

# Distributed Water Systems:

A networked and localised approach for sustainable water services

Business Intelligence and Policy Instruments

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The Victorian Eco-Innovation Lab (VEIL) seeks to identify and promote emerging technical and social innovations that could form part of future sustainable systems. VEIL creates conditions to explore emerging ideas and stimulate new ones, using a 25 year horizon to generate ideas for new trajectories for sustainable development.

VEIL was established through Our Environment Our Future – Victorian Sustainability Statement in 2006 and is funded through the Victorian Government Sustainability Fund. The project is a partnership between the University of Melbourne, Monash University, Royal Melbourne Institute of Technology, and the Swinburne University design school. VEIL is a project of the Australian Centre for Science, Innovation and Society at the University of Melbourne.

The McCaughey Centre aims to build knowledge about the social, economic and environmental foundations of community wellbeing and mental health. A defining feature of the Centre's research is a commitment to improving social and health equity and reducing health inequalities. The Centre undertakes research, policy development, teaching, workforce development and knowledge translation.

The McCaughey Centre was established in 2006 with the support of the Victorian Health Promotion Foundation (VicHealth) and the Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne.

Workshops involving policy officers from across the Victorian Government were held in early 2007 to identify priority areas for eco-innovation in Victoria. A key theme arising from these workshops was concern about the sustainability and security of energy, water and food systems in Victoria given the challenges and responses to climate change. In a series of subsequent workshops and design research projects, the concept of distributed systems has been critical for the modelling of new sustainable systems and the visualisation of aspects of sustainable Melbourne in the year 2032. This briefing paper forms part of a communication process about current global research and practical projects on distributed systems, leading up to an international conference to be held in Melbourne in October 2010. See [www.regenerationconference.org](http://www.regenerationconference.org) for more information. An electronic copy of this paper and details of work done at VEIL can be found at [www.ecoinnovationlab.com](http://www.ecoinnovationlab.com).

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## Paper No. 2:

## A networked and localised approach for sustainable water services

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# Executive Summary:

## Concepts, lessons and implications

An unprecedented water crisis is unfolding across southern Australia, driven by the compounding impacts of climate change, over use and a legacy of short sighted water policies. As many water strategists re-apply traditional methods to meet this 'perfect storm' of supply and demand challenges, a quiet evolution is occurring in water system design. This evolution has emerged as a strong and coherent trend with positive and radical implications for creating a sustainable water future.

### Key Lessons and Implications:

This briefing paper draws on case studies and research to describe the emergence of 'distributed water systems' - a highly networked and localised approach to water infrastructure and critical water services. Cases from Australia, Europe and the US show how distributed water systems can generate positive outcomes that enhance and supplement those provided by our existing infrastructure models. They are able to:

- **Reduce costs and resource use**
- **Improve service security and reduce risk of failure**
- **Strengthen local economies**
- **Strengthen community wellbeing**
- **Regenerate and protect the natural environment**
- **Redefine traditional water systems**

Distributed systems represent an innovative approach for responding to risk and uncertainty. They can build adaptive capacity by increasing the diversity and flexibility of water systems without locking utilities, customers and future governments into rigid pathways for delivering critical services. By creating distributed water systems through infrastructure design choices at the household-to-regional level, Victoria can reduce social, economic and environmental vulnerability to climate change and energy supply shocks.

### The Concept:

**In the distributed systems model, infrastructure and critical services (for water, food and energy) are positioned close to points of demand and resource availability and linked within networks of exchange. Services traditionally provided by a single, linear system are instead delivered via a diverse set of smaller systems - tailored to location but able to transfer resources across wider areas.**

### Recommendations:

Much more can and should be done to understand and foster the evolution of distributed water systems. Support for innovative projects and a reassessment of existing models of governance is required to enable further adaptation in the water sector. A re-evaluation of the impacts that large water projects have on emerging water sector innovation is also required. The inability of existing tools to assess and compare the long-term or non-financial benefits derived from distributed systems highlights the need for research and practical experimentation to build experience and capacity in this area.

## Part One:

## The concept and emergence of distributed water systems

### Introduction:

**Australia needs strong and visionary political leadership in tackling critical water challenges.** The 21<sup>st</sup> Century has seen a convergence of complex and unprecedented threats to the stability of Australia's water sector and those who rely on it. Climate change, a fall in oil production, growing demand for water and new technologies are adding high levels of risk and uncertainty to an environment of increased cost pressures and entrenched water shortages. The Australian water sector sits at a unique cross road. In meeting today's water challenges, we have an opportunity to transform the nation's relationship with water - from controlling and reactive to creative, sensitive and adaptive. Without a transformation – a systemic break from traditional patterns of water management – today's risks and challenges will grow in intensity.

**Securing Victoria's water future will require new decisions and further investment.**

How decision-makers respond to today's water challenges will shape the quality of future water services, environmental costs and social circumstances. Choices made now can also constrain future options and decision-making flexibility, even as uncertainty is growing. Making investment choices in this context requires careful consideration of the forces shaping present and future water systems and determining how alternative infrastructure and governance models can respond. Locking customers, utilities and future governments into rigid pathways for providing water services is unwise. Risk and uncertainty are best met by increasing adaptive-capacity, not just supply capacity - flexibility is key.

**Fortunately, innovative and adaptive models exist.** Governments, developers and utilities around the globe are responding to the same drivers of change affecting Victoria's water systems. They are adopting a highly networked and localised 'distributed systems' approach to water infrastructure and critical services. This paper highlights the emergence of distributed water systems as a promising model for building resilience and reducing risk. This model also offers considerable potential to contribute to more sustainable water services.

The distributed systems approach to water has emerged rapidly around the world mirroring a parallel evolution in ICT, energy and transport services.

The distributed systems approach to water management has emerged rapidly around the world, mirroring a parallel and largely independent evolution in ICT, energy and transport services. In the water sector, this trend is a response to sustainability, climate change and resilience concerns. Market differentiation, technological innovation and shifting community values are also playing enabling roles. Distributed systems represent a localised and highly networked approach to production and consumption. They are capable of supplementing existing water infrastructure and blurring the line between centralised and decentralised water models.

**The centralised and decentralised water models are often seen as opposite sides of a coin.** A centralised approach tries to keep supply capacity ahead of growth in population and water demand and reacts to water shortages by dramatically expanding supply infrastructure in large increments. The Victorian Governments' recent decision to build a \$3.1bn AUS desalination plant is one example. Like other centralised water projects, it will see large volumes of high quality water transported long distances from a large single source and delivered to many customers via a linear<sup>1</sup> distribution system. The public will have a large stake in the project over a long time period, with the assurance of guaranteed water supplies in return. The centralised model has played a

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<sup>1</sup> It is 'linear' in the sense that water flows in one direction - from the desalination plant to user, to the point of treatment and then discharged.

## Part One:

The concept and emergence of distributed water systems.

critical part in protecting public health and has defined the shape of the infrastructure, waterways and services that exists today. On the flip side of the coin sits the 'decentralised' model where water services are provided on-site, with users reliant on local resources without backup from the mains water grid. Remote communities, farms and some eco-villages use these systems.

