TRANSITIONING MELBOURNE TO A WATER SENSITIVE CITY

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ABSTRACT

Melbourne is experiencing a water crisis that is predicted to worsen as its population surges, urbanisation continues and the impacts of climate change manifest themselves. Attempts to address this issue by the government are underway (e.g. desalination plant), but current inquiries into the city’s long term water supply suggest that as early as 2025, Melbourne will need additional water supplies, irrespective of these measures to secure more water for the city. Contemporary research suggests that in order to address the uncertainty regarding the city’s water supply, an alternative approach to current methods of supplying, managing and using water is required (Allan et al. 2010, City of Melbourne 2008, Environment Victoria 2009 and Wong & Brown 2008).

The concept of a water sensitive city is gaining momentum as a necessary adaptation for Melbourne to increase its resilience to future uncertainty, by providing diverse infrastructure associated with the harvesting, treatment, storage and delivery of water. Proponents of this concept argue that the transition of Melbourne to a water sensitive city is a critical step in addressing the city’s future water security, as well as the health of the built and natural environment.

The city of Darebin, a medium growth municipality in the north of Melbourne, was chosen as a case study to test whether infill residential development within the municipality is assisting in transitioning Melbourne to a water sensitive city. To determine if this was occurring, two key ‘water sensitive’ indicators, namely potable water reductions and stormwater quality impacts were analysed. Under Darebin’s Sustainable Design Assessment in the Planning Process (SDAPP) program, residential development applications are requested to undergo a Sustainable Design Assessment (SDA), using an Ecologically Sustainable Design (ESD) assessment tool called Sustainable Tools for Environmental Performance Strategy (STEPS) to predict their environmental performance. The tool assesses and benchmarks performance across five key themes in sustainable building. Two of these themes aligned with the water sensitive indicators used within the research. To answer the research question, both storm and potable water data obtained from Darebin City Council’s SDAPP program was collated and analysed for two development types (units and apartments), and according to a series of density categories (low, medium and high).

This research will examine whether these key indicators in infill residential development are assisting as predictors of whether Melbourne has indeed embarked on this transition to a water sensitive city.
The state government’s aspirational target for a 25% reduction in potable water was viewed as commendable but, in terms of the research, it was considered to be a minimum performance benchmark. The research benchmark for the potable water indicator was set at 40% based on contemporary research and commentary in relation to this indicator (Alternative Technology Association, Australian Conservation Foundation Environment Victoria, Friends Of the Earth and Moreland Energy Foundation Limited, 2009).

The research found that the 65% of the dwellings in both the low and high density unit developments categories were achieving the state government’s aspirational target for a 25% reduction in potable water consumption. However, 64% of the dwellings in the medium density category failed to achieve this target. There were only insignificant numbers in both the low (5%) and medium (6%) density categories that were achieving potable water reductions of 40% or more. However, this differed in the high density category where 44% of the dwellings were achieving potable water reductions of 40% or more. This anomaly was attributed to reduced landscaping and dwelling sizes and hence potable water demand (STEPS tool calculations).

Within the apartment development category, dwellings in all three density categories achieved the state government’s aspirational target for a 25% reduction in potable water consumption (low - 83%, medium - 64% and high - 84%). Again the number of dwellings that achieved potable water reductions of 40% or more was insignificant within the low (13%) and high (none) density categories. However, within the medium density category 33% of the dwellings achieved potable water reductions greater than 40%.

Therefore, it was concluded that both unit and apartment infill development in Darebin were not assisting Melbourne’s transition to a water sensitive city when measured against the research’s benchmark for the potable water indicator.

The second indicator used in the research was stormwater performance. The water sensitive benchmark for stormwater was the STEPS stormwater target score of a 75% reduction in nitrogen. The STEPS stormwater score for this indicator is based on the Best Practice Environmental Guidelines stormwater objectives.

The research found that unit developments are performing dismally in relation to the water sensitive benchmark set for stormwater. Across the unit development density categories high proportions of planning applications failed to meet the STEPS stormwater score (low - 67%, medium - 81%, high - 56%). Apartment developments performed better with 67% of all apartment applications across each
density category achieving the STEPS stormwater score. This result was in part attributed to Darebin’s SDAPP program and strengthens the argument raised in section 7.1 on the role of ESD assessment tools in influencing better environmental outcomes in urban development.

Of the developments that failed to achieve the STEPS stormwater score it was found that they performed extremely poorly. Within the unit development category the majority of applications failed to achieve STEPS stormwater scores greater than 10% - (low-25%, medium -61% and high 44%). Within the apartment development category 33% of all applications failed to achieve a STEPS stormwater score greater than 10%.

The research results also showed that rainwater tank use had a strong relationship with increased potable water reductions and stormwater quality performance. Therefore, the research supports the commonly accepted notion that rainwater tanks promote both potable water reductions and improved stormwater quality outcomes. However, in the unit development category there were instances where tanks were used but the STEPS stormwater score was not achieved. This implies that when rain water tanks are used to fulfil the 5 star standard requirement, the specified minimum capacity (2,000 litres) and area of roof connected to the tank (50sqm) may not be enough to achieve the STEPS stormwater score (BPEG objectives).

The stormwater results and conclusions for unit developments suggest that the VPP Clauses 54.03-4 and 55.03-4 and Standards A6 and B9 governing the stormwater performance of infill residential development cannot deliver best practice stormwater quality outcomes. This is cause for concern because these clauses are used to assess the stormwater performance of all infill residential development within nearly all of Melbourne’s municipalities. Although apartment developments performed better than unit developments in relation to stormwater they did not consistently achieve the STEPS stormwater target. Consequently, it was concluded that both unit and apartment developments in the city of Darebin are not aiding Melbourne transition towards a water sensitive city when measured against the research’s stormwater indicator.

Overall, the research demonstrated that infill residential development in Darebin is failing to assist Melbourne transition to a water sensitive city when assessed against the two water sensitive indicators.
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1 INTRODUCTION

1.1 Australia and water

Australia is experiencing a growth in population and escalating urbanisation whose demands are stretching the capacity of infrastructure, social and natural resources. Compounding these pressures is climate change, a wild card phenomenon whose global and local effects are already being experienced, but whose extent cannot be fully known. Within this context, water security looms as a key challenge for Australian cities.

Australia is the driest inhabited continent on earth, yet its water footprint is one of the highest in the world (see Figure 1.1). Australia's average water footprint is 1393 m$^3$/capita/year and the global average water footprint is 1243 m$^3$/capita/year (Water footprint Network, 2010).

Figure 1.1 - World water footprints

Australia’s large water footprint can, in part, be attributed to post-industrial approaches to water supply, usage and treatment.

1.2 Melbourne’s water crisis

Melbourne is facing a water crisis. The city is almost completely dependent on rivers for its water supply, but inflows to reservoirs have declined dramatically over the past decade due to the combined impacts of drought, climate change and natural variability of climate (DSE, 2008). This unsustainable extraction of water over many years has left Victorian rivers stressed and degraded, with many systems facing collapse (State of the Environment Report, 2008). Yet demand on Melbourne’s dwindling water supplies is only set to grow. By 2036 Melbourne’s population is expected to top 5.5 million people, an increase of 1.8 million that will serve to exacerbate Melbourne’s urban sprawl (Munro, 2009).

Melbourne’s continued urbanisation poses another water related problem. Rapid urbanisation is synonymous with increases in impermeable surfaces, as more buildings and infrastructure are built. An increase in impermeable surfaces causes higher run off rates that create potential flooding and pollution that directly impact on the built environment and health of receiving waters - in this case, Melbourne’s rivers and bays.

To address the water security issues posed by the pressures of a growing population, drought and climate change, as well as the detrimental storm water impacts of urbanisation, Melbourne needs to make a fundamental shift away from a ‘water supply city’ towards a ‘water sensitive city’. A water sensitive city uses integrated water management strategies to ensure that water is supplied, used and disposed of sustainably. A water sensitive city incorporates better resilience to future uncertainty by providing diverse infrastructure associated with the harvesting, treatment, storage and delivery of water. Therefore, transitioning Melbourne to a water sensitive city is a critical step in addressing the city’s future water security and health of the built and natural environment.

1.3 Research question

This research sought to gauge whether infill residential development within Melbourne is responding to the city’s water crisis and the stormwater impacts of continued urbanisation. To rationalise the scope of
the research, the city of Darebin, a medium growth municipality in the north of Melbourne, was chosen to test if infill residential within the municipality is assisting Melbourne transition to a water sensitive city. To determine if this was occurring, two key water sensitive indicators were used to assess the performance of infill residential development within Darebin. These two indicators were potable water use and stormwater performance. The research established benchmarks for each of these indicators to enable data gathered from Darebin’s Sustainable Design Assessment in the Planning Process (SDAPP) program to be analysed. This analysis would be used to answer the research question –

Are infill residential developments in the city of Darebin adequately transitioning Melbourne to a water sensitive city?

To answer the research question, a series of sub-questions informed by Victorian state government policies and contemporary concepts and commentary relating to each of the indicators were posed. These sub questions were:

- Are infill residential developments within the municipality of Darebin achieving a 40% reduction in potable water?

- Are the permeability objectives contained in Clauses 54.03-4, 55.03-4 and Standards A6 and B9 of the Victorian Planning provisions achieving best practice stormwater quality outcomes?

- Are Darebin’s local policies 22.09 and 22.10 and in particular under 22.09-3.1, 22.10-3.1 Sustainability and 22.09-3.12, 22.10-3.12 Utility Services achieving best practice stormwater quality outcomes? (Refer to Appendix 3)

The research viewed a 40% reduction in potable water use and the best practice stormwater quality objectives as the necessary water sensitive targets that infill residential developments within Darebin should meet to assist Melbourne transition to a water sensitive city. For a discussion of the legislative limitations refer to chapter Error! Reference source not found.

1.4 Thesis overview

Chapters 2-7 provide the context of the research. They identify the macro and micro issues facing the state of Victoria and city of Melbourne and highlight the importance of the research. The sequence of the chapters has been structured to provide both theoretical and contextual insight into the research
topic. As the chapters progress the level of detail increases as they approach the research focus. **Chapter 2** introduces the concept of Ecologically Sustainable Development (ESD), the overarching framework of the research. It provides a working definition of ESD and briefly outlines the impacts associated with the built environment and the challenges facing Melbourne. **Chapter 3** examines the potential impacts of climate change on the state of Victoria, particularly in relation to its water systems. **Chapter 4** outlines the water security issues facing Melbourne and presents the government's plan to address them. This is followed by an in-depth discussion of current inquiries into Melbourne's water supply and long-term projections. The chapter finishes by presenting Environment Victoria's alternative plan to addressing Melbourne's water crisis, one that is based on the concept of a water sensitive city. **Chapter 5** presents the concept of a water sensitive city, the theoretical driver for this research. It details the key elements of the concept and identifies the two water sensitive indicators used to test the research question. **Chapter 6** summaries how the built environment is governed within the state of Victoria and details which regulations govern the stormwater performance of infill residential development. The chapter concludes by exposing the weaknesses and loopholes that currently exist in the implementation of these regulations. **Chapter 7** introduces the role of ESD assessment tools in urban development and highlights the local debates on their use within the planning regulatory framework. The chapter presents some local precedents of the use of ESD assessment tools and closes with a description of the Sustainable Design Assessment in the Planning Process (SDAPP) program being used by Darebin and other metropolitan Melbourne councils as a means of assessing the environmental performance of development applications. **Chapter 8** then introduces the research method. It deconstructs the research question by creating a series of sub-questions related to each of the water sensitive indicators used to gauge the water sensitivity of infill residential development in Darebin. A detailed discussion of how the ESD assessment tool Sustainable Tools for Environmental Performance Strategy (STEPS) works is carried out and performance benchmarks for the research's two water sensitive indicators are established. The chapter then defines the two development types and density categories that were used to analyse the research data. **Chapter 9** presents the research results for each water sensitive indicator according to the defined development types and densities. **Chapter 10** combines the discussion and conclusion of the research and presents them under each water sensitive indicator. **Chapter 11** outlines some of the limitations inherent in the legislative framework allowing Melbourne to transition to a water sensitive city. **Chapter 12** offers some recommendations for action and identifies a potential avenue for further research.
2 ECOLOGICALLY SUSTAINABLE DEVELOPMENT (ESD)

This chapter establishes a working definition for sustainability that will be used throughout the research. The impacts of the built environment and its critical role in achieving sustainability outcomes will also be presented. Melbourne’s historical and projected physical and population growth will also be presented to illustrate how the city has, and is, evolving. The environmental issues facing the state of Victoria will be briefly outlined and water resources will be identified as the focus of the research. The chapter will conclude by highlighting the intrinsic link between the water resource issues facing Melbourne and the effects of climate change that will be discussed in further detail in chapter 3.

2.1 Defining ESD

The concept of sustainability forms the overall context for the research being undertaken, therefore, a working definition of sustainability needs to be established. The term ‘sustainability’ in its modern sense is said to have ‘...emerged in the early 1970s in response to a dramatic growth in understanding that modern development practices were leading to worldwide environmental and social crises.’ (Wheeler, 2004, p.19)

The most commonly accepted definition of sustainable development is found in the ‘Brundtland Report’, the 1987 Report of the World Commission on Environment and Development. It defines sustainable development as:

Development that meets the needs of the present, without compromising the ability of future generations to meet their own needs (Brundtland Commission, 1987).

Australia uses the term Ecologically Sustainable Development (ESD) which is defined in the 1992 National Strategy for ESD as:

Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (Australian Government, 1992).

Ecologically sustainable development, environmentally sustainable development, sustainability and sustainable development are all terms that are now widely used by all sections of society. They all share
and express a common sentiment and, in many cases, the words are interchangeable. Therefore, these words will be used interchangeably throughout this research using the Australian definition of ESD.

2.2 ESD and the built environment

The built environment is the physical manifestation of urbanisation and is the focal point for development and consumption. Globally, the built environment is responsible for approximately:

- 30% of the raw materials used;
- 42% of the energy used;
- 25% of water used - Global water consumption has risen almost tenfold since 1900;
- 12% of land use;
- 40% of atmospheric emissions;
- 20% of water effluents;
- 25% of solid waste; and
- 13% of other releases.


The built environment is one of the primary causes of environmental degradation, resource depletion and climate change. This is being exacerbated by the fact that today over half the world's population of six billion people now live in urban centres, with this trend projected to continue (Hall et al. 2000). Australia matches this trend with a population that is highly concentrated in urban centres. Nearly two-thirds (63.9 per cent) or 13,687,640 people were living in the capital cities in June 2008 (ABS 2009a). The majority of Australian people live in large cities of 1 million or more people. As shown in Figure 2.1, the proportion of the Australian population living in cities of between 1 and 3 million people is 22 per cent, while 39 per cent of Australians are living in cities of more than 3 million people. In contrast, almost 70 per cent of Europe's total urban population live in medium and smaller sized cities of fewer than 500,000 people (UN-HABITAT, 2008).
Figure 2.1 - Population distribution, Australia 2008

For these reasons, reducing the negative environmental impacts of our built environment is an integral component in the ESD agenda in Australia. Consequently, strategic and legislative frameworks governing the planning, development and management of the built environment are critical mechanisms to improve the sustainability of the built environment.

However, it must be noted that although the built environment has an important role to play in the sustainability agenda, changes in urban form alone will not make the built environment sustainable. To foster sustainability, cooperation between disciplines must occur. The integration of policies with strategies needs to be implemented to address the underlying impediments to sustainability such as population growth, poverty, fairer trading, supportive transport and resource efficiency. A significant shift in attitudes and lifestyles is also needed if policies striving to achieve sustainability are to be effective (Hall et al. 2000). Indeed, strategies such as trying to create sustainable urban forms will only be achievable if they are underpinned by policies that commit to global sustainability goals, whilst permitting local formation and implementation of solutions (Hall et al. 2000). Engaging and fostering community participation in the development and implementation of decision-making processes is also vital to the success of sustainability initiatives (Wheeler, 2004).
2.3 Melbourne’s growth and sustainability

Melbourne is located on the south east coast of Australia, within the state of Victoria. It is Australia’s second largest city and is home to 3.9 million people (ABS 2009a). Figure 2.2 shows Melbourne’s location.

Figure 2.2 – State of Victoria and Melbourne


2.3.1 Melbourne’s growth

Melbourne is experiencing a continued growth in population that is extending the city’s boundaries and creating some key challenges for its sustainable growth. Figure 2.3 illustrates Melbourne’s outward growth from 1851 to 2004, a trend that continues today.
2.3.2 Melbourne’s population

Medium population growth assumptions prepared by the Australian Bureau of Statistics show that Melbourne’s population is expected to hit 5 million by 2026 and will approach 7 million by 2056 (Figure 2.4). This will be an increase of 1.8 million, 800,000 above the number predicted in 2000 (Munro, 2009).
Melbourne’s population growth and continued sprawl will place increasing pressure on land for industry and commerce, the transport system and water supplies (Department of Infrastructure, 2002). Figure 2.5 shows the predicted sprawl of Melbourne if status quo development continues.
2.3.3 Victoria’s environmental issues

A 2004 report by the CSIRO titled *Environmental Sustainability Issues Analysis for Victoria* highlighted that the key issues facing the state of Victoria are land resources, biodiversity, water resources, climate change, waste and recycling, settlement structures and urban development. The research being undertaken will focus on the water resources issues facing the city of Melbourne. More specifically,
how future water security and the impacts of stormwater on Melbourne’s rivers and bays are being managed within the context of Melbourne’s continued population growth and urbanisation.

2.3.4 Factoring in climate change

Climate change and how it will impact water resources are intrinsically linked to Melbourne’s future, as its local effects pose the biggest challenge to the reliability of Melbourne’s traditional water supply sources. To contextualise these risks Chapter 3 will look at the predicted effects of climate change on the state of Victoria and more specifically Melbourne and its water supply sources.
3 CLIMATE CHANGE (CC)

The potential impacts of climate change (CC) on the state of Victoria and Melbourne’s water resources are a key contextual theme in this research. This chapter will briefly discuss CC and the concepts of adaptation and mitigation. The chapter will then focus on the potential CC impacts on the state of Victoria and will conclude by discussing the degree of risk associated with these impacts on Melbourne’s water resources and systems. The purpose of this chapter is to frame Melbourne’s water crisis in the context of CC, positioning the research in this broader context.

3.1 Climate Change

There is now overwhelming evidence that global average temperatures are increasing as a result of anthropogenic interference of the earth’s climatic system (Stern, 2006; Pittlock, 2005; Stefan, 2008). Furthermore, the IPCC Working Group II Fourth Assessment Report has recently shown, with very high confidence, that recent warming is strongly affecting terrestrial biological systems (IPCC, 2007).

The Earth’s global temperature has warmed significantly over the past 100 years (IPCC, 2007). Global mean warming is expected to range between a 0.4°C to 0.9°C increase from 1990 to 2020 and 0.9°C to 2.2°C to 2050. There is a range of uncertainty in these scenarios, due to uncertainty in future Global CO₂ emissions and in the global circulation models used to assess temperature increases.

The rate of change has not been uniform across the globe, with the northern latitudes experiencing greater warming than other regions. As shown by the IPCC, an increase in average temperatures may lead to potentially severe challenges for society and the natural environment (IPCC, 2007). On average the world is currently 0.74°C warmer than a century ago (IPCC, 2007).

Current international negotiations are attempting to reduce greenhouse gas emissions to a level that is significantly below 1990 levels (up to 80% by 2050). However, due to the inertia of the global climate system, it is generally accepted that average global temperatures will increase by approximately 1.5°C and 6°C by 2100 regardless of any mitigation actions (IPCC 2007; Hennessy 2006). Although it may seem small, even a 2°C rise carries significant consequences. As shown by Garnaut (2008), 1.8°C - 2.3°C warming would mean 10%-17% of the world’s species become extinct, and a 19% - 40% likelihood of irreversible melting of the Greenland Ice Sheet. Some argue that a 2°C average warming could cause
runaway climate change, where positive feedback mechanisms are triggered, such as the drying of the Amazon rainforest or melting of permafrost.

Even if major near-term reductions in our current emissions are achieved, we still have locked-in impacts due to the existing carbon loading in the atmosphere and climate system inertia. At a local level, these changes generate a number of risks for the local government sector, who are responsible for risk management in the local built environment. These risks must be considered and appropriate responses developed.

3.1.1 Adaptation and mitigation

Strategies to deal with climate change generally consist of two elements: adaptation and mitigation (Pittock, 2005). The IPCC defines adaptation as an ‘adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities’ (Metz et al. 2001, p.708). This definition is expanded on by Adger et al. (2005) who state that – ‘adaptation can involve both building adaptive capacity … and implementing adaptation decisions’ (p.77). Mitigation is defined by the IPCC (Metz et al. 2001, p. 716) as ‘an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases’. That is, measures that reduce greenhouse gas emissions.

The connection between adaptation and mitigation is often overlooked. Banuri et al. (2001), advocate that adaptation and mitigation strategies need to be considered together in any climate change response. Environmental lag time means that a degree of human-induced climate change is already inescapable. We will have to adapt to these locked-in current and future changes regardless of mitigation. Mitigation strategies aim to reduce the severity of the impacts and attempt to constrain any climatic change to remain within our capacity to adapt (Pittock, 2005).

Furthermore, there is a direct link between many mitigation actions and adaptation responses. For example, energy efficiency programs that reduce greenhouse gas emissions can improve the weather proofing of buildings via insulation and draught-proofing and reduce the impacts of increasing energy costs - both adaptation actions. Switching to renewable energy reduces emissions and supports the development of Australia’s renewable energy industry - an adaptation response. Planting trees will absorb greenhouse emissions and create shade and address heat island effects. It is important to also
ensure that adaptation responses are as resource efficient as possible and do not contribute unnecessarily to additional greenhouse emissions or detrimental environmental impacts.

3.2 Climate change projections and impacts for Victoria

3.2.1 Heat

Data from the Australian Bureau of Meteorology from the period 1970-2009 shows an increase in mean temperatures of approximately 0.05 – 0.10 degrees per decade for Melbourne (Figure 3.1).

Figure 3.1 – Trend in mean temperature 1970-2009 (degrees /10yrs)

![Trend in Mean Temperature 1970-2009](image)


In general, Melbourne’s climate is expected to become hotter and drier, with more days exceeding 35°C and fewer cold nights. By 2030, the average annual temperature in Melbourne may increase by 0.6°C - 1.2°C from 1990 levels. By 2070, the temperature is expected to rise by a range of 0.9°C - 2°C under a low emission scenario, or around 1.8°- 3.8°C under a high emission scenario (CSIRO, 2007).
Figure 3.2 shows annual average temperature projections for 2070 under the lower and higher emissions growth scenarios as discussed above.

**Figure 3.2 - Annual average temperature change projections for 2070 under the lower and higher emission growth scenarios.**


Perhaps the most significant temperature related hazard for the Melbourne area is the change in return rate of extreme heat days (or heatwaves). The definition of a heatwave differs across the globe, but generally it can be defined as a prolonged period of excessive heat. Heatwaves can have serious human health ramifications, especially on the elderly and infirm. They can also place considerable strain on infrastructure, energy supply and increase livestock and crop losses (Granger & Hayne, 2001). For Melbourne, a high emissions projection shows that the average number of days over 35°C will increase from 9 to 20 by 2070.

### 3.2.2 Fire

It is well documented that increased temperatures are associated with increased bushfire danger (Hennessey et al 2007; Pitman et al 2007). A recent Australian study predicted that under an emissions scenario that results in a 3°C temperature rise, there could be a 100% increase in bushfire and grassland fires across Australia (Pitman et al. 2007). Victoria is sensitive to bushfire risk. It is anticipated that relative to the climate experienced in the period 1974-2003, by 2020 the number of "extreme" fire danger days will increase by 5% - 40%. By 2050, under a low emissions growth scenario, the number of "extreme" fire days is likely to increase by 15% - 25%, while under a higher emissions growth scenario, the number of days is likely to increase by 120% - 230%. For the Melbourne region, the number of
extreme fire danger days is expected to increase by 12% - 38% by 2020 and by 20% - 135% by 2050 (DSE, 2008).

One of the most serious impacts of the heatwave experienced in Melbourne in early February 2009, were the associated bushfires. These claimed the lives of over 170 people and injured 500 more (Victorian Police, 2009). The fires also destroyed at least 2,029 homes and 3,500 structures in total, while thousands more were damaged leaving an estimated 7,500 people homeless (News Com, 2009).

