Total	694	-5.5
Operating	445	-6.1
Corporate	104	-4.4
Capital	61	-3.4
Renewal	56	-4.5
Developer	28	-4.7

Table 3.45 shows that the diminished water demands in the BC1 Option reduces requirement for infrastructure and operating costs in comparison to the BAU Option. The timelines of costs for wastewater management for the BC1 Option are presented in Figure 3.46.

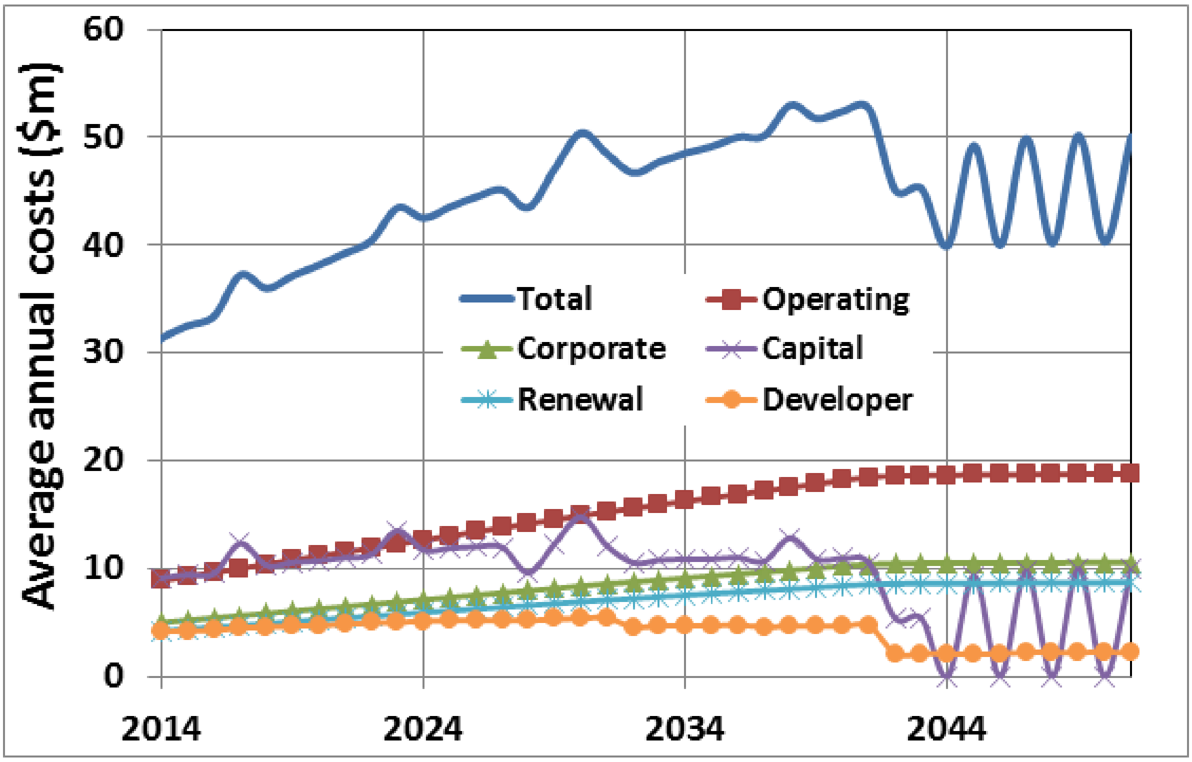

Figure 3.46: Average annual wastewater costs for the BC1 Option

Figure 3.46 shows that the majority of costs for provision of wastewater services in the BC1 Option accrue to the Water Authority and costs increase with population growth. In particular, the costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the BC1 Option are provided in Table 3.46.

Table 3.46: Net present costs of wastewater management for the BC1 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	668	-5.6
Operating	215	-5.4
Corporate	121	-5.4
Developer	72	-5.2
Capital	159	-6.1
Renewal	101	-5.6

Table 3.46 shows that the decreased water demands and stormwater runoff in the BC1 Option generates diminished wastewater discharges with associated reductions in requirement for infrastructure. The outcome is driven by water efficient appliances and reduced stormwater infiltration to sewers that decrease the costs of wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the HGCC Scenario are presented in Figure 3.47.

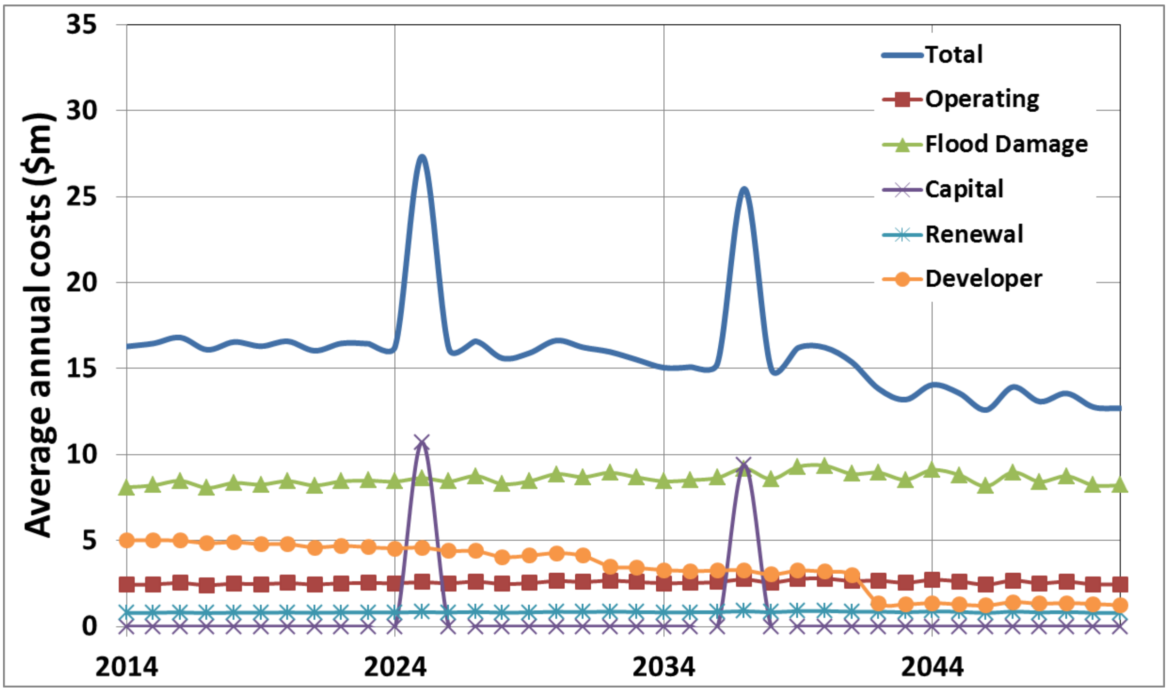

Figure 3.47: Average annual stormwater costs in the BC1 Option

Figure 3.47 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the BC1 Option. The costs of flood risks are seen to be relatively unchanged over time in response to cumulative decreases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the BC1 Option are provided in Table 3.47.

Table 3.47: Net Present Costs of stormwater management and flooding in the BC1 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	305	-3.1
Operating	43	-1.7
Developer	74	-2
Capital	18	-16.5
Renewal	15	-1.7
Flooding	156	-2.4

Table 3.47 reveals that the reduced stormwater runoff in the BC1 Option decreased costs for stormwater management due to a diminished requirement for infrastructure and decreased flood risks. The timelines for annual costs of the total pollutant loads in the BC1 Option are provided in Figure 3.48.

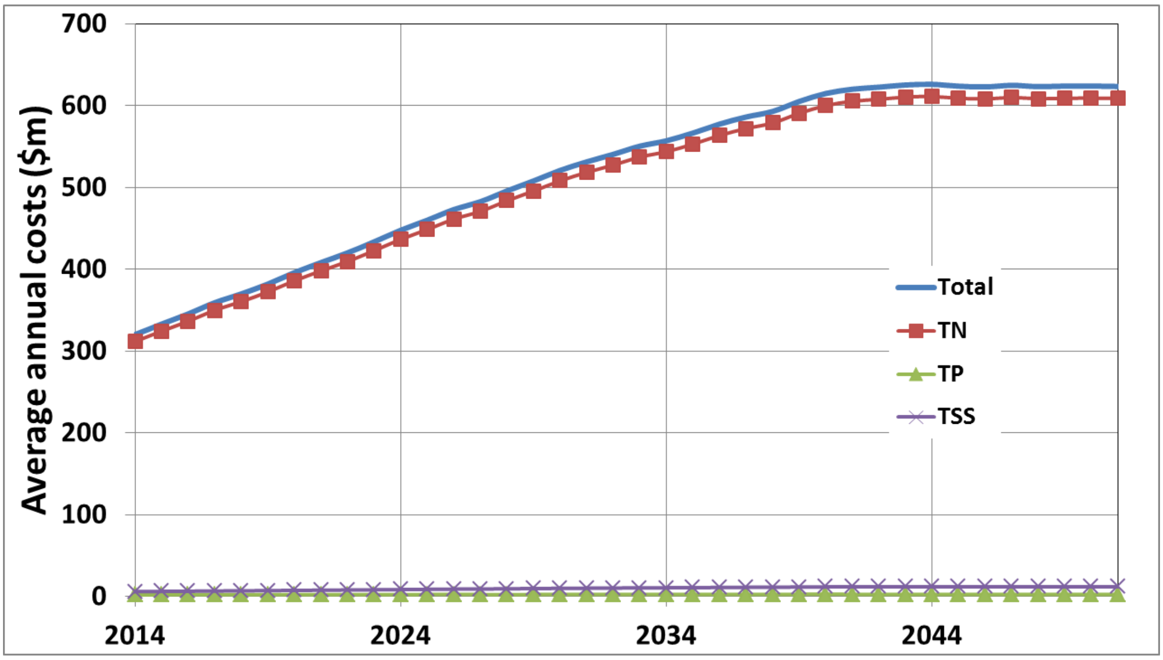

Figure 3.48: Costs of total pollutant loads in the BC1 Option

Figure 3.48 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the BC1 Option. The net present costs to 2051 of the total pollutant loads in the BC1 Option are provided in Table 3.48.

Table 3.48: Net present costs of pollutant loads in the BC1 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	6945	-7.4
Total nitrogen	6793	-4.9
Total phosphorus	19	-7.2
Total suspended solids	324	-2.7

Table 3.48 reveals that the costs of pollutant loads in the BC1 Option are decreased in comparison to the BAU Option due to reduced stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the BC1 Option are presented in Figure 3.49.

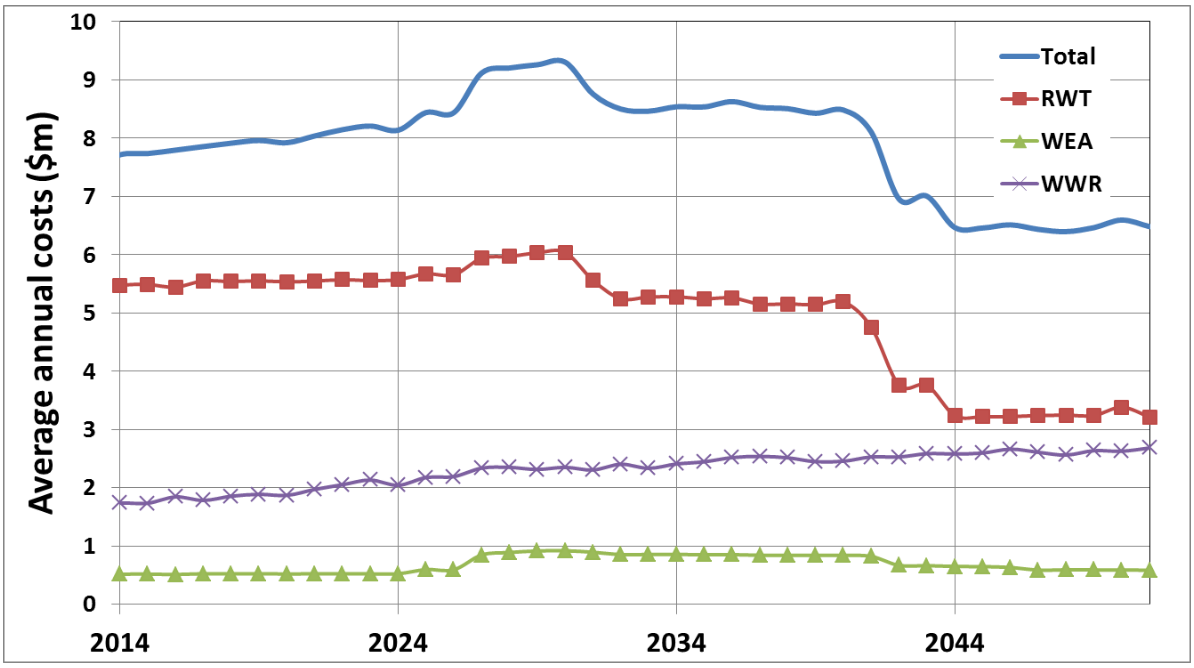

Figure 3.49: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the BC1 Option

Figure 3.49 reveals that the ongoing costs of rainwater harvesting and costs of wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the BC1 Option. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.49.

Table 3.49: Net present costs of water saving measures

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	135	+ 50.7
Rainwater harvesting	86	+ 102.8
Water efficient appliances	10	+ 20.4
Wastewater reuse	39	0

Table 3.49 shows that the greater adoption of water efficiency and rainwater harvesting in the BC1 Option produces greater total costs than the BAU Option. Note that increasing water efficiency in public open spaces balances the demand for wastewater reuse. The timeline of future costs to 2051 of water cycle management by jurisdiction for the BC1 Option are presented in Figure 3.50. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

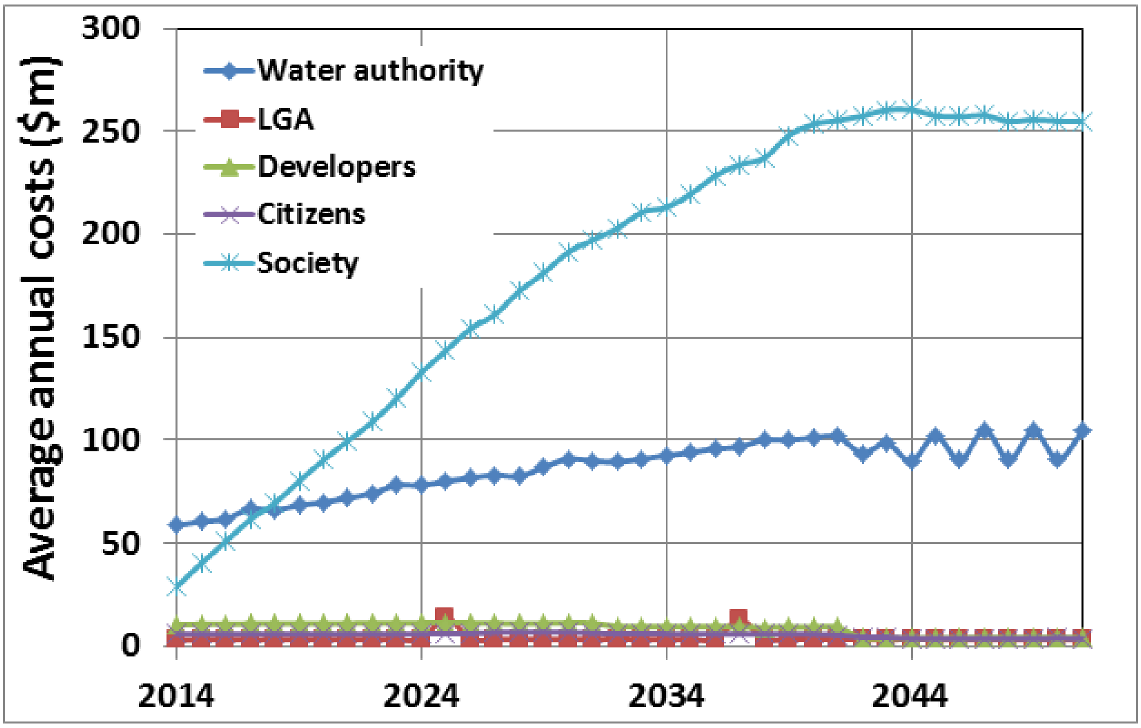

Figure 3.50: Average annual costs versus jurisdiction for the BC1 Option

Figure 3.50 demonstrates that the future costs of water cycle management in the BC1 Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure.

The net present costs that accrue to each jurisdiction in the BC1 Option are presented in Table 3.50.

Table 3.50: Net present costs that accrue to each jurisdiction in the BC1 Option

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,301	-5.3
Local Government	75	-5.6
Developers	116	-35.7
Citizens	96	89.2
Society	2,061	-14.9
Total	3,650	-11.1

Table 3.50 reveals that the BC1 Option generates a 11.1% reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. This represents a net present value of $458 m. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

3.9 Building Controls with stormwater management

The Building Control with stormwater management (BCs) Option included rainwater harvesting, the highest level of water efficiency and vegetated stormwater management in the adjacent street scape adopted for all new and substantially renovated buildings. The 5 m^3 of vegetated stormwater management for each new and renovated building could be street trees, bio-retention, landscaping of similar. This Option is expected to generate a Net Present Value of $661 m for the Ballarat water district that results in decreased costs that accrue to most jurisdictions with increased costs to citizens. The timelines of costs for the BC2 Option are presented in Figure 3.51.