## WHAT ARE DISTRIBUTED SYSTEMS?

## Definition:

In essence, distributed systems are a highly networked and localised approach to production, distribution and consumption.

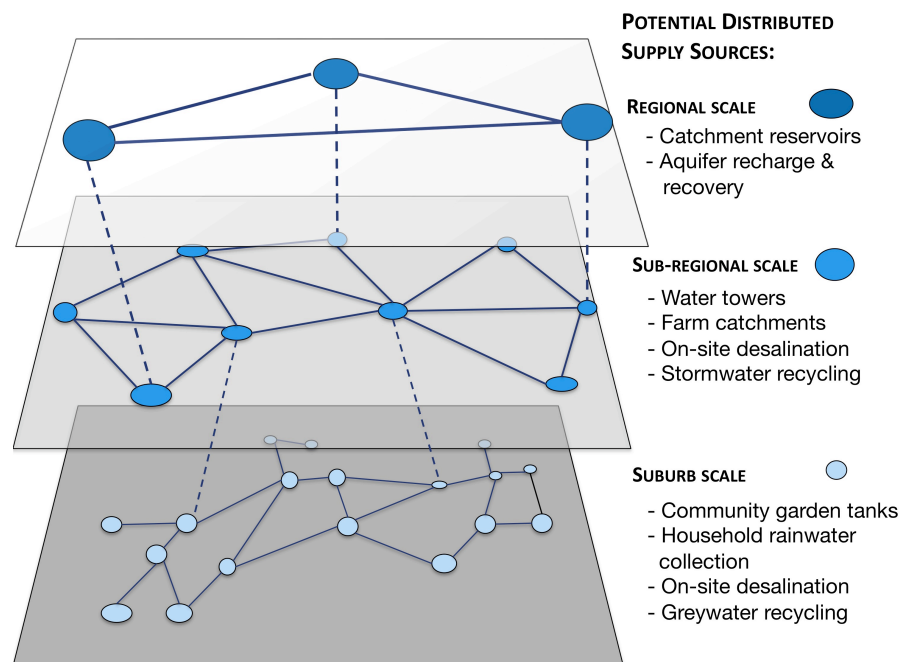
**In the distributed approach, systems of production, distribution and consumption are tailored to match localised demands and resource availability.** Benefits are derived from providing goods and services over short distances and fostering close interaction between the social, technical and environmental agents involved. Costs and resources can be reduced, communities and local economies strengthened and sensitivity to local impacts improved. The distributed model also involves diverse links between systems operating at different scales - from local to regional to global<sup>2</sup>. These networks allow flexible transfer of goods and services over wider areas in response to variation in demand and resource availability - improving the security of services and reducing the risk and scale of system failures.

In distributed systems 'centralised' infrastructure can play a key arterial role at a regional level, while smaller more tailored systems operate and interact more closely with users at the local level. The connection between large and small-scale elements mean that "...a continuum of options from more decentralized to more centralized coexist and work synergistically within any management or service area"<sup>3</sup>. In essence, distributed systems are a highly networked and localised approach to production, distribution and consumption<sup>4</sup>. See figure 1.

**Figure 1: Distributed water supply**

This figure depicts a diverse array of 'design-for-context' water supply systems operating at the household, suburb, sub-regional and regional level. Networks of exchange provide the ability to transfer water within and across systems operating at different scales.

NB: This diagram is a schematic simplification. In reality, separate supply and exchange networks would exist for different types of water quality. Potable and non-potable water systems would not be mixed – but operate in parallel.



<sup>2</sup> Ryan C (2009)

<sup>3</sup> D'Amato V. (2009) <http://www.ncsu.edu/wri/conference/2008ac/index.html>

<sup>4</sup> This definition is evolving as new research and examples emerge.

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The concept and emergence of distributed water systems.

*National Decentralized Water Resources Capacity Development Project (NDWRCDP).*

URL: <http://www.ndwrcdp.org/>

This US EPA funded project supports research and development in the area of onsite and decentralised wastewater and stormwater treatment.

### To further illustrate this model, consider a distributed approach to desalination for boosting Melbourne's water supply.

The Victorian Eco-Innovation Lab with the University of Melbourne Engineering School and SVW Pty Ltd have devised a small gas-fired generator that produces around twenty-five kilowatts of (low-carbon) electricity and uses the waste heat to distil polluted water. Essentially, these small-scale desalination systems are combined heat and power units. They can turn wastewater into useable water while generating electricity to feed into the grid. The unit (known as the 'Blue Box') is portable and can be positioned wherever there is a gas supply and a source of low-quality water near a point of demand. Many such opportunities exist. Sources of polluted wastewater and salty groundwater are widely distributed and available across the urban environment - often near businesses and industries that need water. Recycling poor-quality water for industries that don't need to use precious drinkable quality water but only have access to reticulated 'mains' water can have multiple benefits. Reticulated water can be saved for more critical uses and wastewater can be prevented from entering our natural waterways, sewerage and stormwater systems.

## AIMS AND APPROACH

### Aims and Approach:

**This paper seeks to raise awareness about distributed water systems and explore the potential benefits of this emerging innovation.** A collection of case studies with research and perspectives drawn from practitioners in the field is used to demonstrate the diversity, characteristics and value of the distributed systems model. Using examples from Europe, North America and Australia, this paper explores what the approach means for water systems at a range of scales and highlights why its emergence is relevant to Victoria.

## DRIVERS OF CHANGE

### Sustainability:

#### **Incremental change is not an adequate response to sustainability challenges.**

Given global projections for climate change mitigation and adaptation, step-by-step improvements to production and consumption systems will not reduce environmental pressures at the speed and level required. Our poor record on waterway health is one of many indicators demonstrating this. Despite decades of awareness, community activism and stricter legislation, only 21% of Victoria's larger waterways were in good or excellent condition in 2004<sup>5</sup>. Inability to make major improvements shows that systemic faults exist. These cannot be overcome by good intentions and incremental change. Failure to use Melbourne's stormwater despite the cities' current water stress is another indicator of systemic problems. Around 70% of Melbourne's potable water needs could be met in this way<sup>6</sup>. Not using this water also has a cost. Stormwater causes localised flooding, has a negative impact on waterways and is a major source of nutrient pollution in Port Phillip Bay. Recent projects like the City of Melbourne's strategy for stormwater use in Melbourne<sup>7</sup> reflect a willingness to make more systemic changes but highlight the long way to go. Extensive institutional and structural reforms are needed to embed such innovative change throughout Australian water strategies and planning<sup>8</sup>.

<sup>5</sup> State Govt. of Victoria (2008)

<sup>6</sup> City of Melbourne (2008)

<http://www.melbourne.vic.gov.au/rsr/PDFs/EnvironmentalSustainability/CityasACatchment081208.pdf>

<sup>7</sup> Ibid.

<sup>8</sup> Brown & Clark (2007)



## Part One:

The concept and emergence of distributed water systems.