3.2.3 Rainfall

Although significant uncertainty exists around rainfall change for Melbourne due to its location at the junction of the Southern Australian and Tasmanian weather patterns, Victoria and Melbourne are already experiencing a significant change in rainfall that may be attributed to climate change. Figure 3.3 shows that in the period from 1970 – 2009 Victoria, and indeed the eastern side of Australia has experienced a 50 millimetre drop in rainfall per decade.

Figure 3.3 – Trend in Annual Total Rainfall 1970 -2009 (MM/10YRS)
Source: Australian Bureau of Meteorology, 2010. Figure 3.4 illustrates that the accumulated rainfall for the period October 1996 to May 2004 for the greater Melbourne region experienced its lowest rainfall on record compared to all other periods of similar length.

Figure 3.4 - Accumulated rainfall for the period October 1996 to May 2004

Climate change models suggest this trend will continue, with higher probabilities of decreased rainfall. It is anticipated that Victoria will experience a 4% decrease in annual rainfall by 2030, when compared to 1999-2005 levels. By 2070, this figure is expected to increase to 6% under low emission scenario, or 11% under high emission scenario (DSE, 2008).

Even though decreased rainfall is expected, modelling also predicts storm and rainfall intensities are likely to increase when rain does fall. With intense rainfall comes flood. Global flood catastrophes have increased over the past three decades and are predicted to continue (especially with the onset of sea level rise and increased urban development). As shown by Hennesey et al. (2006), a 25% increase in the duration of a 30 minute rainfall event can see a 1 in 100 year flood event becoming a 1 in 17 year event.

Indeed, a 2010 study by Melbourne Water and private experts found that drainage infrastructure that is, at present, overwhelmed once every five years, will be overwhelmed every three years by 2030. This results in more of the city being vulnerable to inundation by 2030, as the same ageing drainage system struggles to evacuate storms that are expected to carry 30 per cent more rain by 2030. With more water falling during storms, the report predicted the "once-in-five-years" storm would inundate a 25 per cent larger area than it does at present, while the "once-in-100-years" storm would inundate a 15 per cent larger area than it does today.
The report concluded with a frank warning to urban planners: "This change in rainfall intensities may have significant implications on future planning, management and infrastructure ... we may need to revise our infrastructure design standards and some areas currently considered appropriate for development may be vulnerable in the future." (Kerr, 2011).

For the Melbourne region the impacts of changes to rainfall is likely to pose significant challenges to the potable water supply, water for irrigation and environmental flows. Over the next 40 years the demand for water is anticipated to increase by up to 6.5%, but supply is likely to be reduced by as much as 35% (Howe et al 2005). Yearly inflows into Melbourne’s major water storages over the last decade have fallen by nearly 30%. It is also anticipated that the potable water supply may see an increasing occurrence of contamination from algal blooms and bushfire runoff.

3.2.4 Evaporation

The decline in water availability is also likely to be exacerbated as a result of increased evaporation rates due to rising temperatures. Data provided by the CSIRO indicates that the annual average potential evaporation by 2030 is likely to increase by around 3% (1% to 5%), with the largest changes expected in winter. By 2070, evaporation could increase by 4% (1% to 8%) under a lower emissions growth scenario, or by 8% (2% to 16%) under a higher emissions growth scenario (CSIRO, 2004).

As shown in the recent Garnaut Review (2008) climate change could potentially reduce irrigated agriculture by 50% by 2050 and 92% by 2100. Any of these scenarios paint a bleak picture for the economic stability for Melbourne under a ‘business as usual’ approach.
3.3 Climate change impacts on Melbourne’s water systems

The potential climate change impacts on Melbourne’s water supply system, water availability, sewerage system, drainage network and Melbourne’s waterways are summarised in Table 3.1 below.

Table 3.1 - Climate change impacts on Melbourne’s water systems

<table>
<thead>
<tr>
<th>Area</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply</td>
<td>• Reduced water supply due to decreased stream flows and higher evaporation</td>
</tr>
<tr>
<td></td>
<td>• Increased risk of bushfires in catchment areas with associated risk of decreased stream flows and water contamination</td>
</tr>
<tr>
<td></td>
<td>• Reduced environmental condition of streams with associated implications for water harvesting in regulated and unregulated streams</td>
</tr>
<tr>
<td>Sewerage system</td>
<td>• Increased potential for corrosion and odours caused in the sewerage network as a result of increased sewage concentrations associated with water conservation, increasing ambient and seasonal temperatures, and longer travel times within the sewer network</td>
</tr>
<tr>
<td></td>
<td>• Increased incidence of sewer overflows due to increased rainfall intensity during storms</td>
</tr>
<tr>
<td></td>
<td>• Increased risk of pipe failure and collapse due to dry soil conditions</td>
</tr>
<tr>
<td></td>
<td>• Increased salinity levels in recycled water due to rising seawater levels resulting in increased infiltration to sewerage network and at wastewater treatment plants</td>
</tr>
<tr>
<td>Drainage system</td>
<td>• Increased flooding risk and property damage due to increased rainfall intensity during storms</td>
</tr>
<tr>
<td></td>
<td>• Increased risk of damage to stormwater infrastructure and facilities (e.g. underground drains, levee banks, pump stations etc) due to higher peak flows</td>
</tr>
</tbody>
</table>
| Receiving waters | • Reduced health of waterways due to changes in base flows  
|                 | • Potential for negative water quality impacts in Port Phillip Bay due to increased concentration of pollutants entering Bay (longer periods between runoff events and then high intensity events leading to concentrated pollutant runoff) and higher ambient Bay water temperatures. |

Source: Melbourne Water Climate Change Study -Implications of Potential Climate Change for Melbourne’s Water Resources

### 3.3.1 Climate change risk ratings

The risk ratings associated with some of the potential climate change impacts on Melbourne’s water systems are summarised below. Table 3.2 highlights that in the short term (2030) water security, bushfire and stormwater impacts carry a ‘high’ risk rating that will shift to ‘extreme’ in the long term (2070).

#### Table 3.2 - Climate change risk ratings

<table>
<thead>
<tr>
<th>Water Sector</th>
<th>Risk Scenario</th>
<th>Risk Rating</th>
<th>Year 2030</th>
<th>Year 2070</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply and Storage</td>
<td>Water storage</td>
<td>High</td>
<td></td>
<td>Extreme</td>
</tr>
<tr>
<td></td>
<td>Degradation &amp; failure of water supply piping</td>
<td>Moderate</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bushfire impacts on catchments and storage</td>
<td>High</td>
<td>Extreme</td>
<td></td>
</tr>
<tr>
<td>Sewerage System</td>
<td>Degradation &amp; failure of sewer pipes</td>
<td>Moderate</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sewer spills to rivers &amp; bays</td>
<td>Moderate</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Drainage system</td>
<td>Storm water drainage &amp; flooding</td>
<td>High</td>
<td>Extreme</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------------------------</td>
<td>----------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Degradation and failure of drainage infrastructure</td>
<td>Moderate</td>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Paul Holper, Climate Change - how is it likely to affect your region, June 2007, CSIRO

These risk ratings are disturbing and establish it is crucial that the future planning and management of Melbourne’s water resources and systems incorporate adaptation and mitigation strategies to address these risks. These risks are further compounded by the fact that the infrastructure networks most of us rely on for water are inherently inflexible ‘... can be destabilised as a result of changed environmental conditions, requiring a fundamental shift from the established style of network management’ (Guy et al. 2001). Although, the real impacts of CC cannot be known, one thing is clear, uncertainty and risk will become pivotal elements in shaping Melbourne’s water services into the future. As Dutch water researchers Aerts and Droogers note ‘... the new element in adapting to climate change in water management is an unknown future’ (Aerts & Drooger in Ludwig et.al, 2009). The concept of a water sensitive city is gaining widespread support from governments, the building industry and built environment professionals as a model to address Melbourne’s water crisis. This concept will be discussed in chapter 5. The next chapter will look at the extent of Melbourne’s water crisis and discuss the strategies being implemented to deal with it and the impacts of climate change.
4 MELBOURNE’S WATER CRISIS

The previous chapter established that the predicted negative impacts of climate change on Melbourne’s water supply systems in the short and long term are extreme. This is compounded by the fact that Melbourne’s population is growing as is the city’s limits. The purpose of this chapter is to frame Melbourne’s current and predicted water crisis in the context of the preceding chapters. The chapter will begin by providing a snapshot of Melbourne’s water crisis and use profile. This will be followed by a short outline of the state government’s plan for water security. A discussion of a recent study examining Melbourne’s water supply and demand in the near and long term based on different scenarios that account for factors such as population growth, demand, augmentation and climate change will then be presented. The chapter will conclude by presenting Environment Victoria’s alternative approach to the state governments plan for providing water security for Melbourne.

4.1 The crisis

Melbourne is currently experiencing a water crisis that is being attributed to drought, climate change and increasing demand (population growth). Therefore, future water security is a key challenge facing the city. Melbourne is almost completely dependent on rivers and catchments for its water supply which is stored in nine reservoirs surrounding the city.

Figure 4.1 shows the locations of these reservoirs whose combined storage capacity is 1,810,500 ML.
Figure 4.1 - Melbourne’s water storages

The water from these catchments is treated to meet drinking water standards. The majority (90%) needs minimal treatment because the catchments are in pristine environments (state and national parks), while the remaining 10% needs filtering. The treated water is then piped to Melbourne and its surrounds where it is used for a range of purposes. Only a small fraction (approximately 4%) is used for...
human consumption. Wastewater is collected by a separate network of underground pipes that lead to the Western (Werribee) and Eastern (Bangholme) treatment plants. Once treated the effluent from the Western Treatment Plant is discharged to Port Phillip Bay and the Eastern Treatment Plant to Bass Strait. Rainfall on urban catchments (urban stormwater) is collected by a separate network of underground pipes. The majority of Melbourne’s stormwater catchment area discharges directly to Port Phillip Bay or nearby receiving waters that eventually discharge to the Bay (City of Moonee Valley, WSUD Guidelines, 2009).

Inflows to Melbourne’s reservoirs have declined dramatically over the past decade, due to the combined effects of drought and climate change. Since 1996, rainfall in Melbourne’s water supply catchments has fallen well below historic patterns. Between October 1996 and May 2004, the Greater Melbourne Region experienced its lowest rainfall on record in comparison with all other periods of similar duration (CSIRO 2005: 3). As figure 4.2 shows, the result has been a sustained fall in average inflows to Melbourne’s storages since 1997 to around just 376 GL per year. By comparison, the average inflow over nearly one hundred years was 615 GL per year. However, it must be noted that the hydro-meteorological records for many locations in Australia are relatively short (generally less than 100 years) (Daniell, 2009). Many historical records commenced after the Federation Drought (1896-1903) and therefore do not include the extreme variations of the wet and dry in the 1890s. Furthermore, reconstructed climatic records looking at longer 10 and 30-years periods, show that the driest periods occurred in 1766-1775 and in 1770-1799, respectively (Daniell, 2009). This was prior to the period of settlement and meteorological recording. However, the present period of dry is now matching the extreme previously recorded (Daniell, 2009).
Figure 4.2- Melbourne storage inflows 1913-2009

4.1.1 Melbourne’s water storages now

On the 30 June 2010, Melbourne’s total reservoir water storage level was 33.7% (610,386 million litres), increasing from 26% (470,556 million litres) at 1 July 2009. Melbourne’s storages recorded their best year in terms of recovery since the drought began in 1997, due to new augmentations, improved rainfall and reduced water use and behaviour change (Melbourne Water, 2010).

Although rainfall in Melbourne’s major catchments and stream flows into major reservoirs were above 2008/09 levels (one third more and 41% respectively), these figures were still below average overall. Heavy rain in early spring and follow-up falls helped water storages gain 90 billion litres in October, the biggest monthly boost in 17 years. The catchments received the most summer rain (231 millimetres) in five years, but the amount of water that flowed into the storages was almost 34% below average due to chronically dry soils, and stream flows into the major reservoirs being still 16.5% below average (Melbourne Water, 2010). Figure 4.3 shows the steady decline in Melbourne’s water storages.

Figure 4.3 - Water in storage Melbourne


It should be noted that Melbourne’s water storages have since recovered after a wet 2010 and 2011. Melbourne’s overall storage level sits at 64% in May 2012.
4.1.2 Melbourne's water use profile

Melbourne uses more than 400 billion litres (or Giga litres GL) of water a year (Water Smart, 2006). Figure 4.4 provides a snapshot of Victoria's water use profile. It shows that household and industry water use by Melbourne accounts for 10% of Victoria's water use. Of that 10%, residential water consumption accounts for the highest proportion of water used (60%), double that of industry (30%). For this reason, the predicted increase in residential development in Melbourne of 600,000 homes: 316,000 in established areas (infill development); 284,000 in growth areas (green field development), will further exacerbate Melbourne's water crisis because residential water consumption is the largest use sector in Melbourne.

Figure 4.4 - Water use in Victoria and Melbourne - % used by sector

![Water use in Victoria and Melbourne](image)


4.1.3 Government residential water efficiency targets

To address Melbourne's residential water efficiency the Victorian Government set a short-term water conservation target for residential per capita water consumption. The target as outlined in the 2006 report Water Supply Demand Strategy for Melbourne 2006-2055 is:
- 25% reduction* in residential per capita drinking water consumption by 2015, growing to 30% by 2020

* From 1990s average

In combination with additional conservation measures to be implemented in Melbourne, the government aims to bring forward the 30% target to 2015 as set out in Action 3 of the Central Region Sustainable Water Strategy (Victorian Government, 2006). It is important to note that these water reduction targets are aspirational and are not legislated or mandatory.

During 2008, Melbourne’s water supplies dipped to one of the lowest levels since the Thomson Dam (Melbourne’s largest water storage) was built in 1983. This situation was attributed to consistently lower than average rainfall and inflows into Melbourne’s major water catchments. In conjunction with mandatory water restrictions, voluntary water conservation in Melbourne has been driven by a range of programs including Target 155 – a joint initiative of Melbourne Water, the Department of Sustainability and Environment and the retail water businesses.

The Target 155 program was designed to reduce water use and help sustain Melbourne’s dam levels until new water supply projects for Melbourne are completed (see section 4.2). Target 155 aims to reduce the city’s average residential water consumption to less than 155 litres per person per day. In conjunction with the introduction of the strictest water restrictions this target was achieved in 2009/10 when the rolling average daily consumption per person was 148 litres. This compares to 159 litres in 2008/09 and 164 litres in the 12 months before Target 155 began in December 2008 (Melbourne Water, 2010). By comparison the city of Zaragoza in Spain, which shares a similar predicament to Melbourne has lowered water use to 105 litres/person/day in 2008; and is now setting a new target of 90 litres/person/day (Allan et al. 2009).

4.2 The Government’s plan - Our Water, Our Future

To address the water crisis facing Victoria, the State Government updated and released Our Water Our Future - the Next Stage of the Government’s Water Plan in 2007. The plan is a strategic document and it also identifies key infrastructure projects to secure water for the State. The plan aims to provide water security for Victoria’s growing population and economy in the face of drought and the challenge of climate change by:
• Diversifying and boosting water supplies in Melbourne, including through desalination;
• Networking the State’s water resources in a Victorian Water Grid; and
• Enabling a rapid and flexible response to changing future water needs.

The $4.9 billion plan seeks to augment water supply for Melbourne and other regional centres by investing in a number of large scale projects that include a desalination plant, the Sugarloaf Interconnector (takes water from the Goulbourn catchment to Melbourne) and the Tarago reconnection. Figure 4.5 illustrates how much water is expected to be secured by each of these projects to meet Melbourne’s predicted annual water consumption of 630 billion litres by 2055.

Figure 4.5- Summary of strategies to provide water security for Melbourne and the region

Source – Our Water Our Future the next Stage of the Government plan, 2007 p.17

4.2.1 Desalination

The Government’s desalination plant at Wonthaggi is currently being constructed but has drawn a lot of criticism from the Victorian community for a number of reasons. The project’s Environmental Effects Statement (EES) is said to have left many questions unanswered or postpones assessment until the plant
is operational. These claims have recently been supported by the consultants hired to fill in the ‘gaps’ left in the original EES completed in 2008 for the desalination project (The Age, April 2010).

The desalination plant will consume 90 megawatts of electricity a year, which the government has said will be offset by purchasing Renewable Energy Certificates. However, compared to conventional water supply services, desalination increases energy consumption for water services by approximately 3 PJ/year which leads to a tripling of current energy use for water service provision (CSIRO, 2008).

Figure 4.6 shows that desalination consumes the most amount of energy when compared to other methods of water supply such as water recycling and rainwater tank supply. Efficient washing machines and showerheads are listed as saving energy because they save significant amounts of hot water and hence the energy used to heat the water.

\[\text{Figure 4.6 - Comparison of CO}_2\text{ emissions (tonnes) generated or saved}\]


As noted in section 3.1.1 climate change adaptation strategies should ensure that responses are as resource efficient as possible and do not contribute unnecessarily to additional greenhouse emissions or detrimental environmental impacts. It is perhaps ironic that the desalination plant being built by the government to address Melbourne’s water shortages that are in part caused by climate change, is energy intensive and at best is going to make the task of reducing emissions from other sources more
difficult (offsetting using limited Renewable Energy Certificates), and at worst contribute more than a million tonnes of carbon dioxide to Victoria’s annual greenhouse gas emissions (Environment Victoria, 2008).

4.2.2 Sugarloaf pipeline

The Sugarloaf Pipeline was officially connected to the Melbourne system in February 2010. The 70 kilometre pipeline links the Goulburn River near Yea to the Sugarloaf Reservoir in Melbourne’s north-east. It will provide up to 75 GL of water a year from $1 billion of irrigation infrastructure improvements in the Goulburn and Murray River systems. The $750 million project is the largest single boost to the water supply system since the Thomson Reservoir was commissioned in 1984 (Melbourne Water, 2010).

An article in The Age newspaper on June 15 2009 by Peter Kerr titled ‘State water targets rely on rising rainfall level’ identified that rainfall in Victoria must increase in coming years for the water targets assigned to the Sugarloaf interconnector and food-bowl modernisation project to be achieved. The article noted that if the project fails to save 225 GL over the long term, Melbourne will not get the average annual flows of 75 GL it was promised through the Sugarloaf interconnector (The Age, 2009). Given Victoria’s rainfall is predicted to fall under climate change projections (see 3.2.3) this information raises questions on whether this aspect of the Government’s water supply strategy can actually be fulfilled.

4.3 Previous inquiries into Melbourne’s water supply

Five official inquiries into Melbourne’s water supply have taken place over the last decade. The first was prepared by the Water Resources Strategy Committee for the Melbourne area, established by the Victorian Government in October 2000. This inquiry pre-dated the water crisis, with the Committee’s recommended strategy stating that with significant demand reduction by 2050, Melbourne would require only 571 GL per year from the catchments instead of a projected 659 GL per year without demand management. This represented a decrease in per capita usage from the 1990s average of 423 L/p/day down to 327 L/p/day in 2050. The population assumption was that there would be an increase from 3.5 million in 2001 to a projected 4.6 million by 2050 (Water Resources Strategy Committee, 2002). Overall, the strategy highlighted increased climate variability (but not the dramatic drop in supply that has occurred), increasing population (but underestimated the increase by approximately 2 million people by 2050) and a preference for demand reduction over supply increase.
The second inquiry was a study of the implications of climate change on Melbourne’s water supplies, conducted by the CSIRO and Melbourne Water and published in 2005. A major finding was that stream flows would be reduced by as much as 7% to 35% by 2050, with a mid-range reduction of 20% (CSIRO, 2005).

The third inquiry, the Central Region Sustainable Water Strategy, was published as a discussion paper in October 2005, a draft strategy in April 2006 and as a final report in October 2006 and defined a water strategy for Melbourne and its surrounds, including West Gippsland, Port Phillip and Westernport (Victorian Government 2006a). This strategy was consistent with earlier policies of water conservation and efficiency. However, as the strategy was based on the assumption that low inflows would continue, large scale augmentation of water supplies, namely an upgrade of the Eastern Treatment Plant to produce recycled water, was proposed.

By the time of the fourth inquiry commissioned by the Victorian Government, the supply situation had deteriorated and water restrictions had already been introduced (Victorian Government 2006b). The report ‘Water Supply- Demand Strategy for Melbourne’ (2006) was not confident that the historic rainfall pattern would return and that the post-1996 drought was part of natural climate variability. It predicted a partial return to the historic pattern of rainfall (Victorian Government 2006b). Nevertheless, their core supply assumption, which is represented by the ‘long-term average inflows’ line shown in Figure 4.7, was that there would be a gradual decline in inflows to Melbourne’s water catchments, which reflected the judgement of the 2005 CSIRO study.

**Figure 4.7 - Baseline supply-demand forecast**

![Graph showing long-term average inflows, low inflows, and water demand over time from 2005 to 2055.](source: Melbourne Water, Water supply-demand strategy for Melbourne, 2006-2055, Victorian Government 2006b: p.25.)
The baseline demand assumptions incorporated into Figure 4.7 were that per capita demand would remain at the level prior to the introduction of water restrictions and that Melbourne’s population (as with the first inquiry) would increase to 4.6 million by 2050. As Figure 4.7 indicates, under the long-term average inflow assumption, demand for water would exceed supply by around 2020. At the time the report from this fourth inquiry was being prepared, Melbourne catchments were experiencing record low inflows during the winter and spring of 2006 (an El Niño year). This prompted the authors to include a ‘low inflows’ scenario (Figure 4.7), which assumed that there would not even be a partial return to the historic rainfall pattern. Instead, the inflow would stabilise at the average of the period of 1997 to 2005, or about 385 GL per annum. Under this scenario Melbourne’s storages would be rapidly depleted and as a result of this the report recommended examining a range of water conservation measures, as well as supply augmentation possibilities, suggesting stormwater, groundwater, recycled water and desalinated seawater as possible options (Victorian Government 2006). However, the inquiry report was required to work within the framework of ‘no new dams for Melbourne’, ‘water cannot be traded between Melbourne and northern Victoria’; and ‘no water recycling for drinking purposes in the short to medium term’ (Victorian Government 2006b, 3).

The Victorian Government’s White Paper, Our Water Our Future: Securing Our Water Future Together was released in 2004 and set out key water policy. This policy was based on:

- balancing water supply and demand;
- reducing water consumption;
- using alternative supplies including recycled water, grey water and stormwater; and
- using existing water supplies more effectively by interconnecting water systems.

After a year of some of the lowest rainfall recorded in Melbourne (2006), an update on the Victorian Government’s Our Water Our Future 2004 water policy, entitled Our Water Our Future: the Next Stage of the Government’s Water Plan, was released in June 2007 and outlined a series of new major water projects for Victoria (DSE 2007a). These included a desalination plant for Melbourne, irrigation modernisation in Victoria’s North, a pipeline (the Sugarloaf Pipeline) linking water supplies from the Goulburn River to Melbourne, an upgrade of the Eastern Treatment Plant to provide recycled water and new water conservation programs (DSE 2007a). In total, 240 GL of new water supplies would be
delivered to Melbourne by 2011 via desalination (150 GL), irrigation modernisation/Sugarloaf Pipeline (75 GL) and recommissioning of the Tarago Reservoir (15 GL). A 2008 report by DSE described in more detail how the planned augmentations would secure Melbourne’s water supply and emphasised the critical need for the desalination plant for Melbourne’s supplies in the short term (DSE 2008).

A fifth inquiry into Melbourne’s future water supply was conducted by the Environment and Natural Resources Committee of the Parliament of Victoria. In his foreword to the report, committee chair the Hon John Pandazopoulos remarked that “by 2036 Melbourne’s water supplies will require further augmentation” (ENRC 2009: xvii), in addition to the augmentations outlined in the 2007 plan. The inquiry report, released in June 2009, outlines the recommendations of the committee, including an emphasis on mandatory water efficient fixtures, a sustainability rating system that includes water efficiency, strong water recycling targets and mandatory dual-pipe systems in new developments. However, the report utilised the same out-of-date catchment inflow projections used in the 2006 supply-demand inquiry and the 2008 DSE report.

4.4 Current inquiries into Melbourne’s water supply

Water demand is a function of the number of people served and their per capita consumption levels. The 2002 and 2006 water inquiries cited earlier assumed that Melbourne’s population would increase to 4.6 million by 2050. Melbourne’s population has surged since the early part of this decade, primarily as a consequence of increased overseas migration, but also because of an increase in fertility. If migration and fertility continue according to recent and predicted levels, Melbourne will have to provide for a much larger population than was assumed in the Victorian Government studies discussed in section 4.3. The median-level projection of Australia’s Population prepared by the Australian Bureau of Statistics and published in August 2008 assumed that recent fertility and migration trends will continue. In these circumstances Melbourne’s population will grow from 3.7 million in 2006 to 6.5 million in 2050 (ABS 2008).