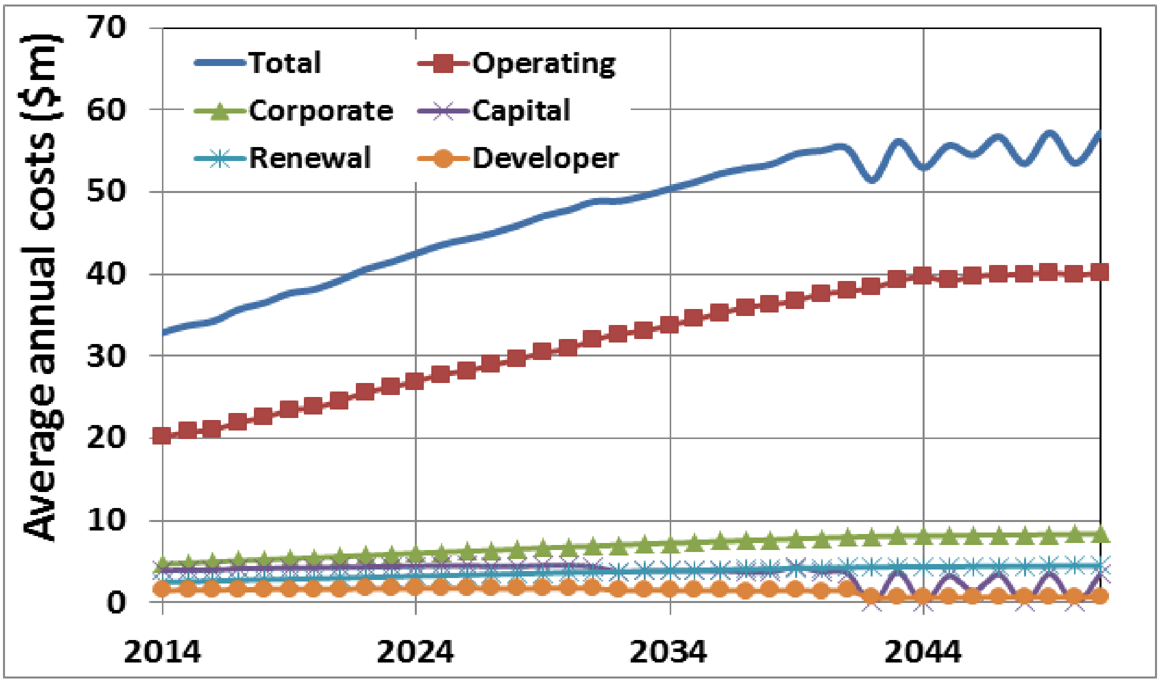

Figure 3.51: Average annual water costs for the Ballarat water district in the BC2 Option

Figure 3.51 highlights that the BC2 Option generates decreased capital and operating expenses, and the frequency of capital expenditure for trunk or regional infrastructure has diminished. The net present costs to 2051 for provision of water services in the BC2 Option are provided in Table 3.51.

Table 3.45: Net present costs to 2051 for water supply

Criteria	NPC ($m)	Change from BAU (%)
Total	694	-5.5
Operating	445	-6.1
Corporate	104	-4.4
Capital	61	-3.4
Renewal	56	-4.5
Developer	28	-4.7

Table 3.51 shows that the diminished water demands in the BC2 Option reduces requirement for infrastructure and operating costs in comparison to the BAU Option. The timelines of costs for wastewater management for the BC2 Option are presented in Figure 3.52.

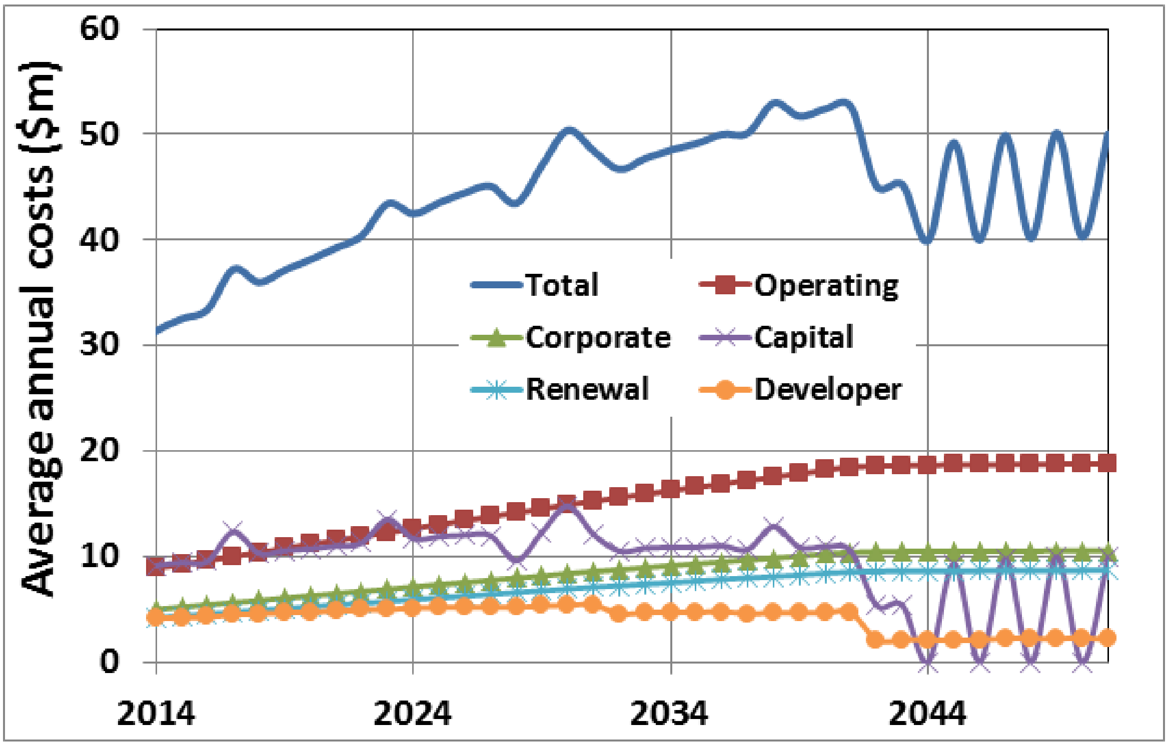

Figure 3.52: Average annual wastewater costs for the BC2 Option

Figure 3.52 shows that the majority of costs for provision of wastewater services in the BC2 Option accrue to the Water Authority and costs increase with population growth. The costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the BC2 Option are provided in Table 3.52.

Table 3.52: Net present costs of wastewater management for the BC2 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	668	-5.6
Operating	215	-5.4
Corporate	121	-5.4
Developer	72	-5.2
Capital	159	-6.1
Renewal	101	-5.6

Table 3.52 shows that the decreased water demands in the BC2 Option generates reduced requirement for infrastructure and diminished wastewater discharges that decrease the costs of wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the BC2 Option are presented in Figure 3.53.

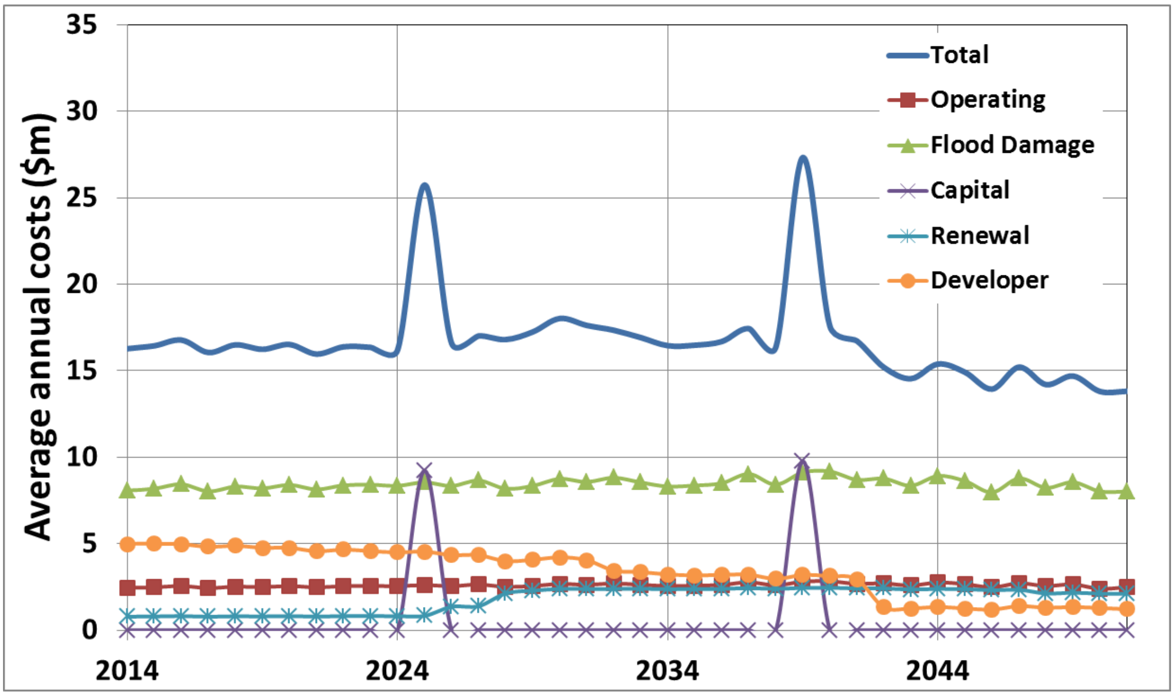

Figure 3.53: Average annual stormwater costs in the BC2 Option

Figure 3.53 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the BC2 Option. The costs of flood risks are seen to be relatively unchanged over time in response to cumulative decreases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the BC2 Option are provided in Table 3.53.

Table 3.53: Net Present Costs of stormwater management and flooding in the BC2 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	332	+ 5.5
Operating	44	+ 0.8
Developer	86	+ 15
Capital	19	-8.6
Renewal	30	+96.8
Flooding	153	-4.5

Table 3.53 reveals that the reduced stormwater runoff in the BC2 Option decreased costs due to a diminished requirement for infrastructure and decreased flood risks. The costs of renewing, operating and installing developer scale stormwater infrastructure increased to account for street scale stormwater management measures. The timelines for annual costs of the total pollutant loads in the BC2 Option are provided in Figure 3.54.

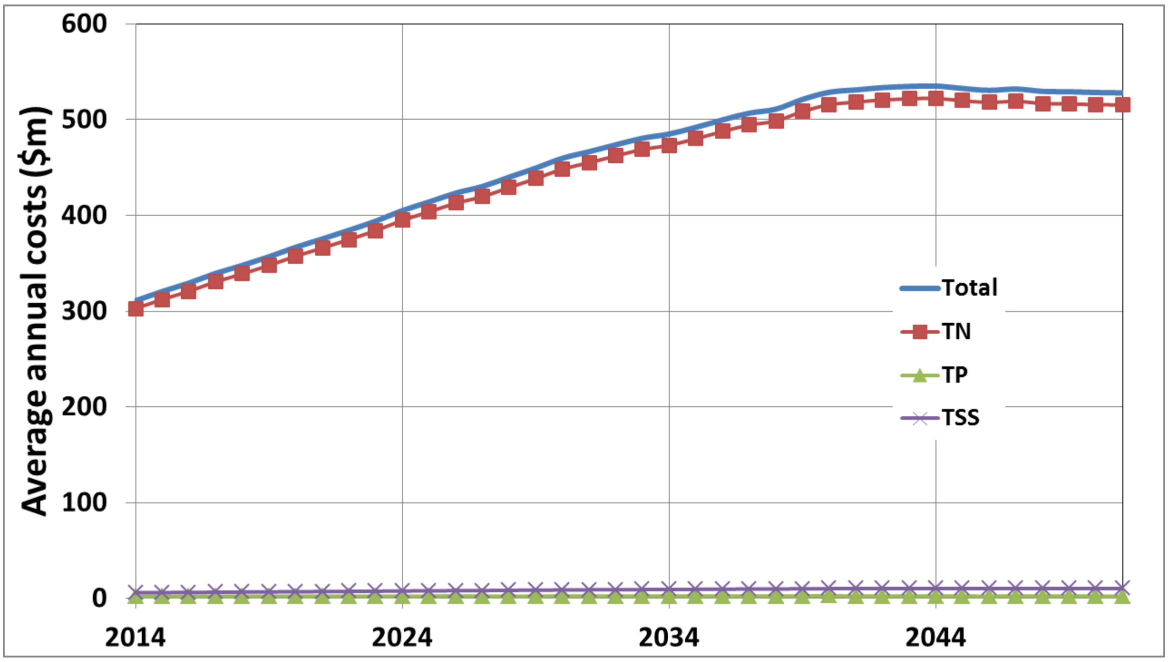

Figure 3.54: Costs of total pollutant loads in the BC2 Option

Figure 3.54 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the BC2 Option. The net present costs to 2051 of the total pollutant loads in the BC2 Option are provided in Table 3.54.

Table 3.54: Net present costs of pollutant loads in the BC2 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	6,724	-10.3
Total nitrogen	6,595	-7.6
Total phosphorus	15	-22.4
Total suspended solids	214	-36.4

Table 3.54 reveals that the costs of pollutant loads in the BC2 Option are decreased in comparison to the BAU Option due to reduced stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the BC2 Option are presented in Figure 3.55.

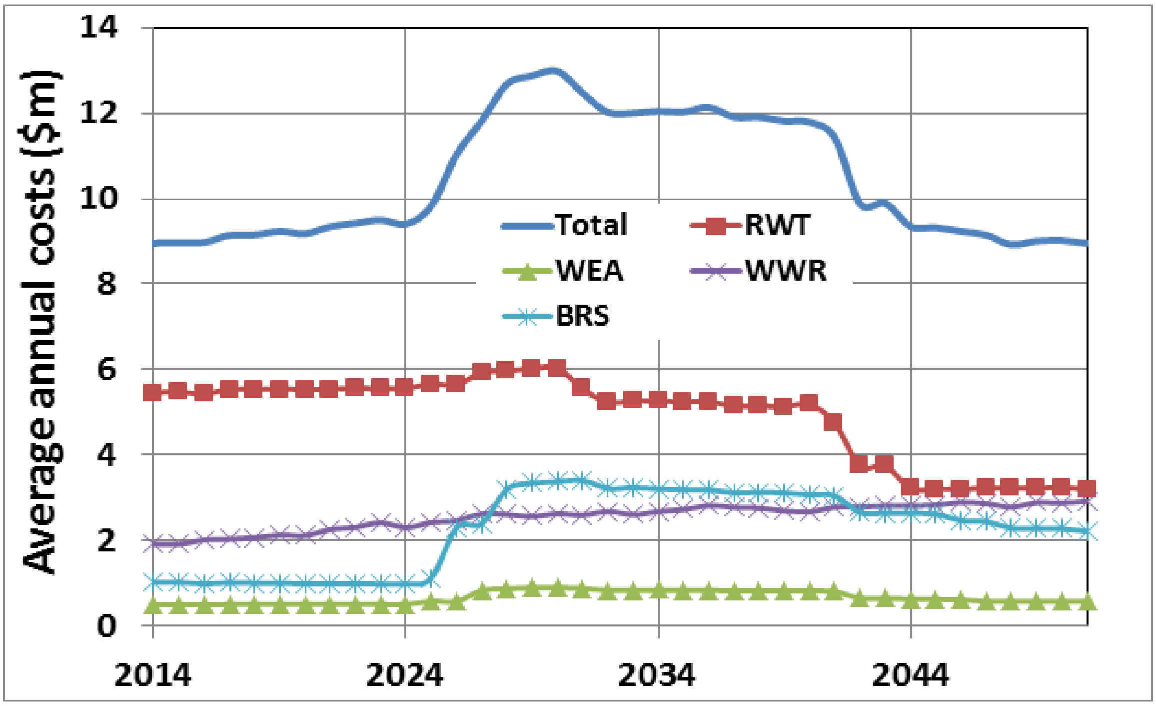

Figure 3.55: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the BC2 Option

Figure 3.55 reveals that the ongoing costs of rainwater harvesting and wastewater reuse from the existing facilities dominate the costs of alternative water supplies in the BC2 Option. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.55.

Table 3.55: Net present costs of water saving measures in the BC2 Option

Criteria	NPC ($m)	Change from BAU (%)
Total	163	+ 82.9
Rainwater harvesting	86	+ 102.7
Water efficient appliances	10	+ 20.4
Wastewater reuse	39	0
Bio-retention	29	-

Table 3.55 shows that the greater adoption of water efficiency and rainwater harvesting, and inclusion of street scale stormwater management in the BC2 Option produces greater total costs than the BAU Option. Note that increasing water efficiency in public open spaces balances the demand for wastewater reuse. The timeline of future costs to 2051 of water cycle management by jurisdiction for the BC2 Option are presented in Figure 3.56. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

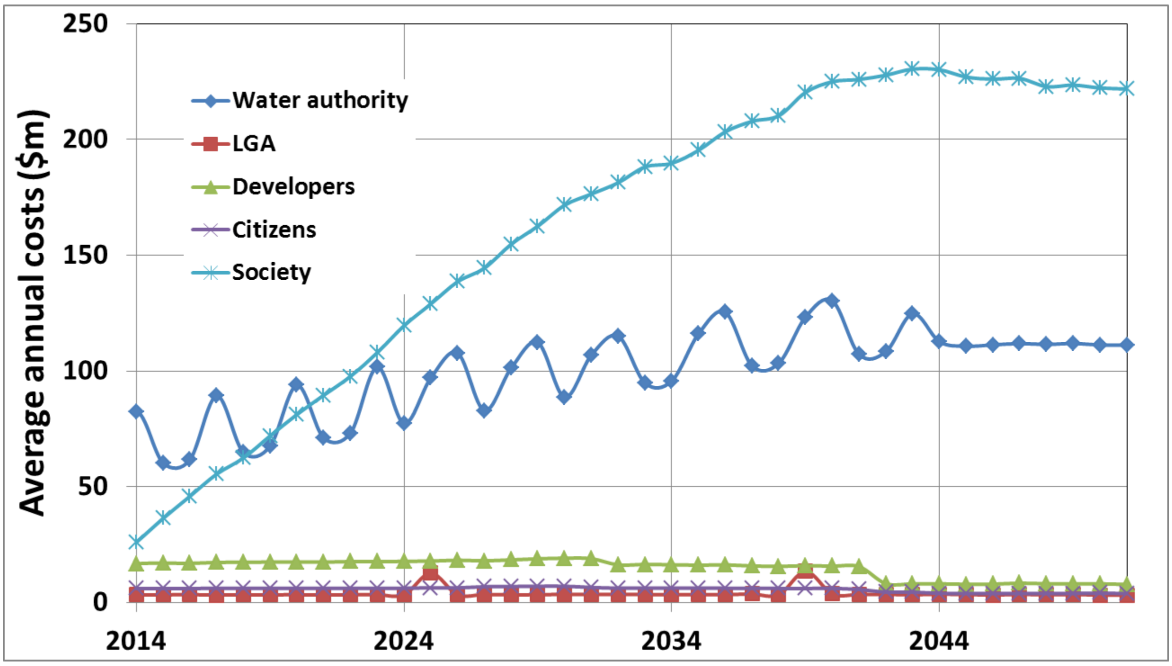

Figure 3.56: Average annual costs versus jurisdiction in the BC2 Option

Figure 3.56 demonstrates that the future costs of water cycle management in the BC2 Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure.