## Climate Change and Peak Oil:

## USEFUL SOURCES:

*The UK Industry Taskforce on Peak Oil and Energy Security (ITPOES).*  
 URL: <http://peakoiltaskforce.net/>  
 The ITPOES is a group of British companies who are raising awareness about the threat of peak oil and encourage contingency planning.

**The impacts from climate change and energy shortages may be too rapid and too large for existing systems to adapt.** The UK Industry Taskforce on Peak Oil and Energy Security report that global oil production will peak between the years 2011 and 2013<sup>9</sup>. Scientists like Newman<sup>10</sup> point out that this will have significant, widespread impacts. Consequences range from troubling to widely catastrophic - depending on the rates at which oil production declines and how quickly societies reduce their need for oil. We are entering a period of forced rapid readjustment with radical consequences for energy dependent services<sup>11</sup>. For example, Australian water utilities require around 7.1 petajoules (PJ) of energy per year with 76% sourced from external (market exposed) sources<sup>12</sup>. This level of energy consumption (equivalent to around 145 000 households<sup>13</sup>) is considerably less than other service sectors (eg. transport) but still represents around a third of Australia's annual wind and solar electricity production<sup>14</sup>. With energy demand at this level, water utilities cannot easily switch to a more secure energy sources and are vulnerable to fluctuations in availability and price. Energy also constitutes a significant cost to water utilities, making up 8% (\$14m) of Melbourne Water's operating costs for 2000/1<sup>15</sup>.

The consequences of climate change and growing water demand highlight the increasing vulnerability of critical water services. Over the next 20 years, Melbourne's population is expected to increase by around 1.35 million people – putting further demand on water sources at a time when catchment yields across Victoria are set to decline. Estimated falls in yield range from 4 to 15% by 2020 and 10 to 40% by 2050<sup>16</sup>. This will reduce the capacity for all regions to meet their own demand and constrain any moves to augment Melbourne's supplies with water from agricultural areas. Fires, heat waves and flooding will also test how well water systems maintain services during and after sudden shocks. Unfortunately, as researchers in this field note, the infrastructure networks most of us rely on for water are inherently inflexible and “...*can be destabilised as a result of changed environmental conditions, requiring a fundamental shift from the established style of network management*”<sup>17</sup>.

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9 ITPOES (2008) <http://peakoiltaskforce.net/>

10 Newman, *et. al.* (2009)

11 Oil shortages will drive impacts throughout all energy dependent markets as actors dependent on oil shift to alternative energy sources where possible. See ITPOES (2008)

12 Kenway, *et. al.* (2008) [www.csiro.au/files/files/pntk.pdf](http://www.csiro.au/files/files/pntk.pdf)

13 Based on 2.5 people per household and 19.1 PJ/person/year energy consumption

14 ABARE (2009) [www.abareconomics.com/publications\\_html/energy/energy\\_08/energyAUS08.pdf](http://www.abareconomics.com/publications_html/energy/energy_08/energyAUS08.pdf)

15 Melbourne Water (n.d.)

[http://www.melbournewater.com.au/content/publications/fact\\_sheets/water/meeting\\_the\\_greenhouse\\_challenge.asp](http://www.melbournewater.com.au/content/publications/fact_sheets/water/meeting_the_greenhouse_challenge.asp)

16 Victorian Department of Sustainability and Environment (2006)

[http://www.greenhouse.vic.gov.au/CA256F310024B628/0/432F5EB1C77A2C9CCA25732100212040/\\$File/2007+Climate+Change+Summary.pdf](http://www.greenhouse.vic.gov.au/CA256F310024B628/0/432F5EB1C77A2C9CCA25732100212040/$File/2007+Climate+Change+Summary.pdf)

17 Guy, *et. al.* (2001)



## Part One:

The concept and emergence of distributed water systems.

People's willingness to cooperate with and support changes to the way water services are managed (or priced) is shaped by their level of understanding and perceptions of fairness.

**Equity and social justice issues must be taken into account.** In the next 10 years, water management responses to climate change and energy scarcity will have important ethical implications. A number of issues are important, in particular:

- Most Victorians are wholly reliant on utilities for water services and therefore cannot avoid being impacted by changes that affect access or price.
- In an environment where water production costs increase and water supplies are more vulnerable, water utilities may place a greater emphasis on managing demand. However, the impacts of price increases on water use are mainly limited to discretionary uses<sup>18</sup> and have a disproportionate effect on the poor<sup>19 20</sup>. It is therefore important to acknowledge that using price to adjust demand has fairness and efficacy limits.
- There is a need to maintain transparency and close feedbacks between stakeholders and utilities. Climate change mitigation and adaptation measures are likely to increase the cost of providing water services and change the way those services are delivered. The level of openness about changes can effect how just such measures are perceived and influence how effective they are.

Public perception is an important element of risk management as much as an indicator of social justice concerns. People's willingness to cooperate with and support changes to the way water services are managed or priced is shaped by their level of understanding and perceptions of fairness<sup>21</sup>. A loss of trust and mutual cooperation between utilities and the public can increase the vulnerability of water systems. This was illustrated in England during a drought in the mid 1990's when trust broke down between a private water-utility and citizens living under voluntary water restrictions. As people began to see the restrictions as unfair (due to poor company public relations and a perception of double standards) the rationing failed, forcing the utility to truck-in water at huge expense<sup>22</sup>.

**We cannot predict all the impacts of complex drivers of change.** What we can expect is that uncertainty and risk will become more forceful players in shaping water system design. As Dutch water researchers Aerts and Droogers note "...the new element in adapting to climate change in water management is an unknown future"<sup>23</sup>. Some certainties can be assumed, such as the need for ecosystem regeneration and a major reduction in carbon emissions and resource use. In a more stressful and unpredictable environment greater transparency between stakeholders and sensitivity to people's expectations will also be necessary.

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18 Nauges & Alban (2000)

19 OECD (2003)

20 Sawkins & Dickie (2005)

21 Jorgensen, *et. al* (2006)

22 Guy, *et. al* (2001)

23 Aerts and Droogers in Ludwig *et. al* (2009)

## Part One:

The concept and emergence of distributed water systems.

Having adaptive capacity means systems can absorb, adjust and rebound quickly to disturbance without losing function.

## AN EMERGING RESPONSE

**We need to expand the capacity of our systems to adapt.** Distributed water systems are evolving as a response to the risks and uncertainties associated with climate change and sustainability issues. This development is also driven by greater cost-pressures, market liberalisation, technological innovation and diverse community demands<sup>24 25 26 27 28</sup>. The distributed model represents a shifting emphasis in the management of water systems. The traditional focus on streamlining operational processes and reducing complexity is turning toward building the capacity to adapt. Having adaptive capacity means systems can absorb, adjust and rebound quickly to disturbance without losing function.

Lessons are emerging from the water sector which illustrate how an over emphasis on the control of short-term variables (such as costs and frequent flood events) can create 'brittle' systems. These systems are incapable of adjusting to change in long-term variables (eg. climate patterns, social expectations or frequency of extreme events) outside the 'managed' environment<sup>29 30</sup>. In contrast, a management emphasis on adaptation accepts that water systems exist within a wider context of interacting social, ecological and technical variables that cannot always (or should not) be controlled. In such dynamic arrangements, cause and effect are often 'non-linear'<sup>31</sup> - capable of producing sudden and unexpected outcomes<sup>32 33 34</sup>.