Should this projected outcome occur, water will have to be provided for an additional 2.8 million people by 2050 rather than the one million assumed in the earlier reports. The scale of the additional water needed will depend on the water consumption patterns of Melbourne residents.
4.4.1 Current predictions on Melbourne’s water situation

The most recent study exploring Melbourne’s future water security is a 2009 study conducted by Monash University’s Sustainability Institute (MUSI). The study presented a number of scenarios of Melbourne’s water storage levels based on supply (inflows) and demand (population and per capita use) to give a snapshot of long-term water supply. The study acknowledged that many factors would influence the actual outcome; so the analysis looked only at broad likely trends. The analysis carried out in this report is outlined and interpreted below. Figure 4.8 shows the six water demand scenarios using different demand and population conditions used in the MUSI report.

Figure 4.8 - Water demand scenarios

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low per capita water demand</td>
</tr>
<tr>
<td></td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>Medium per capita water demand</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>High population scenario</td>
</tr>
<tr>
<td></td>
<td>Medium population scenario</td>
</tr>
</tbody>
</table>
To compare the projected annual water demands of the six scenarios illustrated in Figure 4.8 against annual supply, a medium and low natural inflow to Melbourne’s major water storages in addition to projected levels of supply from augmentation projects (State government plan) was modelled. Figure 4.9 shows the various inflow scenarios modelled. Environmental flows were not directly factored in, but were indirectly included in the system losses component, which increases as a proportion of total use (Monash Sustainability Institute, 2009).

**Figure 4.9 - Water supply projections with medium and low inflows and augmentation after mid 2010**

Source: Monash University, Melbourne’s water situation – the opportunity for diverse solutions, Monash Sustainability Institute, 2009, p.16

In summary, the augmented low inflows, totalling 500 GL/year, are less than what is required for all but the lowest demand scenario - medium population growth and low per capita water demand, scenario
(1b) shown in Figure 4.8. The low average inflow assumption of 300 GL (plus augmentation from the Sugarloaf pipeline and the desalination plant) is plausible, as an average inflow of 300 GL is more than occurred in 2006-07 and 2008-09. This means that additional sources of water would be required before 2050 (Monash Sustainability Institute, 2009).

The study also modelled supply and demand projections under medium and low average inflows. Figure 4.10 and Figure 4.11 show this information and the drop down lines on the graphs indicate when Melbourne’s water storages reach 20 per cent of capacity. At 20 per cent capacity the need to act to limit demand or augment supply (or both) becomes urgent. As is shown in Figure 4.10 and Figure 4.11, this trigger for action usually occurs several years before the storages would be fully depleted (Monash Sustainability Institute, 2009). Figure 4.10 shows projections of water supply levels under medium average inflows using six water demand scenarios based on different demand and population conditions.

**Figure 4.10 - Water supply level projections under medium average flows**

<table>
<thead>
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<th>Key</th>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>a</td>
</tr>
</tbody>
</table>
2  Medium per capita water demand  b  Medium population scenario

3  High per capita water demand

Source: Monash University, Melbourne’s water situation – the opportunity for diverse solutions, Monash Sustainability Institute, 2009, p.18

Figure 4.11 shows projections of water supply levels under medium average inflows using six water demand scenarios based on different demand and population conditions.

**Figure 4.11 - Water supply level projections under low average inflows**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low per capita water demand</td>
</tr>
<tr>
<td>2</td>
<td>Medium per capita water demand</td>
</tr>
<tr>
<td>3</td>
<td>High per capita water demand</td>
</tr>
</tbody>
</table>

Source: Monash University, Melbourne’s water situation – the opportunity for diverse solutions, Monash Sustainability Institute, 2009, p.19
4.4.2 Implications of long-term supply-demand projections

Should low average inflows eventuate, Melbourne’s storages will be quickly depleted under most of the scenarios considered. For example, under the medium per capita demand and high population assumptions, there is a risk that the storages will be depleted by 2029. Under this scenario (2a in Figure 4.11), the drop down line indicates that storages will at 20 per cent of capacity by 2024.

The high population, high demand scenario (3a in Figure 4.11) is of particular note should low average inflows continue. The demand aspect of this scenario could occur if the Government fails to actively maintain a conservation program. The government might be tempted to do so after the additional water from the desalination plant becomes available. In fact this intent has been clearly expressed with the government’s plan - Our Water Our Future.

Therefore, it will become increasingly important that some conservation measures are hard-wired into the system through appropriate changes in legislation that set mandatory potable water reduction targets for new developments and increase the stringency of water efficient appliances and fittings. It is perhaps important to note that although the state government set a target for a 25% reduction in potable water consumption by 2015 and have expressed its intent to bring a 30% reduction target forward to this date, the target is not enforced in anyway. This differs dramatically from the state of New South Wales where it is mandatory for all new developments to demonstrate how a 40 per cent reduction in potable water will be achieved.

The population assumptions used in these scenarios match those projected by the Victorian Department of Planning and Community Development in its 'Victoria in Future' release of 2008. Under this scenario, the storages may peak (where demand exceeds supply) before 2020. Should inflows return to medium levels before augmentation, that is 380 GL per year; the situation will be more comfortable. Under the low per capita demand scenarios the storages are most likely to be full before 2020. These circumstances would raise questions about how the Desalination Plant and the water network should operate once storages are full.

The supply-demand projections outlined in section 4.4.1 indicate that Melbourne needs to immediately begin planning for either additional sources of water beyond what is outlined in the state governments plan or some combination of restraints to population growth and a strong demand management strategy.
4.4.3 Long term outlook

The MUSI report modelled a series of scenarios to gain an understanding of the long term outlook for Melbourne’s water. The long term scenarios to 2051 showed that in the first few years after the desalination plant comes on stream, water use restrictions could be removed and/or environmental flows could be returned with little risk of water shortages, even under a high population assumption. However, as early as 2020, if low inflows occur in a context of high population growth and high per capita demand, the storages would peak and would require additional supplies to be brought online before 2025. Under the medium flow scenario, the peak in storage levels would be more likely to occur after 2025, but new sources of water would be needed before 2030.

The scenarios modelled by MUSI indicate that under some plausible assumptions, and even with the Victorian Governments plans to augment Melbourne’s water supply (see 4.2) the government will have to start planning now to deal with inflows scenarios that are lower than the long-term average. This planning will have to involve further augmentation of the water supply and/or a reduction in the projected demand for water.

The MUSI report states that these new circumstances have arisen because of unforeseen developments on the demand and supply side of the water equation. On the demand side, the recent surge in Melbourne’s population, if sustained, will add some 2.8 million extra consumers between 2006 and 2051 rather than between 1 to 1.5 million as was assumed just a few years ago. On the supply side, the climate change trends have raised the possibility of low flows continuing over the long term. The climate change trend has delivered several low inflow years, including just 165 GL in the 2006 calendar year and 287 GL in the 2008 calendar year.

The Victorian Government has stated that it intends to remove water restrictions after the desalination plant is operational despite the Government’s population projections being consistent with the high population assumption included in the MUSI report modelling. For the long-term (to 2050), the question is whether further supply augmentation measures will be required, or whether continued demand management and efficiency measures can achieve similar security of supply.
4.5 Alternative water supply options for Melbourne

The state government’s plan to address Melbourne’s water security issues (Our Water, Our Future) is just one of many approaches that can be taken to address the city’s water crisis. Indeed, as discussed under section 4.2.1 the State Government’s decision to go ahead with the desalination plant drew a lot of criticism from the Victorian community. It is argued that if Melbourne is to cope with the pressures on its water caused by a growing population, drought and climate change, a fundamental shift in the way water is supplied, managed and used needs to occur.

4.5.1 Environment Victoria’s (EV) vision for Melbourne

EV’s 2008 report titled Water Security, Healthy Rivers – Environment Victoria’s vision for Melbourne identifies a number of risks associated with the Victorian Government’s plan (Our Water Our Future) that elaborate on the brief discussion outlined in sections 4.2.1 and 4.2.2. EV believes that the Government’s emphasis on large scale infrastructure projects represent an inappropriate response to Melbourne’s water challenges and carries a number of significant risks. The risks identified by EV are as follows:

- Undermines the implementation of more sustainable water supply options;
- Undermines the progress on water savings;
- Use of uncertain data;
- Greenhouse gas impacts;
- Spiralling economic costs;
- Environmental damage; and
- Social inequity.

A detailed discussion of these risks will not be carried out because they fall outside the scope of the research, but it is important to note that the EV report contains evidence to support these claims. Instead, the research will look at the alternative plan to secure water for Melbourne presented in this report.
The EV report uses the concept of a water sensitive city that will be discussed in depth within chapter 5. The report identifies sustainable water alternatives to meet Melbourne’s immediate water shortfall to ‘buy time’ for the implementation of longer term sustainable water supply options. A summary of EV’s plan is outlined in Table 4.1.

Table 4.1 - Summary of Environment Victoria’s vision compared with the Government’s plan

<table>
<thead>
<tr>
<th>Timing and amount of water delivered (GL/yr)</th>
<th>To 2012</th>
<th>By 2025</th>
<th>By 2055</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated shortfall</td>
<td>97-145 GL/yr</td>
<td>205-300 GL/yr</td>
<td></td>
</tr>
<tr>
<td>Our water Our Future – next stage plan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tarago reconnection</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Sugarloaf pipeline</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Desalination plant</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td>240 GL/yr</td>
<td>240 GL/yr</td>
<td>240 GL/yr</td>
</tr>
<tr>
<td>Environment Victoria’s Vision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adding purified recycled water to storages</td>
<td>115</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Banning logging from catchments</td>
<td></td>
<td></td>
<td>50-75</td>
</tr>
<tr>
<td>Making better use of urban stormwater</td>
<td></td>
<td></td>
<td>Up to 800 GL/Year</td>
</tr>
<tr>
<td>Making buildings more water efficient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Infill development</td>
<td></td>
<td>19</td>
<td>57</td>
</tr>
<tr>
<td>• Greenfield development</td>
<td></td>
<td>18-24</td>
<td>58-72</td>
</tr>
<tr>
<td><strong>Making existing buildings</strong></td>
<td><strong>20</strong></td>
<td><strong>105</strong></td>
<td><strong>140</strong></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Improving industrial and</strong></td>
<td>Insufficient data available to make specific estimates</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>commercial water use</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tarago reconnection</strong></td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Deliver environmental flows</strong></td>
<td>-35</td>
<td>-35</td>
<td>-35</td>
</tr>
<tr>
<td><strong>for the Thomson and Yarra rivers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>115 GL/yr</td>
<td>237-243 GL/yr</td>
<td>400-439 GL/yr</td>
</tr>
</tbody>
</table>


The EV plan demonstrates that sufficient water to meet Melbourne’s immediate needs can be supplied by alternative and sustainable means which can increase over time to match demand when compared to the government’s plan. Of interest to the research are the potentially huge volumes of water, urban stormwater can provide and the potential water savings of making new buildings more water efficient. According to the CSIRO stormwater harvesting has the potential to reduce urban water consumption by as much as 100GL per annum (Environment Victoria, 2009). Table 4.1 identifies that by making new infill development more water efficient, savings of approximately 19 Giga litres can be achieved by 2025, increasing to 57 Giga litres by 2055. To achieve the savings documented for infill development, EV proposes that all new buildings should be required (legislated) to meet a target of a 40% reduction in mains potable water demand. This potable water reduction target is higher than the state government’s aspirational 25% reduction target (see section 4.1.3). The only legislation currently governing potable water reductions are contained within the Building and Plumbing Code’s 5 Star building standard. These standards mandate maximum flow rates for fixtures (taps, toilets and showerheads) and require the use of either a rainwater tank or solar hot water heater for Class 1 Buildings (detached residential
dwellings). Class 2 Buildings (apartments) need to meet the requirements for fixtures but do not need to install a rainwater tank or solar hot water heater. The most optimistic assessment of water savings that can be attributed to the 5 Star Standard is 15% (Environment Victoria, 2008).

4.5.2 Moving towards alternative water supply options

In comparison to the Environment Victoria plan for securing Melbourne's water, the Government plan shows an inadequate exploration of alternative water supply strategies, and based on current regulations, a real lack of leadership in legislating for higher potable mains water reductions in new and existing buildings. This is particularly disturbing because the Government's stated objective is to 'progressively move back to low level or no water restrictions by 2013' after the desalination plant comes on line (DSE, 2007, p.17).

Additionally, the plan outlined by the Government can be explained as an example of path dependence. Once in place it limits future development paths because it will be less costly to expand an existing system as the number of consumers and per-capita requirements grow, rather than replace it with something different. The technology is expensive and disruptive to install and consumers are not required to change their usage habits. This generates a set of obstacles both in supply and usage to the adoption of new technologies and management practices that differ significantly from what is currently in place (Troy, 2008).

The EV report highlights the short term and fixed nature of the government's approach – 240 GL/yr from 2012 up to 2055. Particularly when the long term outlook of Melbourne's water supply (section 4.4.3) highlighted it is very likely that despite the government's efforts to secure Melbourne's water, more will be needed by 2025. The MUSI modelling discussed in section 4.4 strengthens the relevance of the EV proposal that through various mechanisms seeks to increase the amount of water available over time – 115GL/yr in 2012 up to 400-439 GL/yr in 2055. Therefore, to reduce the vulnerability of cities like Melbourne, there is a need to lessen demand on mains water supply, and source water in various ways, including water harvesting, water recycling and groundwater (PMSEIC, 2007). The EV report used the concept of a water sensitive city as a basis for its vision. This concept is central to the research and will be discussed in detail in the next chapter.
5 WATER SENSITIVE CITIES

Chapter 4 highlighted that despite the Victorian State government’s plans to secure Melbourne’s water, it is very likely that by 2025 Melbourne will require additional water supplies if population growth and the impacts of climate change and drought continue. Chapter 4 concluded by presenting Environment Victoria’s (EV) alternative water supply and management strategy for Melbourne. EV’s proposal was based on the concept of a water sensitive city. This chapter will introduce and elaborate on the concept of a water sensitive city. The concept forms the theoretical framework for the research being undertaken and as such a thorough discussion and understanding of its elements is necessary.

5.1 Transitioning to a water sensitive city

In a time of drought, climate change and population growth, it is necessary for urban communities to incorporate design strategies for water supply and management that provide resilience to future uncertainty. In the past it was an urban challenge to provide piped water, sewerage services and flood mitigation. These remain challenges today, but they can be managed in ways to ensure water is used efficiently, re-used where possible, and waterways are protected from runoff pollution (Wong & Brown, 2008). The concept of a ‘water sensitive city’ can provide solutions for water management that can address these challenges.

Traditionally water has been supplied to cities via centralised infrastructure, that provides limited flexibility for water management and re-use in times of changing climate. Under this model, water supply, storm, waste, and ground water management have been managed as entirely separate infrastructure issues with goals different to current ones of water conservation, reuse, quality and reduced environmental impacts (City of Melbourne, 2008). Although, the latter goals are slowly being addressed in Melbourne, the city is still largely dependent on a centralised infrastructure for its water supply. The Government’s desalination plant (primary means of meeting Melbourne’s water demand) can be described as a ‘bolt on’ piece to the city’s centralised water infrastructure. Although the desalination plant will boost supply it does not increase the water systems’ adaptive capacity or provide flexibility to deal with fluctuations in demand and inflow scenarios (see 4.4.3). It is argued that without a systemic break from traditional water management today’s emerging risks and uncertainty surrounding water will intensify (Biggs et al. 2009).
Figure 5.1 - Traditional water supply city

Source: (adapted from a figure contained in the report by the New Zealand Parliamentary Commissioner for the Environment, 2000). MV WSUD guidelines p12

Figure 5.1 shows the elements of a traditional water supply infrastructure. In contrast to a traditional water supply city, a ‘water sensitive city’ recognises the links within and between the urban water cycle, built form and landscape, and organisational and community values. Under this model a city has access to a diversity of centralised and decentralised water sources, providing cities with the flexibility to access a ‘portfolio’ of water sources at least cost and with least impact on rural and environmental water needs (Wong & Brown, 2008). A water sensitive city uses diverse infrastructure associated with the harvesting, treatment, storage and delivery of the water from both centralised and decentralised water supply schemes (distributed system). A water-sensitive city also considers natural waterways alongside traditional water infrastructure to create a more integrated approach to water management.
Therefore, a water sensitive city has an inbuilt adaptive capacity (resilience) that makes it a good model for Melbourne because it provides a framework for mitigation and adaptation to climate change, drought, population growth and the impacts of continued urbanisation by responding to various water supply opportunities. Figure 5.2 shows how water in a water sensitive city can be sourced and used. Within this model the risks and opportunities for water management are considered on the basis of infrastructure renewal, climate change impacts, urban consolidation and population growth. As this approach effectively changes how water is managed, new regulatory requirements and forms of urban design and architecture will be required to enable Melbourne to transition to a water sensitive city (Wong & Brown, 2008).
5.2 Elements of a water sensitive city

Brown et al (2008) identify three fundamental attributes for implementing a ‘water sensitive city’. These are described in detail below, and include:

- Access to a diversity of water sources (distributed system)
- Provision of ecosystem services for the built and natural environment
- Community engagement (socio-political capital for sustainability).

5.2.1 Access to a diversity of water sources (distributed system)

There are two key factors that allow a water sensitive city to access a diversity of water sources. The first is that it is serviced by a distributed water system that enables water to be produced, distributed and consumed at varying scales ‘... a continuum of options from more decentralised to more centralised coexist and work synergistically within any management or service area’ (D’Amato, 2009). Figure 5.3 schematically depicts how a distributed system can provide a diversity of water sources across a number of scales.

Figure 5.3 – Distributed water supply

Source: VEIL, Distributed Water Systems: A networked and localised approach for sustainable water services, p.3, 2009
The second factor that allows a water sensitive city to access a diversity of water sources is the concept of ‘fit-for-purpose’ water use. Fit for purpose water use helps to prioritise and match available water sources with the most appropriate uses. This approach allows the demand on the high quality potable mains water to be reduced (Figure 5.4). With the exception of wastewater, the closer the match in quality of the source and demand, the less treatment is required, and generally the less energy intensive and most cost efficient (Wong & Brown, 2008).

Figure 5.4 - Fit for purpose water use

Source: Adapted from Total Watermark-City as a catchment, p.9.
5.2.2 Provision of ecosystem services

A water sensitive city recognises that the natural environment provides important ecosystem services. It also acknowledges the water cycle links and synergies that can be made between the built and natural environment. Therefore, a water sensitive city actively tries to encourage sustainable water management practices to ensure its longevity.

Three broad functioning themes are defined by Wong (2007) to help characterise water sensitive city design objectives. They are:

- **Nature conservancy** – conserving and protecting biodiversity in flora and fauna across terrestrial and aquatic environments.

- **Natural / urban interface** – managing the urban/natural environment interface, protecting areas of significant conservation value, and mitigation and rehabilitation of environmental impacts associated with catchment urbanisation. The focus is the transitioning of built and natural environments into a more complex and balanced landscape of natural and created features that provide enhanced physical, biological and social outcomes.

- **Urban ecology** – urban design where the role of bio-mimicry in promoting ecosystem services is actively integrated into the urban landscape. Natural features, built landscapes, art and science all influence the design of the urban landscape.

(City of Melbourne, 2008)

5.2.3 Community engagement

Another critical element in transitioning towards a water sensitive city is community acceptance and organisational commitment to support the strategies inherent in the concept. Therefore, governments at all levels (federal, state and local), the private sector and communities will play an important role in bringing sustainable urban water management practices into the mainstream. This shift will require behavioural change; hence, the uptake of sustainable urban water management practices will be tied to effective changes in behaviour across a city’s community.

Water studies by Nancarrow et al. (2003) have shown that household water consumption is influenced by three variables:
• household size;
• appliance ownership; and
• Attitudes to water use.

It is understood that simply providing information will rarely result in behaviour change. Despite rational economic theory suggesting that people will change practices when it is in their financial interests to do so, it appears that people need additional convincing that the change is warranted (Kurtz, 2002). The threat of resource depletion quite often seems to have little influence on behaviour towards better environmental practices. Behaviour change is most effectively achieved through initiatives delivered at the community level (McKenzie-Mohr and Smith, 1999) and includes the following:

• making the change as easy, attractive and normal as possible;
• acknowledging the role that self-interest plays in the adoption of new practices and technology (Taylor and Wong, 2002);
• using regulatory controls as the most effective means to create change (although this is not applicable in all instances);
• Gaining commitment by involving the community, setting goals, or intervening in such a way as to involve personal contact (Kurtz et al, 2006).

5.3 The impacts of Stormwater

Managing stormwater is a critical component in transitioning to a water sensitive city. Urbanisation has created a dramatic increase in the area of impervious surfaces (buildings, roads and car parks) greatly affecting both the quality and quantity of water infiltrating the soil. Consequently, most of the rainfall in urban areas is converted into run-off (stormwater) that is directed into urban waterways more frequently, faster and carrying more pollutants that ultimately enter receiving waters such as rivers and bays (Brown, 2007).

An analysis of the conditions of major rivers and tributaries within the state of Victoria showed that the majority are in poor condition (see Figure 5.5). Generally, rivers and tributaries in upstream mountainous areas are in good condition while urbanised downstream reaches are in poorer condition.
To address this issue, Melbourne Water, the city’s water supply and management authority, have created a target that by 2025 the state’s rivers and tributaries will be in good or better condition.

Figure 5.5 - Condition of major rivers and tributaries in Victoria's river basins


Stormwater with high nutrient levels promote algal growth and a CSIRO study in 1995 recommended that nutrient levels in Port Phillip Bay be reduced to protect the future health of the bay ecosystem. As a result of this study Melbourne Water are committed to ongoing work to reduce nutrient exports from existing areas and to minimise increases in nutrient exports from developing areas. Melbourne Water has set a reduction target of 1000 tons/year of Nitrogen. A major problem in Western Port Bay is the smothering of seagrass by sediment. Melbourne Water is working to manage the channel and stream erosion that is a main contributor to this problem (Brown, 2007).
5.3.1 Stormwater in Melbourne

In Melbourne, most stormwater enters the Yarra and Maribyrnong rivers and other creeks before entering Port Phillip and Western Port Bays. These higher and more frequent stormwater flows change hydraulic behaviour and geomorphology, detrimentally affect habitats and their higher pollutant concentrations create toxic threats to both aquatic and human lives. Combined, these effects reduce the environmental and recreational values of Melbourne’s waterways and bays (Brown, 2008).

Figure 5.6 illustrates the increase in the volumes of stormwater runoff due to urbanisation in Melbourne. Melbourne’s pre-developed runoff was approximately 200 GL/year. It is now approximately 850 GL/year, an increase of about 650 GL/year. By comparison Melbourne’s annual potable water consumption stands at 500 GL/year. Therefore, the city’s stormwater runoff is about 350 GL/year greater than its water consumption. However, despite this large amount of stormwater being available only negligible quantities of stormwater are captured for reuse (Brown, 2008).

Figure 5.6 – Effects of urbanisation on storm water


Therefore, within the context of drought and the increasing pressures of climate change, population growth and urbanisation interest in reusing stormwater to supplement and replace dwindling potable water supplies is increasing because it presents a tantalising option to supplement Melbourne’s future
water demands. Interestingly, the state government’s plan to secure Melbourne’s future water supply lacks a comprehensive strategy to tap into this resource (see 4.2).

5.4 Water Sensitive Urban Design (WSUD)

The fundamental elements of a water sensitive city seek to make sustainable water management practices the norm. This requires elements such as, but not limited to, water conservation, stormwater quality, wastewater reductions and groundwater quality to be considered together so as to achieve the best long term results for Melbourne – transitioning it towards a water sensitive city. Water Sensitive Urban Design (WSUD) unifies the elements of sustainable water management and provides the approach and tools to deliver these goals on the ground. WSUD seeks to achieve this by:

• Reducing potable water consumption;
• Maximising water reuse;
• Reducing wastewater discharge;
• Minimising stormwater pollution before it is discharged to the aquatic environment;
• Maximising groundwater protection.

These principles are achieved through:

• Managing the demand for water by reducing it
• Assessing the appropriate potable or alternative supply of water for the end purpose
• Applying best practice to stormwater management.
5.4.1 WSUD strategies

Table 5.1 shows what WSUD strategies can be employed to achieve either water quality or quantity objectives.

