Water Management Solutions
Rainwater Tanks & Wastewater

The Greater Melbourne
Alternative Water Plan

Kingspan Environmental Pty Ltd

Urban Water Cycle Solutions Pty Ltd

Urban WaterCycle Solutions
Independent research and consulting

Thirsty Country Pty Ltd

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CONTENTS

1. THE ALTERNATIVE WATER PLAN FOR GREATER MELBOURNE

"We cannot fix our problems using the same thinking that created them in the first place" ALBERT EINSTEIN.

Every household in Melbourne deserves the most efficient water service available. In 2015/16 households provided 74% of the water revenue for Greater Melbourne. The intent of the Plan is to compare two options and what they mean for family and state government budgets.

The Alternative Water Plan reveals unfamiliar challenges for stakeholders. Households have experienced water bill expenditure far in excess of inflation and water bills will continue to rise. Household bills are a result of service providers implementing new centralised technology and inefficient networks which have doubled the costs of delivering 'new' water and costs are projected to continue to rise. The water services model that has served Melbourne well for a century is no longer the most efficient strategy.

The major determinant of Melbourne's water use is the behaviour of buildings and particularly residential buildings. Building performance can drive the change we need for efficient water services delivery, higher amenity and healthy waterways. Building performance can be planned by setting performance targets for water use and stormwater runoff. The implementation costs of performance targets can be accurately estimated, the future demand for water and stormwater runoff can be accurately projected and the most efficient solutions can be selected.

We have investigated and modelled the potential of building design to change how the whole city manages water, energy and stormwater.

1.1. Summary of Results

- Household Bills in Greater Melbourne have risen from $500/household in 2003/4 to $1000/household in 2015/16. Water Utility operating costs have increased by up to 199%.
- The water utility impacts on Household Welfare have risen from $1.2B to $2.5B which is a 143% increase for only 2% more water use and is relative to growth in CPI of 38%. This is affecting the entire Victorian economy.
- The Business as Usual Option is projected to increase household expenditure on water and sewerage services to over $3 billion annually by 2050.
- The Sustainable Building option will save households $1 billion on water services every year after 2035. The water utility impact on household expenditure is projected to fall to $800/household in real terms.
- The sustainable buildings option provides a net present benefit of $1.15 billion and contributes to stormwater management, protection of urban waterways and amenity with urban catchments by reducing
  - stormwater runoff volumes by 14% (94 GL/annum);
  - nutrient loads discharging to waterways by 17%; and
  - the risk of flood damage by 5%.
- Sustainable Buildings in NSW currently save 15% of potable water use or 90GL annually.
- Net whole of system cumulative savings for Greater Melbourne from the Sustainable Buildings option, including the costs of upgrading buildings, are $16B by 2050.

1.2. So what do we need to do?

1. Prepare a State Planning Policy for Sustainable Buildings in Victoria incorporating performance-based targets for all new buildings and renovations. The performance-based targets would include water (40% reduction), energy (40% reduction), stormwater (30% reduction in volume) and green infrastructure.
2. In the interim and prior to June 2018, the Victorian 6-star building requirement should be expanded to ensure rainwater harvesting on all new developments until a permanent strategy is implemented.
3. Convene a high-level government working group, independent of state monopoly interests, for a Systems Approach analysis of Melbourne's future water challenges and water future options and their impact on household welfare and overall community benefit.
4. Request a review by the ACCC of Victorian water services and pricing mechanisms to explore competitive arrangements that may deliver more efficient service delivery.
5. Explore new economic approaches to provision of water cycle services that eliminate fixed tariffs to provide better economic incentives and market signals for a water efficient Melbourne
6. Investigate a mechanism where the benefits for stormwater management of reduced impervious areas at the property are directly recognised in economic decision making.

2. INTRODUCTION

2.1. Kingspan Environmental

Kingspan Environmental Pty Ltd has commissioned the Melbourne Alternative Water Plan to provide an alternative Option. The Victorian Water providers have done an excellent job over a long period of time in serving Victorian communities. However, the models are almost 100 years old, relying on large centralised dams, desalination, treatment plants and distribution systems of pipes and reservoirs over our increasingly widespread cities.

Kingspan Environmental has an international perspective on building materials, renewable technology and commercial expertise. A perspective from other industries can provide key insights and bring different options to the table. Changing the construction and use of our buildings will decentralise and radically transform the demand and supply for water and water infrastructure needs for the next century.

Kingspan Environmental is privileged to be working with the leading independent integrated water expert in Australia, Professor Peter Coombes, on this project. Professor Coombes is a Fellow of Engineers Australia, a former Chief Water Scientist for Victoria, a member of Standards Australia, a former member of the Prime Ministers Science, Engineering and Innovation Council, a former member of the advisory panel on urban water resources to the National Water Commission and an adviser to the United Nations. Michael Smit provides an additional environmental, economic, town planning, and urban design context.

2.2. Values

The report has been commissioned to reflect three values - fairness, transparency and public benefit. In order to be fair, it is important that key evidence and assumptions are clear and transparent. The goal is to ensure that water is provided for the greatest benefit of the entire Victorian community.

2.3. A Systems Approach

The Alternative Plan is based on a Systems Approach and a whole of society perspective. Water cycle management is a system and can be analysed as a model to test different options. Water cycle management, environment and urban areas are complex dynamic systems and no model is perfect, however, the advantage of the digital age is that powerful computing can use billions of pieces of information or big data to model the real world[1]. Once a model is developed, the rules of the model, or scenarios, can be changed to achieve a better outcome. Understanding and modelling the system to test different outcomes is called a Systems Approach. A Systems Approach is a powerful tool for understanding complex dynamic systems.

The Systems Framework incorporates local scale (people and buildings) inputs as a "bottom-up" process that is a fundamental element of the method. The analysis is constructed from the basic elements (local land uses) that drive system behaviours and which account for the distributed, first principles, transactions which allow simulation of both the spatial and temporal performance of the system. Biophysical systems for a region are constructed using four basic components:

- Demands – Local requirement for services and amenity
- Sources – Regional and local water sources, catchments and waterways
- Flux – Transport and treatment of water, wastewater and stormwater throughout the region
- Sinks – Stormwater runoff and wastewater disposal to waterways

This structure is anchored on detailed "big data" inputs, such as demographic profiles, topography, climate and economic behaviours, and linked systems that account for water demands, water supply, sewage flows, stormwater runoff, water quality, human health, energy and environmental considerations. The Framework is a series of applications for continuous simulation of water balances that interact to span all relevant spatial and temporal scales including household or land use to city to national and global scales at timelines ranging between one second and 100 years.

For example, Table 1 shows the spatial drivers used to determine water demand for each dwelling in the system. Figure 1 and Figure 2 show the allocation of costs required to meet the projected demand.

[1] Coombes P.J., and Barry M.E (2015), A Systems Framework Of Big Data Driving Policy Making – Melbournes Water Future", OzWater Conference. Australian Water Association. Brisbane.

Table 1: Correlation of annual average demographic and climate parameters to spatial differences in residential water use

Criteria	Rain (mm/yr)	Ave. max Temp (°C)	Ave. min Temp (°C)	Annual Rain Days	Income ($/p/wk)	Age (yrs)	Use (kL/yr)
Rain (mm/yr)	1						
Ave. max Temp (°C)	-0.68	1					
Ave. min Temp (°C)	-0.29	0.13	1				
Annual Rain Days	0.8	-0.63	-0.26	1			
Income ($/pp/wk)	-0.23	0.12	0.15	-0.22	1		
Age (yrs)	0.37	-0.29	0.09	0.21	-0.1	1	
Use (kL/yr)	-0.15	0.24	-0.17	-0.26	0.17	-0.03	1

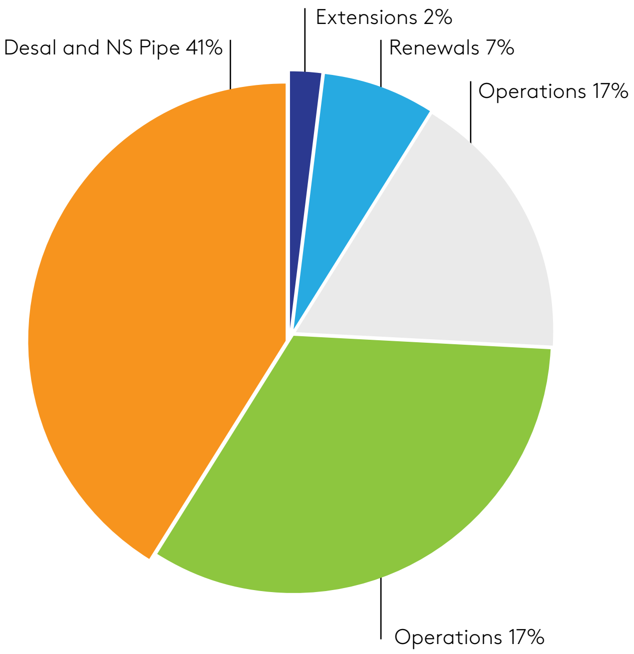


Figure 1: Proportion of water supply costs in 2050

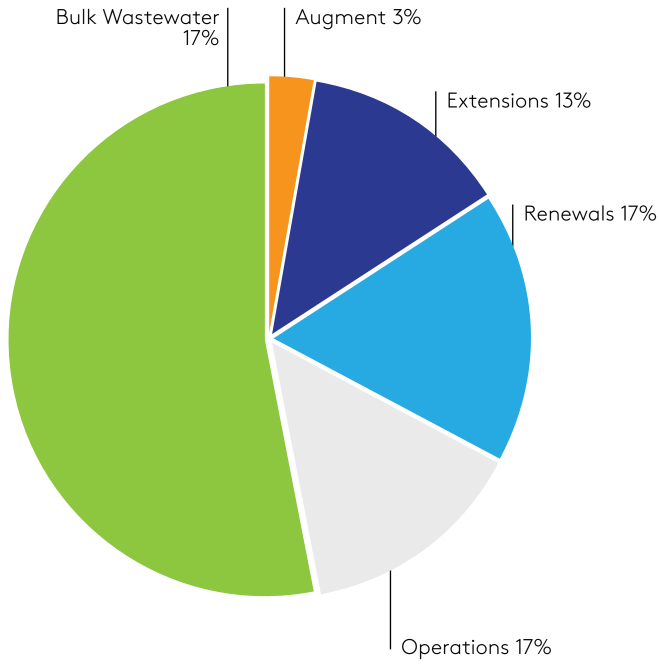


Figure 2: Proportion of wastewater costs in 2050

The process includes multiple replicates of climate sequences and linked responses that yield a probabilistic understanding of system behaviour and risks, rather than a single, static solution. This includes water use and the associated linked generation of wastewater and stormwater runoff at the local scale, distribution infrastructure and information at the sub-regional or precinct scale, and also regional behaviours associated with infrastructure such as water extractions from dams and discharges of sewage to wastewater treatment plants and ultimately to receiving waters.

A general overview of the hierarchy that corresponds to a conceptual description of the Systems Framework is presented in Figure 3. A more detailed description of the Systems Framework[2] is provided in Coombes and Barry (2015).

The Systems analysis includes a wide range of considerations extending from details of household behaviour and associated water balances (at time resolutions of seconds) to the long-term forecasting of bulk infrastructure requirements or flood risks (at time resolutions of years to decades in some cases). Figure 3 illustrates that the scales of analysis are linked by a hierarchy of processes that are modified by feedback loops. For example, the behavioural water demands at the local scale are impacted by water restrictions applied at the catchment scale, and climate and economic processes from the regional scale.

2.4. Reliability of Data

This Plan by its nature presents summary data that represents billions of calculations and months of dedicated modelling. The strength of systems analysis is that it considers the system holistically. By definition, this form of analysis will provide different results to analysis that focuses on separate and isolated

2 Coombes P.J., and Barry M.E., (2015). A Systems Framework of Big Data for Analysis of Policy and Strategy. WSUD2015 Conference. Engineers Australia. Sydney. Australia.