As an approach to navigating greater complexity and uncertainty, adaptive water management fosters:

- **Diversity and flexibility** – by creating multiple ways to deliver a service and having a variety of response options when conditions change.
- **Capacity to detect and respond quickly to new conditions** – through technical and governance systems that build social readiness for change and improve the ability of organisations to process and respond to complex information.
- **Involvement and coordination between stakeholders** – as a way of sharing the risks, costs and lessons associated with putting in place adaptation measures and dealing with change and system failures.
- **Learning from experience and experimentation** – by creating reflexive institutions and educational approaches that evolve as new information emerges; enabling water strategists to draw on lessons from existing experience and innovative methods<sup>35</sup>.

24 Walker & Salt (2006)

25 Stahre & Geldof (2003) [www.greenroof.se/data/archive/media/Forskarrapporter/005-New-approach-to-sustainable-stormwater-planning.pdf](http://www.greenroof.se/data/archive/media/Forskarrapporter/005-New-approach-to-sustainable-stormwater-planning.pdf)

26 Moddemeyer S (2008)

[http://www.iwahq.org/uploads/sgs/sg%20on%20rainwater%20harvesting%20and%20management/vienna%20workshop/papers/2%20Steve%20Moddemeyer\(Decentralized%20strategies%20to%20adapt%20to%20climate%20change\).pdf](http://www.iwahq.org/uploads/sgs/sg%20on%20rainwater%20harvesting%20and%20management/vienna%20workshop/papers/2%20Steve%20Moddemeyer(Decentralized%20strategies%20to%20adapt%20to%20climate%20change).pdf)

27 Pinkham, *et. al* (2004)

28 van Roon (2007)

29 Stahre & Geldof (2003)

30 *Ibid.*

31 The disproportionate impact of small temperature increases on reducing water runoff to rivers or dams is one example of such non-linearity.

32 Stahre & Geldof (2003)

33 Geldof (1995)

34 Olsson and Folke (2004)

35 Adapted from Ludwig *et. al* (2009)

## Part Two:

## Exploring the benefits of distributed water systems

In the following pages, the benefits of distributed water systems are presented by drawing on cases from Europe, United States and Australia. Examples include systems designed for an eco-village, an inner-city apartment building and for low-density suburban contexts (See Table 1). Links to these cases can be found to the left of the table. The cases are explored based on their ability to:

- A. Reduce costs and resource use
- B. Improve service security and reduce risk of failure
- C. Strengthen local economies
- D. Strengthen community wellbeing
- E. Regenerate and protect the natural environment
- F. Redefine traditional water systems

TABLE 1: SUMMARY OF CASES

Name / Location	Description of water system elements
<b>Aurora</b> Melbourne, Australia	An 8,500 lot, residential urban fringe greenfield development that integrates water system elements at the house, street, suburb and regional level. These include efficient appliances, third-pipe reuse of treated grey and blackwater, street edge and landscaped stormwater management and infiltration designs and mains potable water <sup>36</sup> .
<b>Salisbury</b> Adelaide, Australia	The scheme involves over 250 ha of constructed wetlands treating diverted stormwater from residential areas. Treated water is stored in aquifers and extracted for non-potable use by local industries and 3,500 residents <sup>37 38</sup> .
<b>Figtree Place</b> Newcastle, Australia	A residential urban development of 27 townhouses incorporating water system elements at the house, precinct and wider city level. These include communal rainwater collection and storage with reuse for non-potable uses. Landscaped runoff and infiltration zones to recharge a local aquifer that acts as a source for irrigation water. Potable water backup is provided by mains supply <sup>39</sup> .
<b>Maldon</b> Central Victoria, Australia	A scheme to take mine floodwater and use it for nearby farms and road maintenance. The scheme integrates mining, community and farming interests and replaces use and trucking of potable water <sup>40</sup> .

### USEFUL SOURCES:

#### *Aurora - Australia*

[www.wsud.org/downloads/Info%20Exchange%20&%20Lit/WSUD\\_04\\_Conf\\_Papers/WS040035.PDF](http://www.wsud.org/downloads/Info%20Exchange%20&%20Lit/WSUD_04_Conf_Papers/WS040035.PDF)

#### *Salisbury - Australia*

<http://cweb.salisbury.sa.gov.au/manifest/ser/vlet/page?pg=16065&stylen=html>

<http://www.aila.org.au/projects/SA/hassell-salisbury/default.htm>

<http://www.aila.org.au/projects/SA/paddocks/docs/wetlandspaper.pdf>

[www.gtasa.asn.au/file.php?f=A9-3ik.OnaGSo.46](http://www.gtasa.asn.au/file.php?f=A9-3ik.OnaGSo.46)

#### *Figtree Place - Australia*

<http://www.wsud.org/downloads/Info Exchange & Lit/FIGTREE LAST21.pdf>

#### *Maldon - Australia*

<http://www.cuac.org.au/database-files/view-file/2898/>

36 McLean (2004)

[www.wsud.org/downloads/Info%20Exchange%20&%20Lit/WSUD\\_04\\_Conf\\_Papers/WS040035.PDF](http://www.wsud.org/downloads/Info%20Exchange%20&%20Lit/WSUD_04_Conf_Papers/WS040035.PDF)

37 City of Salisbury (n.d. a and b)

38 DAC (2008)

39 Coombes *et. al* (1999) <http://www.wsud.org/downloads/Info Exchange & Lit/FIGTREE LAST21.pdf>

40 Nelson (2008) <http://www.cuac.org.au/database-files/view-file/2898/>

## Part Two:

Exploring the benefits of distributed water systems.

*WestWyck - Australia*

<http://www.westwyck.com/>

*Chicago – United States*

<http://www.artic.edu/webspaces/greeninitiatives/greenroofs/>

<http://www.greenroofs.com/projects/pview.php?id=21>

*Piperton – United States*

[www.aquapoint.com/images/Piperton%20Case%20Study-FOR%20SPE%20ONLY.pdf](http://www.aquapoint.com/images/Piperton%20Case%20Study-FOR%20SPE%20ONLY.pdf)

*Seattle – United States*

[www.seattle.gov/util/stellent/groups/public/@spu/@esb/documents/webcontent/spu01\\_002607.pdf](http://www.seattle.gov/util/stellent/groups/public/@spu/@esb/documents/webcontent/spu01_002607.pdf)

*Hammarby Sjöstad – Sweden*

[http://www.hammarbysjostad.se/inenglish/pdf/HS\\_miljo\\_bok\\_eng\\_ny.pdf](http://www.hammarbysjostad.se/inenglish/pdf/HS_miljo_bok_eng_ny.pdf)

<http://showcase.hcaacademy.co.uk/case-study/ecotowns-hammarby-sjostad-sweden.html>