The net present costs that accrue to each jurisdiction in the BC1 Option are presented in Table 3.56.

Table 3.56: Net present costs that accrue to each jurisdiction for the BC2 Option

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,180	-14.1
Local Government	86	+ 7.7
Developers	207	+ 14.9
Citizens	96	+ 89.1
Society	1,877	-22.5
Total	3,447	-16.1

Table 56 reveals that the BC2 Option generates a 16.1% reduction in costs that accrue to local government, the water authority and society. Local government and society are proportionally higher beneficiaries with citizens and developers experiencing higher costs to create these benefits. This represents a net present value of $661 m. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

3.10 Integrated water cycle management

The Integrated Water Cycle Management (IWCM) Option includes rainwater harvesting for non-drinking indoor uses, the highest level of water efficiency adopted in all new buildings and Wastewater reuse via a third pipe network for toilet, outdoor and open space uses. This Option is expected to generate a Net Present Value of $1,515 m for the Ballarat water district that results in decreased costs that accrue to most jurisdictions with increased costs to citizens and developers. The timelines of costs for the IWCM Option are presented in Figure 3.57.

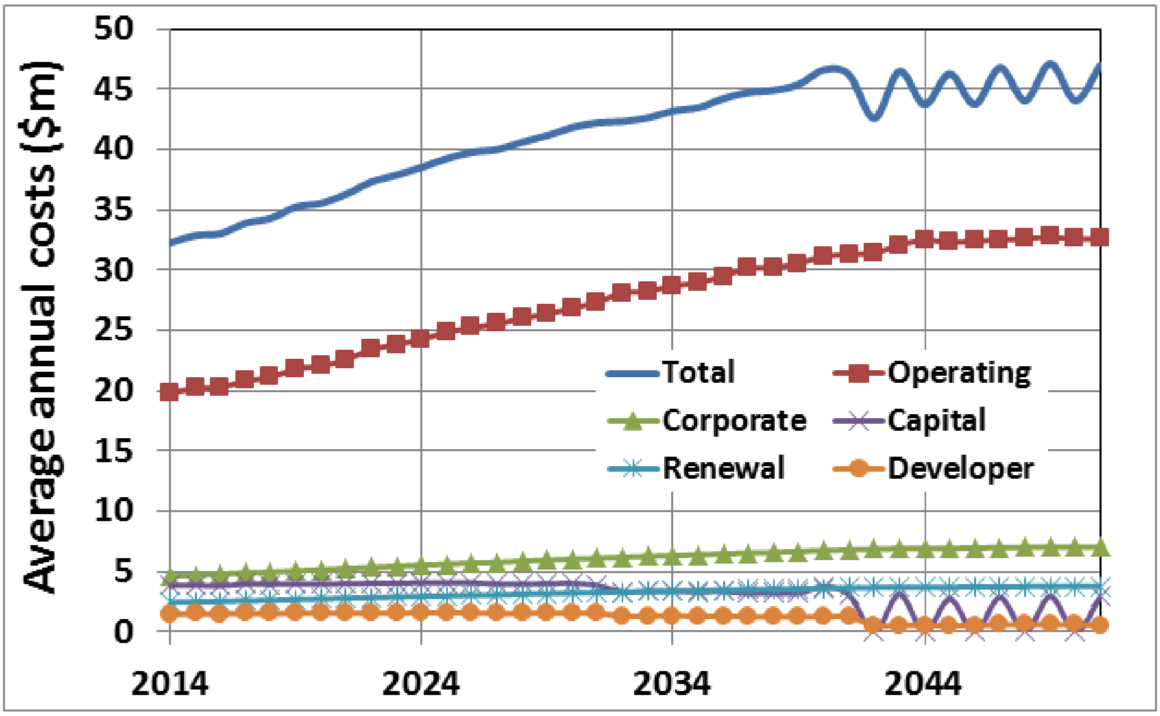

Figure 3.57: Average annual water costs in the IWCM Option

Figure 3.57 highlights that the IWCM Option generates decreased capital and operating expenses, and the frequency of capital expenditure for trunk or regional infrastructure has diminished. The net present costs to 2051 for provision of water services in the IWCM Option are provided in Table 3.57.

Table 3.57: Net present costs to 2051 for water supply in the IWCM Option

Criteria	NPC ($m)	Change from BAU (%)
Total	627	-14.5
Operating	398	-15.9
Corporate	96	-12.1
Capital	56	-11.1
Renewal	51	-12.4
Developer	26	-12.1

Table 3.57 shows that the diminished water demands in the IWCM Option reduces requirement for infrastructure and operating costs in comparison to the BAU Option. The timelines of costs for wastewater management for the IWCM Option are presented in Figure 3.58.

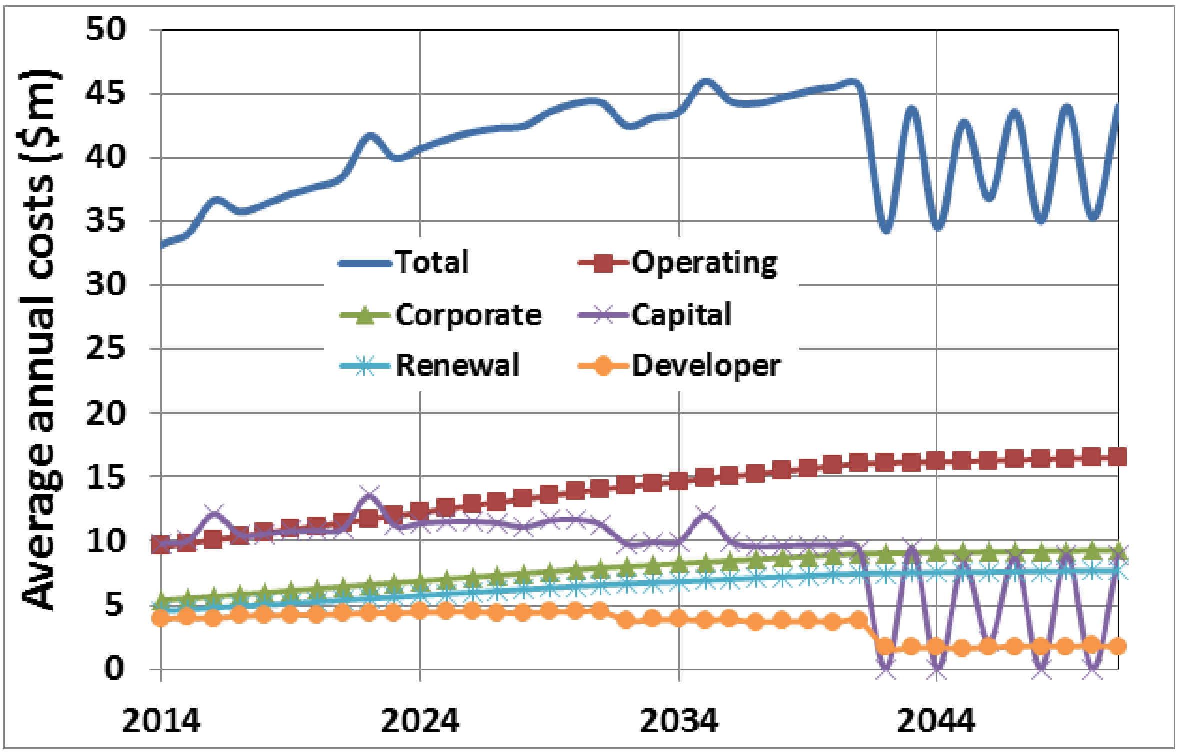

Figure 3.58: Average annual wastewater costs in the IWCM Option

Figure 3.58 shows that the majority of costs for provision of wastewater services in the IWCM Option accrue to the Water Authority and costs increase with population growth. The costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the IWCM Option are provided in Table 3.58.

Table 3.58: Net present costs of wastewater management in the IWCM Option

Criteria	NPC ($m)	Change from BAU (%)
Total	652	-7.9
Operating	208	-8.3
Corporate	117	-8.3
Developer	70	-7.4
Capital	158	-6.9
Renewal	98	-8

Table 3.58 shows that the decreased water demands in the IWCM Option generates reduced requirement for infrastructure and diminished wastewater discharges that decrease the costs of

wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the IWCM Option are presented in Figure 3.59.

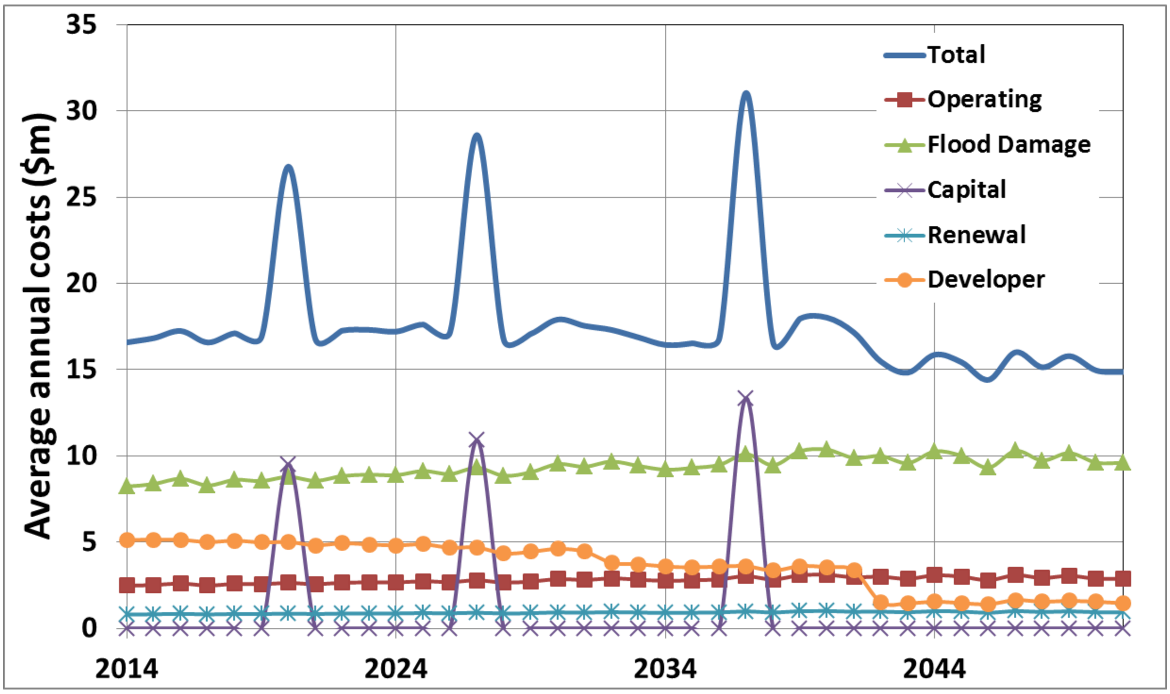

Figure 3.59: Average annual stormwater costs in the IWCM Option

Figure 3.59 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the IWCM Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the IWCM Option are provided in Table 3.59.

Table 3.59: Net Present Costs of stormwater management and flooding in the IWCM Option

Criteria	NPC ($m)	Change from BAU (%)
Total	307	-2.4
Operating	45	+ 3.7
Developer	76	+ 1.1
Capital	17	-21.6
Renewal	16	+ 3.7
Flooding	154	-3.9

Table 3.59 reveals that the reduced stormwater runoff in the IWCM Option decreased costs for stormwater management due to a diminished requirement for infrastructure and decreased flood

risks. The timelines for annual costs of the total pollutant loads in the IWCM Option are provided in Figure 3.60.

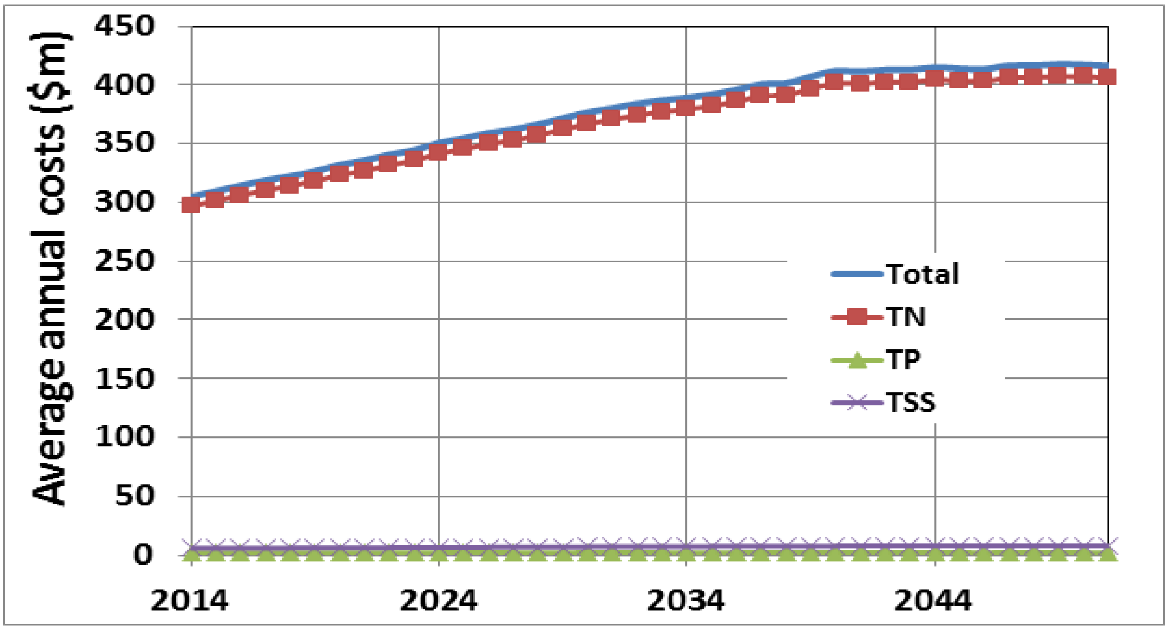

Figure 3.60: Costs of total pollutant loads in the IWCM Option

Figure 3.60 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the IWCM Option. The net present costs to 2051 of the total pollutant loads in the IWCM Option are provided in Table 3.60.

Table 3.60: Net present costs of pollutant loads in the IWCM Option

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	6,184	-17.5
Total nitrogen	5,851	-18.1
Total phosphorus	18	-7.7
Total suspended solids	314	-6.7

Table 3.60 reveals that the costs of pollutant loads in the IWCM Option are decreased in comparison to the BAU Option due to reduced stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the IWCM Option are presented in Figure 3.61.

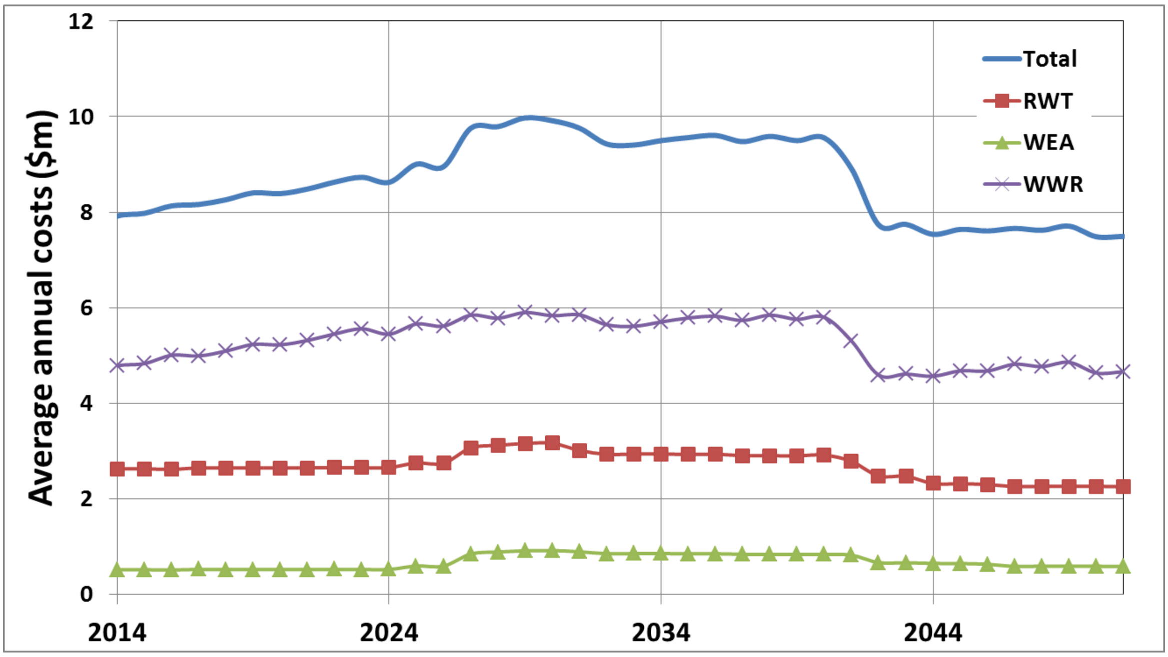

Figure 3.61: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the IWCM Option

Figure 3.61 reveals that the ongoing costs of rainwater harvesting and wastewater reuse from the existing new and facilities dominate the costs of alternative water supplies in the IWCM Option. The annual costs of water efficiency and rainwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.61.