Table 5.1 - Role and function of WSUD measures

<table>
<thead>
<tr>
<th>Focus of WSUD Measure</th>
<th>Water Quality</th>
<th>Water Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross pollutant trap</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Oil / Grit Separator</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Grassed Swale</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Vegetated Swale</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Filtration Trench</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Filtration &amp; Conveyance Trench</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Rainwater Storage Tank</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Pond</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Underground Storage Tank</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Pervious Storage Area</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Grass Buffer</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Constructed Wetland</td>
<td>●</td>
<td>○</td>
</tr>
</tbody>
</table>

Legend

● High

○ Low

Source: MDG Landscape Architects and KLM Development Consultants – Water Sensitive Urban Design Guidelines for the City of Knox, 2001 p.33

WSUD strategies can be implemented at a number of scales from precincts to individual house lots. Given the focus of the research is on infill residential development.
Table 5.2 provides a guide to the most appropriate WSUD measures that can be implemented for this type of development.

### Table 5.2 - Applicability of WSUD measures in new residential developments

<table>
<thead>
<tr>
<th>Situation / location</th>
<th>WSUD strategy applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gross Pollutant Trap</td>
</tr>
<tr>
<td>Detached house (lot &lt; 500m²)</td>
<td>NA</td>
</tr>
<tr>
<td>Medium or integrated housing (lots &gt;300m²)</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Legend**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA</td>
<td>Highly Applicable</td>
</tr>
<tr>
<td>MA</td>
<td>Moderately Applicable</td>
</tr>
<tr>
<td>NA</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

Source: Adapted from MDG Landscape Architects & KLM Development Consultants – Water Sensitive Urban Design Guidelines for the City Of Knox, 2001, p.23
Table 5.2 shows that there are a range of WSUD strategies that are highly applicable to infill residential development. Rainwater tanks are perhaps the most ubiquitous and effective WSUD strategy because they provide reductions in mains water use and stormwater quality and quantity treatment benefits. They allow water from the roofs of buildings to be collected and stored for purposes ranging from a total substitution of mains water (rural areas) to toilet flushing and irrigation (urban areas). While, other WSUD strategies such as are swales, buffers, porous paving and filtration trenches can be integrated into the landscape of the built environment. WSUD strategies can protect the environmental quality of waterways by restoring more natural flow regimes through storage and attenuation, spreading stormwater peak flows over a longer period and reducing flow volumes through increased infiltration, evapotranspiration and removal of pollutants through settlement and filtration processes (Brown, 2008).

5.4.2 Research indicators

In order to answer the research question - Are infill residential developments in the city of Darebin adequately transitioning Melbourne to a water sensitive city. Indicators to benchmark the 'water sensitivity' of infill residential developments are required. Given WSUD provides an approach and the tools to deliver sustainable water management and hence water sensitive city goals on the ground; the research used the following WSUD indicators to gauge the water sensitivity of infill residential developments being analysed.

- Demand management - potable water reductions
- Best practice stormwater objectives

5.5 Summary

This chapter discussed the concept and elements of a water sensitive city. It established that in the context of climate change, drought and a growing population, the concept of a water sensitive city provides a robust approach to meeting and adapting to these challenges. Behavioural change was identified as one of the fundamental aspects necessary to transition to a water sensitive city and regulatory compliance was identified as a mechanism to encourage this. The impacts of stormwater in Melbourne and its direct relationship to urbanisation (increases in impervious areas) were also
presented. WSUD was identified as a valuable strategy to address the impacts of stormwater and as a means of providing alternative water treatment and storage options to reduce the demand on potable water supplies, and hence aid the transition to a water sensitive city through sustainable water management practices. The chapter also identified different WSUD strategies and outlined their applicability to infill residential development. It closed by identifying two key WSUD indicators that would be used in the research to gauge the ‘water sensitivity’ of Darebin’s infill residential developments so as to answer the research question.

The next chapter will identify the regulatory mechanisms governing stormwater within the Planning and Environment Act 1987 (P&E Act), one of the two main legislative arms of the implementation framework that administer the planning, development and management of the state’s built environment.
6 LAND USE AND DEVELOPMENT GOVERNANCE

One of the many considerations that arose out of the discussion of the elements of a water sensitive city in the previous chapter was the acknowledgement that regulatory controls are one of the most effective means of creating behavioural change (see 5.2.3). Therefore, the key objective of this chapter is to frame the research within the local regulatory context that governs the built environment. This will be achieved by identifying and discussing the regulatory mechanisms within the Planning & Environment Act (P&E Act) and Darebin planning scheme that govern storm water for infill residential developments, one of the key indicators being used in the research (see 5.4.2). The chapter will begin by briefly outlining how the built environment is governed within the state of Victoria. This will be followed by a discussion of the content, operation and administration of the P&E Act, and the residential planning provisions governing storm water within the P&E Act and Darebin planning scheme. The chapter will conclude by outlining some planning practice loopholes in the administration of these provisions and present a case study of how this was addressed by a local government.

6.1 Governance of the built environment

The built environment in Victoria is governed by strategic and implementation frameworks that are administered by the state and local governments. Figure 6.1 illustrates the overall strategic and implementation frameworks that govern the built environment in the state of Victoria. The two main legislative arms of the implementation framework that administer the planning, development and management of the state’s built environment are the Building Act and the Planning and Environment Act 1987 (P&E Act). Of particular interest in this thesis is the P&E Act, because it sets out the objectives for planning in the state of Victoria, as well as, the administration processes and criteria for determining planning land use and development decisions. Overarching documents such as Melbourne 2030 and Our Water Our Future fall under the strategic framework and set specific strategic directions that seek to address the issues being faced by the state such as water security (Our Water Our Future), population growth and urbanisation (predicted for Melbourne in 2030). These strategic policies provide the basis for their implementation at both state and local authority levels and as such are cross referenced in the P&E Act.
6.2 The Planning and Environment Act 1987 (P&E ACT)

The objectives contained in the P&E Act are broad and assist in providing the basis for sustainable land use and development at both the state and local government levels. They form the legislative framework for planning schemes, which are the key regulatory tool for guiding land use and
development in Victoria. A planning scheme is a legal document administered by local government and approved by the Minister for Planning. It sets out state and local planning objectives and controls.

### 6.2.1 The role of local government

Local governments (councils) have a statutory responsibility through the P&E Act to administer the planning scheme and provide for the orderly use and development of land. Whilst the state government determines the overarching policies and the framework for planning controls, local government can tailor the Local Planning Policy Framework (LPPF) to address local conditions provided that they are consistent with the overall Victorian Planning Provisions (VPPs). Therefore, municipalities can set their own sustainability agendas through the implementation of Municipal Strategic Statements (MSS) and local planning provisions contained within their planning scheme. However, this process has recently been fettered by the requirement for all planning scheme amendments to be authorised and approved by the Planning Minister / Department of Community Development and Planning (DPCD). Consequently, the ministerial pre-authorisation and final approval processes can therefore limit desired local outcomes as policy prepared by Council can be changed by the Planning Minister / DPCD (Hansen & SBE, 2007).

### 6.2.2 Victorian Planning Provisions (VPPs)

The VPPs are contained in the P&E Act. It is a state-wide statutory template that forms the basis for municipal planning schemes in Victoria. It comprises strategic frameworks, land use zoning, overlays and provisions for specific types of development. All municipalities have a planning scheme to direct how, where and in what form land use and development may occur. Local planning authorities (local governments / councils) are responsible for the administration of planning schemes.

The State Planning Policy Framework (SPPF) is a statement of state policy and is by the state government. The Local Planning Policy Framework (LPPF) is the statement of local policy prepared by local Councils that must be consistent with the state policy. Figure 6.2 details the various sections of the VPPs and whether the content is state or local.
6.2.3 Particular Provisions

The VPPs provide a basis for integrated transport planning, sustainable design and built form, and guidance for the inclusion of environmentally sustainable long term goals and strategic plans. The particular provisions are found at Clauses 52-57 of any planning scheme. They apply to specified categories of use and development.

For a brief outline of the planning system and process refer to Appendix 1 - CASBE SDAPP Fact sheet.
6.3 Planning provisions governing residential storm water

The planning provisions governing residential development are contained in Clause 54.03 (One dwelling on a lot), Clause 55.03 (Two or more dwellings on a lot and residential buildings) and Clause 56 (Residential subdivision). These clauses provide the objectives and standards that single dwellings, all multi unit developments and residential subdivisions requiring a planning permit need to address.

Each of these clauses contains standards and objectives for addressing storm water quality and impacts. The provisions acknowledge that the treatment of stormwater run-off should no longer be considered in isolation of the broader planning and design of the built environment. What follows is a discussion of the relevant standards and objectives governing stormwater under the planning provisions for infill residential development.

6.3.1 Clause 54.03-4 and 55.03-4

Most infill residential development proposals will be assessed under Clause 54.03 (One dwelling on a lot) and Clause 55.03 (Two or more dwellings on a lot and residential buildings). Whilst Clauses 54 and 55 are generally based around neighbourhood character, on and offsite amenity and overall built form, these clauses contain standards and objectives that seek to address stormwater run-off impacts and quality. Within these clauses Standards A6 and B9 define the desired objective which is to limit hard surfaces to reduce the volume of stormwater run-off, which reduces pressure on urban drainage systems and helps protect water quality in downstream waterways.

The aim of Standards A6 and B9 are to limit the amount of hard surfaces that can surround a new development. The Standards set the following performance objective:

“At least 20 per cent of the site should not be covered by impervious surfaces”

(Victorian Planning Provisions, Particular Provision, Clauses 54.03-4 and 55.03-4 Permeability)
Applying the standards

The 20% permeability objective of Standards A6 and B9 is calculated by the following equation:

**Equation 1 – Permeability**

\[
\text{Permeability \%} = (1 - \frac{\text{Total impervious area}}{\text{total site area}}) \times 100
\]

A site’s impervious areas are added up and divided by the total site area and multiplied by 100 to obtain the impermeability \% of a site. If the permeability \% is equal to or greater than 20\% then the development application is deemed to comply with the Standards and addressed stormwater run-off impacts.

Figure 6.3 illustrates what are considered to be impervious areas for a single and two dwellings on a lot. This information is simply extrapolated when larger developments are being assessed i.e. Equation 1 – Permeability still applies.

**Figure 6.3 - Calculating impervious areas**

Source: DSE, VPP Practice Note – Standard A6 and B9 Permeability
The VPP Practice Note for Standard A6 and B9 Permeability states that water cannot penetrate an impervious surface. It defines the following features as impervious surfaces: dwelling, garage, carport, verandah, garden shed, footpath, a swimming pool, outdoor paved areas, a driveway or any other sealed surface. The practice note states that at least 20% of the site should have surfaces that can absorb water — such as garden beds, lawn and other unsealed surfaces. This can include driveways, footpaths and outdoor entertaining areas, provided the materials used for their construction are pervious.

6.3.2 Clause 56 – Residential Subdivision

In 2006 the Victorian Government introduced integrated water management provisions for the design and assessment of residential subdivisions in the Victoria Planning Provisions (VPP’s) to conserve potable water resources and ensure the sustainability of waterways. The residential subdivision planning requirements are contained in Clause 56 of the Victoria Planning Provisions. Clause 56 provides sustainable water management requirements that aim to:

- integrate use of all water resources including rainwater, reused water, recycled water and stormwater
- conserve the supply and reduce the use of potable water
- use alternative water supplies where potable water quality is not required
- use best practice water sensitive design techniques to conserve, reuse and recycle water and manage the quality of stormwater run-off.

Clause 56.07 sets out the integrated water management requirements that must be met for residential subdivision proposals in an urban area. The objectives of Clause 56.07 describe the outcomes to be achieved in a completed residential subdivision. The associated standards contain the requirements or measures that meet the objectives. The requirements of Clause 56.07 apply in areas that have been zoned Residential 1, Residential 2, Residential 3, Mixed Use and Township Zone and any Comprehensive Development Zone or Priority Development Zone that provides for residential development.
6.3.3 Clause 56.07-4 urban run-off management objectives

Figure 6.4 provides an overview of the particular provisions contained in Clause 56.07 Integrated Water management.

Figure 6.4 -Clause 56.07 Integrated water management planning provisions

![Diagram of integrated water management planning provisions]


Although all of the provisions in Clause 56.07 are of interest because they highlight a shift in planning policy towards regulating for water sensitivity in new residential subdivisions, provision 56.07-4 urban run-off management is of particular importance to the research. This is because it deals specifically with urban run-off quality control and references guidelines that set measurable targets for stormwater quality.
Looked at more closely 56.07-4 Urban run-off management and Standard C25 seek to achieve the following objectives:

- To minimise damage to properties and inconvenience to residents from urban run-off.
- To ensure that the street drainage system operates adequately during major storm events and provides for public safety.
- To minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off.

These objectives demonstrate a clear intent to use the planning regulatory framework as a mechanism to achieve sustainable water outcomes in developments that are aligned with the concept of a water sensitive city.

The normal way of meeting these objectives is set out in Standard C25. The standard provides design and management measures for urban stormwater systems, quality and flows. Standard C25 provides that urban stormwater management systems must be designed and managed to the requirements of the relevant drainage authority. In Melbourne, this is either Melbourne Water (the water authority) or the local council where a catchment is 60 ha or less. Where reuse of urban stormwater is proposed, the urban run-off system must be designed and managed to the requirements and to the satisfaction of the water authority and/or drainage authority.

All sites must comply with the stormwater quality objectives outlined in the Urban Stormwater – Best Practice Environmental Management Guidelines produced by the Victorian Stormwater Committee in 1999 (as amended). These guidelines are a referenced document in the State Planning Policy Framework (SSPF) and form part of the State Environment Protection Policy (Waters of Victoria). The guidelines set the following water quality objectives are:

- 80 per cent retention of typical urban annual suspended solids load
- 45 per cent retention of typical urban annual total phosphorus load
- 45 per cent retention of typical urban annual total nitrogen load.
- 70 per cent reduction of typical urban annual litter load.

*WSUD Engineering Procedures 2005*
To achieve the stormwater quality objectives, treatment methods may be distributed throughout the subdivision. If a site is located within a drainage scheme then additional works may not be required on-site. Instead, a financial contribution (off-set) to the water authority or council may be made towards providing offsite urban run-off management infrastructure. Melbourne Water has a Stormwater Offsets strategy for the Melbourne region.

All developments are encouraged to incorporate water sensitive urban design elements. The stormwater quality performance of development proposals is usually assessed using specialist modelling software. Tools such as the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) and Stormwater Treatment Objective – Relative Measure (STORM) software programs, or equivalent, are suitable to use in assessing residential subdivisions.

6.4 Stormwater performance loopholes in planning provisions

The requirements of Clause 56.07 do not apply to the subdivision of land into lots each containing an existing dwelling or car parking space. In practice this qualification means that the majority of infill residential developments going through the planning permit process are exempt from meeting the requirements of Clause 56.07. This anomaly occurs because it is standard practice for infill residential development proposals to obtain a planning permit prior to obtaining a permit for subdivision. This practice occurs because the requirements for a planning permit are more stringent, therefore, from a risk management and administrative (developer and local authority) standpoint, it is more logical to obtain a planning permit prior to a subdivision permit. Therefore, under this modus operandus by local government and developers, infill residential developments that have a planning permit are exempt from addressing the requirements of Clause 56.07 because they are interpreted to contain existing dwellings.

This approach enables infill residential developments that would have needed to undergo an assessment under clause 56 to be assessed under Clauses 54 & 55 of the VPP. Under Clauses 54.03-4 and 55.03-4 the stormwater run-off impacts of developments are assessed using the 20% permeability objective outlined under Standards A6 and B9 (see 6.3.1). Furthermore, DSE’s practice note on Clause 56 - Residential Subdivision states that it is inappropriate to use a planning permit to require or prescribe on-lot works, where works are appropriately provided for in the building or plumbing regulations. For example, rain water tanks on dwellings are appropriately provided for under the 5-Star
standard of the Building Regulations. Therefore, residential planning permit conditions to require water sensitive urban design measures, such as rain gardens, on proposed lots are not supported.

6.4.1 Closing the loophole - Bayside City Council

In 2005 Bayside City Council lodged an amendment with the Planning Minister and the then Department of Sustainability and Environment (DSE) now renamed the Department of Community Development and Planning (DPCD) that sought to:

a) Introduce additions to the Municipal Strategic Statement (MSS) to strengthen the strategic basis for the introduction of stormwater quality requirements for the new development.

b) Introduce a new local policy that established statutory requirements for the incorporation of water sensitive urban design in new developments and implement the objectives and strategies of the MSS. The new policy sought a 100% overall and 65% minimum compliance with the stormwater quality requirements for development.

Developments would be assessed using the MUSIC assessment tool, or equivalent to determine compliance. When 100% compliance could not be achieved, an ‘off-set’ measure would be made available to make up that portion of compliance above 65% not achieved on-site. Applications that did not achieve the minimum 65% on-site requirement would be refused.

c) Incorporate the following three technical documents into the Bayside Planning Scheme to assist in the implementation of the local policy;

- Australian Runoff Quality (draft 2003), Institution of Engineers, Australia, 2003;

(City of Bayside, 2005)

A strategic assessment of the amendment and why it was required found that Victorian state and local planning policy frameworks supported the establishment of water sensitive urban design (WSUD) measures to assist in making new urban development more sustainable. The Association of Bayside Municipalities’ (ABM) Clean Stormwater - a planning framework also supported the introduction of stormwater quality requirements in planning schemes. The proposed requirements sought to introduce
the use of water sensitive urban design (WSUD) in all types of new development to make new
development more sustainable. It established that Water Sensitive Urban Design (WSUD) provided the
means for treating stormwater run-off to Victoria’s stormwater quality standards and would contribute
to achieving the following policy objectives:

• To protect the surface waters and ground waters in the Port Phillip Bay catchment from stormwater
pollutants and the impacts of peak stormwater flows, in accordance with SEPP objectives;

• To implement in Bayside the best practice performance objectives as set out in the Urban Stormwater
Best Practice Environment Management Guidelines;

• To minimise stormwater pollutants and peak stormwater flows at the source in accordance with the
best practice performance objectives;

• To promote the use of water sensitive urban design, including stormwater reuse.

The amendment was required to adapt these higher order policies to a local context and provide an
appropriate local statutory mechanism to implement WSUD measures in new developments. In doing so
the amendment would implement the sustainability objectives of the Bayside Environmental
Sustainability Framework and the Association of Bayside Municipalities’ (ABM) Clean Stormwater - a
planning framework (City of Bayside, 2005).

After four years the Bayside amendment was finally authorised by the Minister of Planning. Bayside City
Council is now implementing the amendment under Clause 22.10 – Water Sensitive Urban Design
(Stormwater Management) a new Local Planning Policy in the Bayside Planning Scheme. Clause 22.10 –
Water Sensitive Urban Design (Stormwater Management) ensures that new infill residential
developments being assessed under Clause 54 and 55 are meeting the same stormwater quality
objectives outlined in Clause 56. Clause 22.10 – Water Sensitive Urban Design (Stormwater
Management) addresses the loophole in planning policy process discussed in section 6.4 and ensures
that best practice stormwater quality outcomes are being addressed by all infill residential development
within the municipality.
6.4.2 Darebin City Council

Bayside City Council's local planning policy is an important precedent for other metropolitan councils such as Darebin, but unfortunately until other councils can get similar amendments approved by the Planning Minister and DPCD, the stormwater impacts of infill residential developments in these municipalities can only be assessed under Clauses 54.03-4 and 55.03-4 and Standards A6 and B9 (see 6.4).

A simple comparison of the requirements outlined in Standards A6 and B9 of Clauses 54.03-4 and 55.03-4 to the those of Standard C25 in Clause 56.07-4 Urban run-off management (refer to 6.3.3) establishes that there is a large degree of difference in the detail of objectives and the methodology to assess storm water quality outcomes in infill and new residential developments despite them having the same intent. That is, to ensure the stormwater runoff impacts of new urban development are minimised.

This variation in methodology that exists in the legislation governing stormwater is at the crux of the research because the performance outcomes of the policies governing infill development will be assessed against the BPEG stormwater quality objectives – the research's benchmark for 'water sensitive' development. Darebin city council is involved in an innovative program called Sustainable Design Assessment in the Planning Process (SDAPP) (see 7.4). Through this program valuable data on the predicated environmental performance of development applications is gathered from ESD assessment tools. Therefore, the analysis of the storm water performance of infill residential developments in the city of Darebin gathered from the tools will enable the research to determine whether they are aiding Melbourne transition to a water sensitive city.

Although ESD assessment tools are becoming the de facto way of assessing the environmental performance of buildings, their inclusion into the Victorian planning framework is limited and perspectives on whether they should be used are varied. The next chapter will discuss the rise of ESD tools, outline local debates and present precedents on their use in regulatory frameworks. The purpose of the next chapter is to highlight the role of ESD assessment tools in urban development in order to set the foundations for the thesis's research method that will be discussed in chapter 8.
7 ESD ASSESSMENT TOOLS

This chapter will concisely outline the role and use of ESD tools in assessing the sustainability aspects of urban development. The local debate on their use in the regulatory frameworks will be summarised and followed by a discussion of the use of an ESD assessment tool in the regulatory framework within the state of New South Wales. The chapter will close by presenting information on an innovative program called the Sustainable Design Assessment in the Planning Process (SDAPP) that uses ESD assessment tools to measure the environmental performance of developments within the planning framework. The SDAPP program is being piloted by a number of local governments within Victoria. One of these local governments is Darebin city council and the data gathered from its SDAPP program will be used to within the research. The aim of this chapter is to demonstrate the increasingly important role of ESD tools in assessing the sustainability of urban development. By doing so the chapter provides the necessary foundation to lead into the research method chapter that will outline how the information gathered from the ESD assessment tools from Darebin’s SDAPP program will be used to answer the research question.

7.1 The role of ESD assessments in urban development

The concept of sustainability is becoming more prominent in urban development. This has resulted in a move towards creating a shared definition of what this means and finding methods to determine and compare the ‘sustainability’ of developments. This process has led to the development of sustainability assessment methods and tools that establish goals and targets, facilitate change in practice, and measure progress and outcomes.

Sustainability assessments can be used to measure sustainability in all stages of development from planning, visioning, design, review, development approval, construction and finally, occupancy. Whilst the quality of sustainability assessment depends on the assessment tools used, they have the potential to deliver many benefits. Some sustainability assessments are already being used to determine regulatory compliance. For example within Victoria, the Building Code of Australia (BCA) requires all new residential developments to obtain a 5 Star energy rating that sets a minimum level of predicted energy consumption. To demonstrate that they have achieved the required level of performance they need to undergo a House Energy Rating (HER) using approved software. Other sustainability assessment
tools such as Green Star, BASIX, STEPS and SDS are also being used locally to provide direction and consistency for the development industry and even as a mechanism to drive market demand for sustainable development (Green Star), which is difficult to achieve without the means to rigorously assess, compare and promote a project’s sustainability rating.

Sustainability assessments can be applied at different points in the building development process and for various reasons. A developer may perform an in-house assessment, or engage a consultant to do the work at any stage of the building procurement process. While a local or regional planning authority such as Darebin city council, may require sustainability to be assessed during the development approval process. What is clearly apparent is that sustainability assessments are gaining momentum and validity, thus signalling their increasingly important role in guiding and quantifying the sustainability of urban development.

7.2 ESD assessments in the regulatory frameworks

Addressing the sustainability of the built environment at local government levels rests within the Building and Planning regulatory frameworks. Within the planning framework, strategic and statutory planning policies and provisions make reference to sustainability, however the consensus is that the Victorian Planning Provisions (VPP’s) and Local Planning Policies (LPP’s) lack a consolidated and comprehensive statement on sustainability outcomes (Hansen & SBE, 2007). This gap in policy intent has led local governments to try and actively address sustainability through the formulation of local policies and other mechanisms at their disposal. However, such initiatives have had little success because they have not been endorsed (regulatory requirement) by the Department of Planning and Community Development (DPCD) formerly the Department of Sustainability and Environment (DSE), who have given no clear direction as to how local governments can assess sustainability within their local regulatory frameworks (Hansen & SBE, 2007).

The Victorian State government’s preference has been to use the building regulatory framework and more specifically the Building Code of Australia (BCA) to address the sustainability of the built environment. The primary vehicle for the inclusion of sustainability is being administered through Victoria’s 5 star standard for new homes and came into effect in July 2005. Although the 5 star currently sets minimum performance standards that are well below other programs in use within Australia and internationally it is seen as a necessary first step to address sustainability in building (Hansen & SBE,
2007). The 5 star standard also has some inbuilt limitations that need to be improved, such as the trade off between water and energy. However, they will not be discussed here because they are beyond the scope of the research. It should be noted that in May 2011, the standard will shift to 6 star and some of the limitations of the current standard will be addressed. Although this will be an improvement (more stringent) the new standard will still lag behind equivalent overseas standards.