*Augustenborg – Sweden*

[www.greenroof.se/data/archive/media/Forskarrapporter/005-New-approach-to-sustainable-stormwater-planning.pdf](http://www.greenroof.se/data/archive/media/Forskarrapporter/005-New-approach-to-sustainable-stormwater-planning.pdf)

<http://www.malmo.se/servicemeny/malmostadinenglish/sustainablecitydevelopment/augustenborgecocity.4.1dadb2b108f69e3b8880002078.html>

<b>WestWyck ecovillage</b> Melbourne, Australia	A small suburban village of 25 people that integrates water system elements at the unit, village and regional level. These include: demand management, rainwater and greywater collection, storage and reuse, on-site sewerage treatment and reuse. Mains utility provides potable water and a backup for small sewage and storm water discharges <sup>41 42</sup> .
<b>Chicago Greenroofs</b> Chicago, USA	A municipal government program encouraging adoption of green roofs as a way to reduce stress on the city's stormwater systems <sup>43</sup> .
<b>Piperton – Cluster Wastewater system</b> Memphis, USA	An urban fringe greenfield development with a low but growing population utilising telemetry controlled sewerage treatment units at the house level. Units are modular and networked at the suburb scale to increase capacity. Also delivering on-site sub-surface irrigation <sup>44 45</sup> .
<b>Seattle Stormwater Projects</b> Seattle, USA	A series of projects across Seattle to reduce stormwater inflow to local waterways. Projects have been scaled for single streets and large urban subdivisions. The approach includes reducing road widths, using porous pavements and creating vegetated infiltration swales using native plant species <sup>46 47</sup> .
<b>Hammarby Sjöstad</b> Stockholm, Sweden	An 11,000 apartment low-rise suburban brownfield development integrating water system elements at the unit, apartment building, street, suburb, regional and country level. These include green roofs, rainwater collection for solar heating, local treatment of stormwater and incorporation of water features into the landscape. Biogas is produced from sewage and reused locally for buses, taxis and cooking stoves with remaining humus used for biomass. Mains supplies potable water <sup>48</sup> .
<b>Augustenborg</b> Malmo, Sweden	A regional scale utilization of multiple site-specific solutions to reduce the area's stormwater problem. Elements were applied in residential areas, a school, an old industrial area and included green roofs, infiltration zones, a wetland and a constructed lake <sup>49</sup> .

41 Anon (2009)

42 Hill M. [WestWyck] pers. comm., March 2009

43 City of Chicago (2009)

44 Aquapoint (n.d.) [www.aquapoint.com/images/Piperton%20Case%20Study-FOR%20SPE%20ONLY.pdf](http://www.aquapoint.com/images/Piperton%20Case%20Study-FOR%20SPE%20ONLY.pdf)

45 Lindell C. [Aquapoint] pers. comm., March 2009

46 Seattle Public Utilities (n.d.) [www.seattle.gov/util/stellent/groups/public/@spu/@esb/documents/webcontent/spu01\\_002607.pdf](http://www.seattle.gov/util/stellent/groups/public/@spu/@esb/documents/webcontent/spu01_002607.pdf)

47 Horner (2002)

48 Glashusett (2006) [http://www.hammarbysjostad.se/inenglish/pdf/HS\\_miljo\\_bok\\_eng\\_ny.pdf](http://www.hammarbysjostad.se/inenglish/pdf/HS_miljo_bok_eng_ny.pdf)

49 Stahre and Geldof (2003)

## Part Two:

Exploring the benefits of distributed water systems.

Greater sensitivity to local conditions also allows systems to take advantage of low-cost, site-specific opportunities.

The examples presented in Table 1 show strongly localised and networked characteristics. All provide water services via a combination of on-site, street, precinct or suburb scale systems and rely to varying degrees on linkages with centralised supply and treatment networks. The 10 cases are localised, 'design-to-context' and interconnected. They are not easily characterised by size, location or the organisations involved. However, many deliver common outcomes that extend well beyond those provided by purely linear, centralised systems. The following sections explore these benefits and outline why a distributed approach makes this possible.

### A. REDUCING COSTS AND RESOURCE USE

Networked and localised water systems can save costs, water and materials. Developing services close to demand can allow technical systems to be smaller, less complex and built on demand. Greater sensitivity to local conditions also allows systems to take advantage of low-cost, site-specific opportunities. While 'economies of scale'<sup>50</sup> may be lost, localised systems that move water short distances and supply water at a standard that matches a specific use can deliver services at lower cost than larger systems<sup>51</sup>. New telemetry and modelling technologies are creating opportunities to down-size water systems.

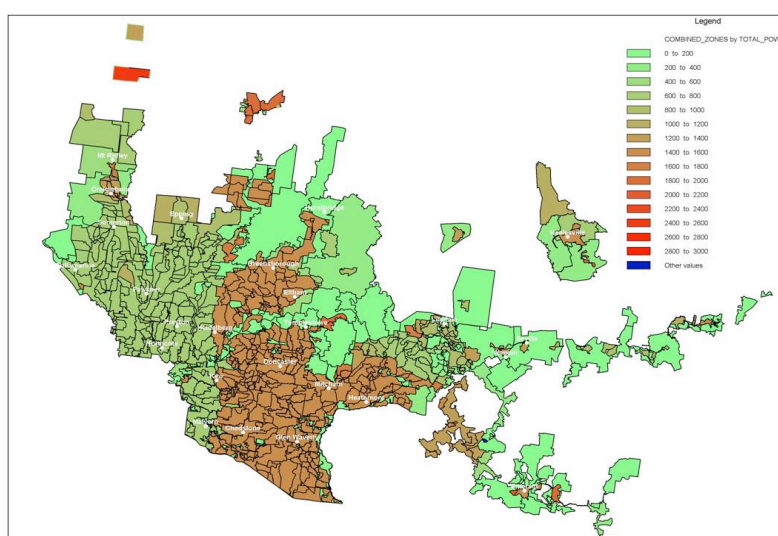
#### New technologies can help identify sites for small-scale system intervention.

The retail utility Yarra Valley Water (YVW) is using spatial information tools to map the energy intensity of providing water supply and treatment services to different suburbs. This is helping identify sites where factors such as gradient, demand and distance from treatment stations mean that small-scale system interventions can save energy. YVW may then choose localised demand management or sewage treatment as a way to cut costs. This ability to track site-specific resource demand is also opening up new areas for mutual cost cutting between developers and utilities<sup>52</sup>.

**Figure 2: Detailed spatial mapping of energy and resource demand can identify sites for localised intervention in centralised service systems.**

This figure depicts the energy demand of service catchments around Melbourne for water treatment and water supply. Colours depict areas with lower (green) to higher (red) energy demand.