Table 3.61: Net present costs of water saving measures in the IWCM Option

Criteria	NPC ($m)	Change from BAU (%)
Total	186	+ 107.9
Rainwater harvesting	86	+ 102.7
Water efficient appliances	10	+ 20.4
Wastewater reuse	90	+ 132.8

Table 3.61 shows that the greater adoption of water efficiency and rainwater harvesting, and inclusion of street scale stormwater management in the IWCM Option produces greater total costs than the BAU Option. Note that increasing water efficiency in public open spaces balances the demand for wastewater reuse. The timeline of future costs to 2051 of water cycle management by jurisdiction for the IWCM Option are presented in Figure 3.62. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

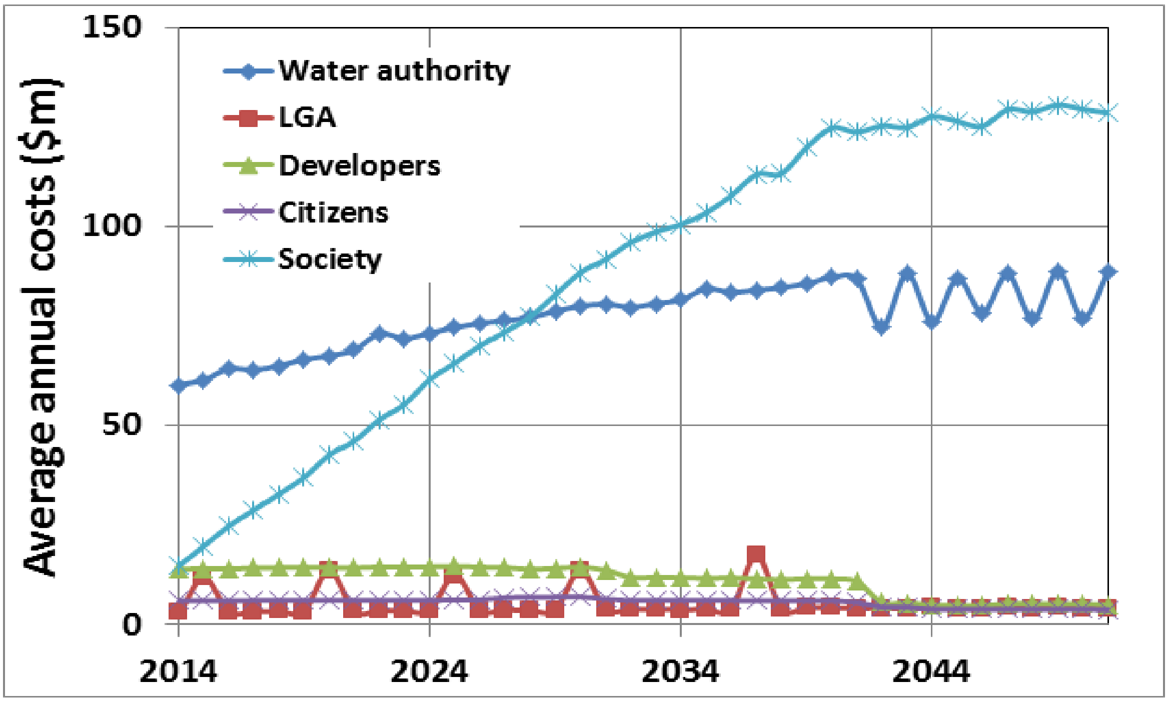

Figure 3.62: Average annual costs versus jurisdiction in the IWCM Option

Figure 3.62 demonstrates that the future costs of water cycle management in the IWCM Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure.

The net present costs that accrue to each jurisdiction in the IWCM Option are presented in Table 3.62.

Table 3.62: Net present costs that accrue to each jurisdiction in the IWCM Option

Jurisdiction	**NPC ($m)**	**Change from BAU (%)**
Water authority	1,244	-9.5
Local Government	84	5.7
Developers	201	11.2
Citizens	96	89.1
Society	968	-60
Total	2,593	-36.9

Table 3.62 reveals that the IWCM Option generates a 36.9% reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. This represents a net present value of $1,515 m. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

3.11 Stormwater Harvesting

The Stormwater Harvesting (SWH) Option includes stormwater harvested from all impervious surfaces that is collected in regional stormwater management storages in new urban areas and treated to potable standards for injection into water distribution infrastructure. The Option includes the highest available level of water efficient appliances and gardens. This Option is expected to generate a Net Present Value of $870 m for the Ballarat water district that results in decreased costs that accrue to most jurisdictions with increased costs to citizens. The timelines of costs for the SWH Option are presented in Figure 3.63.

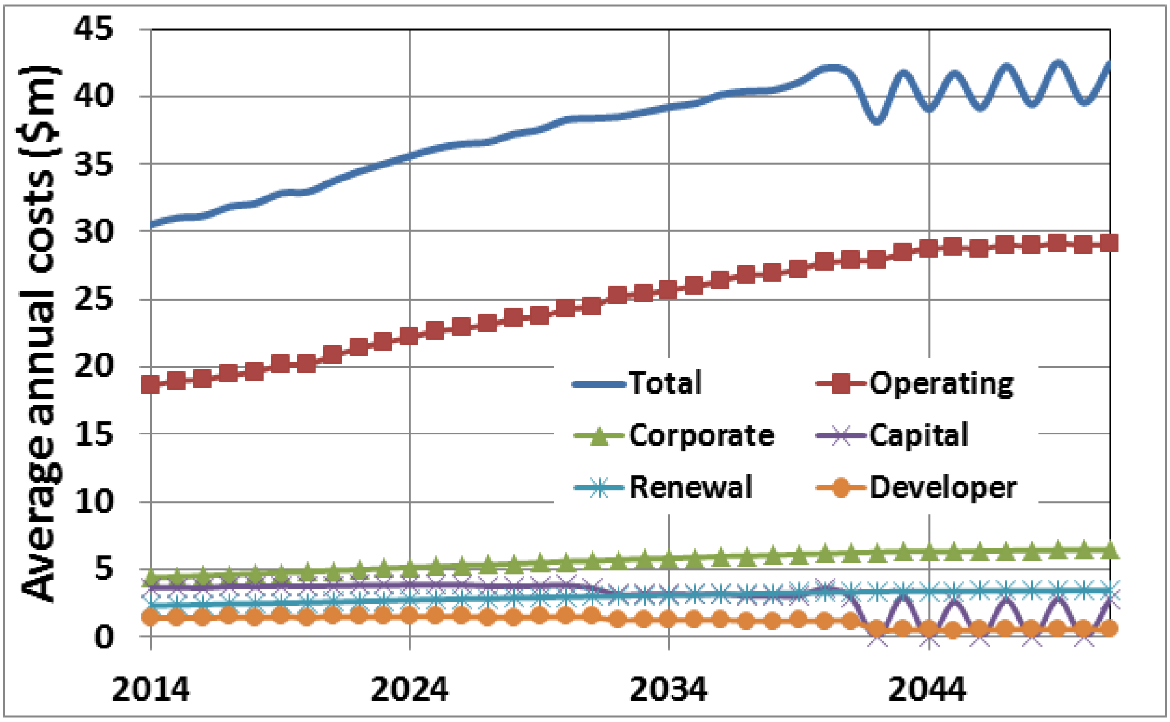

Figure 3.63: Average annual water costs in the SWH Option

Figure 3.63 highlights that the SWH Option generates decreased capital and operating expenses, and the frequency of capital expenditure for trunk or regional infrastructure has diminished. The net present costs to 2051 for provision of water services in the SWH Option are provided in Table 3.63.

Table 3.63: Net present costs to 2051 for water supply in the SWH Option

Criteria	NPC ($m)	Change from BAU (%)
Total	580	-20.9
Operating	364	-23.1
Corporate	90	-17.6
Capital	54	-15.3
Renewal	48	-18.1
Developer	25	-15.4

Table 3.63 shows that the diminished water demands in the SWH Option reduces requirement for infrastructure and operating costs in comparison to the BAU Option. The timelines of costs for wastewater management for the SWH Option are presented in Figure 3.64.

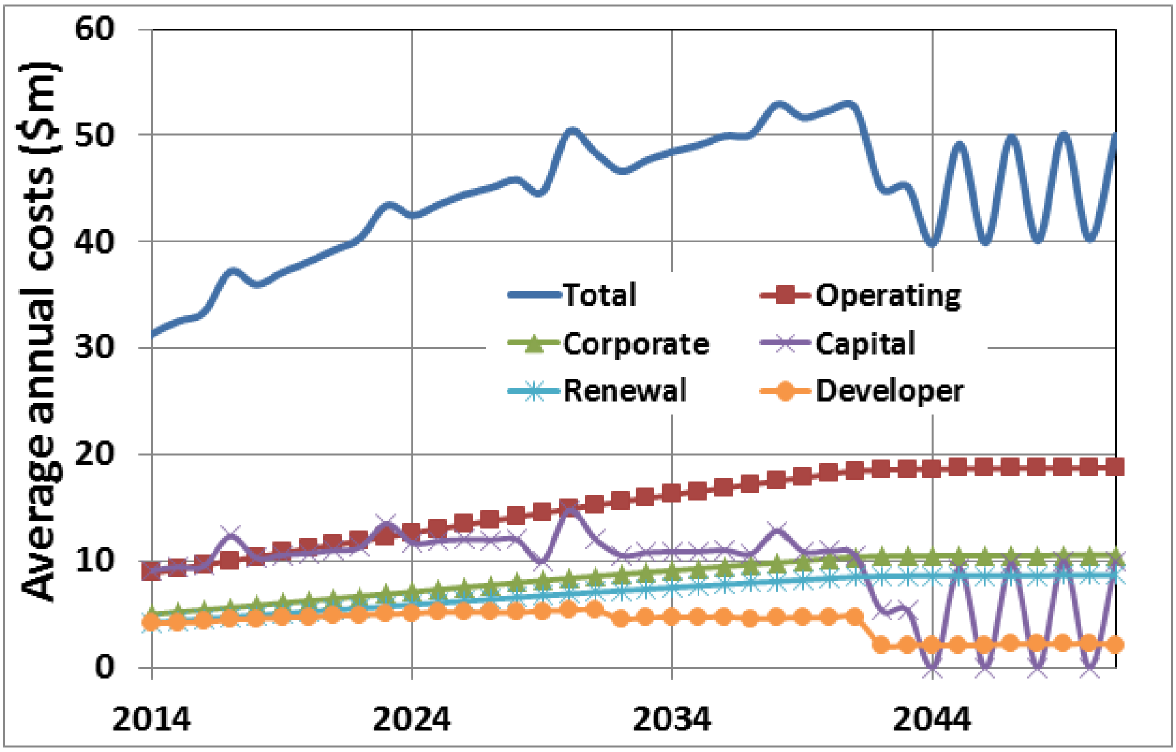

Figure 3.64: Average annual wastewater costs in the SWH Option

Figure 3.64 shows that the majority of costs for provision of wastewater services in the SWH Option accrue to the Water Authority and costs increase with population growth. The costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the IWCM Option are provided in Table 3.64.

Table 3.64: Net present costs of wastewater management in the SWH Option

Criteria	NPC ($m)	Change from BAU (%)
Total	676	-4.6
Operating	215	-5.5
Corporate	121	-5.5
Developer	80	5.5
Capital	159	-6
Renewal	101	-5.7

Table 3.64 shows that the SWH Option generates reduced requirement for infrastructure and diminished wastewater discharges that decrease the costs of wastewater management in comparison to the BAU Option. The physical drivers of these reduced costs are decreased water demands created by water efficiency and reduced infiltration of stormwater into wastewater

networks. The timelines of costs for stormwater management and flood risks for the SWH Option are presented in Figure 3.65.

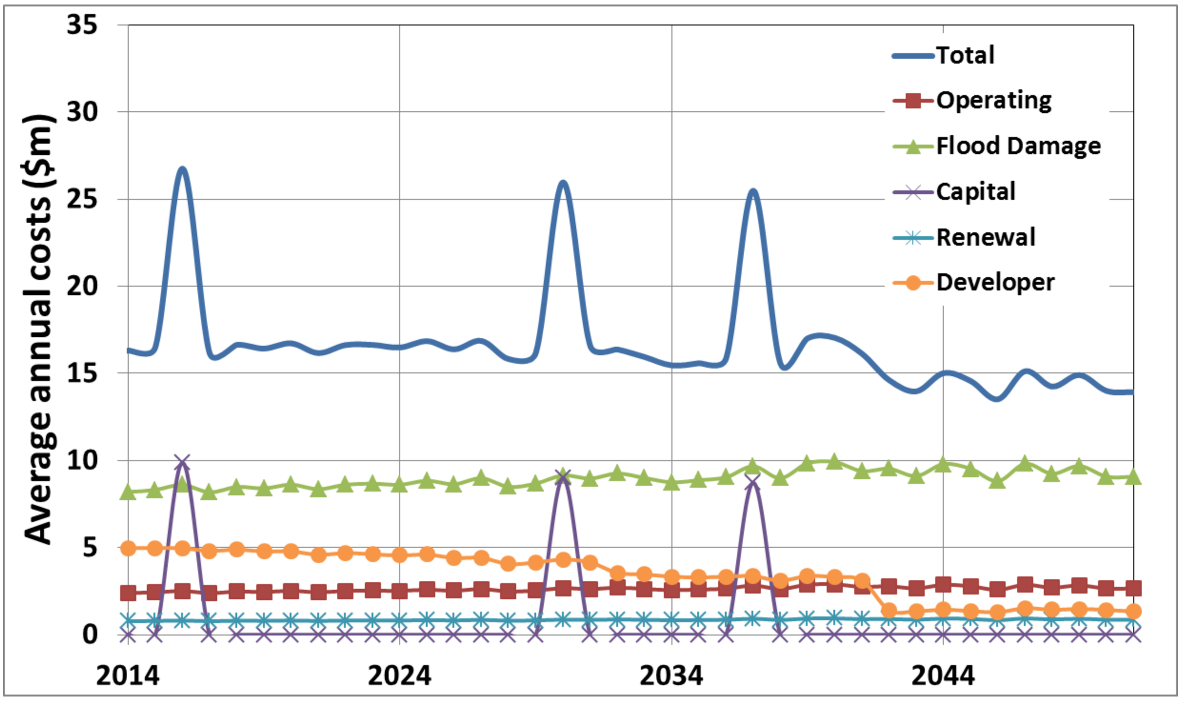

Figure 3.65: Average annual stormwater costs in the SWH Option

Figure 3.65 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the SWH Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the IWCM Option are provided in Table 3.65.

Table 3.65: Net Present Costs of stormwater management and flooding in the SWH Option

Criteria	NPC ($m)	Change from BAU (%)
Total	315	0
Operating	44	0
Developer	75	0
Capital	21	0
Renewal	15	0
Flooding	160	0

Table 3.65 reveals that the SWH Option has not decreased costs of providing stormwater infrastructure and services. The timelines for annual costs of the total pollutant loads in the SWH Option are provided in Figure 3.66.

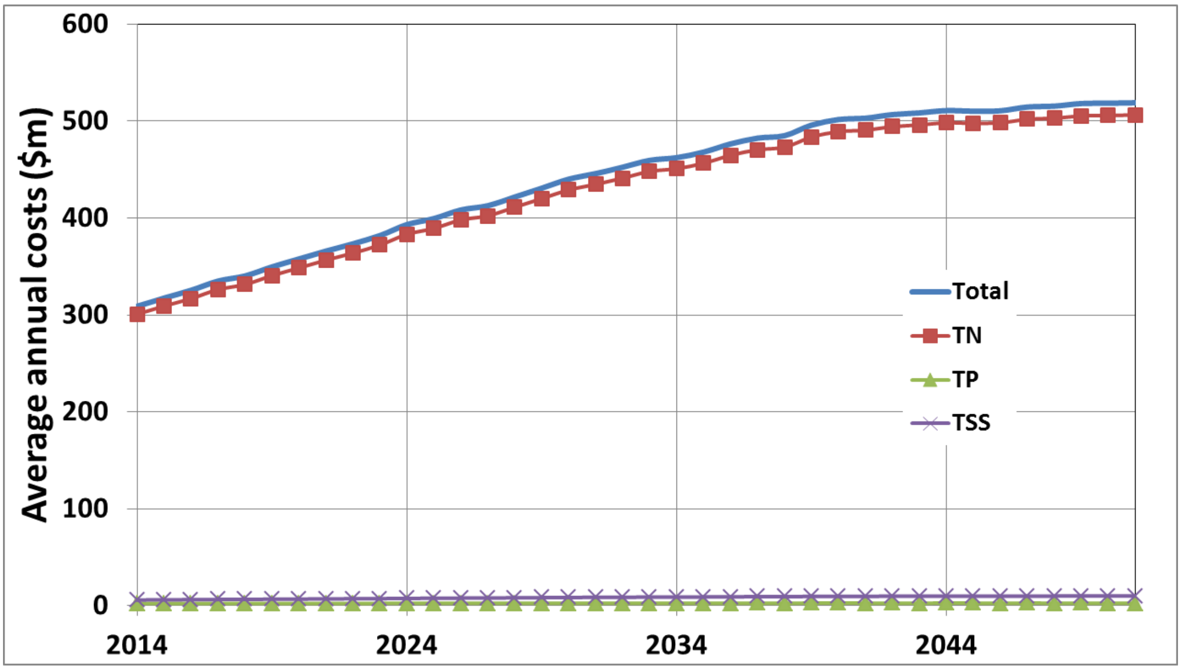

Figure 3.66: Costs of total pollutant loads in the SWH Option

Figure 3.66 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the SWH Option. The net present costs to 2051 of the total pollutant loads in the SWH Option are provided in Table 3.66.