Generally speaking there is a strong perception of disadvantage when Planning sets out more stringent requirements than the Building Code system because a large proportion of buildings do not require planning approval. Planning permits are only required for one or more dwellings on lots greater than three hundred square metres. However, it is argued that the advantages of pursuing sustainable development early during the planning process should outweigh the perceived disadvantages, particularly in terms of achieving sustainable cities and development (Hansen & SBE, 2007). Proponents of including ESD in planning, state that it is vital to the building/planning continuum that planning takes hold of the opportunity to challenge and further ESD in the built environment. In Victoria, planning first incorporated four star energy rated multi-unit dwellings under Clause 55 (ResCode). This was subsequently incorporated into the Victorian building regulations but increased to a minimum 5 star energy rating for all new dwellings and removed from the planning regulations. This precedent is often referenced to highlight how the function of planning can be used to influence higher standards across the planning/building continuum (Hansen & SBE, 2007).

Whilst the planning process can be complex and challenging, requiring developments to comply with sustainability provisions is a fundamental objective of Planning. Therefore, it is not the policies that are the issue as development is already required to be sustainable but rather the process and assessment requirements that may be the issue. Consistent standards and decision making as well as efficient planning processes should be a core objective.

By prioritising the inclusion of sustainability within the building regulatory framework the ensuing and continuous debate over whether sustainability should also be addressed in the planning regulatory framework and to what extent, has entrenched the idea that sustainability should rest solely within the building regulatory system. This is perhaps a rhetorical argument, but trends globally suggest that sustainability should span both the planning and building regulatory frameworks to ensure that sustainability is embedded within all decision making processes for it to be achieved.
7.3 ESD assessment tools in the planning regulatory framework

Whilst there are still questions in Australia over whether the use of ESD assessment tools belongs in planning, there is precedence for the use of tools in a number of situations locally. ESD assessment tools have been used in the planning framework in the state of New South Wales (BASIX tool), by the Armadale Redevelopment Authority (ARA Scorecard), Melbourne Docklands (Docklands ESD Scorecard), Melbourne City Council (Green Star and ABGR requirements) and Clause 56 (MUSIC and STORM tools) of the Victorian Planning Provisions. In all of these cases tools have been used to educate the public, provide consistency of assessment and encourage the early consideration of ESD principles in developments.

The use of ESD assessment tools in planning can assist with decision making, particularly in balancing ESD objectives with other factors. With the aid of ESD assessment tools planners can make informed decisions about the expected environmental performance of new developments because they provide quantifiable outputs that can be measured against policy objectives (see 6.3.3. & 6.4.1)

Within the state of Victoria, the Council Alliance for a Sustainable Built Environment (CASBE), a collection of thirteen Victorian metropolitan local governments, are using the ESD assessment tools - Sustainable Tools for Environmental Performance Strategy (STEPS) and the Sustainable Design Scorecard (SDS), on a voluntary basis as their preferred means to assess the environmental performance of developments within the planning process (refer to 7.4).

7.3.1 BASIX

What is BASIX

Introduced by the New South Wales (NSW) Government in July 2004, the Building Sustainability Index (BASIX) is one of the most robust sustainable planning measures in Australia. BASIX spans the planning/building continuum to ensure residential developments in NSW are designed to use less potable water and are responsible for fewer greenhouse gas emissions by setting energy and water reduction targets.

What does it assess?

BASIX is a free on-line assessment tool that assesses residential development proposals according to the following themes:
- Water
- Thermal comfort
- Energy

Based on data provided by the applicant, the BASIX tool assesses the anticipated water consumption and greenhouse gas emission levels of the proposed development. The expected thermal performance of the proposed building is also assessed. For the Water and Energy indices, points are awarded based on how the proposal is likely to perform against the average of all existing dwellings of the same type. Algorithms within the BASIX tool calculate in qualitative terms how a proposed development is likely to perform against an existing development of the same type (NSW Government, 2010). The building industry’s response to BASIX has been positive with the Board of Architects of New South Wales stating that BASIX heralds a new era for the building industry, not only in easing the approval processes for all involved, but more importantly, the setting of higher standards for design quality, which can ultimately be used to promote sustainable developments."

**BASIX spanning the planning / building continuum**

Residential development proposals must pass specific targets (which vary according to location and building type) before the user can print a BASIX Certificate. The BASIX Certificate lists all the commitments the user has agreed to and must be shown on a project’s documentation before it can get planning approval. The BASIX certificate is then checked at various stages of construction by a building inspector to ensure that the project is being built according to the BASIX specifications (NSW Government, 2010).

**BASIX equivalent in Victoria?**

The BASIX tool is very similar to the STEPS tool being used by CASBE councils in Victoria through their SDAPP program. The only differences are that BASIX is legislated whereas STEPS is voluntary. Also BASIX spans the planning and building continuum, whereas STEPS is targeted specifically at planning to avoid any overlap with the Victorian 5 star regulatory standard as recommended by DPCD.

BASIX sets a specific potable water reduction target that requires 90% of new residential developments to reduce potable water consumption by 40% and stipulates that no new home built in NSW will use more water than the current state average. This differs to Victoria where only an aspirational and not mandated potable water reduction target has been set (25% reduction by 2015, growing to 30% by
2020), although the STEPS tool does assess a development’s performance according to this target. However, BASIX does have a narrower range of assessment categories when compared to STEPS – it does not assess peak energy demand, materials or stormwater.

BASIX provides a good precedent for Victoria because it illustrates that ESD assessment tools can be used to assess the sustainability of residential developments across the planning and building continuum (Hansen & SBE, 2007). Therefore, BASIX enables both planning and building authorities to assess developments in relation to NSW government targets for reductions in greenhouse gas emissions and potable water, as well as thermal comfort requirements. Although Victoria’s 5 star standard addresses energy targets, it does not set mandated targets for potable water reduction or thermal comfort requirements, and is confined to the building realm. Given Victoria’s continued urbanisation, growing population, water crisis and climate change impacts, BASIX provides a template that is worth considering for Victoria. This idea is reinforced by the fact that STEPS, a voluntary tool similar to BASIX is already being used by CASBE councils within Victoria. STEPS could provide an ideal mechanism for ESD requirements within Victoria to span the planning / building continuum, particularly since the tool can incorporate data from the House Energy Rating (HER) tools used to fulfil the 5 star requirements contained under the BCA.

7.4 Sustainable Design Assessment in the Planning Process (SDAPP)

The SDAPP program forms the primary basis of CASBE’s practical advocacy for a sustainable built environment (see 7.3). The SDAPP program seeks to consistently include key environmental performance considerations into the planning permit approvals process in order to achieve more sustainable outcomes for the long-term benefit of the wider community. To facilitate this outcome the SDAPP program endorses the uses of the ESD assessment tools Sustainable Tools for Environmental Performance Strategy (STEPS) and the Sustainable Design Scorecard (SDS).

The SDAPP program is continually maintained and refined through the CASBE network forum (meeting of members and interested local governments) and CASBE’s committee of management to ensure continued consistency with and, where possible, building upon existing minimum performance standards as stated within the Victorian planning and building schemes. Darebin city council is one of ten metropolitan Melbourne councils that form the CASBE group and data gained from its SDAPP program will be used within the research.
The outcomes from the SDAPP programme are both formal and informal, with the former relating to the official planning process and the voluntary submission of environmental performance information gained from the ESD assessment tools, and the enforcement of that information through permit conditions; while the latter refers to the more general, and further reaching, engagement and education of the community, development industry, and council staff on ways in which the built environment can be made more sustainable (CASBE, 2009).

Figure 7.1 illustrates that the SDAPP program and use of the STEPS and SDS tools seeks to capture and improve the environmental performance of a large proportion of buildings.

Figure 7.1 - SDAPP target area


7.4.1 SDAPP at Darebin

The City of Darebin is located in the North of Melbourne within the inner and middle metropolitan area (see Figure 7.2). Darebin is home to approximately 128,500 people and has one of the largest, most diverse communities anywhere in Victoria (City Of Darebin, 2009).
The City of Darebin is committed to sustainability and is a leader in the development of environmental policies, practices and programs. Darebin along with Moreland and Port Phillip City Councils was a founding member of CASBE and has been implementing and refining the SDAPP program since 2006 to attempt to address the policy gaps present in the planning framework that limit the ability of local government to effectively assess the environmental performance and impacts of urban development.

The author of this research has been employed as Darebin’s ESD officer since 2006 and during this time has managed the planning, implementation, and evaluation of Darebin’s SDAPP program. Over this period valuable data on the environmental performance of infill residential development within the municipality has been gathered from the use of ESD assessment tools by planning applicants. Data from the STEPS tool, and particularly the water and stormwater data gathered from planning applications from 2007-2009 will be used in the research. Chapter 8 – Research Method will provide a detailed description of the research design and how data from the STEPS tool was used to answer the research question.
8 RESEARCH METHOD

Chapter 7 established that ESD assessment tools are beginning to play an increasingly important role in guiding, quantifying and monitoring the sustainability of urban development. Tools such as BASIX in New South Wales (see 7.3.1) span the planning and building regulatory continuum and are used to assess the regulatory compliance of developments in relation to sustainability. Within Victoria, planning regulations do not endorse the use of ESD assessment tools as a means of assessing the environmental performance of developments. However, CASBE councils through the SDAPP program have been utilising the ESD assessment tools - Sustainable Tools for Environmental Performance Strategy (STEPS) and the Sustainable Design Scorecard (SDS) - as their preferred means of assessing the environmental performance of developments in planning (see 7.4). The use of the STEPS and SDS ESD assessment tools by planning permit applicants in CASBE councils is voluntary. Nevertheless, through their SDAPP programs and use of the ESD tools, CASBE councils are obtaining critical information on the predicted environmental performance of development applications in Victoria.

8.1 Unravelling the research question

To answer the research question – Are infill residential developments in the city of Darebin adequately transitioning Melbourne to a water sensitive city? Two key ‘water sensitive’ indicators, namely potable water use and stormwater performance were analysed (see 5.4.2). In order to answer the research question a series of sub-questions informed by Victorian state government policies and contemporary concepts and commentary relating to each of the indicators were posed.

Two sub-questions were posed to guide the research in relation to the potable water use indicator. The first question was

- Are infill residential developments within the municipality of Darebin achieving the state government’s aspirational target of a 25% reduction in potable water use?

The research viewed this target as a minimum level of performance for this indicator because it was set in 2006 when the true extent of Melbourne’s water crisis was not fully understood. This potable water reduction target also lags behind contemporary thoughts on an appropriate water reduction target for new infill residential development within the state. Therefore, the question sought to establish how
infill residential developments across the development types and densities were performing in relation to this minimum level of performance.

The second question was:

- Are infill residential developments within the municipality of Darebin achieving a 40% reduction in potable water?

The research viewed this target as the ideal potable water reduction target necessary to transition Melbourne towards a water sensitive city. This target was supported by research conducted by organisations such as Alternative Technology Association, Australian Conservation Foundation Environment Victoria, Friends Of the Earth and Moreland Energy Foundation Limited. Additionally, the state of New South Wales has set this as the mandatory potable water reduction target for new developments. Therefore, the question sought to determine how infill residential developments across the development types and densities within Darebin were performing in relation to this water sensitive benchmark.

The data gathered from these sub-questions for the water sensitive indicator were analysed to determine whether the performance of infill residential development in Darebin is assisting Melbourne transition to a water sensitive city.

Two sub-questions were also posed to guide the research in relation to the stormwater performance indicator. These questions were:

- Are the permeability objectives contained in Clauses 54.03-4, 55.03-4 and Standards A6 and B9 of the Victorian Planning provisions achieving best practice stormwater quality objectives?

- Are Darebin’s local policies 22.09 and 22.10 and in particular under 22.09-3.1, 22.10-3.1 Sustainability and 22.09-3.12, 22.10-3.12 Utility Services achieving best practice stormwater quality objectives?

The research viewed the best practice stormwater quality objectives as the necessary target that infill residential developments should meet in order to transition Melbourne towards a water sensitive city. These objectives set the necessary standard to meet the State Environment Protection Policy (SEPP) requirements that are referenced in the State Planning Policy Framework. As noted previously in section 6.3.3 these objectives are already being used under Clause 56.07-4 Urban run-off management objectives of the VPP for green field development (subdivisions). Therefore, these sub-questions sought
to determine whether the permeability objectives in Clauses 54.03-4, 55.03-4 and Standards A6 and B9 of the Victorian Planning provisions and Darebin's local policies are adequate to achieve best practice stormwater quality objectives.

By answering the sub-questions for each water sensitive indicator, infill residential development within Darebin could be benchmarked to gauge if their water and stormwater performance is assisting Melbourne transition to a water sensitive city. To do this, storm and potable water data obtained from Darebin City Council's SDAPP program from 2007-2009 (see 7.4 for a discussion of the SDAPP program) was collated and analysed. The data was gathered and entered into a database created by the author of the research over the period outlined above from infill residential development planning applications that underwent a Sustainable Design Assessment (SDA) using the STEPS tool.

The STEPS tool therefore forms the research's primary research method. Consequently, to understand the research method it is critical to understand how the STEPS tool operates and how it assesses water consumption and stormwater quality impacts. Section 8.2 provides the necessary overview of the STEPS tool and serves to describe the research method.

8.2 Sustainable Tools for Environmental Performance Strategy (STEPS)

8.2.1 Overview

STEPS is a web based environmental assessment tool that was specifically developed to assess residential developments. STEPS was developed by Moreland City Council in 2004 to enable planning applicants and Councils to assess the predicted impacts of residential developments with a view to improving their environmental performance.

The STEPS tool stands alone in Victoria as it is the only residential ESD assessment tool that goes beyond a simple points scoring system and incorporates a performance based system for each category without allowing trade-offs (Hansen & SBE, 2007). A survey of industry professionals contained in a 2007 report by Hansen & SBE established that the STEPS tool was considered to be highly accessible and easy to use. Furthermore, the report stated that the STEPS tool meets the aims of industry education without being overly onerous (Hansen & SBE, 2007).
The STEPS tool assesses five critical elements in the construction of sustainable buildings and awards points under these assessment categories. The five assessment categories and their objectives are listed below:

1. **Energy**
   - To reduce total operating greenhouse gas emissions per resident;
   - To adopt economically viable energy efficiency design initiatives.

2. **Peak Energy use**
   - To reduce summer peak loading.

3. **Water**
   - To reduce mains/potable drinking water demand for indoor and landscape water use.

4. **Storm water quality impacts**
   - To reduce peak and storm water run off;
   - To improve the quality of storm water run off.

5. **Building materials impacts**
   - To minimise environmental impacts of materials used;
   - To encourage the use of ‘environmentally benign / friendly materials’.

The tool also provides a calculation for the number of bicycle spaces required and the area needed for waste recycling services (Moreland City Council, 2006).

The research focused on the water and stormwater assessment categories of the tool. Therefore the performance targets of these categories need to be understood.

### 8.2.2 STEPS water and stormwater targets

Each STEPS assessment category has a target score that has been specified based on improving current practice. The target scores for each category represent a percentage reduction over current practice that STEPS is seeking to achieve. The tool’s target scores for water and stormwater are shown in Table 8.1.
Table 8.1 - STEPS water & stormwater target scores

<table>
<thead>
<tr>
<th>Assessment category</th>
<th>Target</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>25% reduction</td>
<td>Victorian Governments aspirational target (Water Supply Demand Strategy for Melbourne 2006-2055, 2006)</td>
</tr>
<tr>
<td>Stormwater</td>
<td>75% treatment</td>
<td>Melbourne Water, Department of Sustainability and Environment (DSE) &amp; Association of Bayside Municipalities - Stormwater Treatment Objective – Relative Measure (STORM) methodology</td>
</tr>
</tbody>
</table>

(Moreland City Council, STEPS Guide V5, June 2010, p.7)

The targets under these assessment categories set the benchmarks that will be used to answer the sub-questions posed for each water sensitive indicator. The tool measures potable reductions of developments and as such it can be used to gauge performance against the 25% and 40% reductions targets outlined in the research sub-questions for the water indicator. Similarly, the stormwater target in the tool is based on the BPEG stormwater objectives; hence it automatically references the water sensitive benchmark for the stormwater indicator. Consequently, it is necessary to understand how the STEPS tool assesses infill residential development against these targets.

8.2.3 STEPS water use calculations

The water assessment module of the STEPS tool estimates the total amount of mains water likely to be used within a development. To calculate the predicted water consumption of a development, users need to enter information on the water efficiency of the following fittings:

- Shower heads;
- Toilet;
- Basin Taps;
- Bath Volume; and
- Miscellaneous water use - clothes & dish washing.

For apartments and multi-unit buildings these values reflect the average apartment.

The STEPS tool also calculates water saved for rainwater collection and reuse. This calculation is based on local rainfall patterns tank size and roof catchment area.

For multi-unit development the user will enter values for the whole of site. STEPS will then attribute the savings to the average apartment automatically. How much water is saved depends on how the water is used. Toilet flushing, clothes washing, hot water supply and garden irrigation have been assessed as potential uses for collected rainwater – toilet flushing, clothes washing and hot water supply have the advantage in that they use rainwater all through the year where gardens generally do not need watering in winter and spring (Moreland City Council, 2010).

STEPS water score

Total water use is calculated based on the water appliances selected, their water efficiency and assumptions about patterns of water use. Water supply from rainwater is calculated based on the roof area connected to the rainwater harvesting system, and average rainfall data for the selected locality sourced from the Bureau of Meteorology. The rain collected is calculated for each month, and the amount drawn off calculated for toilets, clothes washing, hot water and gardens (depending on the water uses selected). The irrigation demand varies seasonally and the amount of water left in the tank governs how much water can be collected the following month. A monthly calculation is not as accurate as using daily rainfall data and water consumption calculations, but was chosen to reduce the computer resources required to run the STEPS tool, and provides an acceptable estimate (Moreland City Council 2006). Furthermore, it must be noted that the STEPS water calculator only provides averages and does not take into account climate change scenarios or rainfall variability from the El Nino-Southern Oscillation (ENSO) cycle.

The net mains water consumption is calculated by subtracting the rainwater used from the total water consumption. The STEPS tool then converts this figure into a score that represents a percentage reduction or increase over current practice. Refer to Appendix 4 for a copy of the STEPS water and stormwater assessment module interface.
8.2.4 5 Star Standard and rainwater tank use

On 1st July 2005 the Victorian State Government’s 5 Star Standard came into full effect. Under the Standard new homes must meet the compulsory 5 Star Standard. This means that all new homes must have:

- 5 Star energy rating for the building fabric, plus
- A rain water tank for toilet flushing, or
- A solar hot water system.

However, under the standard, Class 2 buildings (apartments) need to achieve an average 5 Star rating for the whole building and no less than 3 stars for individual apartments. Class 2 buildings are also exempt from installing a rainwater tank or solar hot water heater.

This is an important note to make given both Class 1 and Class 2 buildings are the development types being assessed in the research (see 8.3.3). Therefore, it is possible that the 5 star Standard in relation to the use of rainwater tanks could influence some of the results for the two water sensitive indicators being used in the research.

8.2.5 STEPS stormwater performance calculations

Stormwater Treatment Objective – Relative Measure (STORM) Calculator

The stormwater assessment module of the STEPS tool uses the Stormwater Treatment Objective – Relative Measure (STORM) Calculator algorithms to determine the stormwater quality impacts of a development. The STORM Calculator is also a stand-alone web based tool that can be accessed independently of the STEPS tool on Melbourne Water’s website - http://storm.melbournewater.com.au/.

What follows is a discussion of the STORM tool given the STEPS tool uses the STORM Calculator algorithms to determine the stormwater quality impacts of developments, albeit behind the STEPS tool interface.
What is STORM

Melbourne Water developed the STORM Calculator as a method of simplifying the analysis of stormwater treatment methods. STORM is a simplified method for rating the stormwater quality performance of a development proposal. It is most appropriate for assessing small scale subdivisions of typically less than 1 hectare in area. While it can be used for large developments, the results will be more conservative than more sophisticated models such as the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software.

STORM is intended for use by planning applicants without access to specialist expertise. STORM is a software tool that calculates the performance of a design using a series of curves to measure the effectiveness of nominated stormwater retention features for treating the quality of urban runoff from hard surfaces.

The tool is capable of calculating the performance of a range of commonly implemented treatment measures including:

- Rainwater tanks
- Ponds
- Wetlands
- Rain gardens
- Infiltration systems
- Swales

The STORM Calculator uses rainfall data from any region in the state of Victoria, Australia, by looking at the municipality in which the development is located (Melbourne Water, 2010).

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1 Rain gardens are designed for stormwater quality treatment and as an ornamental feature.
2 An infiltration trench is a shallow, excavated trench filled with gravel or rock, into which run-off drains
3 Swales are linear depression or channels that provide for stormwater collection and conveyance.
Background

The STORM Calculator was developed from the stormwater assessment tool created by the Association of Bayside Municipalities (ABM) and published in the Delivering Water Sensitive Urban Design: Clean Stormwater - A Planning Framework in 2004. The data used for calculating the STORM rating was taken from the MUSIC software (version 3), developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH) in 2005.

How STORM works

The STORM Calculator rates the performance of treatment measures relative to the percentage of best practice targets that have been achieved by those treatment measures. Inputs to the model include impervious areas and a selected treatment measure. The resultant STORM score is then entered into the storm water model of the STEPS tool.

An adjustment factor within the tool accounts for different hydrologic regions and then a series of tables provide treatment performance. A weighted average is calculated, providing a final STORM rating that translates into an equivalent to a STEPS score in the STEPS tool. A STEPS score of 75% means that best practice stormwater quality objectives have been met.

Achieving best practice

The Best Practice Environmental Guidelines (BPEG), published by the Victorian Stormwater Committee, establishes specific stormwater quality objectives to assist in determining the level of stormwater management necessary to meet the State Environment Protection Policy (SEPP) requirements. These guidelines are now a referenced document in the State Planning Policy Framework. The best practice performance objectives from the BPEG, from which the STORM Calculator and hence STEPS rates treatment performance, is:

- Total Nitrogen (TN): 45% retention of the typical annual load.

The reduction in Total Suspended Solids (TSS) and Total Phosphorus (TP) loads have not been included in the STORM calculator as the reduction in TN is usually the limiting factor, making the reduction in TP and TSS mostly irrelevant to STORM calculations.

How accurate is STORM?
The tool is limited to the assessment of discrete treatment measures, that is, it does not model accurately a treatment train where several treatments are designed in series. The tool is also limited to sites where the coverage of impervious surfaces is greater than 40%. Additionally, for large complex sites more sophisticated modelling should be undertaken such as the MUSIC software (Melbourne Water, 2010). Although the tool has these limitations it is a good fit for assessing infill residential development because the sites are typically of a size suited to the tool and treatment trains are typically not employed.

8.3 Defining infill Residential Development types

Infill residential development takes varied forms from a new single dwelling being added to the rear of an existing dwelling, to multi-unit developments (3 or more dwellings on a site) and apartment buildings (3 or more storeys). Each of these types of infill development has different physical characteristics such as changes in scale (number of storeys), density (number of dwellings) and site coverage.

It was assumed that the variations in the physical characteristics of infill residential developments may have a bearing on the water and stormwater results obtained from the STEPS tool. Under this assumption, planning provisions governing infill residential development in Darebin were explored to provide a method to categorise and define the different types of residential infill development represented in the STEPS data being used in the research.

8.3.1 Clauses 54.03-3 & 55.03-3 Site coverage & Standards A5 & B8

Clauses 54.03 (One dwelling on a lot) and 55.03 (Two or more dwellings on a lot and residential buildings) provide the objectives and standards that single dwellings and most multi unit infill residential developments requiring a planning permit need to address.

Clauses 54.03-3 and 55.03-3 Site coverage objectives seek to ensure that the site coverage of developments respect the existing or preferred neighbourhood character and responds to the features of the site. Standards A9 and B8 under these clauses state that the site area covered by buildings should not exceed:

- The maximum site coverage specified in the schedule to the zone, or
• If no maximum site coverage is specified in the schedule to the zone, 60 per cent.

(Victorian Planning Provisions)

8.3.2 Local Planning Policies - Darebin

In addition to Clauses 54.03-03 and 55.03-3 the following Darebin local planning policies were reviewed to further determine a method to categorise and define the different types of residential infill development represented in the STEPS data being used in the research.