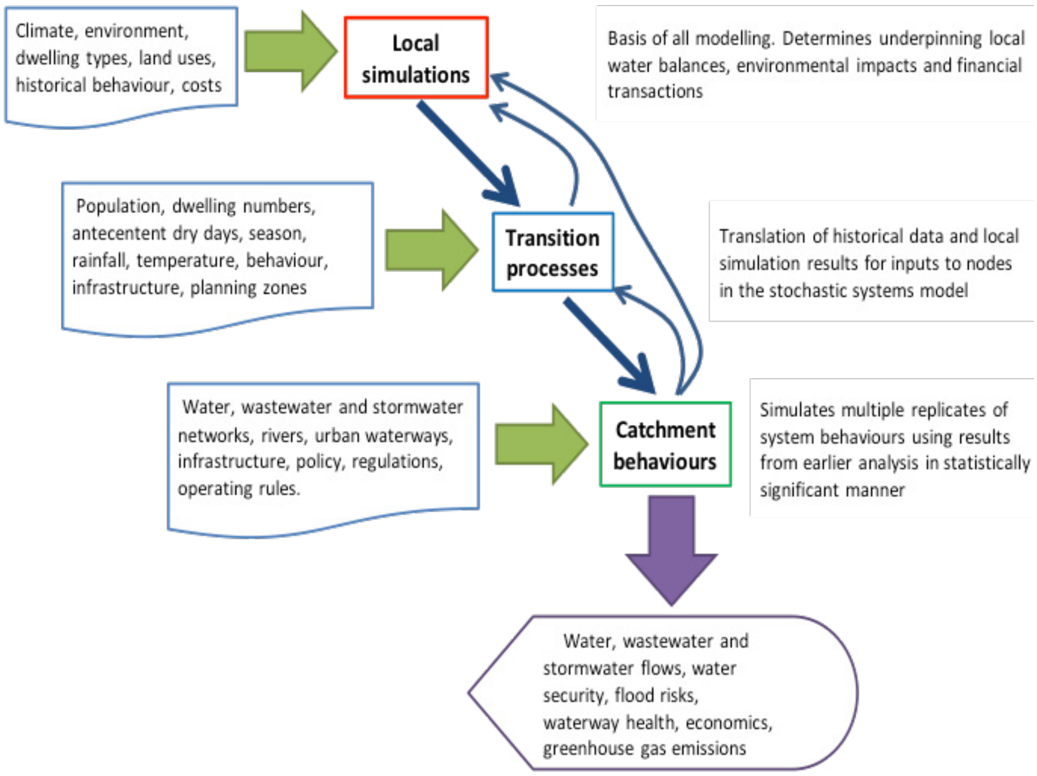


Figure 3: Overview of the hierarchy in the Systems Framework

components of the system. This is illustrated by a calculation of the cost of delivering water services as outlined in Table 2.

A key difference provided by a systems perspective is that all of the operating costs, transport costs and infrastructure servicing costs across the network are cumulative. These costs need to be linked across the entire system to represent a holistic picture of actual costs to service different locations from centralised sources. The underlying data for the systems modelling comes from verified sources, including National Performance Reports from the Bureau of Meteorology, Water Utility and Bulk Water Provider audited Annual Reports, Victorian Regulator reports, Audit Office reports and the Australian Bureau of Statistics.

2.5. Structure of the Report

The Alternative Water Plan discusses some of the issues that Victorians need to address and provides an overview of a Systems Approach. Two Options are proposed, a Business as Usual (BAU) Option and a Sustainable Buildings (SB) Option. Both options are modelled for Melbourne to 2050 and the results are analysed. A case study is presented on the NSW BASIX scheme and a case for rainwater harvesting and water efficient buildings is presented. The issues of managing stormwater and inherent corporate and government risk are discussed as well as the emerging issue of State government water-related debt.

Table 2: Cost of delivering water services comparing approaches

Element	Traditional Analysis	Systems Approach
Desalination Plant	Divide plant operating cost by volume of water generated	Calculates dynamic operating cost to deliver volumes of water to distribution network
Distribution Network	Operating cost generally not considered	Operating and renewal costs calculated to deliver volumes of water to end users across the network
Future costs	Based on capital cost of infrastructure and discounted to net present values	Counts all costs: new infrastructure, bulk water, additional supply required from desalination, required extensions to the distribution network, infrastructure renewal, operating the network for a specific volume, the cost of rainwater harvesting, the cost of water-efficient appliances, the cost of regulatory compliance. Relative cost of operating wastewater system as a result of increased demand including extensions, renewals and operating cost
Cumulative Cost	Costs are considered separately and analysed in isolation	Costs are considered cumulatively and total system costs and benefits are taken into account

3. ISSUES AND CHALLENGES

3.1. The importance of Residential Buildings

Households and buildings are the workhorses of the Victorian urban economy. They are providing the bulk of the increase in water demand and expenditure over the last decade. In 2003-04 households paid 69% of the total water bills, by 2015-16 household bills had increased by 143% to 80% of total water bills. The total property expense and household expense for all water and sewerage services for Greater Melbourne and connected regions are presented in Figure 4.

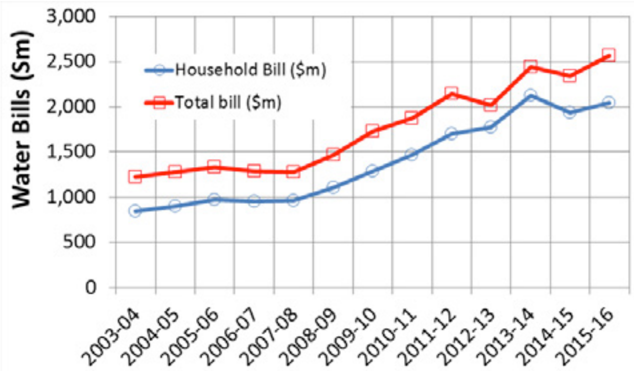


Figure 4: All Property Water Expenses for Greater Melbourne[3]

The behaviour of residential buildings with associated costs and revenues dominate the operation of urban water services for Greater Melbourne.

3.2. Household Welfare and Operating Efficiencies

Household welfare and associated disposable income is an important economic indicator. Household expenditure on water services in Greater Melbourne has increased by 143% since 2003-04 (Figure 5). In contrast, the volume of water supplied to households has only increased by 2% since 2003-04.

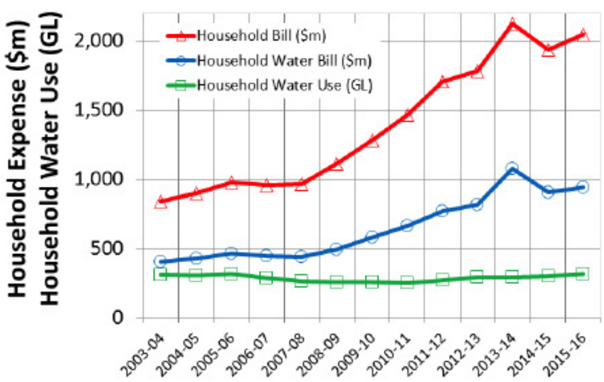


Figure 5: Household water and sewerage expenses for Greater Melbourne and connected regions

A decade-long increase in household water and sewerage bills commenced in 2007-08. These changes in affordability coincide to restructure of water utilities that removed local democratic representation from water utility governance in Victoria and a period of drought.

The Greater Melbourne region has experienced substantial population growth and changes in urban form during the last decade. We accounted for these issues by restricting the data to average annual water bills for connected properties to normalise differences in the number of connections and new connections. The average household expense for water and sewerage services in the Greater Melbourne and connected regions is presented in Figure 6.

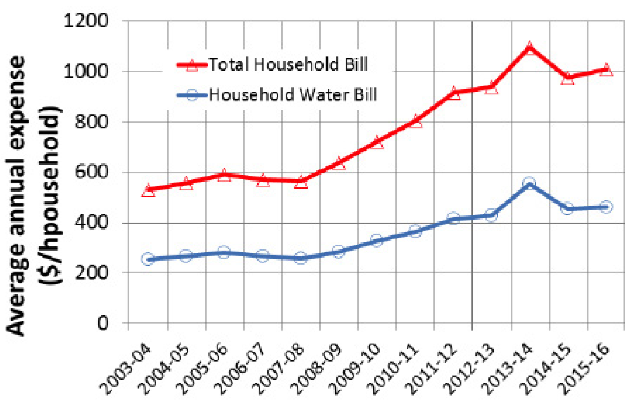


Figure 6: Average annual household water and sewerage expenses for the Greater Melbourne and connected regions

Increases in water and sewerage expenses of each household have also increased substantially by 81% to 89%. In contrast, the consumer price index (CPI) has increased by 38% during the same period and real household disposable income has declined in recent times.[4] In addition, Australia is experiencing low wage growth. During a period of declining household welfare and overall higher costs of living, the average increase in household expenditure on water and sewerage services is far greater than the inflation rate.

These results indicate serious impacts on household welfare and a decline in efficiency of centralised water utility model. This problem is also relevant to North America where unaffordable water bills may triple from 12% to 36% during next five years – this indicates that 36% of American households may not be able to afford utility water and sewerage services in the near future.[5] Similar impacts on household welfare are also

[3] Derived from BOM (2017) National Performance Report 2015-16: Urban Water Utilities, Australian Bureau of Meteorology. Also published in Coombes P. J., Smit M., Byrne J., and Walsh C., (2016) Stormwater, waterway benefits and water resources benefits of water conservation measures for Australian cities. HWRS 2016, Engineers Australia, Queenstown, New Zealand. Greater Melbourne is defined by the supply areas of City West Water, South East Water and Yarra Valley Water. The connected regions include Western Water, Barwon Water and Gippsland Water

[4] ABS (2016) 5206: Australian National Account – expenditure and product. Australian Bureau of Statistics; Commonwealth Government, Budget 2015-16 Mid-year economic and fiscal outlook (15 December, 2015), http://budget.gov.au/2015-16/content/myefo

[5] Mack EA., and Wrase S., (2017), A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States, PLoS ONE 12(1) : e0169488. doi:10.1371/journal.pone.0169488

experienced in the energy sector.[6] Declining household welfare as indicated by reduced disposable income that also reduces consumption throughout the economy which impacts on the overall economic welfare.

Growth in impacts on household welfare provides a macroeconomic perspective on the efficiency of water and sewerage services. The growth in water operating costs of utilities can provide a microeconomic perspective. Changes in water operating costs of water utilities that service Greater Melbourne is presented in Figure 7. The data on operating costs were sourced from the national performance reports published by the Bureau of Meteorology and the National Water Commission.

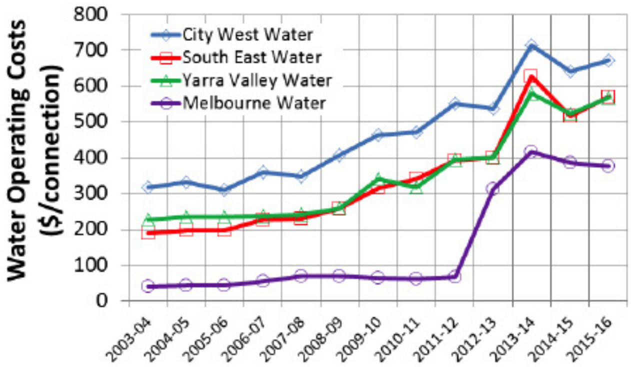


Figure 7: Water utility operating costs for Greater Melbourne

7 reveals that the water operating costs of the water distribution or retail utilities City West Water, South East Water and Yarra Valley Water have increased by 111% to 199% since 2003-04. These costs coincide with population growth and expansion of urban areas. These impacts are highlighted by higher water operating costs in the City West Water region that are further from water sources and has experienced substantial population growth.

The water operating costs of the bulk utility Melbourne Water have increased by more than 820%, after the millennium drought, due to the desalination plant, and increasing transfer and water treatment costs. Dramatic increases in water operating costs per property have occurred during a period of largely good rainfall and generous financial support from the State government. Figure 7 highlights that increases in operating costs were not dominated by water security issues associated with drought – indeed, the large increases in operating costs for Melbourne Water Corporation occurred during 2012-13 after the drought.

A simple analysis of efficiency is measuring the change in resources (measured as the cost of production) required to achieve a unit of production. In the medium run (based on the last 15 years of economic data), increases in water costs (household expenditure and utility operating costs) for Greater Melbourne were between 56 and 412 times greater than increases in water use. This indicates that local water efficiency and sources of water is a high-value economic proposition due to greater reductions in utility operating, augmentation and security costs than any reduction in revenue[7] – this drives lower growth in water bills in the medium run.[8] This result implies that each kilolitre of water saved at buildings has a medium run value of approximately 56 to 412 times any reduction in revenue from water charges provided that all costs are counted in the analysis.

These results also suggest that the historical average medium run marginal costs of water supply were up to $172/kL of urban water supply for the Greater Melbourne region.