Source: Saliba & Gan (2005)



<sup>50</sup> The ability to reduce production costs per unit of service as the size of a system increases

<sup>51</sup> Pinkham *et al.* (2004) [www.rmi.org/images/PDFs/Water/W04-21\\_ValuWstWtr.pdf](http://www.rmi.org/images/PDFs/Water/W04-21_ValuWstWtr.pdf)

<sup>52</sup> Saliba & Gan (2005)

<http://www.yvw.com.au/yvw/Home/AboutUs/ReportsAndPublications/ResearchPublications.htm>

## Part Two:

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## USEFUL SOURCES:

*Kombikraftwerk - Germany*

<http://news.mongabay.com/bioenergy/2007/12/germany-is-doing-it-reliable.html>

This link points to a short video of their distributed energy system that incorporates the use of a reservoir and hydro-turbines to modulate electricity loads in national grid.

*Kristianstad Municipality. Sweden*

<http://www.kristianstad.se/sv/Kristianstads-kommun/Sprak/English/Environment/Biogas/Production/Biogas-from-the-waste-water-treatment-plant/>

[http://www.kristianstad.se/upload/Miljö%20Energi/dokument/energi/fossil\\_fuel\\_free\\_program\\_feb2006.pdf](http://www.kristianstad.se/upload/Miljö%20Energi/dokument/energi/fossil_fuel_free_program_feb2006.pdf)

These links go to detail work done by the municipality to generate energy from wastewater.

*Queensland EPA. Australia*

<http://www.epa.qld.gov.au/publications?id=1616>

This links to a webpage and short report produced by the Queensland EPA titled 'Making sewage treatment plants energy self-sufficient'

*Energy and wastewater treatment.**Central Europe*

<http://www.cyklar.ch/DOWNLOADS/Energy%20self-sufficiency%20as%20a%20feasible%20concept%20for%20WWTP.pdf>

This short paper outlines a number of initiatives in Central Europe to improve energy recovery from wastewater treatment plants.

**Designing for context and building water systems on-demand can cut costs.**

At Piperton in the US, an arrangement of sub-surface, interconnected modular wastewater treatment units was used to service a growing suburban development. Treatment units were linked in a clustered network allowing any excess load at one unit to be diverted to others as required. Capacity (ie. additional treatment units) could be added 'on-demand' to the network as population grew. This represented a significantly lower upfront cost compared to building or expanding capacity in a centralised treatment plant. For this reason, and as identified by researchers at the Rocky Mountain Institute, the centralised approach can be energy and materially inefficient and involve significant opportunity costs<sup>53</sup>. The small size and ability of treatment units to be buried meant little land was taken up for wastewater treatment leaving more for developers. There was also no need to invest in a large treatment plant sized in expectation of higher future demand and run at sub-optimal capacity. Treatment units were monitored and controlled remotely by telemetry technologies cutting operation and maintenance costs to 4 hours of work a month compared to 2-3 full time positions needed for a comparable centralised wastewater facility<sup>54 55</sup>.

**Synergies between water and energy systems reduce the demand for fossil fuels.**

As many water systems are energy intensive, integrating energy and water systems can reduce production costs, peak electricity loads and greenhouse gas emissions. This is happening at a range of scales globally (see links to the left for examples).

Closer to home, Diamond Energy has formed a link with Goulburn Valley Water to construct a 1MW electricity plant to run on biogas from wastewater sludge. This energy will be fed into the grid at periods of peak demand to maximise financial return<sup>56</sup>.

At a smaller scale, the wholesale water utility Melbourne Water has identified 14 sites along its water supply and transfer pipelines where volume of water and elevation differences create enough pressure to run small hydro-turbines. So far, turbines have replaced conventional pressure release valves at six sites. These generated 3,000GJ of energy in the year 2007 to 2008 but have the potential to generate up to around 145,000 GJ per year under ideal conditions. Melbourne Water is also using biogas produced from sewerage sludge digestion to generate electricity and heat. In the year 2007 to 2008 this amounted to around 518,000 GJ. In addition to reducing dependence on fossil fuels for energy, the utility is able to save costs by switching to an internal energy source at periods of peak energy demand. This is reducing strain on electricity suppliers at periods of peak demand<sup>57</sup>.

In Germany, a research project into the supply stability of a national electricity grid based solely on distributed renewable energy has highlighted one potential role of water in distributed energy systems. Their model uses hydro-turbines connected to a reservoir to shed electricity loads. When electricity production exceeds demand the pumps push water up a hill to a storage area. When electricity inputs to the grid from wind and solar generation fall below demand, water is drained through hydro-turbines at the bottom of

53 Pinkham *et. al* (2004)

54 Aquapoint (n.d.)

55 Lindell C. [Aquapoint] pers. comm., March 2009

56 Nelson (2008)

57 Ligtermoet E. [Melbourne Water] pers. comm., April 2009



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the hill boosting electricity production<sup>58</sup>. For a short film of this system visit:  
<http://news.mongabay.com/bioenergy/2007/12/germany-is-doing-it-reliable.html>

#### **Localisation of wastewater treatment and recycling can save water and energy.**

At an urban greenfield site near Townsville, researchers compared four distributed wastewater treatment system (WTP) designs against a centralised 'base case'<sup>59</sup>. One design, which used four treatment plants and on-site greywater reuse, showed how splitting wastewater streams at their source could cut demand for sewerage treatment services by 65%. In another system design, 32-networked WTP's treated all wastewater and then returned it via a third-pipe return system. This design reduced residential demand for potable water by 33.1% and saved six percent on energy compared to the centralised option. The gain in energy efficiency was due to the lower energy needs of many smaller treatment plants and the use of recycled water (which reduced energy for pumping). A similar option using 315 smaller WTP's proved less energy efficient - suggesting that as the treatment system became increasingly localised (for this site), efficiency increased to a point and then declined.

**Integrating water technologies can improve water saving capacity.** While wastewater reuse can deliver valuable water savings, integrating localised, centralised and 'demand-side' technologies can generate even further cuts in water use. For example, the system designed at Figtree Place saved around 60% on water use via efficient appliances, landscaped stormwater features, rainwater harvesting and stormwater capture and reuse technologies<sup>60</sup>. At Aurora, a similar combination of features with the addition of recycled wastewater is expected to deliver 70% savings<sup>61</sup>.

Integration of multiple on-site technologies within high-density areas is also able to cut water use. For example, the Solaire building in New York combined a green roof with onsite wastewater treatment and reuse and rainwater harvesting to achieve a 50% saving water use and a 63% reduction in wastewater discharge<sup>62</sup>. While the system was successful for the developer and occupants, it did not perform well on a standard economic assessment; the payback period was more than 20 years. However, this assessment did not take account of subsidies supporting the operation of mains utilities or the systems' ability to reduce stress on the wider systems into which it feeds. As a result of on-site treatment, the Solaire discharges a lower nutrient pollutant load to waterways, and reduces pressure on supply and discharge mains at a time when combined sewers are reaching capacity<sup>63</sup>.

**Adding decentralised systems to centralised networks can reduce infrastructure costs.** As shown by Coombes and others (2002)<sup>64</sup> reducing demand for mains supply and stormwater services through simple source control technologies can translate to significant savings by delaying capacity expansion. Using economic modelling, these authors showed onsite household rainwater harvesting across two regions of New

reducing demand for  
 mains supply and  
 stormwater services  
 through simple source  
 control technologies  
 can translate to  
 significant savings.