Table 3.66: Net present costs of pollutant loads in the SWH Option

Criteria	NPC ($m)	Change from BAU (%)
Total	6,635	-11.5
Total nitrogen	6,488	-9.1
Total phosphorus	18	-7.7
Total suspended solids	328	-2.6

Table 3.66 reveals that the costs of pollutant loads in the SWH Option are decreased in comparison to the BAU Option due to reduced stormwater runoff to waterways. The timeline of future costs of water efficiency and alternative water sources in the SWH Option are presented in Figure 3.67.

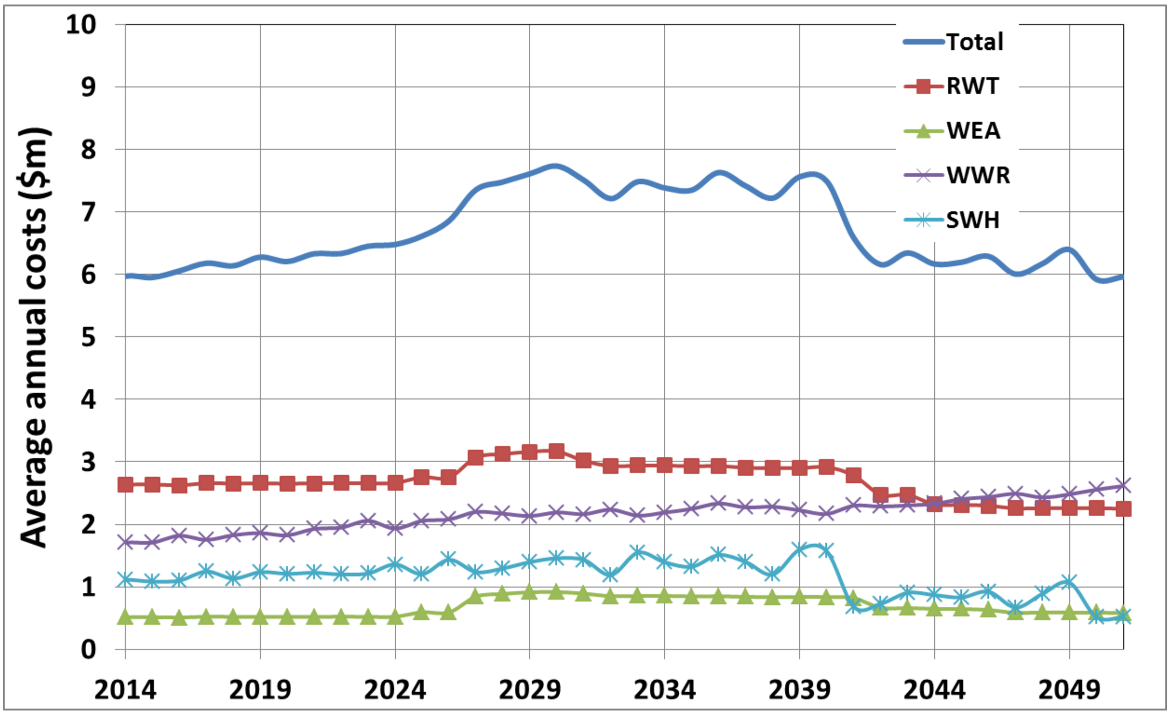

Figure 3.67: Average annual costs of rainwater harvesting, water efficient appliances, wastewater reuse and stormwater harvesting in the SWH Option

Figure 3.67 reveals that the ongoing costs of rainwater harvesting and wastewater reuse from the existing facilities are most significant costs of alternative water supplies in the SWH Option. The annual costs of water efficiency, rainwater harvesting and stormwater harvesting are driven by population growth and accumulation of properties with water efficiency and rainwater harvesting over time. The net present costs of the water savings measures are presented in Table 3.67.

Table 3.67: Net present costs of water saving measures in the SWH Option

Criteria	NPC ($m)	Change from BAU (%)
Total	106	+ 18.5
Rainwater harvesting	43	0
Water efficient appliances	10	+ 20.4
Wastewater reuse	34	-11.4
Stormwater harvesting	19	-

Table 3.67 shows that the greater adoption of stormwater harvesting in the SWH Option produces higher total costs than the BAU Option. Note that increasing water efficiency in public open spaces balances the demand for wastewater reuse. The timeline of future costs to 2051 of water cycle management by jurisdiction for the SWH Option are presented in Figure 3.68. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

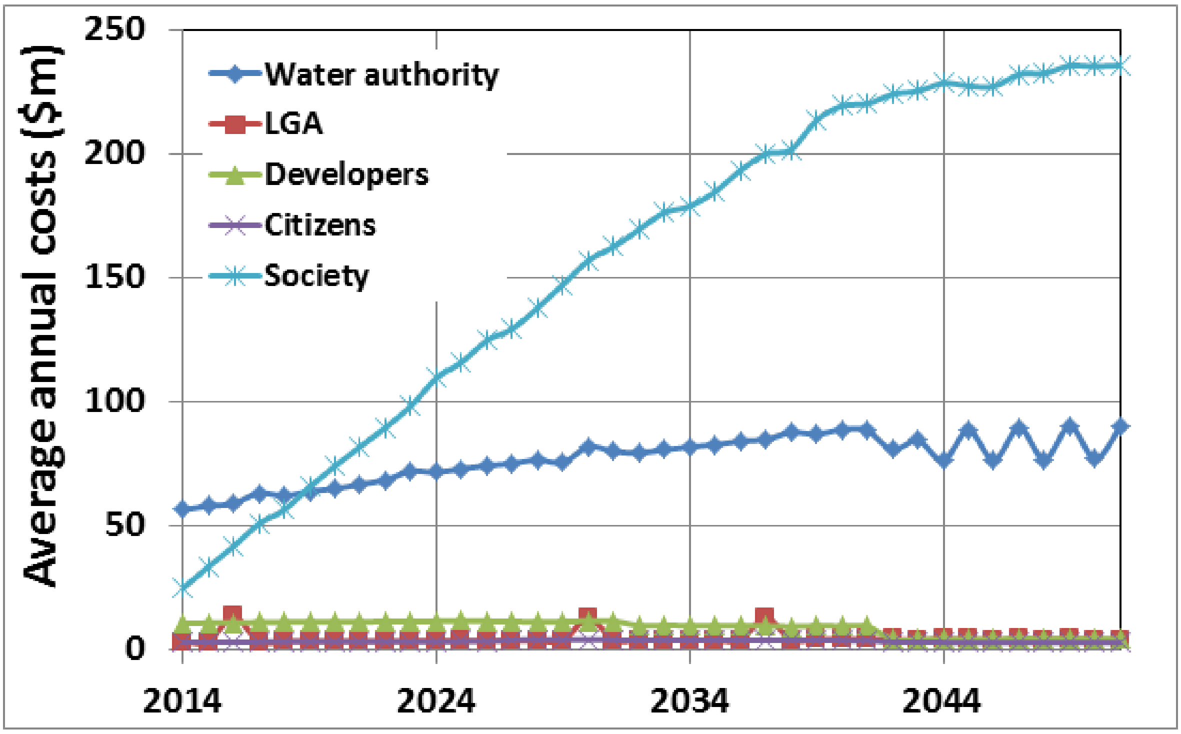

Figure 3.68: Average annual costs versus jurisdiction in the SWH Option

Figure 3.68 demonstrates that the future costs of water cycle management in the SWH Option are dominated Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure.

The net present costs that accrue to each jurisdiction in the SWH Option are presented in Table 3.68.

Table 3.68: Net present costs that accrue to each jurisdiction

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,204	-12.4
Local Government	80	0
Developers	181	0
Citizens	51	0
Society	1,722	-28.9
Total	3,238	-21.2

Table 3.68 reveals that the SWH Option generates a 21.2% reduction in costs that accrue to local government, the water authority, developers and society. The Water Authority and society are proportionally higher beneficiaries and citizens experience slightly higher costs to create these benefits. This represents a net present value of $870 m. These decreases in costs are driven by a reduced requirement for water resources sourced from rivers and associated infrastructure, and reduced impacts on waterways.

3.12 Wastewater Reuse

The Wastewater Reuse (WWR) Option includes treatment and reuse of wastewater using existing or modular treatment plants and distribution via a third pipe network for toilet, outdoor and open space uses at all new buildings. The Option includes the highest available level of water efficient appliances and gardens. This Option is expected to generate a Net Present Value of $701 m for the Ballarat water district that results in decreased costs that accrue to most jurisdictions with increased costs to citizens. The timelines of costs for the WWR Option are presented in Figure 3.69.

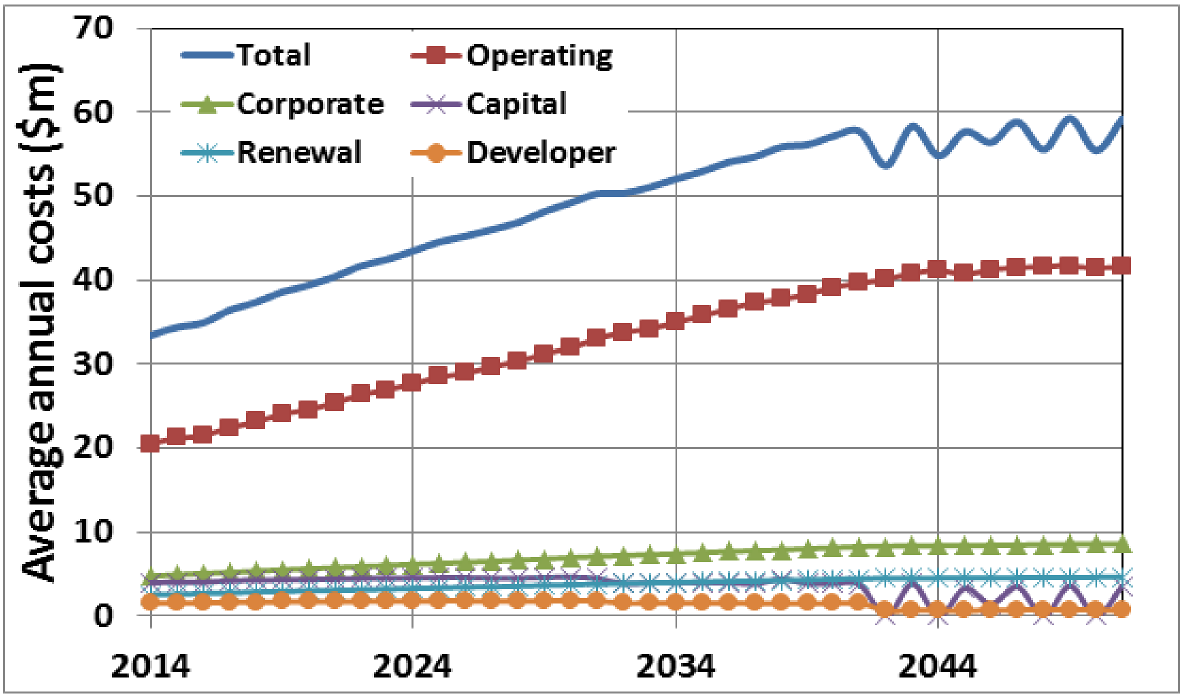

Figure 3.69: Average annual water costs for the Ballarat water district in the WWR Option

Figure 3.69 highlights that the WWR Option generates decreased capital and operating expenses, and the frequency of capital expenditure for trunk or regional infrastructure has diminished. The net present costs to 2051 for provision of water services in the WWR Option are provided in Table 3.69.

Table 3.69: Net present costs to 2051 for water supply in the WWR Option

Criteria	NPC ($m)	Change from BAU (%)
Total	712	-3
Operating	457	-3.4
Corporate	106	-2.4
Capital	63	-1.4
Renewal	57	-2.4
Developer	29	-2.8

Table 3.69 shows that the diminished water demands in the WWR Option reduces requirement for water infrastructure and operating costs in comparison to the BAU Option. The timelines of costs for wastewater management for the WWR Option are presented in Figure 3.70.

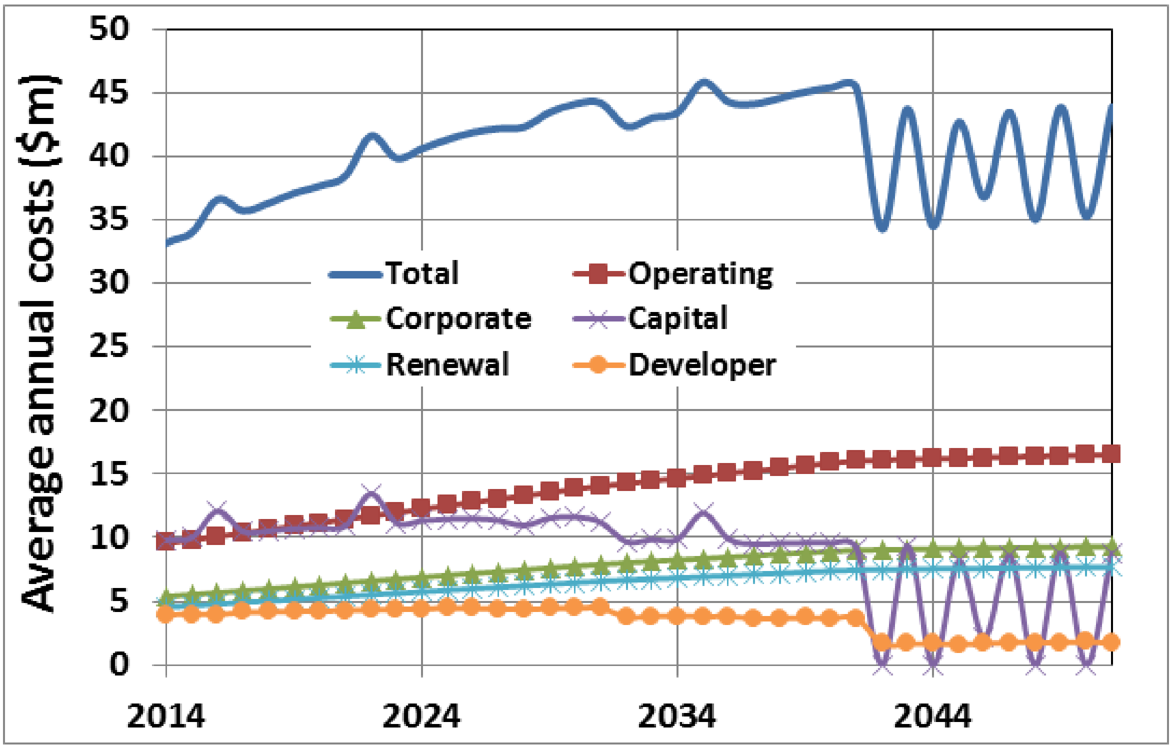

Figure 3.70: Average annual wastewater costs in the WWR Option

Figure 3.70 shows that the majority of costs for provision of wastewater services in the WWR Option accrue to the Water Authority and costs increase with population growth. The costs of operating the wastewater network are seen to accumulate in response to increasing population and water demands. The costs of trunk infrastructure (including new treatment capacity) and developer's costs for local infrastructure are driven by new development. The net present costs to 2051 for provision of wastewater services in the WWR Option are provided in Table 3.70.

Table 3.70: Net present costs of wastewater management in the WWR Option

Criteria	NPC ($m)	Change from BAU (%)
Total	651	-8
Operating	208	-8.3
Corporate	117	-8.3
Developer	70	-7.9
Capital	157	-7.4
Renewal	98	-8

Table 3.70 shows that the decreased water demands created by water efficiency in the WWR Option generates reduced requirement for infrastructure and diminished wastewater discharges that decrease the costs of wastewater management in comparison to the BAU Option. The timelines of costs for stormwater management and flood risks for the WWR Option are presented in Figure 3.71.

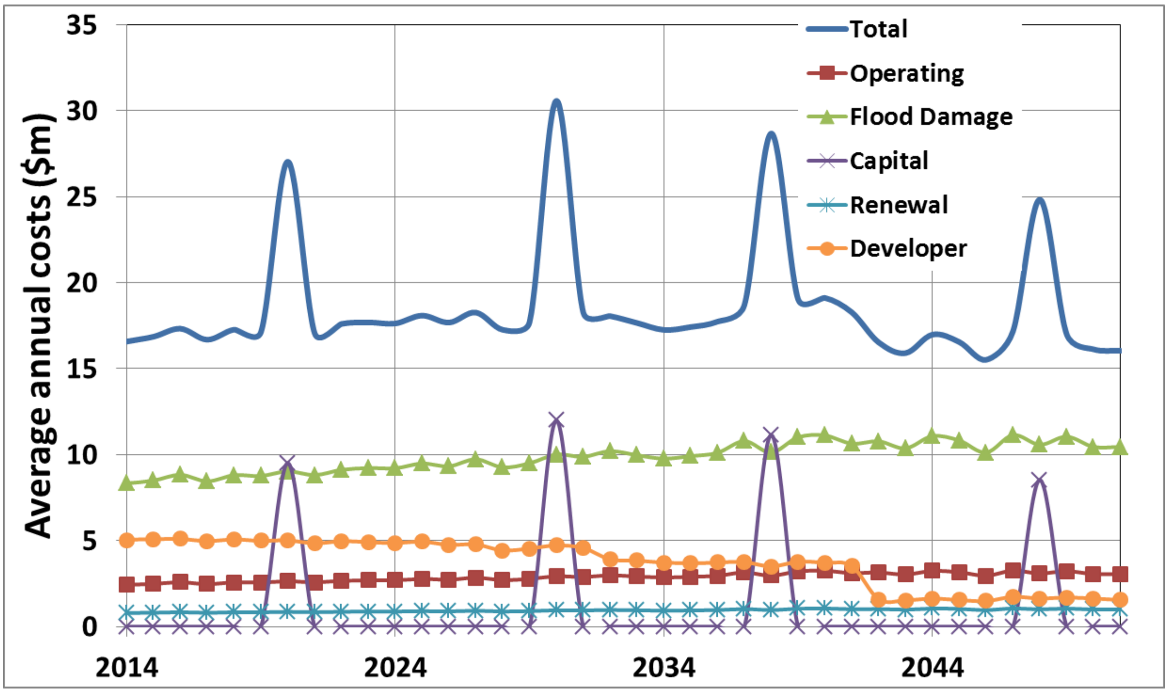

Figure 3.71: Average annual stormwater costs in the WWR Option

Figure 3.71 shows that flood risks, local infrastructure provided by developers and the periodic costs of providing trunk infrastructure are a substantial proportion of the economic costs of stormwater management in the WWR Option. The costs of flood risks are seen to increase over time in response to cumulative increases in urban stormwater runoff and the annual costs of providing local infrastructure by developers decrease over time in response to declining population growth rates. In addition, the requirement for regional or trunk stormwater management is driven by the higher rates of population growth in the first 30 years of the planning horizon. The net present costs to 2051 for stormwater management and flooding in the WWR Option are provided in Table 3.71.