The cost of water supply has not increased by a factor of 412 because the bulk of the water is provided by the former, cheaper technology. The implication is that the water industry has achieved an increase in supply and increased the security of supply but the cost of producing additional water has been truly enormous relative to the former cost of producing water. As more water in future is delivered at the higher cost we can expect significant price rises. Because the urban water system is very large it will take time to change direction so there is some urgency in acting now and avoiding significant additional costs and impacts on household welfare

3.3. Australian Opportunities

There is a great opportunity in the way Australians already manage water in the driest inhabited continent on earth. Australian technology and local behaviour proved their effectiveness when urban storages were drawn down to 15% during the millennium drought.

Household water efficiency and behaviours and local water sources ensured that water supplies for cities were not exhausted during the millennium drought. The utility water demand of cities was substantially reduced. This historical experience highlighted the importance of solutions that both increase local supply and reduce demand for utility water and the effectiveness of strong demand management programs in uniting the community in meeting water saving targets.[9]

Australians have developed building forms which efficiently capture rainwater at the point of use and store that water indefinitely. Australian buildings don't need to build the water equivalent of solar

[6] Saddler H., (2016), Rising power bills signal the end of an era for Australia's electricity grid. Article from Australian National University published in the Conversation, December 15.
[7] Coombes P.J., Smit M., and MacDonald G., (2016), Resolving boundary conditions in economic analysis of distributed solutions for water cycle management. Australian Journal of Water Resources, Vol 20, 11-29.
[8] Coombes P.J., (2017), Why the water supply needs a splash of competition, Australian Financial Review, 18 January
[9] Coombes P. J., Smit M., Byrne J., and Walsh C., (2016) Stormwater, waterway benefits and water resources benefits of water conservation measures for Australian cities. HWRS 2016, Engineers Australia, Queenstown, New Zealand.

panels on our roofs, our roofs are already designed as collection panels. The collected water does not need to be expensively treated, transported and sold to households. Five million Australians already use that water every day.

The contribution of water efficient appliances and rainwater harvesting in the Sydney, Adelaide, South East Queensland (SEQ) and Perth urban regions was derived using comprehensive data from BOM and BASIX in systems analysis and is presented in Figure 8.[10]

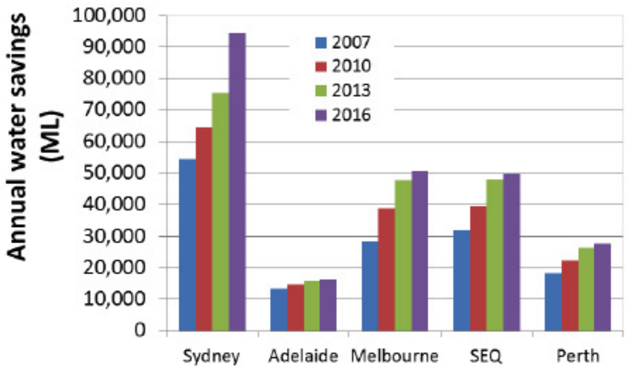


Figure 8: Annual water savings from water efficient appliances and rainwater harvesting for the Sydney, Adelaide, South East Queensland and Perth urban regions

Figure 8 demonstrates that water efficient appliances and rainwater harvesting in existing buildings have made a significant and increasing contribution to water management in Australian capital cities. The Melbourne contribution is nearly 55 GL compared to the utility water supply of 420 GL.

3.4. Water is a Transport Business with Cumulative Impacts and Stormwater Consequences

The historically centralised focus of solutions has defined the urban water sector as essentially a transport industry as demonstrated for water supply in Figure 10 and sewerage disposal in Figure 11 for Greater Melbourne.[11] The growth of cities involves expansion and densification of these networks which dramatically alters the economic characteristics (cumulative costs and volumes in existing networks) of centralised supply solutions as sources are increasingly distant from end uses.[12]

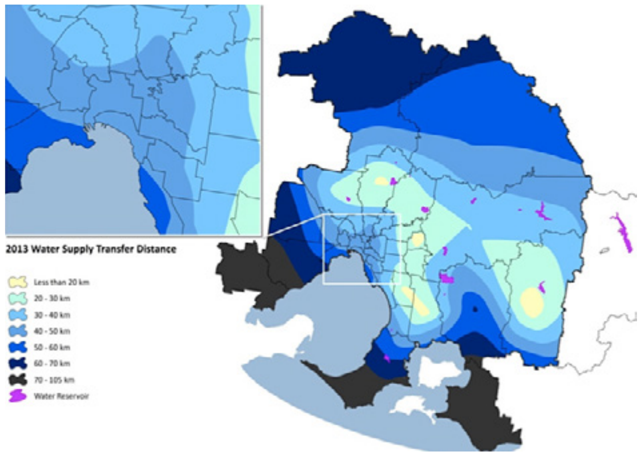


Figure 10: Water supply transfer distances for Greater Melbourne

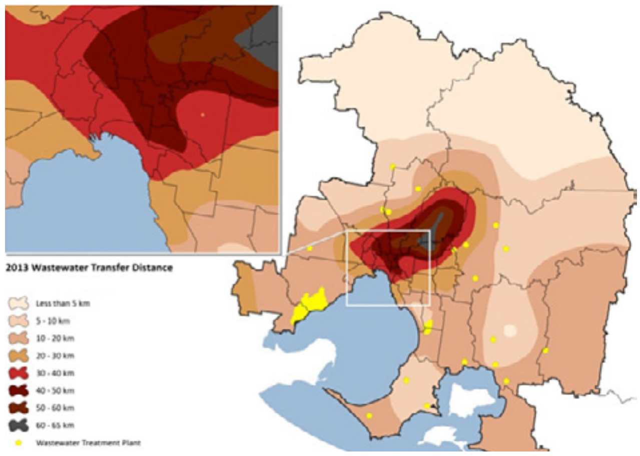


Figure 11: Wastewater disposal transfer distances for Greater Melbourne

Application of transport logistics to these spatial challenges identified in Figure 10 and Figure 11 reveals that local reductions in water demands or local supplies decrease the cumulative costs of transporting water and sewerage throughout networks, and the cumulative impacts on urban waterways (Figure 9). This can produce economic multipliers of benefits throughout the system.

We should be mindful that decisions about solutions involve linked impacts that occur at multiple scales across the water cycle as shown in Figure 9.

[10] ABS (2013) Environmental Issues: water use and conservation (Mar, 2013), Cat No. 4602.0.55.003: customised report.
[11] Coombes P.J. and Barry M.E., 2014, A systems framework of big data driving policy making - Melbourne's water future, OzWater14 Conference, Australian Water Association, Brisbane.
[12] Coombes P.J., 2015, Transitioning drainage into urban water cycle management, HWRS2015, Engineers Australia, Hobart.

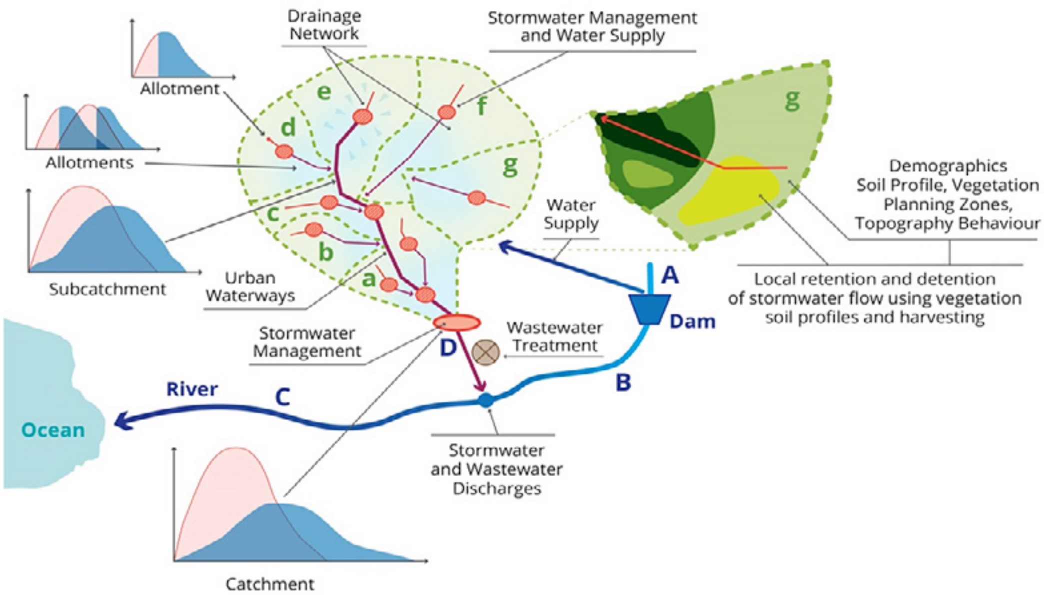


Figure 9: The cumulative impacts of scales across the water cycle on stormwater management

Figure 9 shows that urban catchments incorporate multiple linked scales including regional, urban catchment and distributed sub-catchments that contain local scale processes.

The responses of urban catchments are cumulative rather than static or average and are dependent on spatial and temporal characteristics throughout the catchment. This insight indicates that the impacts of hidden or missed challenges or opportunities within catchments are not linear or average processes and may be exponential in nature. For example, solutions at the local scale can accumulate throughout an urban area to produce substantial benefit at the whole of city scale, and local scale solutions can be delivered at far less cost than centralised solutions.

Emerging approaches to stormwater and water supply management utilise multiple solutions that cascade across scales to mitigate these cumulative impacts for example; household rainwater harvesting overflowing to streetscape measures such as rain gardens, infiltration and vegetation that discharge to sub-catchment scale bio-retention and stormwater harvesting is a treatment train that can restore the natural regimes of flow volumes.

These accumulative and connected outcomes are unlikely to be understood using traditional average and siloed analysis of water, wastewater, stormwater, waterway, environment and human systems. The current practice of excluding stormwater management within catchment to management at the bottom of the catchment (at D in Figure 9) eliminates stormwater management, waterway and amenity benefits from within the bulk of the urban catchments. Management of stormwater at the bottom of catchments does not provide benefits within catchments. This type of catchment design and management is the current practice for new developments in the Melbourne area, for example, the Plumpton and Kororoit land release areas in the Sunbury region.[13]

Urban settlements are subject to a continuum of temporal and spatial change. Our policies and solutions must be flexible and able to evolve in response to these changes. There is also change from historical complete reliance on centralised options to diverse water management strategies.[14]

3.5. Natural Monopolies

Water utilities are considered natural monopolies in some branches of economic theory. Part of the definition of a natural monopoly is that they enjoy an economy of scale and therefore the more water they sell, the cheaper it is to produce. In economic terms, their marginal costs are assumed to be declining. Natural monopolies have a natural advantage over the competition and are assumed to have an economic advantage that allows them to provide a more efficient service than partial supply to the market by any competitor.

In some cases, this may be right. Natural monopolies operate in a range of production scales and when the water utilities were established they probably were

[13] Weise R., (2016), Why best practice is destroying our waterways, Stormwater Australia National Conference, Gold Coast, Queensland.
[14] PMSEIC., (2007), Water for Our Cities: building resilience in a climate of uncertainty, A report of the Prime Minister's Science, Engineering and Innovation Council working group, Australian Government, Canberra.

the most efficient solution. However, the scale of production now required and the area of the network has arguably generated substantial diseconomies of scale.

There is also an issue of considering fixed and variable costs over time. An investment in expensive fixed assets such as a dam or desalination plant is considered by the water industry to be a fixed costs, which is ignored, in short-run assessments. This results in a perception that selling more water only generates small additional costs. Nevertheless, classic economic theory does not support ommiting assumed fixed costs to derive marginal costs.[15] All costs and benefits must be counted to determine water policies.

In any event, water supply, protection of the environment and welfare of communities are not short-term issues. Water needs to be provided for the next 20, 50 and 100 years. We need to plan for the long term and over the long term according to classical economic theory, all fixed costs become variable. So the fixed costs of a new desalination plant required in 25 years time should actually be considered variable costs affecting decisions about today's water use.

If water utilities were natural monopolies than steady levels of revenue would be able to pay for the increasingly less expensive water supply provided by larger and larger infrastructure. Marginal costs would be decreasing. However, the analysis of operating efficiencies in Section 3.3 of this report indicates the historical marginal cost of providing additional water since 2003 has increased by a factor of 56 to 412. This insight is supported by the dramatic increases in the average medium run marginal costs of up to $172/kL of water supply. These results indicate that water utilities can no longer be seen as natural monopolies that are the sole and most efficient solution to providing water resources.