58 Kombikraftwerk, (2007) <http://www.kombikraftwerk.de/index.php?id=27>

59 Fyfe *et. al* (2009)

60 Coombes *et. al* (1999)

61 McLean (2004)

62 Clerico (2005)

63 Arpke & Clerico (2006)

64 Coombes *et. al* (2002)



The ability of small-scale networked systems to be expanded on demand can also cut back on investment and operating costs.

South Wales could reduce peak demand by 5%, lower extraction from mains water by 55% and reduce stormwater discharges by 56%. This translated into a 34-year delay for upgrades in supply infrastructure.

**Local solutions can be low-tech and low-cost.** If local conditions are suitable, low-tech solutions to problems such as stormwater runoff can deliver material and cost savings. In Seattle, a number of projects that deal with stormwater at its source by changing street design and creating infiltration zones have been highly successful. Compared to a conventional system, stormwater runoff has been reduced at some sites by 98%, water velocity<sup>65</sup> by 20% and costs by 25%. The need for piping and storage infrastructure was also reduced<sup>66 67</sup>. While not on the same scale, the avoidance of materials in the Figtree case also generated a one percent saving on construction costs.

As these examples illustrate, distributed systems can cut water and energy use - reducing consumption of fossil fuels. The ability of small-scale networked systems to be expanded on demand can also cut back on investment and operating costs. Avoiding 'over-capacity' by incremental system expansion has environmental implications, since the majority of life cycle impacts from water systems are generated during operation<sup>68 69</sup>. Localised approaches to water harvesting and dealing with stormwater can also cut the financial and material intensity of infrastructure systems.

At some point along the process of expanding localisation, energy savings from reduced distribution distances may be offset by higher overall energy demand from multiple on-site systems<sup>56</sup>. Site-specific factors such as gradient, population density and availability of renewable energy will therefore play a critical role in shaping system efficiency and consumption of resources.

## B. IMPROVING SERVICE SECURITY AND REDUCING RISK OF FAILURE

Critical service systems must be able to avoid shocks and absorb disturbances without losing their functionality. As the following examples illustrate, networked and localised water systems can generate increased 'resilience' by:

- Enabling users to produce water and operate with reduced water supply
- Providing a range of response options
- Increasing the role of local stakeholders in management of the water systems
- Increasing transfer networks
- Containing impacts where they occur

### **Diversifying water service pathways reduces customer vulnerability to shocks.**

Simply adding a non-potable water supply option to supplement existing potable supplies can significantly improve people's resilience to water restrictions. In Salisbury, while most households rely solely on potable mains water, a growing number have (as

<sup>65</sup> The faster water flows, the greater its erosion potential and the further it can carry pollutants.

<sup>66</sup> Horner (2002)

<sup>67</sup> Seattle Public Utilities (n.d.)

<sup>68</sup> Opray & Grant (2006)

<sup>69</sup> Pinkham *et. al* (2004)

The local government and community now have an integral role and stake in protecting their local water source ... and are also better able to take responsibility because of their proximity and understanding of it.

...multiple localised systems have the combined potential to reduce pressure on larger networks.

yet) unlimited access to non-potable water from the areas' stormwater treatment, storage and reuse scheme. At the height of recent water restrictions in Adelaide, most Salisbury residents had no option but to limit or stop outdoor watering, having a major impact on household gardens and affecting the state of the community generally (see section on community wellbeing below). However, for the 3,500 people connected to the stormwater reuse scheme, the mains water restrictions did not have the same affect. People were still able to use water for gardening and other outdoor purposes<sup>70</sup>.

The Salisbury scheme is improving resilience by increasing and diversifying water supply and also by improving the ability of key stakeholders to monitor, influence and provide feedback on the health of the local supply system. The local government and community now have an integral role and stake in protecting a key water supply source (stormwater) and storage area (the underlying aquifer). They are also better able to take responsibility because of their proximity and understanding of it. As potable supplies from the Murray River become increasingly insecure, neighbouring local governments are planning to adopt and expand this approach<sup>71</sup>.

**Integrating multiple water systems can increase user options when problems occur.** At an urban village scale, the combination of on-site and centralised water system elements give residents at WestWyck a range of supply and treatment options. As a result, residents at the village have a more robust system for water services than their non-village neighbours. Services rely on less water (thanks to efficient appliances) via multiple water sources (due to capture and reuse technologies). In addition to potable water supply from mains network, rainwater is collected for hot water and washing, on-site treated greywater is used for toilets and gardens and onsite treated blackwater is used for landscape irrigation. Residents at WestWyck are better able to cope with reduced external supplies because they are 'prosumers': producing water as well as consuming it<sup>72</sup>.

The integration of decentralised systems into centralised networks can enable each to reduce stress on the other and increase the resilience of both. At WestWyck, discharge of sewerage sludge to mains is limited to one minute per day and stormwater discharge is reduced by 97%<sup>73</sup>. While a single development of this scale does little to influence the stability of a centralised stormwater or sewerage system it may ameliorate local flooding. It also highlights how multiple localised systems have the combined potential to reduce pressure on larger networks.

**Diversifying water transfer networks can help share and lessen the risks to water supplies.** During recent bushfires in Victoria, important catchments came under threat of burning and ash contamination. The catchment feeding the Upper Yarra Reservoir was one. This reservoir is the only conduit for transporting water from Melbourne's largest water storage (the Thompson Dam) to the city. If the Upper Yarra Catchment had burnt, Melbourne's main water supply would have been shut-off while ash contaminants were left to settle - a process that can take months. In contrast, at other

70 Naumann B. [City of Salisbury] pers. comm., April 2009

71 DEWHA (2008) [www.environment.gov.au/water/programs/wsa/projects/pubs/sa08.pdf](http://www.environment.gov.au/water/programs/wsa/projects/pubs/sa08.pdf)

72 The term 'prosumer' was coined by Kotler (1986) to describe a person or organisation that produces some of the goods or services they consume.

73 Hill M. [WestWyck] pers. comm., March 2009

...localised approaches to water service provision can have a lower and more stable risk profile compared to centralised systems.

threatened sites, the existence of water transfer networks linking different reservoirs allowed more than 10 billion litres to be pumped out to connected storage areas and saved from contamination<sup>74</sup>. This event highlights the role of water networks in helping avoid shocks and increasing capacity to adapt.

**Localised structures can help minimise and contain impacts.** In a localised water supply scenario, where wastewater is reused in homes (eg. via a third pipe), cross contamination with potable water lines represents the main risk for water supplies. The main risk in a conventional centralised system, aside from poor rainfall, is catchment contamination (eg. due to algal blooms or fire). Comparing the impact of these potential scenarios is revealing. A 'third-pipe' crossover may represent a serious health risk, but one that is restricted to a small number of homes. Conversely, a toxic algal bloom or major fire in a supply reservoir will affect thousands of homes. For these reasons, and as calculated by the Yarra Valley Water utility in Melbourne, localised approaches to water service provision can have a lower and more stable risk profile compared to centralised systems<sup>75</sup>.