Table 3.71: Net Present Costs of stormwater management and flooding in the WWR Option

Criteria	NPC ($m)	Change from BAU (%)
Total	315	0
Operating	44	0
Developer	75	0
Capital	21	0
Renewal	15	0
Flooding	160	0

Table 3.71 reveals that the reduced stormwater runoff in the WWR Option produced similar costs to the BAU Option. The timelines for annual costs of the total pollutant loads in the WWR Option are provided in Figure 3.72.

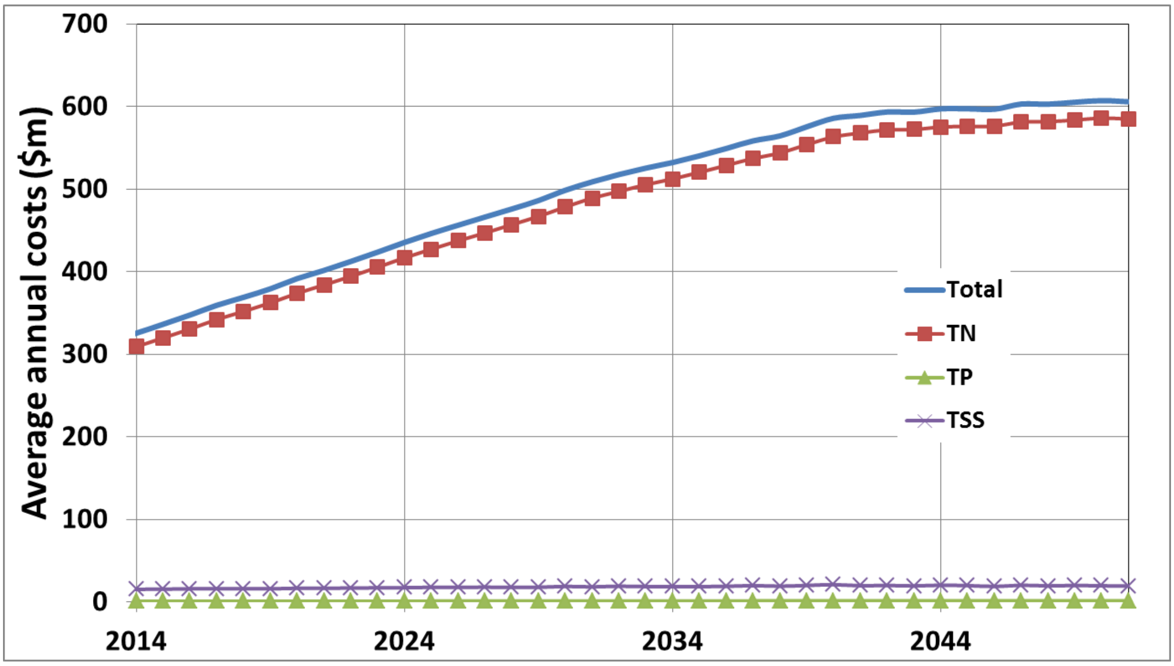

Figure 3.72: Costs of total pollutant loads in the WWR Option

Figure 3.72 shows the costs of the total pollutant loads within waterways in the City of Ballarat jurisdiction that includes runoff from rural, urban and natural catchments for the WWR Option. The net present costs to 2051 of the total pollutant loads in the WWR Option are provided in Table 3.72.

Table 3.72: Net present costs of pollutant loads in the WWR Option

Criteria	NPC ($m)	Change from BAU (%)
Total	7,046	-6
Total nitrogen	6,761	-5.3
Total phosphorus	18	-7.7
Total suspended solids	267	-20.6

Table 3.72 reveals that the costs of pollutant loads in the WWR Option are decreased in comparison to the BAU Option due to reductions in discharges of wastewater effluent to waterways. The timeline of future costs of water efficiency and alternative water sources in the WWR Option are presented in Figure 3.73.

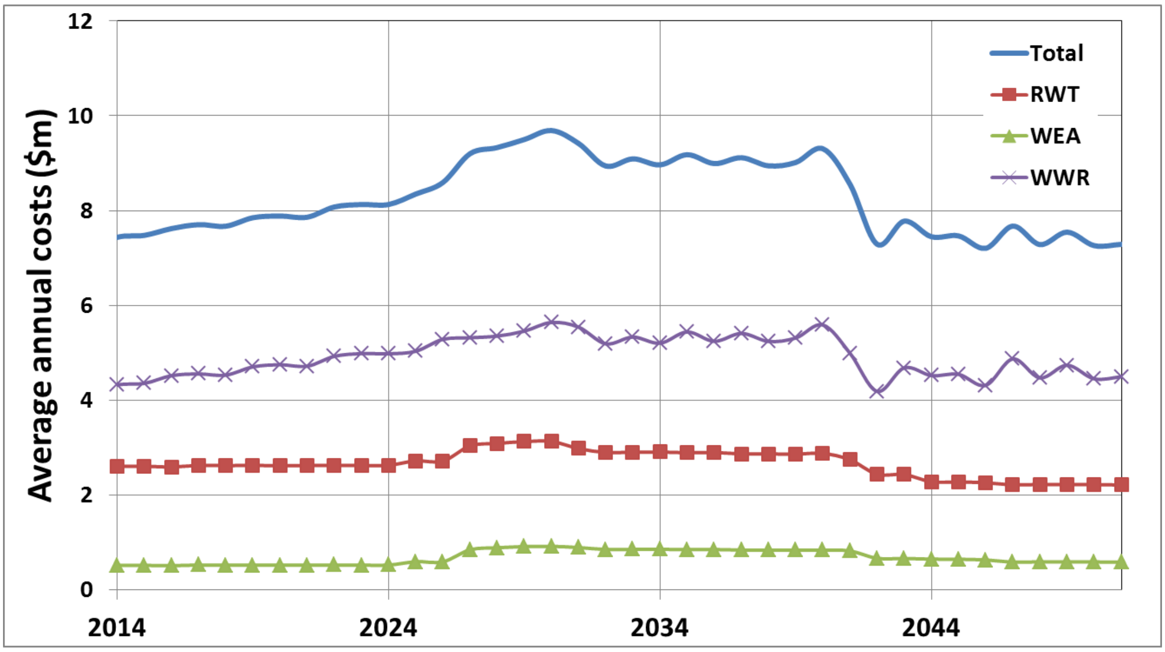

Figure 3.73: Average annual costs of rainwater harvesting, water efficient appliances and wastewater reuse in the WWR Option

Figure 3.73 reveals that the ongoing costs of rainwater harvesting and wastewater reuse from the existing and new facilities are most significant costs of alternative water supplies in the WWR Option. The annual costs of water efficiency, rainwater harvesting and wastewater reuse are driven by population growth and accumulation of properties with water efficiency, rainwater harvesting and wastewater reuse over time. The net present costs of the water savings measures are presented in Table 3.73.

Table 3.73: Net present costs of water saving measures in WWR Option

Criteria	**NPC ($m)**	**Change from BAU (%)**
Total	137	53
Rainwater harvesting	42	0
Water efficient appliances	10	20.4
Wastewater reuse	84	118.7

Table 3.73 shows that the greater adoption of wastewater reuse and water efficiency in the WWR Option produces higher total costs than the BAU Option. The timeline of future costs to 2051 of water cycle management by jurisdiction for the WWR Option are presented in Figure 3.74. Note that the society costs represent flood risks and increases in pollutant costs since 2010.

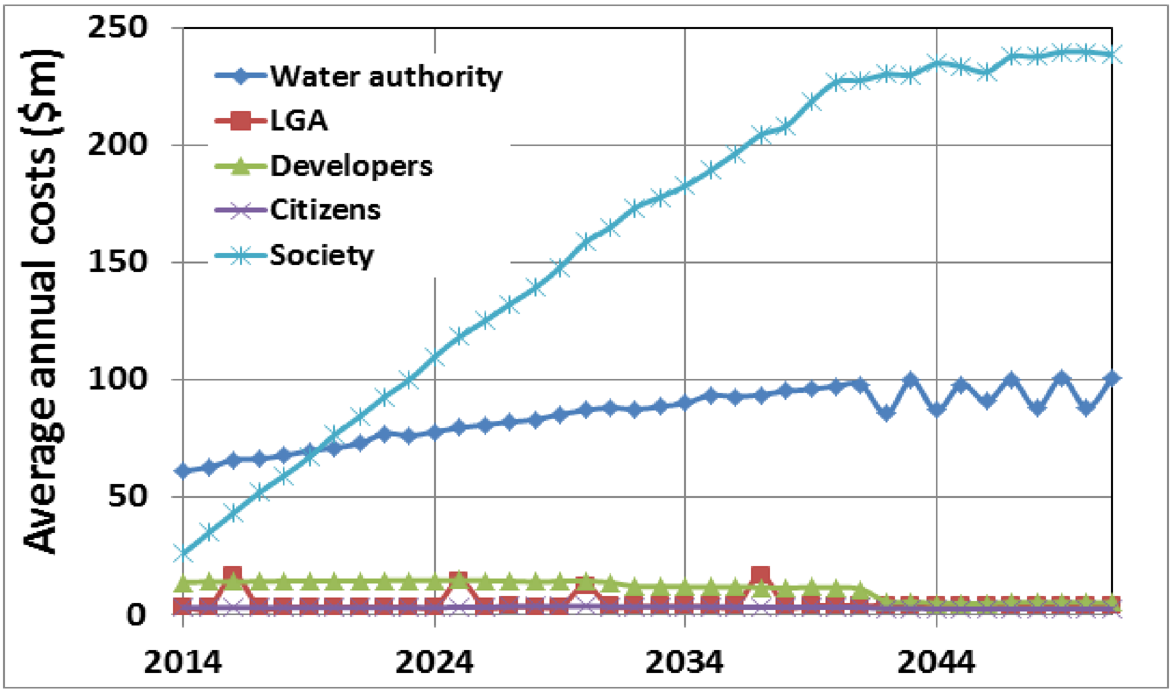

Figure 3.74: Average annual costs versus jurisdiction in the WWR Option

Figure 3.74 demonstrates that the future costs of water cycle management in the WWR Option are dominated by Water Authority and Society costs that are subject to substantial increases in response to population growth. The costs that accrue to the Water Authority display substantial periodic variation or "lumpy investment" cycles that are driven by a requirement for trunk or regional infrastructure.

The net present costs that accrue to each jurisdiction in the WWR Option are presented in Table 3.74.

Table 3.74: Net present costs that accrue to each jurisdiction in the WWR Option

Jurisdiction	NPC ($m)	Change from BAU (%)
Water authority	1,319	-4
Local Government	80	0
Developers	202	12.1
Citizens	53	3.3
Society	1,753	-27.6
Total	3,407	-17.1

Table 3.68 reveals that the WWR Option generates a 17.1% reduction in costs that accrue to local government, the water authority and society. Citizens and developers experience higher costs to create these benefits. This represents a net present value of $701 m. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

4 Sensitivity Testing of Selected Inputs

The economic framework within the Systems Framework was designed to allow the analysis of a wide range of alternative inputs and assumptions – this process is known as sensitivity testing. This process acknowledges that a substantial proportion of disagreement about opportunities is associated with different opinions about costs of the elements of any strategy or different views about including all costs and benefits of all options.

This investigation has endeavoured to include all available costs and benefits in a unique linked systems analysis which provides unprecedented ability to explored the trade-offs between elements of the Options and Scenarios. Whilst this report has compiled multiple layers of data and information, and incorporated a hind casting process to derive the most likely costs of the key processes in the systems analysis, there are opportunities to test different assumptions about key inputs. A selection of sensitivity tests were undertaken and are presented below.

4.1 Rainwater harvesting and water efficient appliances

The inputs to the economic framework were altered to analyse the impacts of a 100% increase in all costs associated with rainwater harvesting and water efficient appliances. These increased costs included installation, operating and replacement costs. It is noteworthy that all Options and Scenarios include rainwater harvesting and water efficient appliances, and the real differences between the Options is the rate of installation of these measures. The impact of the increased costs of rainwater harvesting and water efficient appliances on the performance of the scenarios is provided in Table 4.1.

Table 4.1: Impact of increased costs of rainwater harvesting and water efficient appliances on the Scenarios

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)						
	BAU	**NoGW**	**Bulk**	**Bulk2Irr**	**CC**	**HG**	**HGCC**
WA	1,374	1,519	1,527	1,527	1,451	1,541	1,567
LGA	80	80	80	80	68	90	79
Developers	181	181	181	181	180	227	220
Citizens	102 (+100)	102 (+99)	102 (+99)	102 (+99)	102 (+91)	115 (+100)	115 (+100)
Society	2,423	2,423	2,423	2,423	2,708	2,983	2,987
Total	**4,159 (+1.2)**	**4,305 (+1.2)**	**4,312 (+1.2)**	**4,312 (+1.2)**	**4,508 (+1.1)**	**4,956 (+1.2)**	**4,968 (+1.2)**

Table 4.1 reveals that an increase in the costs of rainwater harvesting and water efficient appliances by 100% results in additional net present costs that range from $53 m for BAU to $55 m of the high growth scenario (HG). The overall net present costs to citizens increased from 91% to 100% and the total net present values are increased by about 1% for all scenarios.

The impact of the increased costs of rainwater harvesting and water efficient appliances on the performance of the Options is provided in Table 4.2.

Table 4.2: Impact of increased costs of rainwater harvesting and water efficient appliances on the Options

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
Water authority	1,374	1,301	1,180	1,244	1,204	1,319
Local Government	80	75	86	84	80	80
Developers	181	116	207	201	181	202
Citizens	102 (+100)	192 (+100)	192 (+100)	192 (+100)	106 (+100)	105 (+100)
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**4,159 (+1.2)**	**3,746 (+2.6)**	**3,543 (+2.8)**	**2,689 (+3.7)**	**3,294 (+1.7)**	**3,459 (+1.5)**

Table 4.2 shows that an increase in the costs of rainwater harvesting and water efficient appliances by 100% results in additional net present costs that range from $53 m for WWR to $96 m of building control Option (BC1). All total net present values are increased by 1.2% (BAU) to 3.7% (IWCM). The increased costs of rainwater harvesting and water efficient appliances do not substantially decrease the viability of the building scale (BC1 and BC2) and IWCM Options.

4.2 Streetscape Options

The economic analysis also includes additional stormwater management on properties, within street scapes and in parks (Option BC2). These additional measures include strategic landscaping (designed to retain and filter stormwater runoff), bio-retention facilities and a range of vegetated measures that disconnect impervious (hard) surfaces from direct connection to drainage infrastructure. The inputs to the economic analysis were altered to test the impact of a 100% increase in the costs for installation, maintenance and replacement costs of street scape measures.

The relative impact of the increased costs of street scape stormwater management measures on the performance of the Options is provided in Table 4.3.

Table 4.3: Impact of increased costs of rainwater harvesting and water efficient appliances on the Options

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
Water authority	1,374	1,301	1180	1,244	1,204	1,319
Local Government	80	75	93 (+8.2)	84	80	80
Developers	181	182	236 (+13.7)	201	181	202
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1877	968	1,722	1,753
Total	**4,108**	**3,716**	**3483 (+1)**	**2,593**	**3,238**	**3,407**

Table 4.3 demonstrates that a 100% increase in the costs of streetscape stormwater management measures generates an increase in net present costs to developers of $29 m (13.7%), Local government of $8 m (8.2%) and an overall increase in total net present costs of 1%. The

increased costs of streetscape measures impacts on development costs of urban development. However, there are insignificant impacts on the overall benefits of the strategy which are driven by reduced impacts of nutrients in waterways.

4.3 Stormwater Harvesting Options

The economic analysis also includes stormwater harvesting with treatment to drinking water standards and injection of treated stormwater into existing water distribution systems (Option SWH). The inputs to the economic analysis were altered to test the impact of a 100% increase in the costs for installation, maintenance and replacement costs of stormwater harvesting facilities. The relative impact of increased costs of stormwater harvesting facilities on the performance of the Options is provided in Table 4.4.

Table 4.4: Impact of increased costs of stormwater harvesting on the Options

Jurisdiction	**Net Present Cost ($m) versus reduction in costs (%)**					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
Water authority	1,374	1,301	1,301	1,244	1,222 (+1.6)	1,319
Local Government	80	75	86	84	80	80
Developers	181	182	207	201	181	202
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**4,108**	**3,716**	**3,568**	**2,593**	**3,257 (+0.6)**	**3,407**

Table 4.4 demonstrates that a 100% increase in the costs of stormwater harvesting generates an increase in net present costs to the water authority of $19 m (1.6%) and an overall increase in total net present costs of 0.6%. The increased costs of stormwater harvesting generate small increases in the net present costs experienced by the water authority. Nevertheless, there are insignificant impacts on the overall benefits of the strategy which are driven by reduced stormwater and water supply impacts.