What are the implications of this? Water utilities and regulators currently behave and make decisions as if they were a natural monopoly. Water utilities continue to invest in the same technologies and assume the services they provide are the most economically efficient in the oligopoly market. The implication is that there is a powerful economic argument for water utilities and their regulators to reconsider the centralised model used to provide water services and the technologies used to supply and treat water and wastewater. There is also a need to account for the scale of assumptions in analysis – average centralised assumptions and analysis are unlikely to reveal the cumulative opportunities and challenges that occur across multiple scales.[16] Stormwater management, protection of urban waterways, enhanced urban amenity and reduced impacts on rural waterways are also important considerations for regulators.

3.6. Current Water Management

Household water efficiency and behaviours and local water sources ensured that water supplies for cities were not exhausted during the millennium drought. The utility water demand of cities was substantially reduced. This historical experience highlighted the importance of solutions that both increase local supply and reduce demand for mains water and the effectiveness of strong demand management programs in uniting the community in meeting water saving targets.

In spite of this history, the current focus is on centralised water supplies provided by water utilities including dams and desalination and centralised recycling. The desalination plant can be relied on to provide water security for Victoria. Demand management and alternative water sources are not considered relevant unless Victorian is in a drought. Nevertheless, utility water supply is not the only source of household water supply in Greater Melbourne as demonstrated by Figure 12.

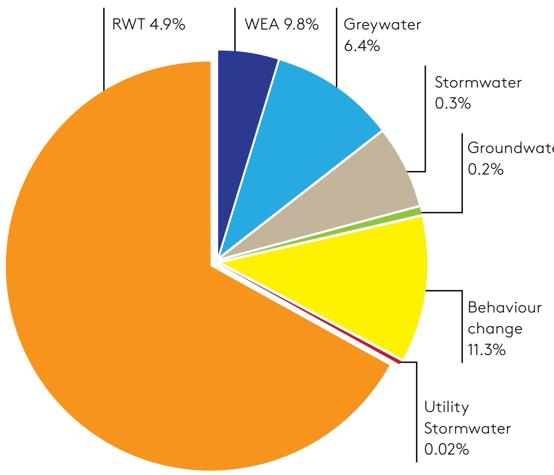


Figure 12: Household water supply in Greater Melbourne for 2016

[15] Pindyck R.S. and Rubinfeld D.L., Microeconomics, (Pearson Education, 8th Ed, 2015), 288-289, 385-390; Hubbard R.G., Garnett A.M., Lewis P., and O'Brien A.P., Microeconomics, (Pearson Education, 3rd Ed, 2013), 448-449

[16] Coombes P.J., and Barry M., (2016), Impact of spatial and temporal averages on prediction of water security using systems analysis. Proceedings of t he 37th Hydrology and Water Resources Symposium, Queenstown, New Zealand.

The following sources of household water supply, and water efficient appliances and behaviours for the Greater Melbourne region in 2016 was derived using detailed information from the ABS, BOM, water utilities and government agencies (Table 3).

Source	Residential Supply (GL)	Proportion (%)
Rainwater harvesting	18.6	4.9
Water efficient appliances	37.1	9.8
Greywater	24.2	6.4
Stormwater	0.96	0.25
Groundwater	0.82	0.22
Behaviour change	42.7	11.3
Utility recycled water	0.93	0.24
Utility stormwater	0.06	0.02
Utility supply	252.9	66.9
Total Potential Demand	378.3	

Table 3: Household water supply in Greater Melbourne for 2016

Note that behaviour change was derived from shorter showers, less full flushes of toilets and reduced clothes washer loads as defined by statistics provided by the Australian Bureau of Statistics (ABS). The quantum of behaviour change has diminished since the 2013 data. Figure 12 highlights that the household water balance for Greater Melbourne is far greater than the focus on centralised water supplies from water utilities.

There are important factors at play in addition to mains water supply in Melbourne's water services including distributed supply solutions like rainwater harvesting, greywater reuse and stormwater harvesting and demand side factors including water efficient appliances and water-efficient behaviour. Without these local contributions, the mains water demand could be more than 100 GL higher. These results also reveal that despite a decade of high-profile projects and media coverage the supply contribution from utility recycled water and stormwater is insignificant. The explanation for this may be with nearly all the revenue coming from sales of centrally managed water there is little incentive to develop alternative sources.

3.7. Democratic Governance

Water is a basic community need and the provision of water is a primary requirement of government. Decisions about water services should, therefore, be made with a high level of accountability to the community and local communities should have a say in how water services are provided to them. Governance that includes local elected representatives provides checks and balances that ensure transparency of pricing decisions, an overview of large investment decisions and representation of a range of stakeholder interests without undue influence from private industry or bureaucratic interests.

3.8. Calculating the current take up rate of Rainwater Harvesting

The Business as Usual option estimates a 30% rate of rainwater harvesting for new dwellings and a 10% rate for renovations with most tanks being 2-3 kL. This is historically accurate for the late 2000s, however, sales data for Melbourne from Kingspan indicates the rate is now less than 20% of new dwellings and tank size has shrunk to 2 kL. Application of these statistics to the Business as Usual option would further improve the case for the Sustainable Buildings option. The modelling has retained the 30% figure and the authors note this is likely to overstate the take-up rate and underestimate the benefits.

4. WHAT ARE THE OPTIONS FOR WATER MANAGEMENT?

This report investigates two Options for Greater Melbourne[17] and assesses key performance indicators for each Option. Both Options are based on the same assumptions about population growth and demographics. The current water system for Greater Melbourne is considered to include water, wastewater and stormwater services for the region shown in Figure 13.

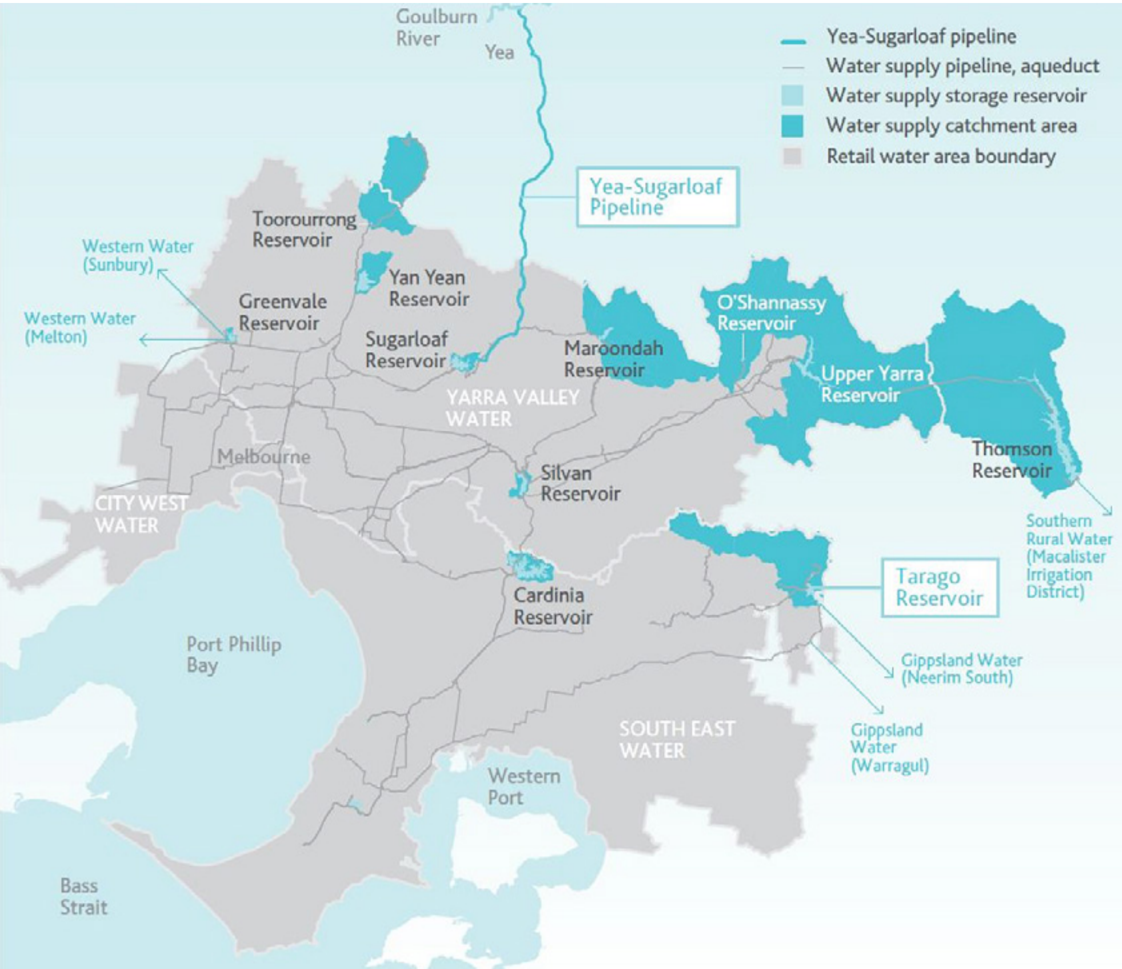


Figure 13: Water supply system for Greater Melbourne

The storage system is based on a series of large catchment reservoirs with reliance on the Wonthaggi desalination plant and the North-South Pipeline to make up any shortfall. Services are provided through a large treatment and distribution network for both water and sewage, with a third collection and distribution system for managing stormwater. There is an existing demand management component of rainwater supplies, water efficient appliances and water-efficient behaviour in the system which reduces the actual level of water demand.

Streamflow is harvested from Thomson, Yarra, Bunyip and Goulburn River catchments to supply the Greater Melbourne region and surrounding areas (Figure 13). Water from storages in these catchments is transferred to a seasonal balancing network of Cardinia, Silvan and Greenvale Reservoirs. Water from the seasonal reservoirs is then transferred to local distribution networks within the water retail areas to supply water demands in each local government area (LGA). Water demands, wastewater discharges and stormwater runoff were determined for land uses and demographics within 36 LGAs.

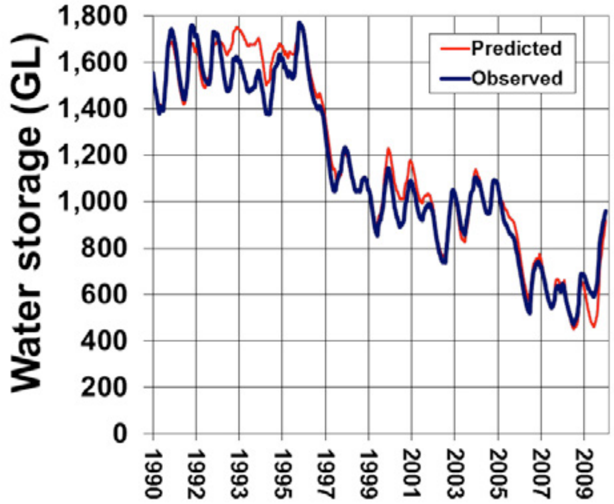
The desalination plant supplies water to Cardinia Reservoir when dam levels are less than 65%. Streamflow was harvested from the Goulburn River via the Yea-Sugarloaf pipeline to Sugarloaf Reservoir when dam levels were less than 30%. The observed effectiveness of water restrictions in the Greater Melbourne region during the 2000-2009 drought was used to develop restriction criteria and associated demand reductions for domestic outdoor demand as shown in Table 4.

[17] Greater Melbourne is defined by the supply areas of City West Water, South East Water and Yarra Valley Water. The connected regions include Western Water, Barwon Water and Gippsland Water

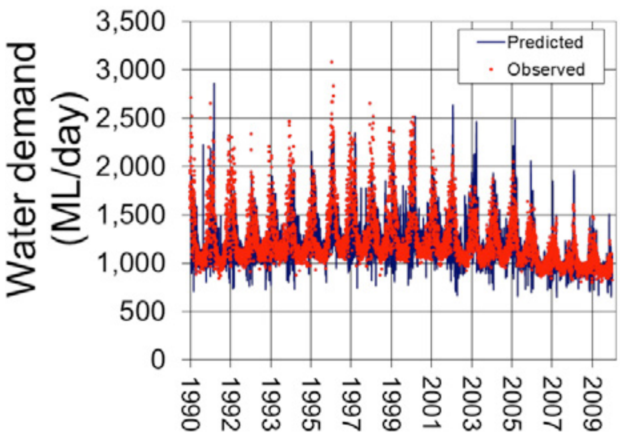
Criteria	Storage in dams less than (%)					
	60	50	45	40	35	30
Reduction in residential outdoor demand (%)	33	33	57	75	75	100
Reduction in residential indoor and non-residential demand (%)	5	10	10	15	15	20

Table 4: Water restriction triggers for residential and non-residential demands

The predictions from the System Framework were compared to observations of water cycle behaviours from the period 1990 to 2010. For example, verification of predictions of total storage volumes and regional water demands are presented in Figure 14.