• Clause 22.09 Residential and mixed use development of less than four storeys in business 1 and business 2 zones

• Clause 22.10 Residential and mixed use development of four or more storeys

The site coverage objective in Clauses 54.03-03 and 55.03-3 do not apply to developments covered by these local policies. Under both these local policies there is no site coverage objective hence developments can occupy 100% of the site.

8.3.3 Infill residential development types

By using Clauses 54.03-3 and 55.03-3 Site coverage objectives and Darebin’s local policies 22.09 and 22.10, infill residential development data from the STEPS tool was categorised and defined accordingly:

Units

Developments covered by and adhering to Clause 55.03-3 Site coverage objective, i.e. their site coverage does not exceed 60% of the site.

Apartments

Developments that are not covered or adhere to Clauses 54.03-3 and 55.03-3 Site coverage objectives are covered by Darebin’s local policies 22.09 and 22.10.

These developments have no limitations on site coverage and are either residential infill developments of less than four storeys in business 1 or business 2 zones, or are a development of four or more storeys.
8.3.4 Infill residential development types and density

Although, the aforementioned categories and definitions of infill residential development types address scale and site coverage, they do not account for density (number of dwellings). Therefore, to address the potential impact of density on the research, a method to define different scales of development within these categories was developed.

Within the realm of planning, terms such as low, medium and high are used to define development density but there are no definitive numbers attributed to these terms within state or local planning policies and legislation. Furthermore, interpretations of the numbers associated with these terms vary widely across municipalities and even between planning officers within a given council.

In the absence of any definitive and recognised interpretation of density, the following levels of density were defined for each infill development type identified in section 8.3.3.

Units

In order to sort the STEPS water and stormwater for unit developments the following density levels were defined.

- low density - 1-2 units
- medium density – 3 -5 units
- high density - 6 plus units

Note:

Darebin City Council’s engineering department imposes a standard stormwater planning permit condition on developments of 3 or more units on a lot. The condition requires all developments covered by this planning permit condition to reduce storm water flows to pre-development levels. Therefore the requirement acknowledges that developments of 3 or more dwellings have an increased impact on storm water outcomes and as such aligns with the medium density level defined above.

Similarly, planning provisions require different car parking levels for developments of 5 or more units. Although this distinction applies to car parking, in the absence of any other meaningful methods to define density levels the author has used this regulatory requirement as a guide to support the logic of the density levels outlined above.
Apartments

In order to sort the STEPS water and stormwater for Apartment developments the following density levels were defined.

- low density - 15 or less
- medium density - 15- 30 apartments
- high density - 30 or more apartments

Unlike the unit development category there were no regulatory or council triggers that could be used to determine density categories. In the absence of such information the author selected the aforementioned categories.

8.4 STEPS data analysis

8.4.1 STEPS water data

Units and apartments

Section 0 outlined how STEPS calculates water consumption and translates it into a percentage reduction or increase score that is measured against the Victorian governments 25% potable water reduction target.

Therefore, to answer the sub-questions for the potable water indicator, namely:

- Are infill residential developments within the municipality of Darebin achieving the state government’s aspirational target of a 25% reduction in potable water use?
- Are infill residential developments within the municipality of Darebin achieving a 40% reduction in potable water as per Environment Victoria’s suggested state target?

STEPS water data obtained from planning applications for infill residential development (units and apartments) within Darebin across the densities established in section 8.3.4 was analysed. The results would then be interpreted to determine whether the potable water reductions being achieved are transitioning Melbourne towards a water sensitive city.
8.4.2 STEPS stormwater data

The STEPS target score for stormwater is 75% (Table 8.1 in section 8.2.2). This target score is calculated using algorithms from the STORM Calculator and represents the best practice stormwater performance quality objectives to meet the State Environment Protection Policy (SEPP) requirements. Section 8.4.2 outlined how STEPS calculates stormwater performance in relation to these best practice stormwater objectives.

Units

The stormwater impacts of residential infill developments defined as Units (see 8.3.3) are assessed under Clauses 54.03-4 and 55.03-4 Permeability objectives and Standards A6 and B9 (see 6.3.1). The objectives of this clause are to reduce the impact of increased stormwater run-off on the drainage system and to facilitate on-site stormwater infiltration. To achieve these objectives Standards A6 and B9 under this clause state that:

At least 20 per cent of the site should not be covered by impervious surfaces.

(Victorian Planning Provisions, Particular Provision, Clauses 54.03-4 and 55.03-4 Permeability)

Apartments

Residential infill developments defined as Apartments (see 8.3.3) are not covered by Clauses 54.03-4 and 55.03-4 Permeability objectives and standards because they are covered by the Darebin’s local policies 22.09 and 22.10. Developments covered by these local policies can have 100% site coverage thus ruling out the application of Clause 54.03-4 Permeability objectives and standards.

Under these local policies stormwater impacts are addressed under 22.09-3.1, 22.10-3.1 Sustainability and 22.09-3.12, 22.10-3.12 Utility Services.

The objectives of 22.09-3.1 and 22.10-3.1 Sustainability seek to establish a high standard of energy efficiency for the design, construction and fit out of multi-level development and to minimise water use. The design guidelines under these clauses state the following with regard to stormwater:

On-site drainage system shall take into account the need for on-site stormwater detention or retention and re-use, and the scope for on-site stormwater infiltration.
The objectives of 22.09-3.12, 22.10-3.12 Utility Services are to ensure that local utility services are adequate to handle the loads imposed by residential development. The design guidelines under this clause state that:

Council will consult with the relevant utility service providers for water supply, sewerage, stormwater drainage and power in relation to the adequacy of utility services to support the development proposed. Consultation with senior planning officers at Darebin established that developments covered by Darebin’s local policies are no longer referred to the water authorities such as Melbourne Water and Yarra Valley Water because generic planning conditions were being placed on developments that did not specify any stormwater quality objectives.

**Approach**

It is important to note that none of the planning clauses outlined above that govern unit or apartment type infill residential development refer to best practice stormwater quality objectives. Yet the intent contained in the objectives of these clauses is to address the stormwater impacts of infill residential development.

Therefore, to answer the following sub-questions for the stormwater indicator:

- Are the permeability objectives contained in Clauses 54.03-4, 55.03-4 and Standards A6 and B9 of the Victorian Planning provisions achieving the best practice stormwater quality objectives to meet the State Environment Protection Policy (SEPP) requirements that are referenced in the State Planning Policy Framework?

- Are Darebin’s local policies 22.09 and 22.10 and in particular under 22.09-3.1, 22.10-3.1 Sustainability and 22.09-3.12, 22.10-3.12 Utility Services achieving best practice stormwater quality objectives to meet the State Environment Protection Policy (SEPP) requirements that are referenced in the State Planning Policy Framework?

STEPS stormwater data obtained from planning applications for residential infill development (units and apartments) within Darebin across the densities established in section 8.3.4 were analysed. The results were then interpreted to determine whether the state and local policies governing stormwater are achieving best practice stormwater quality objectives to meet the State Environment Protection Policy (SEPP). As noted previously, the best practice stormwater quality objectives would be the research’s ‘water sensitive’ benchmark for the stormwater performance of infill residential developments.
Therefore, the answers to these sub questions were then used to ascertain if the stormwater performance of infill residential development in Darebin is transitioning Melbourne towards a water sensitive city.
9 RESULTS

Chapter 8 established that water and stormwater data gathered from the city of Darebin’s SDAPP program would be used to answer the research question through a series of sub-questions (see 8.1). Chapter 8 defined two types of infill residential development based on state and local planning policies. These development types and their density categories (low, medium and high) accounted for variations in building scale and typology. They were defined as follows:

- Units
- Apartments

The water and stormwater results of the research will be presented according to the development types and density categories outlined above and discussed in more detail within section 8.3.

9.1 Unit and Apartment numbers assessed

9.1.1 Units

The water and storm water performance of 118 planning applications for unit developments were assessed. Figure 9.1 shows that low (46%) and medium (47%) density unit developments formed the majority of the unit applications assessed, while high density unit developments formed the remaining proportion (7%).

Figure 9.1 - Unit development planning applications

- Low (1-2 Units)
- Medium (3-5 Units)
- High (6+ Units)
Table 9.1 shows that the 118 applications assessed represent a total of 364 dwellings. The medium density category contained the largest number of dwellings (197) an average of 3.6 dwellings per application, followed by the high density category (89) an average of 9.9 dwellings per application, then the low density category (78) an average of 1.4 dwellings per application.

<table>
<thead>
<tr>
<th>Density</th>
<th># of applications</th>
<th># of dwellings</th>
<th>Average dwellings/application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (1-2 units)</td>
<td>55</td>
<td>78</td>
<td>1.4</td>
</tr>
<tr>
<td>Medium (3-5 units)</td>
<td>54</td>
<td>197</td>
<td>3.6</td>
</tr>
<tr>
<td>High (6+ units)</td>
<td>9</td>
<td>89</td>
<td>9.9</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>364</td>
<td></td>
</tr>
</tbody>
</table>

9.1.2 Apartments

The water and storm water performance of 15 planning applications for apartment developments were assessed. Figure 9.2 shows that low density apartment applications formed the majority of planning applications (60%) while medium and high density apartment applications formed the remaining proportion of applications assessed (20% each).
Table 9.2 shows that the 15 apartment planning permit applications represent 444 dwellings. The high density category contained the largest number of dwellings (326) an average of 107 dwellings per application, followed by the low density category (67) an average of 7.4 dwellings per application and the medium density category (51) an average of 17 dwellings per application.

<table>
<thead>
<tr>
<th>Density</th>
<th># of applications</th>
<th># of dwellings</th>
<th>Average dwellings/application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (&lt; 15 apartments)</td>
<td>9</td>
<td>67</td>
<td>7.4</td>
</tr>
<tr>
<td>Medium (15-30 apartments)</td>
<td>3</td>
<td>51</td>
<td>17</td>
</tr>
<tr>
<td>High (30+ apartments)</td>
<td>3</td>
<td>326</td>
<td>107</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>444</td>
<td></td>
</tr>
</tbody>
</table>

9.1.3 Assessing water data by dwelling numbers

The STEPS water data obtained from a planning permit application for both unit and apartment developments represent the typical predicted performance of an average dwelling (see 0). Given a
planning application may fall into one of the three density categories outlined in 8.3.4. The STEPS water data for a single application can represent the performance of a number of dwellings. Therefore, the water results for each density category are presented according to the number of dwellings represented in the planning applications rather than the number of applications.

9.2 Water results

9.2.1 Unit water results

Figure 9.3 shows the water performance of dwellings in the three unit development density categories. Dwellings that are marked as passed either achieved or surpassed the STEPS target score of a 25% reduction in potable water use. Dwellings that are marked as failed did not achieve the STEPS target score of a 25% reduction in potable water use.

Figure 9.3 - Unit development water performance

Figure 9.3 shows that dwellings in each density category performed as follows:

Low density (1-2 units)
Out of the 78 dwellings represented in the low density category, 51 dwellings (65%) met or surpassed the STEPS score for water, while 27 dwellings (35%) failed to achieve the STEPS target score.

**Medium density (3-5 units)**

Out of the 197 dwellings represented in the medium density category 71 dwellings (36%) met or surpassed the STEPS water score, while 126 dwellings (64%) failed to achieve the STEPS target score.

**High density (6+ units)**

Out of the 89 dwellings represented in the high density category 58 dwellings (65%) met or surpassed the STEPS score for water, while 31 dwellings (35%) failed to achieve the STEPS target score.

**9.2.2 Unit water results - detailed analysis**

Further analysis of the unit water results was conducted to gain a better understanding of how well or poorly dwellings within the specified development densities achieved potable water reductions.

The following water reduction thresholds were set to conduct the detailed analysis.

**Pass**

- ≥ 40% - research benchmark for a water sensitive dwelling
- 30-39% - Victorian state government’s aspirational target - 30% reduction by 2020 from 1990s average
- 25-29% - Victorian state government’s aspirational target - 25% reduction in residential per capita drinking water consumption by 2015 from 1990s average

**Fail**

- 10-24%
- <10%
Table 9.3 - Unit water results breakdown

<table>
<thead>
<tr>
<th>Density</th>
<th>Percentage reduction in potable water (%)</th>
<th></th>
<th></th>
<th></th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass</td>
<td>30-39</td>
<td>25-29</td>
<td>10-24</td>
<td>&lt;10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (&lt;3)</td>
<td></td>
<td>5%</td>
<td>25%</td>
<td>35%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4/78)</td>
<td>(20/78)</td>
<td>(27/78)</td>
<td>(10/78)</td>
</tr>
<tr>
<td>Medium (3-5)</td>
<td></td>
<td>6%</td>
<td>10%</td>
<td>20%</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12/197)</td>
<td>(20/197)</td>
<td>(39/197)</td>
<td>(81/197)</td>
</tr>
<tr>
<td>High (5+)</td>
<td></td>
<td>44%</td>
<td>-</td>
<td>21%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(39/89)</td>
<td></td>
<td>(19/89)</td>
<td>(7/89)</td>
</tr>
</tbody>
</table>

Dwelling numbers and percentages (%)

Table 9.3 shows that:

**Low density (1-2 units)**

Within this density category 51/78 dwellings (65%) passed the STEPS water score. 4/78 dwellings (5%) achieved a 40% or greater reduction in potable water use. 20/78 dwellings (25%) achieved between 30-39% reductions in potable water, and 27/78 dwellings (35%) achieved between 25-29%
27/78 dwellings (35%) failed to achieve the STEPS water score. 10/78 dwellings (13%) achieved a 10-24% reduction in potable water use, and 17/78 dwellings (22%) failed to achieve savings greater than 10%.

**Medium density (3-5 units)**

Within this density category 71/197 dwellings (36%) passed the STEPS water score. 12/197 dwellings (6%) achieved a 40% or greater reduction in potable water use. 20/197 dwellings (10%) achieved between 30-39% reductions in potable water, and 39/197 dwellings (41%) achieved between 25-29% reductions in potable water.

126/197 dwellings (64%) failed to meet the STEPS target score. 81/197 dwellings (41%) achieved a 10-24% reduction in potable water, and 45/197 dwellings (23%) failed to achieve savings greater than 10%.

**High density (6+ units)**

Within this density category 58/89 dwellings (65%) passed the STEPS water score. 39/89 dwellings (44%) achieved a 40% or greater reduction in potable water use, and 19/89 dwellings (21%) achieved a 25-39% reduction in potable water.

31/89 dwellings (35%) failed to meet the STEPS water score. 7/89 dwellings (8%) achieved a 10-24% reduction in potable water, and 24/89 dwellings (27%) failed to achieve savings greater than 10%.

**9.2.3 Units – rainwater tank use**

The use of rainwater tanks is a common WSUD feature that can reduce potable water consumption. To gain an understanding of how the use of rainwater tanks affected the water performance of the dwellings this data was analysed as well.

**Low density (1-2 units)**

Within this density category 38% (30/78) of the dwellings used rain water tanks. None of the dwellings that failed to meet the STEPS water score used rain water tanks.
Medium density (3-5 units)

Within this density category 18% (35/197) of the dwellings scored used rain water tanks. None of the dwellings that failed to meet the STEPS water score used rain water tanks.

High density (6+ units)

Within this density category 8% (7/89) of the dwellings used rain water tanks. Only 1% (1/89) of the dwellings that used a rain water tank failed to meet the STEPS water score.

9.2.4 Units – rainwater tank use - detailed analysis

Further analysis of the use of rainwater tanks was conducted to gain a better understanding of how their use affected the potable water reduction performance of dwellings according to the performance thresholds set in section 9.2.2.

Table 9.4 - Unit rainwater tank use

<table>
<thead>
<tr>
<th>Density</th>
<th>Percentage reduction in potable water (%)</th>
<th>Tank used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td></td>
<td>≥40</td>
<td>25-29</td>
</tr>
<tr>
<td>Low (&lt;3)</td>
<td>5% (4/78)</td>
<td>10% (8/78)</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>3% (2/78)</td>
</tr>
<tr>
<td>Medium</td>
<td>2% (4/197)</td>
<td>7% (13/197)</td>
</tr>
<tr>
<td>(3-5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>(8/197)</td>
<td>(7/197)</td>
<td>(21/197)</td>
</tr>
<tr>
<td>High (6+)</td>
<td>7%</td>
<td>-</td>
</tr>
<tr>
<td>(6/89)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37%</td>
<td>21%</td>
</tr>
<tr>
<td>(33/89)</td>
<td>(19/89)</td>
<td>(6/89)</td>
</tr>
</tbody>
</table>

**Low density (1-2 units)**

Within this density category 5% (4/78) of the dwellings achieved a 40% or greater reduction in potable. All of these dwellings used rainwater tanks.

26% (20/78) of the dwellings achieved potable water reductions of between 30-39%. Of these dwellings 23% (18/78) used rain water tanks and 3% (2/78) did not.

34% (27/78) of the dwellings achieved potable water reductions between 25-29% reductions. 10% (8/78) used rain water tanks and 24% (19/78) did not.

35% (27/78) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks.

**Medium density (3-5 units)**

Within this density category 6% (12/197) of the dwellings achieved a 40% or greater reduction in potable. 2% (4/197) used rain water tanks and 4% (8/197) did not.

10% (20/197) of the dwellings achieved potable water reductions of between 30-39%. Of these dwellings 7% (13/197) used rain water tanks and 3% (7/197) did not.

20% (39/197) of the dwellings achieved potable water reductions between 25-29% reductions. 9% (18/197) used rain water tanks and 11% (21/197) did not.
64% (126/197) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks.

High density (6+ units)

Within this density category 44% (39/89) of the dwellings achieved a 40% or greater reduction in potable. 7% (9/89) used rain water tanks and 37% (8/197) did not.

No dwellings achieved potable water reductions of between 30-39%.

21% (19/89) of the dwellings achieved potable water reductions between 25-29% reductions. All of these dwellings did not use rain water tanks.

35% (31/89) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks. Only 1% (1/89) of the dwellings used a rainwater tank and it achieved potable water reductions of between 10-25%.

9.2.5 Apartment water results

Figure 9.4 shows the water performance of dwellings in the three apartment development density categories. Dwellings that are marked as passed either achieved or surpassed the STEPS water target - 25% reduction in potable water use. Dwellings that are marked as failed did not achieve the STEPS target score of a 25% reduction in potable water use.

Figure 9.4- Apartment development water performance
Figure 9.4 shows that dwellings in each density category performed as follows:

**Low density (<15 apartments)**

Out of the 67 dwellings represented in the low density category, 56 dwellings (83%) achieved or surpassed the target set in the STEPS tool. 11 dwellings (17%) failed to achieve the STEPS target score.

**Medium density (15-30 apartments)**

Out of the 51 dwellings represented in the medium density category, 33 dwellings (65%) achieved or surpassed the target set in the STEPS tool. 18 dwellings (35%) failed to achieve the STEPS target score.

**High density (30+ apartments)**

Out of the 326 dwellings represented in the high density category, 273 dwellings (84%) met or surpassed the STEPS score for water. 53 dwellings (16%) failed to achieve the STEPS target score.

**9.2.6 Apartment water results - detailed analysis**
Further analysis of the apartment water results was conducted to gain a better understanding of how well or poorly dwellings achieved potable water reductions.

The following water reduction thresholds were set to conduct the detailed analysis.

**Pass**
- ≥40% - Research benchmark for a water sensitive dwelling
- 30-39% - Victorian state government’s aspirational target - 30% reduction by 2020 from 1990s average
- 25-29% - Victorian state government’s aspirational target - 25% reduction in residential per capita drinking water consumption by 2015 from 1990s average

**Fail**
- 10-24%
- <10%

<table>
<thead>
<tr>
<th>Density</th>
<th>Percentage reduction in potable water (%)</th>
<th>Pass</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≥40</td>
<td>30-39</td>
</tr>
<tr>
<td>Low (&lt;15)</td>
<td></td>
<td>13% (9/67)</td>
<td>24% (16/67)</td>
</tr>
<tr>
<td>Medium (15-30)</td>
<td></td>
<td>33% (17/51)</td>
<td>31% (16/51)</td>
</tr>
</tbody>
</table>

Table 9.5 - Apartment water performance breakdown

108
Table 9.5 provides an outline of this detailed analysis. It shows that:

Low density (>15 apartments)

Within this density category 56/67 dwellings (83%) passed the STEPS water score. 9/67 dwellings (13%) achieved a 40% or greater reduction in potable water use. 16/67 dwellings (25%) achieved between 30-39% reductions in potable water, and, 31/67 dwellings (46%) achieved between 25-29%

11/67 dwellings (17%) failed to achieve the STEPS water score. 10/67 dwellings (15%) achieved a 10-24% reduction in potable water use, and 1/67 dwellings (2%) failed to achieve savings greater than 10%.

Medium density (15-30 apartments)

Within this density category 33/51 dwellings (64%) passed the STEPS water score. 17/51 dwellings (33%) achieved a 40% or greater reduction in potable water use. 16/51 dwellings (31%) achieved between 30-39% reductions in potable water. No dwellings achieved potable water reductions between 25-29%

18/51 dwellings (35%) failed to achieve the STEPS water score. All of these dwellings failed to achieve potable water reductions greater than 10%.

High density (30+ apartments)

Within this density category 273/326 dwellings (84%) passed the STEPS water score. All of these dwellings achieved potable water reductions of between 30-39%.

53/326 dwellings (16%) failed to meet the STEPS water score. All of these dwellings failed to achieve potable water savings greater than 10%.

9.2.7 Apartments – rainwater tank use
The use of rainwater tanks is a common WSUD feature that can reduce potable water consumption. Therefore to gain an understanding of how the use of rainwater tanks affected the water performance of the dwellings this data was analysed as well.

Low density (<15)
Within this density category 41% (28/67) of the dwellings that passed the STEPS water score used rain water tanks. None of the dwellings that failed to meet the target used rain water tanks.

Medium density (15-30)
Within this density category 64% (33/51) of the dwellings that passed the STEPS water score used rain water tanks. None of the dwellings that failed to meet the target used rain water tanks.

High density (30+)
Within this density category 84% (273/327) of the dwellings that passed the STEPS water score used rain water tanks. None of the dwellings that failed to meet the target used rain water tanks.

9.2.8 Apartments – rain water tank use - detailed analysis
Further analysis of the use of rainwater tanks was conducted to gain a better understanding of how their use affected the potable water reduction performance of dwellings according to the performance thresholds set in section 9.2.2

Table 9.6 – Apartment rainwater tank use

<table>
<thead>
<tr>
<th>Density</th>
<th>Percentage reduction in potable water (%)</th>
<th>Tank used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>≥40</td>
<td>Fail</td>
</tr>
<tr>
<td>Fail</td>
<td>30-39</td>
<td>10-24</td>
</tr>
<tr>
<td></td>
<td>25-29</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

110
<table>
<thead>
<tr>
<th>Density (</th>
<th>12%</th>
<th>24%</th>
<th>5%</th>
<th>-</th>
<th>-</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (&lt;15)</td>
<td>(8/67)</td>
<td>(16/67)</td>
<td>(4/67)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium (15-30)</td>
<td>1%</td>
<td>-</td>
<td>42%</td>
<td>15%</td>
<td>1%</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>(1/67)</td>
<td></td>
<td>(28/67)</td>
<td>(10/67)</td>
<td>(1/67)</td>
<td></td>
</tr>
<tr>
<td>High (30+)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>35%</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(18/51)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16%</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(53/326)</td>
<td></td>
</tr>
</tbody>
</table>

**Low density (<15)**

Within this density category 12% (8/67) of the dwellings achieved a 40% or greater reduction in potable water. 1% (1/67) of the dwellings did not use a rainwater tank.

24% (16/67) of the dwellings achieved potable water reductions of between 30-39%. All of these dwellings used rain water tanks.

47% (32/67) of the dwellings achieved potable water reductions between 25-29% reductions. 5% (4/67) used rain water tanks and 42% (28/67) did not.

16% (16/67) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks.
Medium density (15-30)

Within this density category 34% (17/51) of the dwellings achieved a 40% or greater reduction in potable. All of these dwellings used rainwater tanks.

31% (16/51) of the dwellings achieved potable water reductions of between 30-39%. All of these dwellings used rainwater tanks.

No dwellings achieved potable water reductions between 25-29% reductions.

35% (18/51) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks.

High density (30+)

Within this density category 84% (273/327) dwellings achieved potable water reductions of between 30-39%. All of these dwellings used rainwater tanks.

No dwellings achieved potable water reductions greater than 40% or between 25-29%.