4.4 Wastewater Reuse Options

The economic analysis also includes reuse of treated wastewater for toilet and outdoor uses (Option WWR). The inputs to the economic analysis were altered to test the impact of a 100% increase in the costs for installation, maintenance and replacement costs of wastewater reuse facilities. The relative impact of increased costs of wastewater reuse facilities on the performance of the Options is provided in Table 4.5.

Table 4.5: Impact of increased costs of wastewater reuse on the Options

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
Water authority	1,374	1,301	1,301	1,244	1,204	1,375 (+4.2)
Local Government	80	75	86	84	80	80
Developers	181	182	207	201	181	231 (+14.1)
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**4,108**	**3,716**	**3,568**	**2,593**	**3,238**	**3,491 (+2.5)**

Table 4.5 reveals that a 100% increase in the costs of wastewater reuse generates an increase in net present costs to the water authority of $56 m (4.2%), to the developer of $29 m (14.1%) and an overall increase in total net present costs of 2.5%. The increased costs of wastewater reuse generate increases in the net present costs experienced by the water authority and the development industry. However, there are insignificant impacts on the overall benefits of the strategy which are driven by reduced wastewater, stormwater and water supply impacts.

4.5 Operating Costs for Water and Wastewater Services

The operating costs of providing future water and wastewater services are significant as represented by the net present costs of water and wastewater operations of $188 m and $226 m respectively. Inputs to the economic framework were altered to analyse the impacts of a 100% increase in all operating costs associated with providing water and wastewater services. These increased costs included bulk water supply, operating and replacement costs but do not include the capital costs of new infrastructure. The impact of the increased costs of operating water and wastewater services on the performance of the scenarios is provided in Table 4.6.

Table 4.6: Impact of increased costs of operating water and wastewater services on the Scenarios

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)						
	BAU	**NoGW**	**Bulk**	**Bulk2Irr**	**CC**	**HG**	**HGCC**
WA	2,474 (+80)	2,716 (+78.8)	2,762 (+80.9)	2,715 (+77.8)	2,614 (+79.8)	2,744 (+78)	2,797 (+78.5)
LGA	80	80	80	80	68	90	79
Developers	181	181	181	181	180	227	220
Citizens	51	51	51	51	53	58	115
Society	2,423	2,423	2,423	2,423	2,708	2,983	2,987
Total	**5,208 (+26.8)**	**5,451 (+28.1)**	**5,496 (+29)**	**5,450 (+27.9)**	**5,623 (+26.1)**	**6,101 (+24.6)**	**6,198 (+26.2)**

Table 4.6 reveals that an increase in the costs of operating water and wastewater services by 100% results in additional net present costs that range from $53 m for BAU to $55 m of the high

growth scenario (HG). The overall net present costs to citizens increased from 91% to 100% and the total net present values are increased by about 1% for all scenarios.

The impact of the increased costs of operating water and wastewater services on the performance of the Options is provided in Table 4.7.

Table 4.7: Impact of increased costs of operating water and wastewater services on the Options

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	**BC1**	**BC2**	**IWCM**	**SWH**	**WWR**
WA	2,474 (+80)	2,339 (+79.8)	2,339 (+79.8)	2,210 (+77.7)	2,139 (+77.7)	2,361 (+78.9)
LGA	80	75	86	84	80	80
Developers	181	182	207	201	181	202
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**5,208 (+26.8)**	**4,754 (+27.9)**	**4,606 (29.1)**	**3,559 (+37.3)**	**4,174 (+28.9)**	**4,448 (+30.6)**

Table 4.7 shows that an increase in the operating costs of providing water and wastewater services by 100% results in additional net present costs that range from $935 m (28.9%) for SWH Option to $1038 m (27.9%) for the BC1 Option. All total net present values are increased by 26.8% (BAU) to 37.3% (IWCM). The increased costs do not substantially decrease the viability of the alternative Options.

4.6 Waterway Pollutant Costs

The cost of discharging nitrogen to waterways of $2,225/kg that was sourced from Melbourne Water Corporation dominates the net present costs to society in the economic analysis. Inputs to the economic framework were altered to include the highly conservative willingness to pay results for Total Nitrogen ($6.45/kg), Total Phosphorus ($43.42/kg) and Total Suspended Solids ($0.84/kg) derived from wastewater treatment plant costs for the recent successful ACT government business case.[10] The impact of these substantially decreased costs of waterway pollutants on the performance of the scenarios is provided in Table 4.8.

[10] AECOM, Urban Water Cycle Solutions and BMT WBM (2013). A Long Term Plan to Improve Water Quality in the ACT and Murrumbidgee River System. Reports submitted to the ACT Environment Directorate.

Table 4.8: Impact of substantially decreased costs of waterway pollutants on the Scenarios

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)						
	BAU	NoGW	Bulk	Bulk2Irr	CC	HG	HGCC
WA	1,374	1,519	1,527	1,527	2,614	1,541	1,567
LGA	80	80	80	80	68	90	79
Developers	181	181	181	181	180	227	220
Citizens	51	51	51	51	53	58	115
Society	30 (-98.7)	30 (-98.8)	30 (-98.8)	30 (-98.8)	22 (-99.2)	42 (-98.6)	31 (-98)
Total	**1,715 (-28.2)**	**1,861 (-56.2)**	**1,868 (-56.2)**	**1,868 (-56.1)**	**2,937 (-47.8)**	**1,958 (-60)**	**2,012 (-59.5)**

Table 4.8 reveals that a substantial decrease in waterway pollutant costs by 100% results in additional net present costs that range from $2,393 m (28.2%) for BAU to $2,956 m (98.6%) of the high growth scenario (HG). The overall net present costs to society decreased from 28.2% to 60% and the total net present values are increased by about 1% for all scenarios.

The impact of the decreased costs of waterway pollutants on the performance of the Options is provided in Table 4.9.

Table 4.9: Impact of increased costs of operating water and wastewater services on the Options

Jurisdicti on	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	BC1	BC2	IWCM	SWH	WWR
WA	1,374	1,301	1,301	1,244	1,204	1,319
LGA	80	75	86	84	80	80
Developers	181	182	207	201	181	202
Citizens	51	96	96	96	51	53
Society	30 (-98.7)	17 (-99)	20 (-98.9)	26 (-97.3)	27 (-98.4)	27 (-98.4)
Total	**1,715 (-28.2)**	**1,672 (-55)**	**1,711 (-42)**	**1,651 (-36.3)**	**1,543 (-52.4)**	**1,681 (-50.7)**

Table 4.9 shows that decrease in waterway pollutants results in reduced net present costs that range from $942 m (97.3%) for IWCM Option to $2,044 m (98.9%) for the BC2 Option. All total net present values are increased by 28.2% (BAU) to 55% (IWCM). A diminished value for reducing waterway pollution has impacted on the viability of the BC1 Option that includes streetscape stormwater management measures.

4.7 Regional Stormwater Management

The economic analysis includes the infrequent investment in regional stormwater management (usually for flood mitigation) that is dependent on multi-agency funding, provision of regional infrastructure (such as the upgrade of the Western Highway by VicRoads) or grant funding. Inputs to the economic analysis were altered to remove investment in regional stormwater infrastructure. The impact of removing investments in regional stormwater management on the performance of the scenarios is provided in Table 4.10.

Table 4.10: Impact of removing investment in regional stormwater management on the Scenarios

Jurisdiction	Net Present Cost ($m) versus reduction in costs (%)						
	BAU	NoGW	Bulk	Bulk2Irr	CC	HG	HGCC
WA	1,374	1,519	1,,527	1,527	2,614	1,541	1,567
LGA	59 (-26.4)	59 (-26.4)	59 (-26.4)	59 (-26.4)	54 (-20.3)	60 (-33.4)	58 (-26.2)
Developers	181	181	181	181	180	227	220
Citizens	51	51	51	51	53	58	115
Society	2,423	2,423	2,423	2,423	2,708	2,983	2,987
Total	**4,087 (-0.5)**	**4,233 (-0.5)**	**4,240 (-0.5)**	**4,240 (-0.5)**	**5,609 (-0.2)**	**4,868 (-0.6)**	**4,948 (-0.4)**

Table 4.10 reveals that removal of investment in regional stormwater management results in reduced net present costs that range from $14 m (20.3%) for CC to $30 m (33.4) of the high growth scenario (HG). The overall net present costs to society decreased from 0.2% to 0.5% for all scenarios.

The impact of the decreased costs of waterway pollutants on the performance of the Options is provided in Table 4.11.

Table 4.11: Impact of removing investment in regional stormwater management on the Options

Jurisdicti on	Net Present Cost ($m) versus reduction in costs (%)					
	BAU	BC1	BC2	IWCM	SWH	WWR
WA	1,374	1,301	1,301	1,244	1,204	1,319
LGA	59 (-26.4)	58 (-23.3)	66 (-23.3)	61 (-27.8)	59 (-26.4)	59 (-26.4)
Developers	181	182	207	201	181	202
Citizens	51	96	96	96	51	53
Society	2,423	2,061	1,877	968	1,722	1,753
Total	**4,087 (-0.5)**	**3,698 (-0.5)**	**3,548 (-0.6)**	**2,570 (-0.9)**	**3,217 (-0.7)**	**3,386 (-0.6)**

Table 4.11 shows that removal of investment in regional stormwater management results in reduced net present costs that range from $18 m (23.3%) for BC1 Option to $23 m (27.8%) for the IWCM Option. All total net present values are increased by 0.4% (BAU) to 0.9% (IWCM).

4.8 Summary of Sensitivity Analysis

Changes in costs of rainwater harvesting and water efficient appliances displayed an even impact on all of the Scenarios. Increases in the costs to operate water and wastewater services generated greater impacts on the Scenarios with greater dependence on bulk water sources with limited local use of groundwater resources. Reductions in the costs of pollutants discharging to waterways provided that greatest reductions in costs for the high growth Scenarios.

The results of the investigation of the sensitivity of the Options to changes in costs are summarised as impacts on the economic ranking of Options in Table 4.12.

Table 4.12: Summary of the sensitivity analysis on the ranking of Options

Sensitivity test	**Rank versus Option**					
	1	**2**	**3**	**4**	**5**	**6**
Base	IWCM	SWH	WWR	BC2	BC1	BAU
Rainwater and water efficiency	IWCM	SWH	WWR	BC2	BC1	BAU
Street scape measures	IWCM	SWH	WWR	BC2	BC1	BAU
Stormwater harvesting	IWCM	SWH	WWR	BC2	BC1	BAU
Wastewater reuse	IWCM	SWH	WWR	BC2	BC1	BAU
Operational	IWCM	SWH	WWR	BC2	BC1	BAU
Waterway pollutants	SWH	IWCM	BC1	WWR	BC2	BAU
Regional stormwater management	IWCM	SWH	WWR	BC2	BC1	BAU

Table 4.12 reveals that the ranking of Options were mostly insensitive to the selected changes in costs and the IWCM, SWH and WWR Options show consistent high value for the Ballarat region. However, a substantial reduction in the costs of pollutants discharging to waterways creates a significant change in the viability and economic ranking of the BC2, IWCM and WWR Options.

Reductions in pollutants loads discharging to waterways via stormwater runoff and wastewater discharges is a significant contributor to the value of the IWCM Option that includes wastewater reuse and rainwater harvesting, to the WWR Options that includes wastewater reuse and to the BC2 Option that includes streetscape stormwater management measures.

This investigation has completed a sensitivity analysis of the key drivers of the economic performance of the Scenarios and Options. However, many other combinations of costs and assumptions are possible. To enable the reader to further investigate the economic performance of the Scenarios and Options this report is supported by a web-based interactive analysis that can be accessed at www.systemsframework.com. User names and passwords for the web-based analysis will be assigned upon request to Urban Water Cycle Solutions at thecoombes@bigpond.com.

5 Insights

This report has focused on the economic behaviour of the Ballarat water district in the context of the performance of the entire region for Business as Usual (BAU), for Scenarios that may challenge the future performance of the System (such as Climate Change and High population Growth) and Options for future management (including building, precinct and regional scale strategies). A Systems Framework of the Ballarat region was developed as part of the Living Ballarat Project to assist in understanding the whole of water cycle challenges and opportunities across the region.

The Dynamic Economic Framework utilised in this analysis is a linked component of the Systems Framework that combines the all available costs for the whole of water cycle across the region to produce a range of economic futures. The economic analysis of the entire system (Systems Economics) utilised in this investigation is based on cash flows of costs throughout the water cycle system.

Whilst the Economic Framework allows rapid assessment of almost all inputs, this report has presented the results for the inputs provided in Section 2 using a real discount rate of 5%. The results presented in this report should be considered in conjunction with the previous reports, namely "*Systems analysis of water cycle systems – analysis of base case scenarios for the Ballarat region*" and "*Summary of the performance of options and key insights*".

The Systems Framework was built up from 25 local scale land uses within 144 State Suburbs across the region and includes whole of water cycle processes at local, suburb, town and regional scales. This structure captures timelines of spatial, temporal and behavioural variations of the water cycle across the region. The Framework for the Living Ballarat project is complete for a range of Scenarios and Options.

The framework has been developed to a state where it can be reliably and robustly applied to detailed and targeted 'what if' analyses, including assessments of future water security and economics under a range of climatic and population growth scenarios, and future alternative strategies. The spatial and temporal detail within the Systems Framework allowed understanding, reproduction and testing of the complex interactions between waterways, reservoirs, operations, water demands, water restrictions and financial impacts.

This report provides a set of detailed cash flows and net present costs (NPC) for water, wastewater and stormwater services, and for waterway pollution. These results are combined by jurisdiction into economic futures for the Water Authority, Local Government, Developer, Citizen and Society. Note that the Society jurisdiction includes changes in the costs of flood risks and waterway health since 2010.

5.1 The Scenarios

The systems analysis of the Ballarat region includes a range of scenarios that were selected to reveal the performance of water cycle systems across the region in response to uncertainty about the future. Note that a Scenario is different to the choice of an Option for future water cycle management. A majority of future costs of water cycle management accrue to the Water Authority and to Society as defined by impacts on waterways and flood risks. The costs of providing reticulated water and sewerage services, managing flood risks and impacts on waterways are the dominant economics costs for the Ballarat Water District. The total net present costs of water cycle management to 2051 for the BAU option is $4,108 m.

Only using groundwater resources for drought relief results in a requirement to augment water security infrastructure and a 3.6 % ($146 m) increase in costs that accrue to the water authority.

A greater reliance on external water supplies from the Goulburn, Campaspe and Loddon catchments by not extracting water supply to meet urban water demands from the Moorabool and Yarrowee Catchments generates an overall 3.7% ($153 m) increase in costs that accrue to the water authority.

An increase in regional irrigation demands and greater reliance on external water supplies from the Goulburn, Campaspe and Loddon catchments by not extracting water supply to meet urban water demands from the Moorabool and Yarrowee Catchments generates an overall 3.7% ($148 m) increase in costs that accrue to the water authority.

The impact of high emissions climate change generates an overall 8.6 % ($351 m) increase in costs that accrue to the water authority, developers and society. Reductions in costs to local government are generated by reduced costs for managing stormwater quality and the diminished costs to Society are created by reduced pollutant loads.

Accelerated population growth with 2051 population achieved in 2041 creates an overall 10.2% ($790 m) increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, developers and society. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, and greater impacts on waterways created by additional urban growth.

A combination of accelerated population growth and high emissions climate change generates an overall 19.5% ($803 m) increase in costs that accrue to all jurisdictions with a higher proportion of costs impacting on local government, the water authority and society. These increases in costs are driven by a requirement for additional resources and infrastructure to service a higher population, greater impacts on waterways created by additional urban growth and reduced availability of water resources.

A sensitivity analysis revealed that changes in costs of rainwater harvesting and water efficient appliances displayed a similar impact on all of the Scenarios. Increases in costs to operate water and wastewater services generated greater impacts on the Scenarios with greater dependence on bulk water sources with limited local use of groundwater resources. Reductions in the costs of pollutants discharging to waterways provided that greatest reductions in costs for the high growth Scenarios.

5.2 The Options

The analysis of the water cycle for the Ballarat region included a range of Options for future water cycle management. Inclusion of building scale strategies for water efficiency and rainwater harvesting for all new and renovated buildings provided an overall 11.1% ($458 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

Inclusion of building scale strategies for water efficiency, rainwater harvesting and street scale stormwater management for all new and renovated buildings creates a 16.1% ($661 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

An Integrated Water Cycle Management (IWCM) strategy that includes reuse of wastewater, rainwater harvesting and water efficient buildings provides an overall 36.9% ($1,515 m) reduction in costs that accrue to local government, the water authority, developers and society. Local government and society are proportionally higher beneficiaries and citizens experience higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

Stormwater harvested from precinct scale stormwater management storages in new urban areas and treated to potable standards for injection into water distribution infrastructure generates an overall 21.2% ($870 m) reduction in costs that accrue to local government, the water authority, developers and society. The Water Authority and society are proportionally higher beneficiaries and citizens experience slightly higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

Wastewater Reuse using existing or modular treatment plants and distribution via a third pipe network for toilet, outdoor and open space uses at all new buildings provided an overall 17.1% ($701 m) reduction in costs that accrue to local government, the water authority, developers and society. The Water Authority and society are proportionally higher beneficiaries and citizens experience slightly higher costs to create these benefits. These decreases in costs are driven by a reduced requirement for water resources and infrastructure, and reduced impacts on waterways.

An investigation into the sensitivity of the Options to changes in costs demonstrated that the relative value of Options were mostly insensitive to the selected changes in costs. The IWCM, SWH and WWR Options show consistent high value for the Ballarat region. However, a substantial reduction in the costs of pollutants discharging to waterways creates a significant change in the viability and economic ranking of the BC2, IWCM and WWR Options.