Verification of predicted total storage volumes using observed data



Verification of predicted water demands using observed data

Figure 14: Verification of Predicted Total Storage Data and Verification of Predicted Water Demands

Figure 14 demonstrates that observed patterns and magnitudes of total water storages and regional water demands were successfully reproduced by the Systems Framework that uses 'bottom up' processes with detailed lot, neighbourhood and system-wide processes rather than global averages. This analysis utilised the audited costs for Greater Melbourne that were derived during the Melbourne's Water Future project and extended in current research.[18]

Option 1: Business as Usual (BAU)

The first Option is called the Business as Usual (BAU). This Option continues to apply the current approaches and technology employed for water cycle management. As demand increases Victoria will increasingly use the Wonthaggi desalination plant to support catchment storages and additional water is sourced from the North-South pipeline and additional desalination plants.

In the event of a drought, there will be community programs to encourage water-saving behaviour and increased reliance on rainwater tanks. The existing 6-star Nathers building regulations will be relied on to provide water-efficient appliances. There are no water saving targets for buildings in this Option. New and renovated building includes 3-star and 4-star water efficient appliances as shown in Table 5.

Table 5: Characteristics of appliances

Appliances	3 star	4 star	Savings (%)
Toilets	6/3 Litre flush	4.5/3 Litre flush	20
Showers	9 Litres/minute flowrate	7 Litres/minute flowrate	22
Clothes Washers	80 Litres/wash	58 Litres/wash	28

It was assumed that rainwater harvesting and 4-star appliances will be implemented at 30% of new dwellings and at 10% of renovated dwellings. The following rainwater supply assumptions were made:

- Detached housing: Rainwater captured from 100 m^2 roofs and stored in 3 kL tanks to supply toilet and outdoor uses;
- Semi-detached housing: Rainwater captured from 80 m^2 roofs and stored in 3 kL tanks to supply toilet and outdoor uses;
- Unit dwellings: Rainwater captured from 50 m^2 of roof area for each unit and stored in 2 kL of storage for each unit to supply toilet and outdoor uses.

[18] Coombes P.J., and Bonacci Water (2013), Modelling in support of the Living Victoria Ministerial Council. https://urbanwatercyclesolutions.com/melbsystems/

Option 2: Sustainable Buildings

The second Option is called the Sustainable Buildings (SB) Option. This Option includes the assumptions above but incorporates demand management into Victorian planning controls using water, stormwater runoff and energy saving targets required for all new buildings.

Water savings targets of a 40% saving in comparison to 2015 levels are required. The stormwater runoff target aims for a 30% reduction in stormwater runoff from properties as compared to the stormwater runoff from the developed site in 2015. These targets can be achieved using different solutions to suit the site constraints such as rainwater harvesting, higher levels of water efficient appliances, recycling systems and water efficient gardens. It was assumed that rainwater harvesting, more efficient appliances and water-efficient gardens will be implemented at 90% of new dwellings and at 50% of renovated dwellings. The following rainwater supply assumptions were made in the analysis:

- Detached housing: Rainwater captured from 100 m^2 roofs and stored in 3 kL tanks to supply laundry, toilet and outdoor uses, overflowing to gardens;
- Semi-detached housing: Rainwater captured from 80 m^2 roofs and stored in 3 kL tanks to supply laundry, toilet and outdoor uses, overflowing to gardens;
- Unit dwellings: Rainwater captured from 50 m^2 of roof area for each unit and stored in 2 kL of storage for each unit to supply toilet and outdoor uses, overflowing to gardens.

It was assumed that land use planning control would facilitate the upgrade of 90% of the building stock by 2050 based on annual population growth and urban renewal in each local government area without the need for expensive intervention or retrofit.

This report has used the Systems approach to compare and contrast a Business as Usual Option and Sustainable Buildings Option up to 2050 for Greater Melbourne and report on the projected outcomes based on a series of key performance indicators. The costs of rainwater harvesting and water efficient appliances were included in both options are shown in Tables 6 and 7 with further discussion in the Living Ballarat report.[19]

Table 6: Costs for rainwater harvesting

Component	Cost	Cost unit
Capital cost (residential)	3,500	$/dwelling
Capital cost (Units)	14,500	$/10 dwellings
Capital cost (non-residential)	14,500	$/building
Operating	160	$/ML
Capital and renewal - pump	650	$/building
Renewal – tank (residential)	2,000	$/building
Renewal – tank (Units and non-residential)	10,000	$/building

Table 7: Costs for water efficient appliances

Component	Cost	Cost unit
Capital cost	500	$/equivalent residential building
Operating	0	$/ML
Renewal	500	$/equivalent residential building

A design life of 15 years was assumed for pumps and water efficient appliances, and of 30 years for rainwater storages. Note that the cost of water efficient appliances is the difference in expense to upgrade to the next level of efficiency.

[19] Coombes P.J., and Barry M.E., (2014), Systems Analysis of Water Cycle Systems Economic analysis of Options and Scenarios for the Living Ballarat project. Report by the Chief Scientist. Urban Water Cycle Solutions. https://urbanwatercyclesolutions.com/ballaratregionwatersystems/

5. ASSESSMENT OF THE OPTIONS

The results for the BAU and SB options are summarised in Table 8. Note that the costs are net present values to 2050 using real interest rates of 0%, 4% and 7%.

Table 8: summary of results for the BAU and SB options to 2050 for the Greater Melbourne region

Performance Measure	Business as Usual option in 2050	Sustainable Buildings option in 2050	Associated Costs and Savings
Water Demand	48% increase	27% increase 107 GL reduction $3.3 B saving (Range: $8.9 B to $1.7 B)	BAU option requires upgrades to mains, water treatment plants, sewage treatment plants and increased operating costs across the system. SB option will require less additional system capacity and operating costs.
Additional Desalination Plant Supply augmentation	2032 and 2038	2048	BAU option projects two additional Desalination Plants of 50 and 100 GL costing approximately $1B and $2B.
North South Pipeline required	Yes	No	BAU option has additional operating transport costs associated with NS pipeline
Stormwater runoff	15% increase	2% decrease 89 GL reduction $0.4 B saving (Range: $1.2 B to $0.2 B)	BAU option has additional stormwater infrastructure costs
Reduction in flood damage	-	5% decrease $0.27 B saving (Range: $1.1 B to $0.1 B)	SB option reduces flood damages
Reduction in nitrogen loads	-	14% decrease $0.48 B saving (Range: $1.3 B to $0.3 B)	SB option improves urban stormwater quality
Increase in wastewater volume	40% increase	26% increase 64 GL reduction $1.5 B saving (Range: $4.6 B to $0.6 B)	BAU option requires additional infrastructure and operating costs

Table 8 illustrates two very different future Options for Melbourne. The Business as Usual (BAU) option creates significant increases in demand for water throughout Greater Melbourne. Additional water is sourced from regional Victoria and two additional desalination augmentations are required with associated capital and operational costs.

The Business as Usual Option results in a 15% increase in stormwater runoff with associated additional risks of flooding with discharge of pollutant loads into urban waterways and Port Philip Bay. In contrast, the Sustainable Buildings option reduces the growth in demand for water and delays the need for another desalination plant.

The Sustainable Buildings option includes rainwater harvesting and green infrastructure that substantially change the stormwater runoff regimes of Greater Melbourne. This results in reduced stormwater runoff with associated diminished flood damages and pollutant loads discharging to urban waterways and bays. This option also reduces some of the stormwater inflow to the wastewater network.

The sustainable buildings option also employs a higher level of water efficiency which reduces the growth in wastewater discharges. Sustainable Buildings also reduce net present costs to 2050 for water cycle management by more than $5.95 billion. This equates to a total cumulative saving to households, water utilities, Councils and State government of more than $16 billion to 2050.

There is a range of additional economic benefits associated with the Sustainable Buildings Option as outlined in Figures 14 and 15. The Sustainable Buildings option reduces the costs of providing water cycle services which reduce the need for increases in water and sewerage tariffs. Note that these results are presented in 2016 dollar values.

The sustainable buildings option provides a net present benefit of $1.15 billion from improved stormwater management by reducing stormwater runoff volumes by 14% (94 GL/annum), nutrient loads discharging to waterways by 17%, and risk of flood damage by 5%. This option contributes to the protection of urban waterways and bays, and to improves the amenity of urban areas.

Figure 15 shows that total annual expenses for utility bills in the BAU option increase by $1,218 m or 62% by 2050 for the Greater Melbourne region. In contrast, the utility bills only increase by $306 m or 16% in the Sustainable Buildings option. This equates to an annual saving of $912 m which can be used elsewhere in the economy. Note that this analysis has included all of the costs of water efficient appliances and rainwater harvesting.

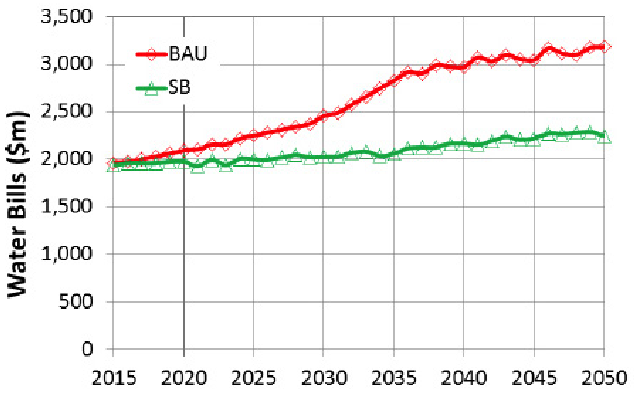


Figure 15: Total expenses paid by properties for utility bills to 2050 for Greater Melbourne (in 2016 dollars)

The Sustainable Buildings option reduces the impacts of utility bills on properties as shown in Figure 14. These figures are based on the Victorian Planning population projections of a population of 8 million by 2051 for Greater Melbourne with associated spatial estimates of new housing growth. Rates of substantial renovation of dwellings (greater than 50% housing value) that are spatially varying across Greater Melbourne from 0.12% to 1.21% per annum were also used in the analysis.

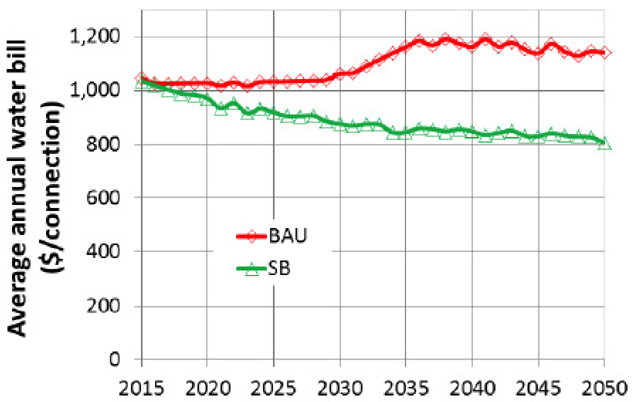


Figure 16: Total expenses paid by properties for utility bills to 2050 for Greater Melbourne (in 2016 dollars).

Figure 16 reveals that the Sustainable Buildings option reduces annual water bills across Greater Melbourne by $335 per property by 2050 via the mechanism of reduced water tariffs. This will outcome will reduce the impacts on household welfare and firms. However, these results underestimate the benefits as only regional cost savings such downward pressure on water usage tariffs was considered. Households also experience local benefits.

5.1. Household impacts across Greater Melbourne

The reduction in mains water use at dwellings will also lead to lower bills and household economic savings, and this additional benefit is outlined in Table 9.