16% (53/327) of the dwellings failed to meet the STEPS water target score. None of these dwellings used rainwater tanks.

9.3 Stormwater results

Unlike the water results, the number of dwellings represented in each planning application is not critical when assessing stormwater quality impacts. This is because the STEPS stormwater score is calculated for a whole development site. Therefore, the stormwater results are presented according to the number of planning applications, given each application represents a single development site.

9.3.1 Unit stormwater results
Figure 9.5 shows the stormwater performance of planning applications (development sites) in the three unit development density categories. Applications that are marked as passed either achieved or surpassed the STEPS stormwater score - a 75% reduction in nitrogen. This target score represents the best practice stormwater performance quality objectives to meet the State Environment Protection Policy (SEPP) requirements and hence reflects the research’s water sensitive benchmark for this indicator. Applications that are marked as failed did not achieve the STEPS stormwater score.

Figure 9.5 - Unit development stormwater performance
Figure 9.5 shows that applications in each density category performed as follows:

**Low density (1-2 units)**

Out of the 55 applications represented in the low density category, 18 applications (33%) met or surpassed the STEPS score for stormwater, while 37 applications (67%) failed to achieve the STEPS target score.

**Medium density (3-5 units)**

Out of the 54 applications represented in the medium density category, 10 applications (19%) met or surpassed the STEPS score for stormwater, while 44 applications (81%) failed to achieve the STEPS target score.

**High density (6+ units)**

Out of the 9 applications represented in the high density category, 4 applications (44%) met or surpassed the STEPS score for water, while 5 applications (56%) failed to achieve the STEPS target score.

9.3.2 Unit stormwater results - detailed analysis
Further analysis of the results was conducted to get a better understanding of how well or poorly applications in each of the unit development density categories performed in relation to the 75% stormwater target set in the STEPS tool.

Table 9.7 - Unit development stormwater performance breakdown

<table>
<thead>
<tr>
<th>Density</th>
<th>Stormwater performance - Percentage (%) reduction in Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>≥75</td>
</tr>
<tr>
<td>Low</td>
<td>33% (18/55)</td>
</tr>
<tr>
<td>(1-2 units)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>19% (10/54)</td>
</tr>
<tr>
<td>(3-5 units)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>44% (4/9)</td>
</tr>
<tr>
<td>(6+ units)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1 shows that:

Low density (1-2 units)

Of the 37/55 (67%) applications that failed to achieve the STEPS target score of 75%, 14/55 (25%) failed to achieve a 10%, 2/55 (4%) achieved between 10-25%, 10/55 (18%) achieved between a 25-50% and 11/55 (20%) achieved between 50-74% reductions in nitrogen.

Medium density (3-5 units)
Of the 44/54 (81%) applications that failed to achieve the STEPS target score of 75%, 33/54 (61%) failed to achieve a 10%, 1/54 (2%) achieved between 10-25%, 5/54 (9%) achieved between a 25-50% and 5/54 (9%) achieved between 50-74% reductions in nitrogen.

High density (6+ units)

Of the 5/9 (56%) applications that failed to achieve the STEPS target score of 75%, 4/9 (44%) failed to achieve a 10% and 1/9 (12%) achieved between 10-25% reductions in nitrogen.

9.3.3 Units – Stormwater and rainwater tanks

The use of rainwater tanks is a common WSUD feature that can improve stormwater quality outcomes. Therefore to gain an understanding of how the use of rainwater tanks affected the stormwater performance of the applications this data was analysed as well.

Low density (1-2 units)

Within this density category 67% (37/55) of the applications used rainwater tanks. 24% (13/55) of the applications that used rainwater tanks passed the STEPS stormwater score. The remaining 43% (24/55) of the applications used tanks and failed to meet the STEPS stormwater target.

Medium density (3-5 units)

Within this density category 33% (18/54) of the applications used rainwater tanks. 15% (8/54) of the applications used tanks and passed the STEPS stormwater score. The remaining 18% (10/54) of applications that used rainwater tanks failed to meet the STEPS stormwater score.

High density (6+ units)
Within this density category 22% (2/9) of the applications used rainwater tanks. 11% (1/9) of the applications used tanks and passed the STEPS stormwater score. The remaining 11% (1/9) of applications used rainwater tanks but failed to meet the STEPS stormwater score.

### 9.3.4 Units – stormwater and rainwater tanks - detailed analysis

Further analysis of the use of rainwater tanks was conducted to gain a better understanding of how their use affected the storm water performance of the applications.

#### Table 9.8 - Unit rainwater tank use

<table>
<thead>
<tr>
<th>Density</th>
<th>Stormwater quality score (% reduction in nitrogen)</th>
<th>Tank used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td></td>
<td>≥75</td>
<td>74-50</td>
</tr>
<tr>
<td>Low (1-2 units)</td>
<td>24%</td>
<td>18%</td>
</tr>
<tr>
<td>Medium (3-5 units)</td>
<td>15%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>(8/54)</td>
<td>(5/54)</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(2/54)</td>
<td></td>
</tr>
<tr>
<td>High (6+ units)</td>
<td>11%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1/9)</td>
<td></td>
</tr>
</tbody>
</table>
Low density (1-2 units)

Within this density category, 31% (17/55) of the applications achieved or surpassed the STEPS stormwater score. 24% (13/55) used rainwater tanks and 9% (4/55) did not.

The remaining 69% (38/55) of the applications failed to achieve the STEPS stormwater score. 20% (11/55) of these achieved between 74-50%. 18% (10/55) used rainwater tanks and 2% (1/55) did not.

19% (10/55) of the applications achieved between 50-25%. 15% (8/55) of these applications used rainwater tanks and 4% (2/55) did not.

4% (2/55) of the applications achieved between 25-10% and all of these applications used rainwater tanks.

The remaining 25% (14/55) of applications achieved less than 10%. 9% (5/55) of these applications used rainwater tanks and 16% (9/55) did not.

Medium density (3-5 units)

Within this density category, 19% (10/54) of the applications achieved or surpassed the STEPS stormwater score. 15% (8/54) used rainwater tanks and 4% (2/55) did not.

The remaining 81% (44/54) of the applications failed to achieve the STEPS stormwater score. 9% (5/54) achieved between 74-50% and used rainwater tanks.

9% (5/54) of the applications achieved between 50-25%. 5% (3/54) of these applications used rainwater tanks and 4% (2/55) did not.

2% (1/54) of the applications achieved between 25-10% and all of these applications did not use rainwater tanks.

The remaining 61% (33/54) of applications achieved less than 10%. 4% (2/54) of these applications used rainwater tanks and 57% (31/54) did not.
High density (6+ units)

Within this density category, 44% (4/9) of the applications achieved or surpassed the STEPS stormwater score. 11% (1/9) used rainwater tanks and 33% (3/9) did not.

The remaining 56% (5/9) of the applications failed to achieve the STEPS stormwater score. 11% (1/9) achieved less than 10% and used rainwater tanks and 45% (4/9) did not.

9.3.5 Apartment stormwater results

Figure 9.6 shows the stormwater performance of planning applications (development sites) in the three apartment development density categories. Applications that are marked as passed either achieved or surpassed the STEPS score - a 75% reduction in nitrogen. This target score represents the best practice stormwater performance quality objectives to meet the State Environment Protection Policy (SEPP) requirements. Applications that are marked as failed did not achieve the STEPS score.

Figure 9.6 - Apartment stormwater performance

![Bar chart showing stormwater performance by density category](chart)

Figure 9.6 shows that applications in each density category performed as follows:

**Low density (<15 apartments)**

Out of the 9 applications represented in the low density category, 6 applications (67%) achieved or surpassed the target set in the STEPS tool. 3 applications (33%) failed to achieve the STEPS target score.

**Medium density (15-30 apartments)**
Out of the 3 applications represented in the medium density category 2 applications (67%) achieved or surpassed the target set in the STEPS tool. 1 application (33%) failed to achieve the STEPS target score.

High density (30+ apartments)

Out of the 3 applications represented in the high density category 2 applications (67%) met or surpassed the STEPS score for water. 1 application (33%) failed to achieve the STEPS target score.

9.3.6 Apartment stormwater results - detailed analysis

Further analysis of the results was conducted to get a better understanding of how well or poorly applications in each of the apartment development density categories performed in relation to the 75% stormwater target set in the STEPS tool.

Table 9.9 - Apartment stormwater performance breakdown

<table>
<thead>
<tr>
<th>Density</th>
<th>Stormwater performance - Percentage (%) reduction in Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>≥75</td>
</tr>
<tr>
<td>Low (&lt;15 apartments)</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(6/9)</td>
</tr>
<tr>
<td>Medium (15-30 apartments)</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(2/3)</td>
</tr>
<tr>
<td>High (30+ apartments)</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>(2/3)</td>
</tr>
</tbody>
</table>

Table 9.9 shows that:
Low density (<15 apartments)

3/9 (33%) of the applications failed to achieve the STEPS target score of 75%. All of these applications failed to achieve a STEPS stormwater score greater than 10%.

Medium density (15-30 apartments)

1/3 (33%) of the applications failed to achieve the STEPS target score of 75%. All of these applications failed to achieve a STEPS stormwater score greater than 10%.

High density (30+ apartments)

1/3 (33%) of the applications failed to achieve the STEPS target score of 75%. All of these applications failed to achieve a STEPS stormwater score greater than 10%.

9.3.7 Apartments – Stormwater and rainwater tanks

The use of rainwater tanks is a common WSUD feature that can improve stormwater quality outcomes. Therefore, to gain an understanding of how the use of rainwater tanks affected the stormwater performance of the applications this data was analysed as well. Given the spread of results a detailed analysis was not carried out.

Table 9.10 graphically demonstrates the percentage of apartments that passed and failed the stormwater score and had rainwater tanks.
Table 9.10 – Apartment stormwater performance and rainwater tank use

<table>
<thead>
<tr>
<th>Density</th>
<th>Stormwater quality score (% reduction in nitrogen)</th>
<th>Tank used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td>Low (&lt;15 apartments)</td>
<td>44%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(4/9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(2/9)</td>
<td></td>
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<tr>
<td>Medium (15-30 apartments)</td>
<td>67%</td>
<td>-</td>
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<td>High (30+ apartments)</td>
<td>67%</td>
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Table 9.10 shows that:

**Low density (<15 apartments)**

Within this density category, 44% (4/9) of the applications used rainwater tanks and passed the STEPS stormwater score. 22% (2/9) passed the STEPS stormwater score but did not use tanks.

None of the applications that failed to meet the target 33% (3/9) used rain water tanks.

**Medium density (15-30 apartments)**

Within this density category, 67% (2/3) of the applications passed the STEPS stormwater score and used rain water tanks.

None of the applications that failed to meet the target 33% (1/3) used rain water tanks.

**High density (30+ apartments)**

Within this density category, 67% (2/3) of the applications passed the STEPS stormwater score and used rain water tanks.

None of the applications that failed to meet the target 33% (1/3) used rain water tanks.
10 DISCUSSION AND CONCLUSIONS

The discussion of the results and the conclusions that can be drawn from the research will be presented as a combined chapter. The discussion and conclusions will be presented under the two key water sensitive indicators used in the research, namely potable water reductions and stormwater quality impacts. The conclusions that can be drawn from the research for each indicator will demonstrate how infill residential development in Darebin is performing and whether they are aiding Melbourne’s transition to a water sensitive city.

10.1 Water discussion

As outlined in the research method, two sub-questions for the water indicator were posed to gauge whether infill residential development within Darebin across the defined development categories and densities were assisting Melbourne transition to a water sensitive city (see 8.1). The research viewed the state government’s target for a 25% reduction in potable water (STEPS benchmark score) as a minimum level of performance for this indicator. The research viewed a 40% reduction in potable water as the necessary benchmark that infill residential developments (dwellings) should meet to transition Melbourne towards a water sensitive city.

10.1.1 Unit developments

General analysis

The water results for the low and high density unit development categories showed that 65% of the dwellings in both groups achieved or surpassed the STEPS target score for a 25% reduction in potable water use. 35% of the dwellings in both categories failed to achieve the target.

The medium density unit development category displayed a different trend to that of the low and high density categories. Here, 64% of dwellings failed to achieve the STEPS target score of a 25% reduction in potable water use, while 36% achieved or surpassed the target score.
Detailed analysis

The detailed analysis showed that a small proportion of dwellings in the low (5%) and medium (6%) density categories were achieving potable water reductions of 40% or more. Within these density categories the majority of dwellings achieved between a 25-29% reduction in potable water – low density (35%) and medium density (20%). The remaining dwellings in these categories achieved between a 30-39% reduction in potable water - low density (25%) and medium density (10%).

Within the high density category a large proportion of dwellings (44%) achieved potable water reductions of 40% or more. The remaining dwellings (21%) achieved between 25-29% reductions in potable water. This trend could be due to the fact that landscaped areas in higher density developments are less (more buildings and impervious surfaces on the site) and, as such, they are potentially advantaged in the STEPS tool because their landscape irrigation demand would be reduced. Another contributing factor could be that higher density developments usually have smaller dwellings with fewer bedrooms. The STEPS tool uses the number of bedrooms to calculate potable water consumption (see 8.2.3).

Failures

Of the dwellings that failed to achieve a 25% reduction in potable water use, the majority in the low (22%) and high (27%) density categories failed to achieve potable water savings greater than 10%. These results indicate that very little is being done to reduce potable water consumption, even though these applications are covered by the 5-star standard. Therefore, it can be assumed that these developments did not install rainwater tanks, but would have chosen to install solar hot water heaters as per the trade off between energy and water that is currently inherent within the 5-star standard (see 8.2.4). The remaining dwellings in these categories achieved between 10-24% reductions in potable water - low density (13%) and high density (8%). In the medium density category, 41% achieved between 10-24% reductions in potable water and 23% failed to achieve potable water savings greater than 10%. Again these results show that despite there being some water requirements within the 5-star standard, potable water reductions of 25% or greater are not being met in all three categories (low - 35%, medium -64% and high- 35%).
Rainwater tanks

Within the low and medium density categories a good proportion of dwellings that surpassed the 25% water reduction target used rainwater tanks - low density (38%) and medium density (18%). However, only 8% of the dwellings in the high density category that surpassed the 25% water reduction target used rainwater tanks.

The detailed analysis showed that there was a correlation between increased potable water reductions and the use of rainwater tanks in the low and medium density categories. This trend was not as strong in the high density category, despite 65% of the dwellings achieving and surpassing the STEPS target.

This trend in the high density category could be explained by the requirement under the 5-Star Standard for new dwellings to install either a rainwater tank or a solar hot water heater (see 8.2.4). The lack of a strong correlation between increased potable water reductions and the use of rainwater tanks in the high density category could be attributed to the fact that as unit developments increase in density, open space to house rainwater tanks becomes limited. This is because high density unit developments still need to meet open space requirements of the planning provisions. Therefore, it is highly likely that high density unit developments would install solar hot water heaters instead of rainwater tanks in order to meet the open space requirements of the planning provisions. This reasoning would explain the low use of rainwater tanks in this density category.

Within the low and medium density categories none of the dwellings that failed to achieve the 25% potable water reduction target used rainwater tanks. Within the high density category only 1% of the dwellings that achieved between 10-24% reductions in potable water used rainwater tanks. For those dwellings in the high density category that failed to meet the STEPS water score but used rainwater tanks, the results suggest that some of the variables such as water efficient fittings and appliances, rainwater tank size, roof area connected to the tanks and proposed uses of rainwater may not have been optimised to achieve greater potable water reductions targets.
10.1.2 Apartment developments

General analysis

The water results for all three density categories showed that most dwellings achieved or surpassed the STEPS target score for a 25% reduction in potable water use – low density (83%), medium density (65%) and high density (84%). Therefore, the remaining dwellings in these categories – low density (17%), medium density (35%) and high density (16%) failed to achieve a 25% reduction in potable water use.

Detailed analysis

The detailed analysis showed that 33% of the dwellings in the medium density category and 13% in the low density category achieved potable water reductions of 40% or more. No dwellings in the high density category achieved potable water reductions of 40% or more.

The majority of dwellings (46%) in the low density category achieved between 25-29% reductions in potable water. 24% achieved between 30-39% reductions in potable water. The remaining 17% failed to achieve the STEPS water score. 15% of these dwellings achieved a 10-24% reduction in potable water use. A further 2% of the dwellings failed to achieve savings greater than 10%.

84% of the dwellings in the high density category achieved between 30-39% reductions in potable water. Similarly, in the medium density category 31% of the dwellings achieved between 30-39% reductions in potable water.

The remaining 35% of dwellings in the medium density category failed to achieve the STEPS water score. All of these dwellings failed to achieve potable water reductions greater than 10%. Similarly, the remaining 16% of dwellings in the high density category failed to meet the STEPS water score. All of these dwellings also failed to achieve potable water savings greater than 10%.

These results show that apartment developments are achieving higher potable water reductions than unit developments, with a larger proportion achieving 30% or greater reductions.

Rainwater tanks

Across all three density categories a good proportion of dwellings that surpassed the 25% water reduction target used rainwater tanks – low (50%), medium (65%) and high density (84%).
The detailed analysis showed that across all three density categories there was a good relationship between increased potable water reductions and the use of rainwater tanks. This is particularly true for dwellings that achieved a 30% or greater reduction in potable water use.

Across all three density categories, none of the dwellings that failed to achieve the 25% potable water reduction target used rain water tanks.

It is interesting to note that despite there being no regulatory requirement to use rainwater tanks within apartment type developments (Class 2 buildings, see 8.2.4), they are being used. The use of tanks is then more likely an outcome of the need to address council stormwater requirements (see discussion in 10.3.2). As a result of this, good potable water reductions are being achieved. Indeed, the research results for the stormwater performance of apartments across the three density categories show that they are achieving good stormwater outcomes (see 10.3.2 & 10.4).

### 10.2 Water conclusions

The research shows that the majority of unit developments within the city of Darebin (except in the medium density category) are achieving the state government’s aspirational target for a 25% reduction in potable water consumption. However, across the low and medium density categories, only nominal numbers of dwellings are achieving potable water reductions of 40% or more (the research’s benchmark for a water sensitive dwelling/development). Dwellings in the high density category are achieving better potable water reductions and this may be attributed to their size (lower number of bedrooms) and reduced landscaping and hence irrigation demands that the STEPS tool accounts for in its potable water calculations.

The majority of apartment developments across the three density categories achieved the state government’s aspirational target for a 25% reduction in potable water consumption. The number of dwellings that achieved potable water reductions of 40% or more was small, except in the medium density category (33%). These results suggest that it is easier for apartment developments to achieve greater potable water reductions. Their improved performance could be attributed to the following factors that are accounted for within the STEPS tool’s algorithms for potable water:

- Smaller dwelling size (lower number of bedrooms);
- Minimal/reduced landscaping (often 100% site coverage) and hence low irrigation demands; and
- Use of rainwater tanks to address stormwater quality outcomes.

The research also revealed that across all density categories in both apartment and unit developments there was a strong correlation between increased potable water reductions and the use of rainwater tanks. This correlation was particularly strong for apartment developments where all the dwellings that achieved the STEPS target in the medium and high density categories used rainwater tanks. This trend was not carried through in the high density category of unit developments where only 7% used rainwater tanks and 37% did not use tanks but did pass the STEPS score. This result suggests that another WSUD measure was used within these applications to achieve the potable water reductions.

Of those dwellings that failed to achieve the 25% potable water reduction target none in the apartment developments used rainwater tanks. This also applied to unit developments, with the exception of 1% in the high density category that failed to meet the STEPS target despite having used rainwater tanks. This anomaly in the results hints at the potential lack of knowledge or technical support for developers to optimise the variables that enable rainwater tank use to deliver good potable water savings (see 10.3.1 rainwater tanks for a further discussion).

The research demonstrates that apartment developments are largely achieving the state governments target for a 25% reduction in potable water. However, the performance of unit developments is not uniform, particularly in the medium density category.

The state government’s aspirational target for a 25% reduction in potable water is commendable but, in terms of the research, is considered to be a minimum performance benchmark. Furthermore, the target is not legislated and as a result achieving consistent potable water savings across both unit and apartment development densities as illustrated by the results are difficult. However, the results suggest that apartments are generally achieving better potable water reductions that may be attributed to their reduced landscaping and irrigation requirements as well as smaller dwelling sizes and use of rainwater tanks.

The performance of unit and apartment developments across the defined density categories illustrated that only a small proportion of dwellings are achieving a 40% reduction in potable water. The research showed that this target is achievable. However, based on the overall performance of both unit and apartment developments, it can be concluded that the potable water reductions being achieved by infill residential development in Darebin are currently not assisting Melbourne transition to a water sensitive city.
10.3 Stormwater discussion

The research used the STEPS stormwater target score of a 75% reduction in nitrogen as the water sensitive benchmark for this indicator. The STEPS stormwater target score is based on the BPEG stormwater performance objectives (see 8.2.5). The STEPS stormwater score was therefore the necessary benchmark that infill residential developments should meet in order to transition Melbourne towards a water sensitive city.

The research sought to determine how the stormwater performance of infill residential developments that are required to meet the objectives contained in the VPP’s (Clauses 54.03-4 and 55.03-4) and Darebin’s LPPF (22.09-3.1, 22.10-3.1 Sustainability and 22.09-3.12, 22.10-3.12 Utility Services) rate when benchmarked against the STEPS stormwater score. By doing so the research would be able to determine whether the stormwater performance of infill residential development in Darebin is transitioning Melbourne to a water sensitive city.

10.3.1 Unit developments

General analysis

The stormwater results across all three density categories showed that a high proportion of the applications failed to meet the STEPS stormwater score (75% reduction in nitrogen) – low density (67%), medium density (81%) and high density (80%).

Therefore, although all the applications assessed met their respective requirements under the VPP’s and Darebin’s LPPF (see 8.4.2) the majority failed to meet the STEPS score for stormwater and hence the research’s water sensitive benchmark for this indicator.

Detailed analysis

The detailed analysis showed that of the applications that failed to achieve the STEPS score the majority failed to achieve reductions in nitrogen greater than 10% - low density (25%), medium density (61%) and high density (44%). This trend implies that across all three density categories very little is being done to address stormwater quality performance outcomes despite the fact that all the applications meet their
respective requirements under the VPP’s that govern stormwater (Clauses 54.03-4 and 55.03-4) and Darebin’s local planning policies.

**Rainwater tanks**

Within the low and medium density categories a good proportion of applications that met or surpassed the STEPS stormwater score (75% reduction nitrogen) used rainwater tanks - low density (24%) and medium density (15%). These results compare well with the potable water reduction results for these density categories, illustrating that rainwater tanks are good for both water and stormwater outcomes. However, only 11% of the applications in the high density category that met or surpassed the STEPS stormwater score used rainwater tanks. 33% of the applications in the high density category achieved the STEPS score but did not use rainwater tanks. The low use of rainwater tanks in the high density category is assumed to be linked to the balance developers are trying to achieve between the five star standard (see 10.1.1 rainwater tanks) and the open space requirements of planning provisions. Furthermore, these results suggest that other WSUD measures may have been employed to meet the STEPS stormwater score.

Within the medium and high density categories a small proportion of the applications that failed to achieve the STEPS stormwater score used rainwater tanks - medium density (18%) and high density (11%). However, in the low density category 46% of the applications that failed to achieve the STEPS score used rainwater tanks. This is an insightful result because although there is a strong relationship between rainwater tank use and potable water savings (see 10.2) and stormwater performance (see below); the use of rain water tanks does not automatically mean the STEPS stormwater score will be achieved. This implies that when rain water tanks are used to fulfil the 5 star standard requirement, the specified minimum capacity (2,000 litres) and area of roof connected to the tank (50sqm) may not be enough to achieve the STEPS stormwater score (BPEG objectives). This indicates that tank sizes, the area of roof connected to tanks and intended uses may need to be optimised to achieve both the water and stormwater indicator benchmarks. This reinforces the discussion regarding the need for an optimisation of variables for tank use raised in the discussion on units in the high density category that used tanks but failed to meet the STEPS target for water (see 10.2). Indeed, within the 5 star standard there is no recognition of the potential benefits of the use of rainwater tanks on improved stormwater outcomes. The standard focuses solely on potable water reductions.
The detailed analysis showed a healthy association between increased stormwater performance and the use of rainwater tanks in the low and medium density categories. However, this trend was not strongly reflected in the high density category. The reason for this is possibly because other WSUD measures (rain gardens) have been employed to meet the STEPS stormwater score.

10.3.2 Apartment developments

General analysis

The stormwater results across all three apartment density categories showed that a higher proportion of applications were meeting the STEPS stormwater score (75% reduction in nitrogen) than the unit developments. 67% of the applications across all three apartment density categories met or surpassed the target.