Reductions in pollutants loads discharging to waterways via stormwater runoff and wastewater discharges is a significant contributor to the value of the IWCM Option that includes wastewater reuse and rainwater harvesting, to the WWR Options that includes wastewater reuse and to the BC2 Option that includes streetscape stormwater management measures.

5.3 Key Insights

The systems analysis has produced a richness of results and information that are available for additional analysis. Only a fraction of the information and results are presented in this report. The analysis using the economic framework has utilised real data from Central Highlands Water, City of

Ballarat and a wide range of published reports by the National Water Commission, The Essential Services Commission and others.

The whole of System finances and economics of the Living Ballarat region are highly sensitive to variation in physical (and financial) parameters throughout the scales (temporal and spatial) within and external to the regional. Only a small proportion of regional costs are fixed or invariant from a Systems Economic perspective.

Including the entire water cycle, including linked or dependent regional systems, counting all costs and use of a planning horizon that is consist with the behaviour of infrastructure reveals the highly sensitive and variable nature of the System's economics.

There is substantial value on the table within the Living Ballarat Options that indicate that the project can provide outstanding value to the State of Victoria. However, the most significant future economic costs are to society for declining waterway values, water supply, wastewater management and flooding.

The Ballarat water district is potentially challenged by a range of Scenarios. Changes in operating rules, reliance on regional bulk water sources, increases in regional irrigation demands, climate change and high population growth has substantial economic impacts on the Ballarat water district.

A significant proportion of the economic benefits revealed from this investigation are derived by smoothing the investment cycle for regional infrastructure by use of local and precinct strategies that impact as smaller increments of costs.

Some of the economic benefits derived from the systems analysis are dependent on understanding and acceptance of the improved and synergistic performance created by various local and precinct scale strategies.

This analysis has incorporated all available financial data and economic information in a whole of systems economic framework. Certainty about the analysis can be further improved by inclusion of additional information and knowledge about inputs and processes.

The Systems Economics Frameworks utilised in this investigation are based on input output economics (cash flows), whole of system costs and whole of water cycle costs. The analysis is not based on valuations of infrastructure. This analysis is different to economic or financial analysis used to satisfy various regulatory assessments.

A fully dynamic economic model is now available for Living Ballarat that can allow gaming in seconds. This capability should allow unprecedented value for testing assumptions and a wide range of perceptions in a workshop forum.

Importantly, a Systems Economics framework has been created for Living Ballarat that allows testing of the majority of "contentious inputs" from the most objective perspective possible – this is a first for the water industry and it is recommended that OLV and the PCB utilise this powerful capability to understand the potential of the region.

Local or building scale strategies improve the overall viability of the water cycle in the region by reductions in water demands, wastewater discharges, stormwater runoff, pollutant loads to waterways and reliance on bulk water source resulting in diminished impacts on waterways. This creates reduced costs for water supply, wastewater and stormwater management with increased costs to citizens for building scale solutions.

Precinct scale strategies such as wastewater reuse and stormwater harvesting improve the overall viability of the water cycle in the region. The wastewater reuse strategy produces moderate benefits that are derived from reduced water demands and wastewater discharges with associated diminished impacts on waterways.

However, the most significant benefits are derived from the stormwater harvesting for potable use (perhaps via managed aquifer storage processes) and for the multiple scale integrated water cycle management (IWCM) strategy.

Appendix A: Summary of the performance of Options and key insights.

Key Insights

A. The magnitude of the waterway benefits from all Options is dependent on the proportions of the different land uses generating stormwater runoff to waterways and the proportion of the waterway catchments that include alternative options.

B. It is noteworthy that water efficiency and wastewater reuse in remote waterway catchments can improve waterway health in other catchments due to the configuration of reticulated wastewater networks and locations of treatment plants.

C. The security of water supplies in the Ballarat and Maryborough districts is dependent on the availability of ground water resources.

D. The water security provided by regional bulk water sources to the Ballarat water district is dependent on irrigation demands.

E. The alternative options were able to reduce streamflows in waterways impacted by increased urban stormwater runoff and increase streamflows in stressed waterways currently used for bulk water supplies.

F. Beneficial impact of Building Scale Options on waterways is driven by reduced stormwater runoff and diminished wastewater discharges created by additional water efficient appliances which reduced discharges of wastewater effluent to waterways.

G. Rainwater harvesting and bio-retention strategies (which can be rain gardens, landscaping, street trees and so on) generate direct benefits to waterways in the Building Scale Options.

H. The Building Scale options were able to reduce streamflows in waterways impacted by increased urban stormwater runoff and increase streamflows in stressed waterways currently used for bulk water supplies.

I. The beneficial impact on waterways for the precinct scale IWCM Options were driven by reduced wastewater discharges created by additional water efficient appliances and reuse of wastewater which reduces discharges of wastewater effluent to waterways.

J. Rainwater harvesting and wastewater reuse generate direct benefits to waterways in the IWCM Option.

K. The IWCM option was able to reduce streamflows in waterways impacted by increased urban stormwater runoff and increase streamflows in stressed waterways currently used for bulk water supplies.

L. The beneficial impact on waterways from the WWR Option was driven by reduced wastewater discharges created by additional water efficient appliances and reuse of wastewater which reduces discharges of wastewater effluent to waterways.

M. Wastewater reuse in the WWR Option generates direct benefits to waterways that are subject to discharges from wastewater treatment plants.

N. The beneficial impact on waterways was also driven by reduced wastewater discharges created by additional water efficient appliances which reduces discharges of wastewater effluent to waterways.

Introduction

A range of Options for water cycle management were chosen to test the behaviour of water cycle throughout the Ballarat region. This report focuses on the performance of alternative Options relative to the base case for the Ballarat and Maryborough water districts from the context of the performance of the entire region and whole of water cycle behaviours. The Systems Framework of the Ballarat region that was developed as part of the Living Ballarat Project was utilised allow understanding of whole of water cycle challenges and opportunities across the region.

Options

The details of the alternative options are provided in a set of briefing notes and summarised in Table 1.

Table 1: Summary of the Alternative Options

Option	Description
BAU NoGW	Ground water resources are only used during droughts
Bulk	Water supply is not sourced from the Moorabool and Yarrowee Catchments
Bulk 2Irr	Water supply is not sourced from the Moorabool and Yarrowee Catchment with a 100% increase in regional irrigation demands
BC1	Rainwater harvesting and highest level of water efficiency adopted in all new and substantially renovated buildings
BC2	Rainwater harvesting and highest level of water efficiency adopted in all new and substantially renovated buildings. Include 5 m^3 of vegetated stormwater management for each new and substantially renovated building (this could be street trees, bio-retention, landscaping of similar)
IWCM	Rainwater harvesting for non-drinking indoor uses and highest level of water efficiency adopted in all new buildings. Wastewater reuse via a third pipe network for toilet, outdoor and open space uses.
SWH	Stormwater harvesting from all impervious surfaces, stored and treated to supplement water supply for all new buildings. The highest available level of water efficient appliances and water efficient gardens.
WWR	Wastewater reuse via a third pipe network for toilet, outdoor and open space uses at all new buildings. The highest available level of water efficient appliances and water efficient gardens.

Results

The results of the systems analysis of Options for average annual water demands, wastewater discharges and steamflows in selected waterways is provided in Table 2.

Table 2: Change in annual average water demands and streamflows (ML/annum)

Option	Water Demand	Wastewater discharge	Goldfields Pipe	Moorabool River	Yarrowee River	Burrumbeet Creek
BAU 2014	12,846	13,060	494	8,445	28,573	1,850
BAU 2051	26,511	26,419	7,796	9,391	43,464	1,706
Bulk	26,511 (0%)	26,419 (0%)	19,835 (+154%)	19,403 (+107%)	44,250 (+2%)	1,706 (0%)
Bulk2Irr	26,511 (0%)	26,419 (0%)	18,422 (+136)	19,770 (+111%)	44,245 (+2%)	1,706 (0%)
BC1	22,865 (-14%)	25,626 (-3%)	5,333 (-40%)	10,427 (+11%)	37,061 (-15%)	1,621 (-5%)
BC2	22,865 (-14%)	25,626 (-3%)	5,333 (-40%)	10,427 (+11%)	36,510 (-16%)	1,604 (-6%)
IWCM	19,186 (-28%)	23,605 (-11%)	3,528 (-68%)	11,521 (+23%)	39,790 (-8%)	1,569 (-8%)
SWH	18,077 (-32%)	25,626 (-3%)	3,176 (-74%)	12,394 (+32%)	40,175 (-8%)	1,365 (-20%)
WWR	23,399 (-12%)	23,712 (-10%)	5,696 (-34%)	10,068 (+7%)	40,895 (-6%)	1,467 (-14%)

Table 2 reveals the key findings of the investigation for buildings scale strategies:

1. Reductions in water demands of 3,665 ML (14%) and 234 ML (14%) by 2051 in the Ballarat and Maryborough districts respectively. These reductions in demands for water from regional waterways and groundwater were generated by additional rainwater supply and greater levels of water efficiency in new and redeveloped buildings.

2. Reliance on bulk water supplies from the Campaspe and Goulburn River catchments via the Goldfields pipeline was reduced, on average, by up to 2,410 ML/year (40%) by 2051.

3. Streamflows in the flow-stressed Moorabool River can be increased, on average, by up to 1,040 ML (11%) by 2051.

4. In contrast, the impacts of urban development and wastewater discharges on increased average flows in waterways is decreased by 1,094 ML/annum (14%), 2,140 ML/annum (5%) and 130 ML/annum (1%) in the Yarrowee River and Bet Bet Creek respectively. These changes will have the impact of reducing erosion, sedimentation and impacts on bio-diversity in the waterway corridor.

5. Peak daily flows are reduced from 21% for 1 year ARI rain events to 10% for 100 year ARI rain events for streamflows in waterways. As these flows include runoff from entire catchments including agricultural areas, greater reductions in peak flows are expected within urban areas. This result indicates reduced requirement for stormwater infrastructure and mitigation of a proportion of flood risks.

Table 2 also reveals the key findings of the investigation for Precinct Scale strategies:

6. The IWCM Option provides reductions in water demands of 7,326 ML (27.6%) and 175 ML (10%) by 2051 in the Ballarat and Maryborough districts respectively. These reductions in demands for water from regional waterways and groundwater were generated by additional rainwater supply, greater levels of water efficiency in new and redeveloped buildings, and reuse of wastewater.

7. The IWCM Option decreases wastewater discharges to the Ballarat and Maryborough wastewater treatment plants by 2,814 ML (11%) and 157 ML (14%) respectively.

8. The IWCM Option decreases reliance on bulk water supplies from the Campaspe and Goulburn River catchments via the Goldfields pipeline by, on average, by up to 4,049 ML/year (68%) by 2051.

9. The IWCM Option increases streamflows in the flow-stressed Moorabool River by, on average, up to 2,130 ML (23%) by 2051.

10. In contrast, the IWCM Option mitigates impacts of urban development and wastewater discharges on increased average flows in waterways is decreased by 3,673 ML/annum (9%), 137 ML/annum (8%) and 91 ML/annum (1%) in the Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively. These changes will have the impact of reducing erosion, sedimentation and impacts on bio-diversity in the waterway corridor.

11. The IWCM Option reduces peak daily flows from 21% for 1 year ARI rain events to 1% for 100 year ARI rain events for streamflows in waterways. As these flows include runoff from entire catchments including agricultural areas, greater reductions in peak flows are expected within urban areas. This result indicates reduced requirement for stormwater infrastructure and mitigation of a proportion of flood risks.

12. The WWR Option provides reductions in water demands of 3,113 ML (12%) and 120 ML (7%) by 2051 in the Ballarat and Maryborough districts respectively. These reductions in demands for water from regional waterways and groundwater were generated by additional rainwater supply, greater levels of water efficiency in new and redeveloped buildings, and reuse of wastewater.

13. The WWR provides reductions in wastewater discharges to the Ballarat and Maryborough wastewater treatment plants by 2,706 ML (10%) and 75 ML (7%) respectively.

14. The WWR Option decreases reliance on bulk water supplies from the Campaspe and Goulburn River catchments via the Goldfields pipeline by, on average, by up to 2,032 ML (34%) by 2051.

15. The WWR Option increases streamflows in the flow-stressed Moorabool River by, on average, up to 678 ML (7%) by 2051.

16. In contrast, the WWR Option mitigates the impacts of urban development and wastewater discharges on increased average flows in waterways is decreased by 2,569 ML (6%), 234 ML (14%) and 14 ML/annum in the Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively. These changes will have the impact of reducing erosion, sedimentation and impacts on bio-diversity in the waterway corridor.

17. The WWR Option provides minimal reductions in peak daily flows are reduced from 5% for 1 year ARI rain events to 1% for 100 year ARI rain events for streamflows in waterways. As these flows include runoff from entire catchments including agricultural areas, greater reductions in peak flows are expected within urban areas.

18. The SWH Option provides reductions in water demands of 8,435 ML (31.8%) and 194 ML (11%) by 2051 in the Ballarat and Maryborough districts respectively. These reductions in demands for water from regional waterways and groundwater were generated by additional rainwater supply, greater levels of water efficiency in new and redeveloped buildings, and reuse of wastewater.

19. The SWH Option decreases reliance on bulk water supplies from the Campaspe and Goulburn River catchments via the Goldfields pipeline by, on average, by up to 4,445 ML (74%) by 2051.

20. The SWH Option increases streamflows in the flow-stressed Moorabool River by, on average, by up to 3,003 ML (32%) by 2051.

21. In contrast, the SWH Option mitigates the impacts of urban development and wastewater discharges on increased average flows in waterways is decreased by 3,289 ML (8%), 244 ML (20%) and 155 ML/annum (1%)in the Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively. These changes will have the impact of reducing erosion, sedimentation and impacts on bio-diversity in the waterway corridor.

22. The SWH Option mitigates peak daily flows are reduced from 21% for 1 year ARI rain events to 1% for 100 year ARI rain events for streamflows in waterways. As these flows include runoff from entire catchments including agricultural areas, greater reductions in peak flows are expected within urban areas. This result indicates reduced requirement for stormwater infrastructure and mitigation of a proportion of flood risks.

23. The Bulk Option provides substantial increases in the flows in the Moorabool River (average increase of 84% and maximum increase by 2051 of 128%) and improves the

availability to water supply for irrigation, stock and domestic uses in the Moorabool catchment.

24. The Bulk Option also avoided harvesting water from the headwaters of the Yarrowee River system. This resulted in small increases in flows in the Yarrowee River (average of 7% and maximum of 10%). Given that the Yarrowee River also receives treated wastewater from the Ballarat South wastewater treatment plant and the Ballarat CBD is subject to flooding, it is preferable that the Yarrowee River remains a water supply option.

25. The Bulk Option results in over 230% increases in water supply via the Goldfields pipe from the Campaspe and Goulburn River systems. An increase in regional irrigation demands in the Bulk2Irr Option decreases the water supply via the Goldfields pipe by 18% because the available of bulk water supplies is diminished.

26. The Bulk Option increases flows in the Moorabool River by up to 128% and reduces flows in the Campaspe and Goulburn Rivers by 0.7% and 0.1% respectively.

The impacts of the alternative options on water quality in waterways is summarised in Table 3.

Table 3: Water quality in waterways as indicated by average nitrogen loads (kg/annum)

Option	Yarrowee River	Burrumbeet Creek	Bet Bet Creek
BAU 2014	114,463	7,999	10,250
BAU 2051	265,247 (+132%)	5,424 (-32%)	9,625 (-6%)
BC1	257,275 (-3%)	4,619 (-15%)	9,265 (-4%)
BC2	225,455 (-15%)	4,280 (-21%)	9,175 (-5%)
IWCM	234,375 (-12%)	4,336 (-20%)	9,383 (-3%)
SWH	218,563 (-18%)	4,697 (-13%)	9,213 (-4%)
WWR	239,153 (-10%)	4,341 (-20%)	9,577 (-0.5%)

Table 3 reveals that following water quality benefits for waterways:

27. The BC Options reduce nitrogen loads by 40,790 kg/annum (15%), 1,144 kg/annum (21%) and 642 kg/annum (5%) for Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively.

28. The IWCM Options decrease nitrogen loads by 30,875 kg/annum (12%), 1,090 kg/annum (20%) and 242 kg/annum (3%) for Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively.

29. The WWR Options reduce nitrogen loads by 26,079 kg/annum (10%), 1,083 kg/year (20%) and 44 kg/annum for Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively.

30. The SWH Options reduce nitrogen loads by 46,684 kg/annum (18%), 727 kg/year (13%) and 411 kg/annum (4%) for Yarrowee River, Burrumbeet Creek and Bet Bet Creek respectively

The impact of the alternative Options on water security is presented in Table 4.

Table 4: Impact on water security as indicated by year of augmentation

Option	Ballarat	Maryborough
BAU	>2051	>2051
BAU NoGW	2037	2019
Bulk	2042	>2051
Bulk 2Irr	2030	>2051
BC1	>2051	>2051
BC2	>2051	>2051
IWCM	>2051	>2051
SWH	>2051	>2051
WWR	>2051	>2051

Table 4 shows that the alternative options have the following impact on water security:

31. The BAU NoGW Option highlights the importance of ground water resources for the security of water supplies to the Ballarat and Maryborough districts. Only using groundwater during droughts reduces the security of the Ballarat and Maryborough districts by up to 14 and 32 years respectively.

32. The Bulk Option decreases the security of the water supply to the Ballarat water district by 9 years with unacceptable levels of water restrictions experienced by 2042.

33. The Bulk2Irr Option includes twice the regional irrigation demands. These increased regional irrigation demands reduce the security of the Ballarat district water supply by 14 years resulting in unacceptable levels of water restrictions by 2030.