Table 9: Local reductions in household water demand, stormwater runoff and water charges

LGA	Savings at each residential property		
	Water use (%)	Stormwater runoff (%)	Water bill ($/yr)
Banyule	47	33	245
BassCoast	50	35	254
BawBaw	52	34	251
Bayside	44	32	257
Boroondara	43	28	261
Brimbank	42	40	246
Cardinia	45	41	243
Casey	49	38	275
Darebin	45	30	222
Frankston	46	36	242
GlenEira	44	27	237
Greater Dandenong	47	32	251
Greater Geelong	38	43	264
Hobsons Bay	43	35	212
Hume	39	39	241
Kingston	46	32	230
Knox	49	35	267
Manningham	45	40	284
Maribyrnong	47	34	188
Maroondah	51	32	250
Melbourne	51	13	218
Melton	33	41	206
Mitchell	41	39	193
Monash	48	35	254
Moonee Valley	44	31	186
Moreland	44	31	220
Mornington	46	38	224
Murrindindi	50	47	235
Nillumbik	57	42	403
Port Phillip	48	15	194
Stonnington	42	23	277
Whitehorse	48	33	237
Whittlesea	41	41	245
Wyndham	43	40	205
Yarra	48	22	221
Yarra Ranges	51	33	280

A combination of the results this analysis indicate (for example) that a sustainable dwelling in Wyndham will ultimately benefit (in 2016 dollars) from $335 per annum in reduced upwards pressure in water tariffs, $96 per annum in decreased fixed and sewage tariffs, and by $205 per annum from water savings due to avoided water expenses. So a total of $636 annual benefit will ultimately accrue to households in Wyndham due to lower water and sewage tariffs and avoided water expenses realised by rainwater harvesting and water efficient appliances as shown in Figure 17.

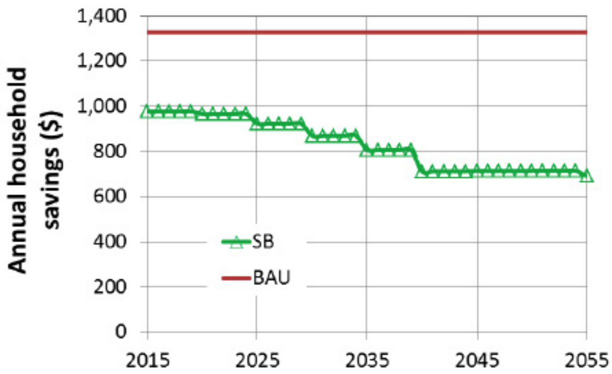


Figure 17: Timeline of direct benefits to a household in Wyndham (in 2016 dollars)

Figure 17 demonstrates that households will benefit from reduced purchases of mains water, and from lower water and sewage tariffs (in real terms) that are driven by lower costs experienced by water utilities. However, the local benefits from reduced utility costs must be passed on to homeowners via pricing decisions every five years by the Essential Services Commission as indicated by the downwards steps in SB series in Figure 17.

Alternatively, the increases in water and sewage tariffs may continue at the current rate of nearly three times the inflation rate and households will experience similar benefits to Figure 17. In either situation, the magnitude of the benefits to households that implement the sustainable building strategy will continue to grow.

We are mindful that Table 9 also reveals that households with water efficient appliances and rainwater harvesting that overflows to gardens, in Wyndham, also reduces stormwater runoff volumes by 40% and water demand by 43%. Some benefits accrue directly to homeowners but a majority of the benefits accrue to water authorities, councils, developers and state government. For example, households pay the costs of local infrastructure but there are currently no mechanisms to reward households and building owners who reduce impacts on urban waterways and Port Philip Bay.

Transfer of these benefits to households is dependent on institutions, such as Melbourne Water, accepting there are reduced impacts from sustainable buildings and passing those benefits onto home owners. This process of financial transfers can involve a government accepting less regional infrastructure from developers and relying on the transfer of these benefits via reduced prices of housing.

Recent applied economic research into market-based instruments may have established a more direct mechanism for Melbourne Water and authorities to transfer some of the benefits of mitigating impacts on waterways to sustainable households.[20] Whilst insights of these economic trials are limited by the market dominance of Melbourne Water (dominant firm oligopoly process rather than a market), the process has provided an interim market value and process for encouraging household mitigation of impacts on waterways. The cumulative costs and benefits at a household in Wyndham with the impact of a market-based instrument (MBI) of $622 for the protection of waterways are presented in Figure 18.

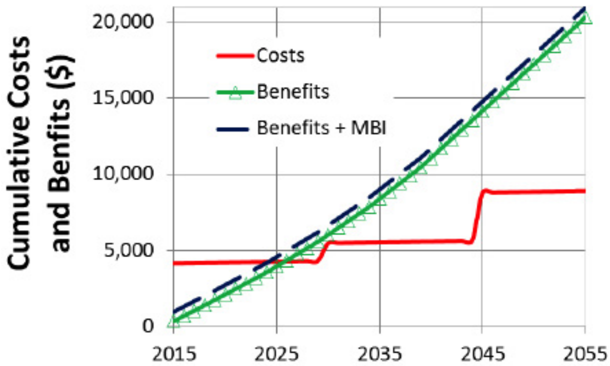


Figure 18: Timeline of cumulative costs and benefits to a household in Wyndham (in 2016 dollars)

Figure 18 demonstrates that the cumulative benefits overwhelm the costs of operating household rainwater harvesting and water efficient appliances in Wyndham. Application of the Market-Based Instrument for the protection of waterways shifts the pay-back period from 11 years to 9 years and demonstrates that additional small incentives can realise strong benefits to households. Nevertheless, our example is based on a lower rainfall location which indicates greater household benefits will apply to the remainder of Greater Melbourne. Creation of a regulated market for the sustainable buildings initiative will also create strong economic efficiencies. Acceptance of the benefits of sustainable buildings on reduced requirement for stormwater infrastructure, such as reduced size of stormwater constructed wetlands and retarding basins, should provide downwards pressure on housing prices and minimise payback periods for local infrastructure.

[20] Cheesman J., Harvey L., and Walsh C.J., (2016), Using market -based instruments to deliver cost-effective stormwater management outcomes. Stormwater2016. Stormwater Australia Conference, Gold Coast

The additional sustainable provided throughout Greater Melbourne is shown in Figure 19.

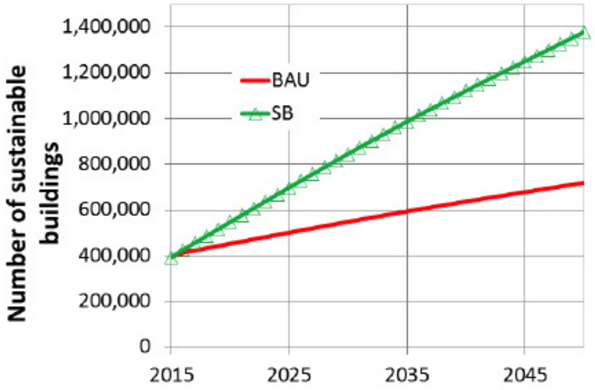


Figure 19: Timeline of sustainable buildings within Greater Melbourne

Figure 19 highlights that the Sustainable Buildings strategy will provide an additional 659,000 sustainable buildings by 2050. It is noteworthy that Kingspan data indicates that our analysis may have over-stated the number of sustainable buildings in the BAU option. The benefits of the Sustainable Buildings strategy may be greater than revealed in this investigation.

5.2. Why does the Sustainable Building option perform so well?

The consistent small variations in water use at each individual building accumulate across millions of buildings to produce a significant impact across the entire system. A reduction of a couple of litres per day at the household level reduces the demand profile for water by more than a billion litres over a year. The system costs are cumulative - the cost of water storage is added to the cost of treatment or desalination, transfers to local reservoirs, distribution to houses, transfers of wastewater, pumping stations and sewage treatment plants. This cumulative cost can be greater than $20,000/ML or $20/KL. A billion litre reduction in the use of utility water is reflected in cumulative savings in treatment, water transfers, sewage transfers and sewage treatment throughout the system.

Unfortunately, these changes also operate in reverse, small increases in demand as forecast in the Business as Usual Option can result in significant demand and cost increases across the system.

The system also operates over time. Small increases at the household level each year generate large changes in system-wide demands over longer periods. Increased demand drives incremental upgrades to the distribution system each year. Then more significant expansion of treatment plants and pipe networks are required each decade and finally major supply augmentation in a quarter of a century. Small decreases at the household level have the reverse effect, delaying the need for incremental distribution upgrades, delaying new treatment plants and avoiding the need for major supply augmentation altogether.

The Business as Usual scenario supports a level of water efficient appliances but does not require a performance target from new buildings. There is no requirement for an overall and ongoing small savings from each new building. Demand management programs are only required during in a drought situation which allows long term small increases in demand until there is a crisis.

In contrast, the Sustainable Buildings option has a subtle and powerful impact. By operating on new and renovated buildings, over time a high proportion of the building stock is upgraded while avoiding the need for expensive and invasive retrofitting. Costs of operating and implementing the option are low and largely borne by homeowners, who also enjoy the resultant savings.

Setting a performance target ensures a consistent and reliable small savings for each building generating long-term reductions in demand and costs savings compared to the Business as Usual Option. Water efficiency and rainwater harvesting provide savings or replace the use of utility water at the site which largely eliminates significant transport costs from the system. Rainwater harvesting is an efficient water supply, it is simple to collect and requires minimal treatment for use and has significant benefits for stormwater management, waterway health and reduced flood risks. By responding to a performance target rather than a regulated outcome builders are not locked into a rainwater harvesting solution and can choose other options that better suit the site context.

5.3. Combining different water sources

There are important benefits from 'modern' water management systems. Large dams, treatment plants and pipe distribution networks provide critical water security. However, when the centralised infrastructure system is combined with a decentralised supply system, both systems operate more efficiently. The decentralised system can provide local water at the point of use with little additional system costs for infrastructure, treatment or storage.

The centralised system can operate more efficiently because the overall volume and peak volumes within the system are reduced. However, if the water system relied entirely on decentralised sources such as rainwater the storage systems would need to be much larger. A 5 kL rainwater tank is sufficient in urban areas to utilise regular local rainfall, takes up minimal space and relies on the mains water system for water security. Integrated water cycle management, in this case, a combination of mains water and distributed solutions including water efficient appliances, rainwater, greywater and water efficient behaviour is more efficient than either system on its own as shown for peak water demands in Figure 20.

Figure 20 illustrates the impact of combining different water sources to change the profile of peak utility water demands.

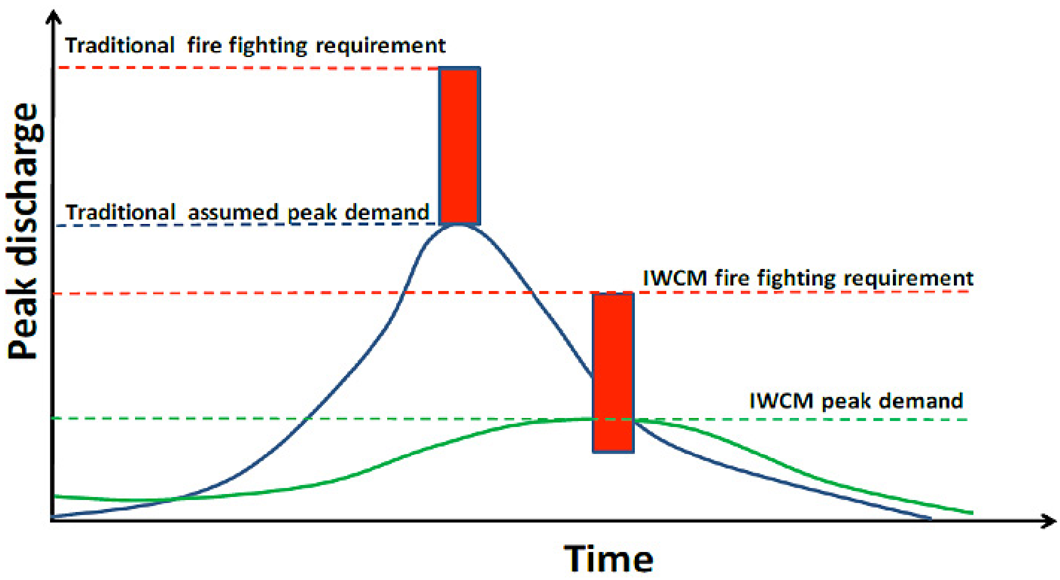


Figure 20: Changes in assumptions about peak discharges generated by IWCM strategies

6. CASE STUDY BASIX

The benefits of the Sustainable Buildings option are verified by real world experience with BASIX in NSW that has been operating since 2004.