This trend implies that apartment developments can achieve better stormwater quality outcomes than unit developments, despite the fact that Darebin’s local policies governing apartment developments neither reference the BPEG stormwater objectives (STEPS score basis), nor are apartment developments required under the 5 star standard to install rainwater tanks. Consequently, this trend could be linked to Darebin’s SDAPP program that uses the STEPS tool to benchmark developments’ environmental performance. Under Darebin’s SDAPP program statutory planners request that developments covered by its local policies meet the STEPS stormwater score. For this reason apartment developments may be performing better in relation to stormwater. Furthermore, the stormwater results for apartments show their improved performance is linked to rainwater tank use (see rainwater tank discussion below). This observation also strengthens the argument raised in section 7.1 on the role of ESD assessment tools in influencing better environmental outcomes in urban development.

Detailed analysis

The detailed analysis showed that across all three density categories all applications that failed to meet the STEPS score failed to achieve reductions in nitrogen greater than 10% - low density (33%), medium density (33%) and high density (33%).
This trend suggests that across all three density categories in the instances where applications fail to meet the STEPS score, no strategies to improve stormwater quality performance outcomes are being pursued. This outcome is at odds with the point made above that Darebin’s SDAPP was a catalyst for better stormwater outcomes. However, it must be noted that the SDAPP program is voluntary, hence this contradiction could be explained by the voluntary nature of the program – i.e. these applications chose not to address stormwater quality (failed to meet the STEPS score).

**Rainwater tanks**

Across all three density categories a high proportion of applications that met or surpassed the STEPS stormwater score used rainwater tanks - low density (44%), medium density (67%) and high density (67%). None of the applications that failed to meet the STEPS score used rainwater tanks. It was only within the low density category that 22% of the applications met the STEPS stormwater score without having used a rainwater tank. Again this result suggests that another WSUD measure was used to achieve the STEPS stormwater score.

The results showed a compelling relationship between increased stormwater performance and the use of rainwater tanks in all three density categories, reinforcing the knowledge that rainwater tanks are a good WSUD measure to improve stormwater performance.

### 10.4 Stormwater conclusions

The research showed that the majority of unit developments across all density categories within the city of Darebin are failing to meet the STEPS stormwater score and hence the research’s water sensitive benchmark for this indicator. Apartment developments in all three density categories performed considerably better than the unit developments in relation to the STEPS stormwater score indicating that it is easier for apartment developments to meet the water sensitive benchmark for stormwater (STEPS score). This was attributed to Darebin’s SDAPP program that encourages statutory planners to use the STEPS tool to benchmark the performance of apartment developments covered by its local policies. This view is supported by the fact that there was a high use of rainwater tanks within a development type that under the 5 star standard are not required to provide rainwater tanks.
Across all density categories in both the unit and apartment development types, applications that failed to meet the STEPS stormwater score performed extremely poorly (achieved less than a 10% STEPS score). This indicates that very little is being done to address stormwater quality within these applications.

The research also revealed that across all density categories in both apartment and unit developments there were a strong correlation between increased stormwater quality performance and the use of rainwater tanks. Of those apartment applications that failed to achieve the STEPS target none used rainwater tanks. Whereas, only a small proportion of the unit developments across the density categories that failed to achieve the STEPS target used rainwater tanks. This perhaps can be attributed to a lack of knowledge within the development industry to optimise the variables associated with rainwater tank use to get good stormwater outcomes.

The research demonstrates that Clauses 54.03-4 and 55.03-4 and Standards A6 and B9, contained in the Victorian planning provisions that govern the stormwater performance of unit developments, are not sufficient in ensuring infill residential development achieve the water sensitive benchmark for this indicator. Consequently, unit developments in the city of Darebin are not aiding Melbourne transition towards a water sensitive city.

It is important to note that the aforementioned clauses govern the stormwater performance of all infill residential development across the state of Victoria. Therefore, apart from developments within the city of Bayside who successfully lodged a local amendment to address this issue (see 6.4.1), developments in all other Melbourne municipalities, are most likely failing to meet the Best Practice Environmental Guidelines (BPEG) stormwater quality objectives (STEPS stormwater score/ research benchmark). And, as a result of this the stormwater performance of infill development across Melbourne may not be aiding Melbourne transition towards a water sensitive city.

The research also demonstrates that although a higher proportion of apartment developments are achieving the STEPS stormwater target, performance is not uniform because they are either performing well or extremely poorly. The relative success highlighted in the apartment development category can be attributed to Darebin’s SDAPP program which engages statutory planners to actively seek better stormwater and environmental outcomes for developments using the STEPS tool. Nevertheless, Darebin’s local policies should be updated to reference the Best Practice Environmental Guidelines (BPEG) stormwater quality objectives so that best practise stormwater performance outcomes can be
achieved through legislation rather than a voluntary SDAPP program. By doing so, this would enable all infill apartment developments covered by Darebin’s local policies to transition Melbourne to a water sensitive city.

10.5 Conclusion

The research aimed to determine if infill residential development within the city of Darebin is assisting Melbourne transition to a water sensitive city. The background chapters established that for Melbourne the idea of transitioning towards a water sensitive city is becoming increasingly important in the context of climate change, population growth and continued urbanisation. Melbourne is facing a water crisis and despite the Victorian Government’s initiatives to provide water security for Melbourne (desalination plant & sugarloaf interconnector), recent research suggests that additional water supplies will be needed by 2025 at the earliest and 2030 at the latest. Therefore, the Government needs to start planning now to deal with water inflow scenarios that are lower than the long-term average, given the city’s water supply is almost entirely dependent on catchments. Consequently, transitioning Melbourne to a water sensitive city should be considered as a key strategy to address the uncertainty facing the city because it provides a flexible model for the city to collect, use and reuse water. The planning framework governs land use and development. Ergo, it is a powerful point in the urban development process to assess whether infill residential developments are embracing water sensitive city strategies to increase the future resilience of the city.

The research used two key water sensitive city indicators to test whether infill residential developments in the city of Darebin are aiding Melbourne transition towards a water sensitive city. The first indicator was potable water reductions. The research set a 40% reduction in potable water as the benchmark for a water sensitive development. This target was significantly different from the state government’s aspirational target of a 25% reduction in potable water. The state government target was considered as a minimum performance benchmark within the research.

The research found that the 65% of the dwellings in both the low and high density unit developments categories were achieving the state government’s aspirational target for a 25% reduction in potable water consumption. However, 64% of the dwellings in the medium density category failed to achieve this target. There were only insignificant numbers in both the low (5%) and medium (6%) density categories that were achieving potable water reductions of 40% or more. However, this differed in the
high density category where 44% of the dwellings were achieving potable water reductions of 40% or more. This anomaly was attributed to reduced landscaping and dwelling sizes and hence potable water demand (STEPS tool calculations).

Within the apartment development category, dwellings in all three density categories achieved the state government’s aspirational target for a 25% reduction in potable water consumption (low - 83%, medium - 64% and high 84%). Again the number of dwellings that achieved potable water reductions of 40% or more was insignificant within the low (13%) and high (none) density categories. However, within the medium density category 33% of the dwellings achieved potable water reductions greater than 40%.

The use of rainwater tanks in both the apartment and unit development categories displayed a clear association between increased potable water reductions and rainwater tank use, particularly for apartments. Within the apartment development type, the use of rainwater tanks in dwellings that passed the STEPS water score was as follows: low – 41%, medium - 65% and high – 84%.

Overall, only a small proportion of dwellings in both the apartment and unit development categories were achieving a 40% reduction in potable water. Therefore, it was concluded that the potable water reductions being achieved by infill residential development in Darebin are currently not transitioning Melbourne towards a water sensitive city.

The second indicator used in the research was stormwater performance. The water sensitive benchmark for stormwater was the STEPS stormwater target score of a 75% reduction in nitrogen. The STEPS stormwater score for this indicator is based on the BPEG stormwater objectives.

The research found that unit developments are performing dismally in relation to the water sensitive benchmark set for stormwater. Across the unit development density categories the following applications percentages failed to meet the STEPS stormwater score: low – 67%, medium - 81%, high – 56%. Apartment developments performed better and this was in part attributed to Darebin’s SDAPP program and the use of rainwater tanks. 67% of all apartment applications across each density category achieved the STEPS stormwater score. This trend strengthens the argument raised in section 7.1 on the role of ESD assessment tools in influencing better environmental outcomes in urban development.

Of the developments that failed to achieve the STEPS stormwater score it was found that they performed extremely poorly. Within the unit development category the majority of applications failed to achieve STEPS stormwater scores greater than 10% - (low -25%, medium -61% and high 44%). Within
the apartment development category 33% of all applications failed to achieve a STEPS stormwater score
greater than 10%.

The research results also showed that rainwater tank use had a strong relationship with increased
stormwater quality performance. Therefore, the research supports the commonly accepted notion that
rainwater tanks promote both potable water reductions and improved stormwater quality outcomes.
However, in the unit development category there were instances where tanks were used but the STEPS
stormwater score was not achieved. This implies that when rain water tanks are used to fulfil the 5 star
standard requirement, the specified minimum capacity (2,000 litres) and area of roof connected to the
tank (50sqm) may not be enough to achieve the STEPS stormwater score (BPEG objectives).

The stormwater results and conclusions for unit developments suggest that the VPP Clauses 54.03-4 and
55.03-4 and Standards A6 and B9 governing the stormwater performance of infill residential
development cannot deliver best practice stormwater quality outcomes. This is cause for concern
because these clauses are used to assess the stormwater performance of all infill residential
development within nearly all of Melbourne’s municipalities. Although apartment developments
performed better than unit developments in relation to stormwater they did not consistently achieve
the STEPS stormwater target. Therefore, Darebin’s local policies should be updated to reference the
Best Practice Environmental Guidelines (BPEG) stormwater quality objectives so that good stormwater
performance can be achieved through legislation rather than being attributed to Darebin’s voluntary
SDAPP program. Consequently, both unit and apartment developments in the city of Darebin are not
aiding Melbourne transition towards a water sensitive city when measured against the research’s
stormwater indicator.

The combined conclusions drawn from each of the water sensitive indicators used within the research
prove that the use of rainwater tanks are promoting good potable water reductions and improved
stormwater performance in both unit and apartment developments. However, the overall performance
of both unit and apartment developments in relation to the research’s water sensitive benchmarks for
potable water and stormwater show that infill residential development in Darebin is currently not
helping Melbourne transition to a water sensitive city. The reasons for this are examined in the
following chapter outlining the limitations of current legislative support for transitioning Melbourne to a
water sensitive city.
11 LIMITATIONS OF LEGISLATIVE SUPPORT

This chapter seeks to identify some of the limitations inherent in the regulatory framework available to transition Melbourne to a water sensitive city.

11.1.1 Sustainable Design Assessment in the Planning Process (SDAPP)

It is important to reiterate that within the state of Victoria there is no legislative support for the use of ESD assessment tools to assess developments within planning. Consequently, Darebin’s SDAPP program is voluntary, and therefore the data used in the research only captures a proportion of infill residential development planning applications processed by Darebin during the period 2007-2009 from which STEPS water and stormwater data for the research was used.

Error! Reference source not found. outlines the proportion of residential planning permit applications that underwent a Sustainable Design Assessment under Darebin’s SDAPP program during the research sample. These figures were determined by comparing Planning Permit Activity Reports (PPAR) data for Darebin against the number of planning applications that underwent a STEPS assessment. The figures show a steady increase in the proportion of applications that are undertaking an SDA, from 4% in 2006/2007 to 41% in 2009/2010. Please note that Darebin SDAPP program started in late 2006.

Figure 11.1 – Percentage of planning applications that undertook an SDA
Within this context it is important to note that the majority of development within the municipality of Darebin is carried out by developers. Darebin is one of Melbourne’s growth areas and although developers are meeting the city’s need for more housing, profit is their primary driver. This results in the adoption of a compliance approach where developers are only prepared to meet minimum regulatory standards within their developments. Therefore, unless council explicitly seeks better environmental outcomes it is highly likely that potable water reduction targets and stormwater quality objectives above what is legislated are not being achieved. Therefore, although the study sample of planning applications that underwent a SDA and were used in the research is small, it is very probable that the trends outlined in the results hold true for the majority of development in the municipality.

11.1.2 Predicted environmental impacts

It is important to note that the STEPS tool provides data on the predicted environmental impacts of infill residential developments. The actual environmental impacts of a development can only be known once it is built and inhabited. Consequently, the possibility exists that there could be a large degree of variation between the predicted and actual water and stormwater performance of developments presented in the research. Potable water reductions are particularly tricky to predict because water use is directly linked to user behaviour despite the fact that average water use figures are used within the STEPS tool’s algorithms.

11.1.3 Enforcement and Verification

Given the SDAPP program is voluntary, there are also issues regarding the enforcement and verification that information contained in planning applications that underwent an SDA were actually incorporated into developments. Currently, Darebin does spot checks on developments to ensure that what was incorporated within the planning application is actually carried through in construction.

Planning permit conditions

Another, mechanism that is being used to try and address this issue is the use of ESD conditions on planning permits that require the commitments contained in an SDA to be carried out within developments. Although there are no regulatory requirements for the use of ESD assessment tools in planning, CASBE councils have been successfully employing ESD planning permit conditions to ensure
that developments meet and address the ESD objectives of the SDAPP program and ESD assessment tools such as STEPS.

The use of planning permit conditions also allows building surveyors to check that what was specified in the planning permit is transferred into the building permit and hence built product.

**Victorian Civil Administrative Tribunal (VCAT)**

To date there is a long case history at VCAT regarding Councils use of ESD planning permit conditions that is both positive and negative. VCAT in the past has generally found that ESD principles are more appropriately dealt with in building permit approvals process.

VCAT has suggested that ESD principles should not be an ‘add-on’ feature at the end of the process, but should have a place in the planning assessment of the proposal at the fore front, as ESD principles have been recognised at all levels of planning schemes. However, it has noted that ESD assessment should not apply to all developments, rather they should be encouraged in larger scale developments because of the net gains that can be achieved (Hansen & SBE, 2007).

### 11.1.4 Water city indicators

It must be acknowledged that the two water sensitive city indicators used to guide the research are just two of many indicators that could be used to gauge water sensitivity (see 5.2). The two indicators were chosen because they could be directly linked to planning regulations governing the stormwater performance of infill residential development and to gauge potable water reductions in relation to the state government potable water reduction target. Additionally, both of the indicators could be measured using the STEPS tool and as a result of this a fairly accurate picture of the state of progress of infill residential development according to this indicators could be ascertained.

### 11.1.5 Infill residential development

The research recognises that infill residential development forms a small percentage of Darebin’s residential building stock. The research acknowledges that the performance and impact of existing dwellings on the two water sensitive indicators would have a far greater impact than infill residential development. However, regulatory mechanisms to effect change within the existing building stock are
very limited and perhaps better dealt with through behaviour change programs. Therefore, the research chose to focus on infill residential development because regulatory mechanisms exist to influence good outcomes in relation to the two water sensitive indicators.

Possible strategies to try and address this based on the research are outlined as recommendations in the final chapter. Additionally, the discussion of the research results also raised a series of hypotheses that will be presented as potential avenues for further research.

12 RECOMMENDATIONS AND FURTHER RESEARCH

This chapter will briefly outline a series of recommendations that potentially can help infill residential development in Darebin transition Melbourne to a water sensitive city. These recommendations stem from the research discussions and conclusions. The chapter will also put forward another larger research avenue that has arisen from the thesis.

12.1 Recommendations

The following recommendations outline potential actions for the Victorian state government, Department of Community Development and Planning (DPCD), Darebin City Council and Melbourne Water, Australian Building Codes Board and the Building Commission to pursue to improve both the potable water reductions and stormwater performance of infill residential development.

12.1.1 State government and DPCD

Potable water reductions

In order to promote consistent and greater reductions in potable water in infill residential developments within the state of Victoria it is recommended that the state government introduce a more stringent and mandatory potable water reduction target of 40%. The current aspirational 25% reduction target set by the government is too low and is not legislated. As a result of this it will be difficult for new infill residential development to transition Melbourne to a water sensitive city in the absence of a stricter and mandated target. There is already precedence for such a measure locally,
albeit in the state of New South Wales, where a mandatory potable water reduction target of 40% for all new residential developments has been set and is supported through the BASIX system. The suggested 40% potable water reduction target is realistic given a small proportion of developments assessed in the research are already achieving it. Furthermore, contemporary studies support this as a good target for Melbourne given the continued pressures of population growth and the effects of climate change on water supplies.

The need for mandatory potable water reductions is also echoed in a report released by the Environment and Natural Resources Committee of the Parliament of Victoria in 2009 whose recommendations included a call for an emphasis on mandatory water efficient fixtures, a sustainability rating system that includes water efficiency, strong water recycling targets and mandatory dual-pipe systems in new developments.

**Clauses 54.03-4 and 55.03-4 Permeability and Standards A6 and B9**

The Victorian state government and DPCD should undertake an investigation into the effectiveness of these clauses of the Victorian Planning Provisions in their ability to deliver best practice stormwater quality outcomes in infill residential developments. The research suggests that they are inadequate and should be updated to reference the BPEG stormwater quality objectives. There already are precedents for their use within the VPPs within Clause 56 of the Victorian Planning provisions and within Bayside City Council’s local planning policy amendment. Therefore it seems that the aforementioned clauses and standards are perhaps in a need of an update to reflect current approaches and expectations for the stormwater performance of infill developments.

### 12.1.2 Darebin City Council

**Local planning policy amendment**

In the absence of the Victorian state government and the DPCD carrying out an investigation into the effectiveness of Clauses 54.03-4 and 55.03-4 Permeability and Standards A6 and B9 of the Victorian Planning provisions to deliver best practise stormwater quality objectives. Darebin should seek an amendment to its local planning policies similar to the one lodged by Bayside city council to address the inadequacy of these clauses in delivering best practise stormwater quality outcomes as demonstrated
by the research conclusions. By doing so, Darebin can address the poor stormwater quality performance of infill residential developments within the municipality.

**Update local policies**

Additionally, Darebin should also explore updating its local policies to reference the BPEG stormwater quality objectives to ensure that apartment developments in the municipality consistently achieve water sensitive city outcomes in relation to stormwater. Currently, Darebin’s SDAPP program seems to be driving good outcomes but this program is voluntary and there should be a regulatory trigger in place to ensure that good stormwater outcomes are required as the norm.

Both of the aforementioned recommendations can be facilitated through Darebin’s planning scheme and Municipal Strategic Statement review process that occurs every three years. Darebin is currently under taking such a review and these recommendations will be presented to Darebin’s strategic planning department who handle the review process.

### 12.1.3 Melbourne Water

Melbourne Water is owned by the Victorian Government. It manages:

- $8.4 billion in assets;
- Looks after Melbourne’s water supply catchments;
- Treats and supplies drinking water;
- Removes and treats most of Melbourne’s sewage;
- Provides recycled water for non-drinking purposes; and
- Manages rivers and creeks and major drainage systems throughout the Port Phillip and Westernport region.

Source: [http://www.melbournewater.com.au/content/about_us/who_we_are/who_we_are.asp?bchp=1](http://www.melbournewater.com.au/content/about_us/who_we_are/who_we_are.asp?bchp=1)
Some of the research findings show that there is a large degree of variation in the stormwater performance of both unit and apartment developments in relation to stormwater quality outcomes i.e. they perform either well or very poorly (see 10.4). This is happening despite Melbourne Water’s comprehensive WSUD website, resources and educational programs. This issue is one that Melbourne Water is aware of and is seeking to address. This particular issue will not be discussed here, but what will is the occurrence of poor stormwater quality outcomes when tanks are being used. Generally it is accepted that the use of rainwater tanks will deliver both potable water reductions and good stormwater quality outcomes – the research results support this. However, the research revealed that there are instances where this was not occurring. The research discussion suggested that there is a lack of information to aid in the optimisation of the variables associated with rainwater tank use (see 10.3.1 rain water tanks). Indeed, although both the STEPS and STORM tools have the ability to assess rainwater tank use and their variables, it can be said that their calculations are not transparent and the generated results do not provide clear directions on how tank use can be optimised. Therefore, the research recommends that Melbourne Water develops an easy to use tool that graphically allows people to optimise rainwater tank use according to a number of variables to achieve both potable water and stormwater results. Although, the STEPS tool does integrate a potable water page with some water related data outputs and allows the STORM score to be keyed referenced in the tool, these two elements (tools) do not combine to provide a clear and cohesive module that promotes understanding to aid better decision making.

12.1.4 Australian Building Codes Board & Building Commission

As discussed previously the current 5 star standard will be replaced by the 6 Star Standard that will be introduced in Victoria to align with national energy efficiency measures in the Building Code of Australia on 1 May 2011. The 6 Standard will apply to the thermal performance of a home, renovation or addition, plus the installation of a solar hot water system or a rainwater tank for toilet flushing (Building Commission, 2011)

Although an increase in the stringency of the regulation governing the energy efficiency of dwellings is a good outcome. The new standard will not address the trade off that exists between energy and water in the current and soon to be introduced standard - the choice of using a rainwater tank (potable water savings) or a solar hot water heater (energy savings). The research results showed that this trade-off is
having an impact on the potable water reductions and stormwater performance of unit developments
that do not use a rainwater tank. To address this the research recommends that the Australian Building
Codes Board & Building Commission work together with organisations such as Melbourne water to
broaden the scope of the standard to encompass water and stormwater considerations without there
being an inherent trade off with energy efficiency measures such as the use of a solar hot water heater.

12.2 Further research

This section proposes a larger study be undertaken that builds on and expands upon the research
presented in this thesis. The data used in the research was collected from Darebin City Council, one of
ten CASBE councils using the SDAPP process to achieve better environmental outcomes through the
planning framework. The results of the research present a snapshot of how developments within the
municipality of Darebin are performing in relation to storm water quality objectives and reductions in
potable water use. The research provides an isolated picture when considered within the context of
Melbourne’s development and growth. The nine other CASBE councils are collecting similar data and a
possible avenue for further research would be to collate and analyse this data to form a more
comprehensive picture of how developments across CASBE councils are performing in relation to the
water sensitive indicators. Therefore, a more complete picture of whether infill developments across a
number of Melbourne’s municipalities are transitioning it towards a water sensitive city could be
determined. This would also allow the effectiveness of local and state planning policies governing the
stormwater performance of infill residential development to be thoroughly evaluated.

A study of this nature could be used to conduct a sensitivity analysis, whereby the expected increase in
infill residential developments and their predicted potable water reductions could be charted against
water supply scenarios. With further research such an exercise could potentially be used to assist water
supply authorities in predicting supply upgrades and maintenance within the study municipalities.
Similarly, the stormwater results from such a study could be used to chart development in flood prone
areas and guide infrastructure upgrades and projects. A study of this nature would be most beneficial if
it included the following organisations as project partners, namely:

- Victorian state government;
- Department of Community Development and Planning (DPCD);
- CASBE councils;
- Municipal Association of Victoria; and
- Melbourne water and other water supply authorities.
13 ABBREVIATIONS

BPEG: Best Practise Environmental Guidelines

CASBE: Council Alliance for a Sustainable Built Environment

CC: Climate change

CSIRO: Commonwealth Scientific and Industrial Research Organisation

ESD: Ecologically Sustainable Development

LPPF: Local Planning Policy Framework

MUSIC: Model for Urban Stormwater Improvement Conceptualisation

MUSI: Monash University Sustainability Institute

PPAR: Planning Permit Activity Report

SEPP – State Environmental Protection Policy

SDA: Sustainable Design Assessment

SDAPP: Sustainable Design Assessment in the Planning Process

SDS: Sustainable Design Scorecard

STEPS: Sustainable Tools for Environmental Performance strategy

STORM: Stormwater Treatment Objective Relative Measure

VCAT: Victorian Civil Administrative Tribunal


WSUD: Water Sensitive Urban Design
14 REFERENCES


Commonwealth Scientific and Industrial Research Organisation Commonwealth Scientific and Industrial Research Organisation, Australia.


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Moreland City Council 2010, STEPS Guide V5, Moreland City Council, Melbourne.

Moreland City Council 2006, STEPS Algorithms V5, Moreland City Council, Melbourne.


15 APPENDICES
Appendix 1 - CASBE SDAPP Fact sheet
Appendix 2 – Planning on a page
Appendix 3 – VPP Clauses 54-03 and 55-03 and

Darebin local Policies 22.09 & 22.10
Appendix 4 – STEPS tool water and stormwater interfaces