BASIX is designed to correct for the potential failure of the market to deliver socially optimal investment in energy and water efficiency, at the time that a residential dwelling is constructed. The market failure arises because[21]:

- often the party responsible for the design and construction of a dwelling differs from the ultimate dwelling resident and so sub-optimal trade-offs between upfront capital costs and ongoing operating costs are made – the so-called "split incentives" problem;
- there is a lack of information about the opportunities for cost-effective investment in water and energy efficiency measures as part of the construction of a dwelling;
- water and energy prices do not (currently) adequately include the cost of environmental (and other) external impacts; and
- of a lack of access to finance to fund cost-effective energy or water efficiency investments.

The Building Sustainability Index is a NSW State Environmental Planning Policy that applies to all buildings in NSW and requires developers to meet targets for water and energy savings based on carefully researched local climate data. BASIX is non-prescriptive which allows applicants a choice of technologies and design measures to achieve targets, and there is more than one pathway to achieve the target. BASIX mandates a performance outcome rather than a solution.

Houses must demonstrate up to a 40% water saving and 40% reduction in greenhouse gas emissions based on 2004 average household water and energy use for that area. Average water use in 2004 in NSW was 90,000 litres per person so this represents an annual saving of 86,000 litres for a household of 2.4 persons. Roof area, building materials, window areas and the number of bedrooms used by the tool to calculate water and energy use. Four key factors are used estimate rainwater tank efficiency and therefore calculate their 'score' in BASIX; local rainfall, connected catchment (roof area), the size of the tank, and number and type of connected water uses (demand).

BASIX integrates water and energy use with long-term land use planning. All residential planning and building permits must be accompanied by a BASIX certificate certifying the targets have been met. Targeting new houses and renovations incrementally upgrades all residential building infrastructure over time

6.1. Outcomes to date

More than 417,000 sustainable buildings have been approved up to 2016. Sydney saves 93 billion litres each year from rainwater harvesting and water efficient appliances (Figure 7). However, Sydney also had 127,000 homes with rainwater harvesting in 2007 and a substantial number of houses with water efficient appliances as a result of initiatives prior to the BASIX policy. Sydney's annual utility water use was about 530 GL for 2015-16 with rainwater harvesting and water efficient appliances providing a 15% saving on Sydney's annual consumption. More than 90% of BASIX applicants choose a rainwater tank to meet water saving targets

The NSW State government calculated nett benefits of household savings between $225 million and $1.1 billion from 2010 to 2050. The cost of compliance was estimated between $1,000 and $22,000 in 2009 per detached dwelling. However the upper bound was influenced by the high cost of solar panels to achieve energy efficiency on larger dwellings. The NERA report found that the net cost to the homeowner was negative as energy and water savings exceeded the initial cost.18 Nevertheless, these results did not include regional cost savings and underestimated the benefits across the Greater Sydney region.

Analysis of the comprehensive water use and demographic data underpinning the ABS environmental series and the BASIX policy has allowed an exhaustive evaluation of the wider benefits of the program. These benefits include improved water security, reduced utility operating costs, diminished impact on household affordability and diminished impacts on waterways for the Sydney region. This analysis suggests that BASIX has provided in excess of $4B of cumulative benefits to Greater Sydney region. A broader interpretation of these results is that the full benefits of demand management interventions are not fully understood.

The change in operating costs of major utilities in NSW is compared to the operating costs of Victorian, Queensland and the average of all major utilities outside of NSW in Figure 21. This data on operating costs was sourced from the national performance reports published by the Bureau of Meteorology and the National Water Commission.

[21] Nera economic consulting, (2010), BASIX Post-Implementation Cost-Benefit Analysis
An Economic Evaluation of the State Environmental Planning Policy- Building Sustainability Index (BASIX) A Report for the Department of Planning

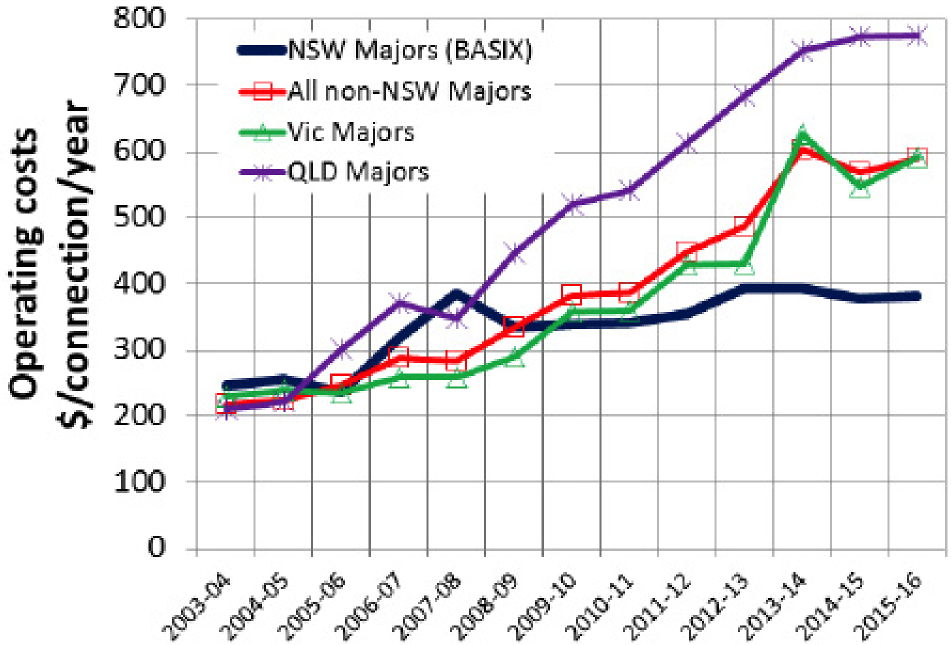


Figure 21: Water operating costs for major utilities

Figure 21 shows that the growth water operating costs is significant for South East Queensland (267%), Victoria (157%) and for the average of all major utilities outside of the NSW (171%). Major utilities in Adelaide (140%) and Perth (77%) have also experienced significant growth in water operating costs.

In contrast, the growth in water operating costs of NSW major utilities (55%) is substantially less than the other areas. The significant impact of dependence on water grid infrastructure (long pipe transfers between regions) in South East Queensland seems to be driving the highest growth in costs whilst the BASIX policy for sustainable buildings is driving the smaller increases in utility operating costs.[22]

6.2. Victorian Building Regulations regarding Water Efficiency

The Victorian Building Authority requirements for Water Efficiency are presented for comparison purposes. The Victorian Building Authority[23] specifies that new dwellings (Class 1 buildings) require:

– A rainwater tank receiving rainfall from a minimum catchment area of 50 square metres and having a minimum capacity of 2,000 litres connected to all toilets in the building for the purpose of sanitary flushing, or

– A solar water heater system (which may include a heat pump water heater system) installed in accordance with the Plumbing Regulations 2008.

In either case, documentation must be provided to the relevant building surveyor to ensure compliance. For new Class 1 buildings, the applicant must separately provide details of any rainwater tank or solar water heater system, including size and location of a rainwater tank and the type and size of solar water heater system to be installed. There is provision for acceptable alternatives to rainwater harvesting including greywater or recycled water.

There is some provision for water efficient appliances through the Watermark registration required through the National Plumbing Code of Australia[24], however, Victoria does not appear to have implemented a system for specifying water efficiency rates for showers, tapware and appliances as required in Western Australia and New South Wales.

However, the impact of this regulation is distorted by the federal subsidy for solar hot water systems which reduces the take up for rainwater harvesting systems. In addition, the minimum capacity of the rainwater tank is all that most builders will provide, limiting the rainwater harvesting benefits that might have been achieved from larger rainwater tanks.

[22] Coombes P.J., Smit M., and MacDonald G., (2016), Resolving boundary conditions in economic analysis of distributed solutions for water cycle management. Australian Journal of Water Resources, Vol 20, 11-29.
[23] Practice Note 2014-55 Issued July 2014
[24] Phone conversation with Victorian Building Authority, 19 April 2017

7. BENEFITS OF RAINWATER HARVESTING

Rainwater Harvesting is only one element of an integrated water cycle management approach. However, rainwater harvesting is an integrated solution as it creates synergies that have a cumulative effect across the entire system.

Rainwater Harvesting is an existing and widely adopted technology. Over 5.1 million Australians own a rainwater tank and rainwater provides 67% of residential water supply outside our capital cities and while this report does not require drinking of rainwater, over 3 million Australians do so every day.

Considerable attention has recently been given to rainwater harvesting design specifications by the Rainwater Harvesting Association of Australia and Urban Water Cycle Solutions building on the previous work done by RHAA on the Australian Rainwater Harvesting Standard HB230. The specifications recognise rainwater harvesting as an integrated system including roof collection, storage, pumps and bypass designs. Clear design guidelines assist in achieving desired outcomes in water quality and rainwater harvesting yields.

Rainwater harvesting significantly reduces utility water use. A well-designed house with water efficient appliances and with rainwater supply connected to the toilet, outdoor and clothes washers will save about 90,000 litres of potable water each year. Rainwater supplies to toilets and washing machine provide fairly constant reductions in demands for utility water. The CSIRO estimates of annual savings of closer to 40,000 litres only consider rainwater harvesting, not water efficient appliances, and are benchmarked against the general population that includes greater than 30% of houses with rainwater harvesting which artificially under-estimates actual savings.

Rainwater harvesting reduces stormwater peak flows and total volume as discussed below in Stormwater Management. This improves urban stormwater quality and waterway health. It reduces the cost of infrastructure to manage stormwater, the amount of land required for wetlands and reduces the cost of flooding. In a drought situation, rainwater harvesting continues to provide water long after all runoff into dams ceases. Rainwater harvesting is, therefore, climate change resilient for both droughts and intense rain events.

Rainwater harvesting is a local solution that generates local jobs. Australian companies dominate tank and pump construction, local builders and plumbers install rainwater harvesting systems and maintaining rainwater harvesting systems is a growing industry. A study in South East Queensland estimated an additional 800 jobs would come from water saving targets on new buildings.[25]

7.1. Understanding Catchment Behaviour – Rainwater Harvesting continues long after the dams have stopped filling

One of the issues recognised during the millennium drought was the impact of increased temperatures on reducing runoff from dam catchments. As temperatures have increased over the last two decades the behaviour of our traditional catchments has changed. Catchments are dryer and soils absorb more water before runoff occurs. More rainfall is required before stream flow into the dam is achieved. Coombes and Barry estimated that catchment runoff was unlikely not occur if annual rainfall was below 500 mm.

In contrast, rainwater harvesting from impervious roof catchments provides reliable runoff even from small rainfall events of a few millimetres. Rainwater harvesting continues to provide reliable water supply long after the dam catchment has dried up. In a climate change scenario, the benefits of rainwater harvesting over traditional catchments improve even further as shown in Figure 22.

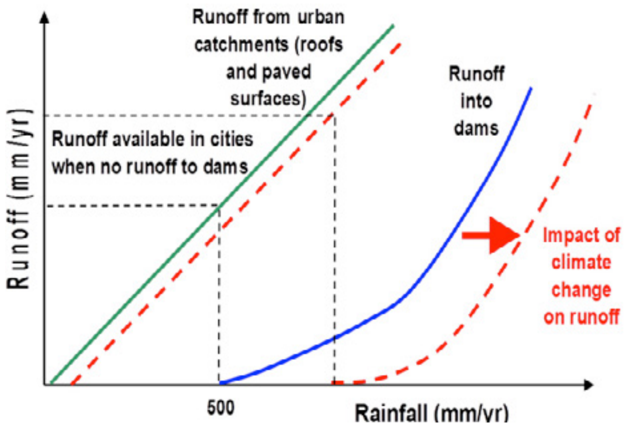


Figure 22: Runoff from traditional catchments vs runoff from rainwater harvesting (Coombes and Barry, 2005)[26]

[25] Coombes P.J., Smit M., and MacDonald G., (2016), Resolving boundary conditions in economic analysis of distributed solutions for water cycle management. Australian Journal of Water Resources, Vol 20, 11-29.
[26] Coombes P. J., and Barry M. E., (2008), The relative efficiency of water supply catchments and rainwater tanks in cities subject to variable climate and the potential for climate change, Australian Journal of Water Resources, 12 85-100

Does it rain in urban areas during a drought?

The monthly rainfall at the Melbourne Botanic Gardens from 2000 to 2016 is presented in Figure 23. A 12-month trend line shows that average monthly rainfall remained above 30 mm during each month.

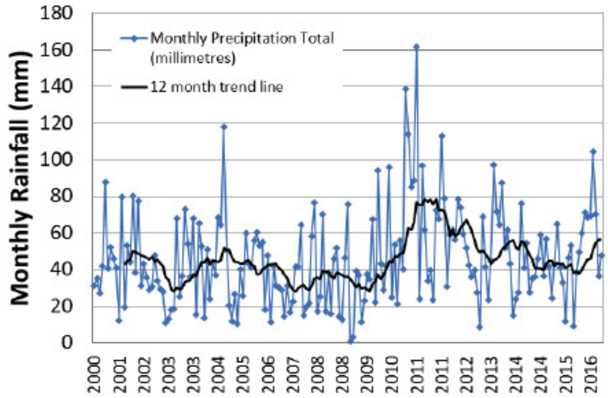


Figure 23: Melbourne Botanic Gardens Monthly Rainfall 2000-2016

Figure 23 illustrates that during the worst phases of the Millennium drought reliable average monthly rainfall of greater than 30 mm was achieved. This would provide at least 3000 litres each month from a 100 m^2 roof.

However, as shown in Figure 24, average annual rainfall depths vary across the Greater Melbourne region and the rainfall at the Melbourne Botanic Gardens experiences relatively low rainfall depths. Higher rainfall yields are available at many other locations.

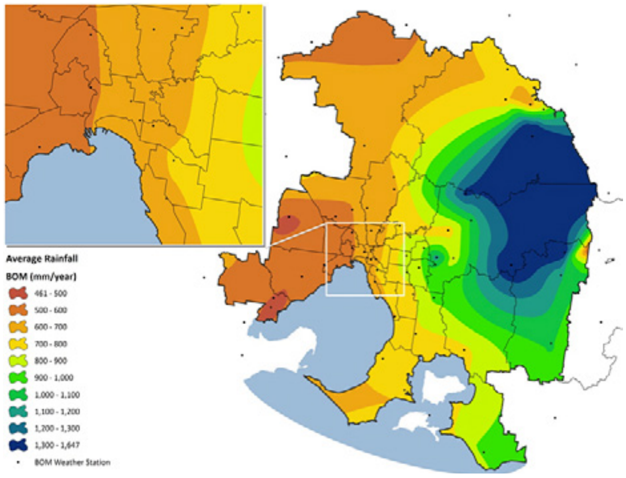


Figure 24: Average annual rainfall depths for Greater Melbourne

8. STORMWATER MANAGEMENT

Rainwater harvesting implemented through the Sustainable Buildings option reduces stormwater peak flows and the total volume of stormwater runoff because in real world case studies (BASIX) 90% of builders choose a rainwater tank to achieve water saving targets. This improves water quality and waterway health. It reduces the cost of infrastructure to manage stormwater, the amount of land required for wetlands and reduces the cost of flooding. The expected reductions in stormwater runoff are provided in Figure 25.

Figure 25 illustrates spatial distribution of stormwater runoff reductions as a result of a Sustainable Buildings option modelled in 2012. The majority of LGAs in greater Melbourne experienced a 30% stormwater reduction through the Sustainable Buildings Option. In the current assessment used in this plan, the net present stormwater savings from the Sustainable Buildings Option vs the Business as Usual Option for flooding, infrastructure and reduction of nutrients were over $1.15 billion to 2050.

The sustainable buildings option contributes to stormwater management, protection of urban waterways and amenity with urban catchments by reducing stormwater runoff volumes, nutrient loads and risks of flood damage.

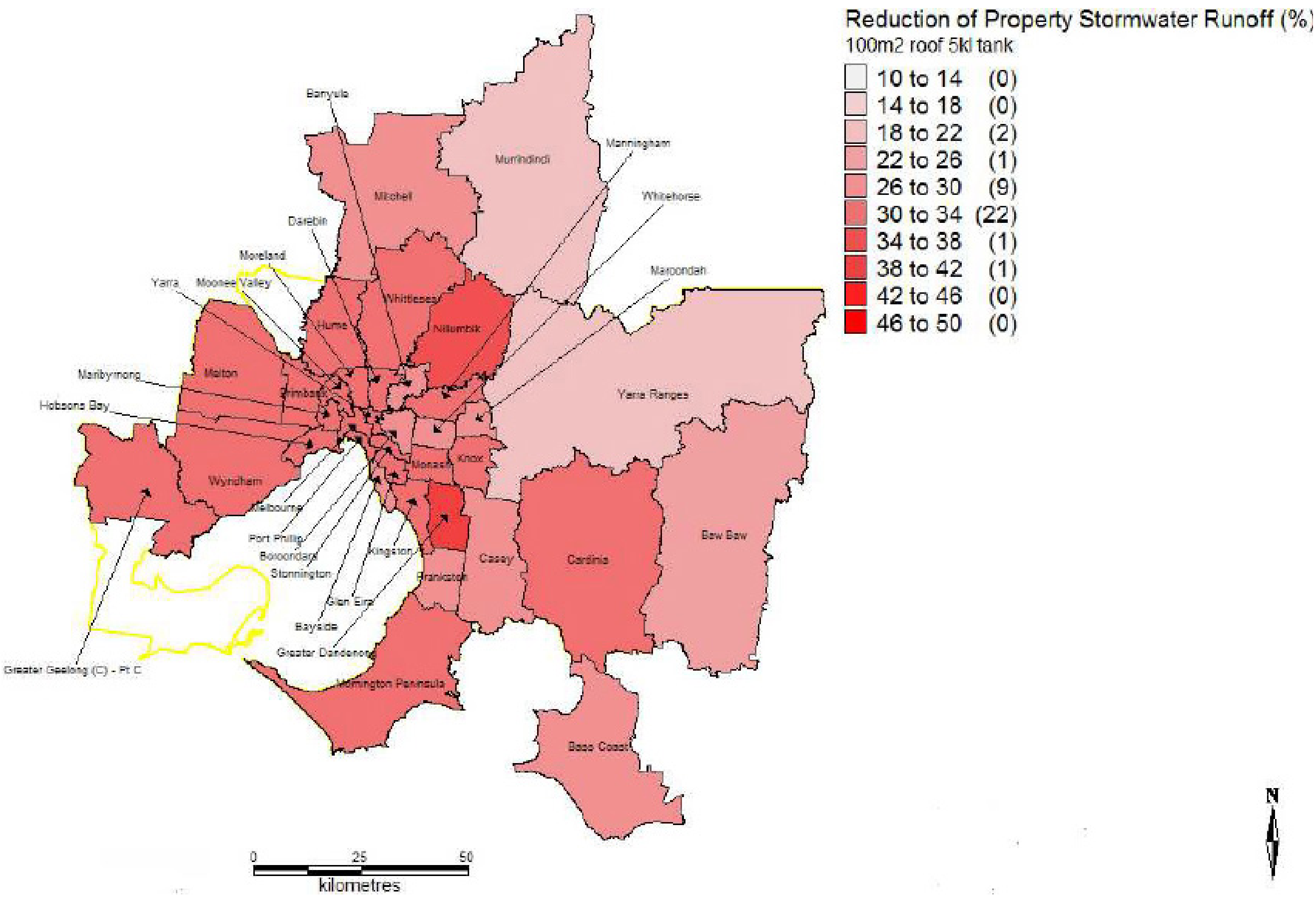


Figure 25: Reduction of property stormwater runoff

9. MANAGING DEBT AND RISK

9.1. Managing Debt

The historical increases in marginal cost outlined in Section 3.3 have far-reaching implications. Additional demand for water has a multiplier effect throughout the centralised infrastructure system through supply, treatment, distribution and wastewater systems in both capital and operational costs. Historically over a 15 year period, the additional 2% of water use resulted in costs of $77/kL for water services and $174/kL for total water services. If this trend continues then each additional unit of water, currently being charged at a variable rate of $3.60/kL will result in additional system costs of over $100/kL in increased capacity and operating costs in the medium run. This economic data spans 15 years of activity and can be expected to provide a reliable assessment of the actual situation.

These results are driven by major infrastructure upgrades and operating costs. Governments are required to hold higher debt levels until increased water charges can pay off the debt. Following the millennium drought, South East Queensland invested in the Tugun desalination plant, the Western Recycling Plan and the creation of an SEQ water grid. SEQWater, the bulk water provider, now has a debt of over $9B and a debt asset ratio of 0.85, over half of all revenue is required for interest payments. The Queensland government did implement a version of the Sustainable Buildings legislation but reversed it in 2012.

9.2. Risk Management

There are some existing elements of the Greater Melbourne urban water system that present a potential risk for water managers. Figure 11 and Table 3 show that rainwater harvesting, water efficient appliances and water saving behaviour is reducing potential demand in greater Melbourne by 125GL. If the current levels of rainwater harvesting, water efficient appliances, greywater and behaviour are not supported and promoted then demand could significantly increase without any increase in population. The resultant 125 GL increase in demand would require an additional desalination plant.

The Business as Usual Option projections in this report did not include an allowance for a Water Grid which is an option that has been adopted in Queensland and this would add considerable infrastructure and operational costs to the network.

9.3. Climate Change Risk

The Australian Prudential Regulation Authority (APRA)[27] provided a legal opinion that company directors who fail to properly consider and disclose climate-related risks to their companies could be held personally liable. If a similar argument were applied to government policy than a rigorous analysis of climate related risk would be applied to water policy. APRA noted the practice and expectations of corporate governance are moving beyond mere documentation of static metrics towards robust, scenario-based thinking about risks as the new standard for risk management. This expectation is consistent with the Systems Approach outlined in this Water Plan.

9.4. Climate Change Scenario testing of the Business as Usual and Sustainable Buildings Options

The Alternative Water Plan modelling of both scenarios also included the latest climate change projections of the IPCC.[28] Climate change is expected to reduce annual rainfall and associated runoff whilst generating more intense rain events.[29] This will increase the challenges of providing secure water supplies and mitigating urban stormwater runoff. In this situation, the capacity of ageing stormwater network or increased runoff from increasing development density can be supplemented by source control measures and integrated solutions. Integrated solutions and flexible approaches to design can avoid costly replacement of existing infrastructure. The following insights resulted from the analysis – the Greater Melbourne region will experience:

- Increased temperatures
- More intense rain events
- More frequent droughts
- Lower streamflow volumes

[27] http://www.apra.gov.au/Speeches/Pages/Australias-new-horizon.aspx
[28] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.
[29] Wasko, C. and Sharma, A. (2015), Steeper temporal distribution of rain intensity at higher temperatures within Australian storms, Nature Geoscience, 8(7), 527 - 529.

Low and high emissions climate change scenarios were examined where low emissions was defined as an annual change in daily average temperature of 0.025°C and high emissions were defined as a 0.05°C annual change. These climate change scenarios resulted in the following changes in the need for augmentation using desalination to:

- For BAU:
  - High emissions: 2020, 2026 and 2045
  - Low emissions: 2021 and 2036
- For SB:
  - High emissions: 2029 and 2045
  - Low emissions: 2041 and 2050

The high and low emissions climate change scenarios are also expected to increase the net present costs of the BAU option by 16% and 12% respectively. In contrast, the SB option is expected to experience increases in net present costs for high and low emissions scenarios of 10% and 5%.

The proposed Sustainable Buildings option also mitigates some of the expected climate change impacts on the economics of the water cycle for Greater Melbourne. This is the subject of our ongoing investigations and will be reported in the next version of this alternative water plan.

10. CONCLUSIONS

The Alternative Water Plan presents an alternative to the current water services model for Melbourne. It utilises independent systems analysis from Professor Peter Coombes.

The Systems Approach analysis underlying the Alternative Water Plan is robust, scenario-based evaluation of all the cumulative costs and transfers with the Greater Melbourne Area up to 2050. The analysis represents the whole of society values including households, water utilities, government and the environment.

Only two options were assessed using the Systems Approach, the Business as Usual Option and the Sustainable Buildings Option. Many other Options exist.

Buildings and Households drive water use demand and water expenditure. Modifying building design transforms water and energy use, and stormwater runoff at every scale, from household to regional. The impacts of small household changes are cumulative and significant at the metropolitan and long term scale.

The Sustainable Buildings Option is verified by real world implementation and benefits in NSW resulting in an estimated $4B saving since 2004.

The Sustainable Buildings Option has projected cumulative benefits of over $16B up to 2050 taking into account costs, benefits, loss of revenue at household, utility and government scales.

Kingspan Australia would be interested to discuss these results with a broad range of community stakeholders.

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