## C. STRENGTHENING LOCAL ECONOMIES

The ability of firms and regions to avoid economic losses and readjust in response to natural and human-led shocks is attributed to their diversity, flexibility and the inter-connectedness between commercial actors<sup>76 77 78</sup>. Distributed systems demonstrate many of these attributes by forming diverse networks and having sensitivity to local conditions. Examples illustrate how this approach has saved jobs, cut water bills for local businesses and led to new commercial opportunities.

**Making use of local resources can reduce costs and save jobs.** The Salisbury storm water reuse scheme has been successful in improving the economic viability of local businesses and community. This was achieved by diversifying water supplies with a low cost water source in close proximity to important industries. Prior to the scheme, one of Australia's largest wool processors considered relocating away from the area due to the high cost of obtaining water from the River Murray; potentially jeopardising 700 jobs. In a joint venture, the company and the local government created a stormwater treatment wetland capable of providing more than 1 billion litres annually - enough to meet the company's needs. A similar scheme also assists a local nursery and car manufacturing plant. The treated water has lower salinity than water from the Murray and can be provided at half the cost. Investigations into the wool processing plant also found that by blending post-processing sludge with residential green-waste a nutrient rich fertilizer could be made that is suitable for horticulture and viticulture businesses. Developing this opportunity would provide a cheap agricultural resource and reduce sludge input to Adelaide's largest wastewater treatment plant by 20%<sup>79</sup>.

74 Ker (2009)

75 Pamminer (2008) <http://www.yvw.com.au/NR/rdonlyres/3604431E-734A-43CE-B870-EA5F3B8F67E7/0/NUWGPYVWcasestudy08v5.pdf>

76 Kreuger (1998) [sbaer.uca.edu/research/icsb/1997/pdf/46.pdf](http://sbaer.uca.edu/research/icsb/1997/pdf/46.pdf)

77 Rose & Lao (2005)

78 WRI (2008) [pdf.wri.org/world\\_resources\\_2008\\_roots\\_of\\_resilience\\_front.pdf](http://pdf.wri.org/world_resources_2008_roots_of_resilience_front.pdf)

79 City of Salisbury (n.d. a)

Ability to capitalise on  
local water resource  
opportunities can also  
build surprising  
synergies across  
industry sectors ...

Rather than being  
passive recipients ...  
locals have a major  
stake in the  
effectiveness of the  
scheme

**Openness to local opportunities can lead to valuable partnerships.** Ability to capitalise on local water resource opportunities can also build productive synergies across industry sectors and improve economic conditions. At Maldon in central Victoria, mine operators were dealing with mine flooding by pumping groundwater seepage into holding tanks. They had a problem with the water not evaporating fast enough. As a solution, local farmers formed a group and gained government backing to pipe this water for livestock and council use. The arrangement now saves pumping and containment costs for the mine, provides cheap water supply for farmers (who previously relied on trucked potable quality water) and has helped the council stop using potable water for road maintenance. In addition to improving resilience during a period of water restrictions, the system has reduced environmental costs of daily water carting and avoided a scale-back in road maintenance<sup>80 81</sup>.

#### D. STRENGTHENING COMMUNITY WELLBEING

Constructed water systems play a critical role in maintaining community wellbeing. The two previous subsections illustrated their ability to influence security of service and economic stability for example. Examples also highlight the potential for water systems to improve amenity, integrate and empower communities and strengthen local identity.

**Incorporation of ecosystem services can improve urban amenity.** In Seattle, local stormwater infiltration projects have been designed to deliver a range of community benefits including safer neighbourhoods (via reduced vehicle speeds and expanded footpaths) and an increase in the quantity and quality of urban green-space. Rather than being passive recipients of these benefits, locals have a major stake in the effectiveness of the scheme, playing a primary role taking care of the vegetated infiltration areas. These projects have been highly popular with local residents; with some believing property prices have improved as a result. While untested, these claims are consistent with studies on factors that effect real estate values<sup>82 83 84</sup>.

At WestWyck, the water system is integrated with the site's aesthetic and functional space due to proximity between points of supply, use and discharge. Residents are physically exposed to and are supportive of the system; benefiting from attractive vegetated areas (fed by storm- and blackwater); a communal vegetable garden (fed by rainwater tanks) and a greater sense of well-being in the knowledge that they are reducing strain on the wider environment<sup>85</sup>.

**Localisation of water systems can increase community participation.** The stormwater treatment features in Salisbury and Augustenborg have increased local amenity and provided multiple urban spaces that are actively used for recreation and educational purposes. Furthermore, including Augustenborg residents in discussions over stormwater plans led to the partial recreation of a creek that had been 'culverted' years before. The planners' use of local knowledge gave an effective stormwater

80 Lucas B. [Mount Alexander Shire Council] pers. comm., May 2009

81 Nelson (2008)

82 Emrath (2002)

83 Kong *et. al.* (2007)

84 Luttik (2000)

85 Hill M. [WestWyck] pers. comm., March 2009

solution that also had historical value. This process and outcome gave locals a connection to and a stake in changes occurring in the surrounding landscape<sup>86</sup>. At a larger scale, the Salisbury scheme played an important role in building local pride by creating a positive identity for the area as a pioneer in more sustainable water systems. This is particularly significant for a suburb long maligned as ‘poor’ and ‘working class’. Mirroring the involvement of the community in Seattle, Salisbury residents are active beneficiaries of the new water supply system and actively support further changes. For example, community attitudes have been instrumental in driving the council’s roll out of residential water meters on non-potable water supply lines and developing small-scale ‘rain-vaults’ to collect and reuse stormwater in new high-density developments<sup>87</sup>.

The ability of water systems to ensure ‘non-essential’ services despite supply shortages is also relevant to community wellbeing. Anecdotal evidence from Salisbury residents has described how a visible decline in home maintenance was observed once people’s gardens had died as a result of water restrictions. This occurred across previously well-maintained suburbs<sup>76</sup>.

## E. REGENERATING AND PROTECTING THE NATURAL ENVIRONMENT

Constructed water systems can have a major negative impact on natural waterways. This includes the loss of habitat and biodiversity, changed hydrological conditions and pollution<sup>88</sup>. Part of the problem has been the inability of stakeholders to see, understand and value the impacts they are having on the environment. The impact of upstream land use and nutrient discharges on coastal marine ecosystems is a typical example. Water systems that develop close links with the natural environment can reduce impacts close to source and even improve environmental health.

**Design to context offers opportunities to re-introduce lost habitat.** In Salisbury, construction of storm and wastewater treatment wetlands initially occurred on cleared land that was part of a much wider area subject to flooding and slow drainage. The 260ha of constructed wetlands have re-established valuable habitat for native birds, reptiles and fish that originally existed in the area. Since construction, reduced weed density and improvements in plant diversity, soil conditions suggest habitat conditions are continuing to improve<sup>89</sup>. The scheme also reduces wider environmental impacts by cutting water drawn from the drought stricken Murray River and limits the volume of nutrient laden stormwater discharged into important marine fish breeding grounds<sup>90</sup>. The use of constructed wetlands and a lake to reduce nutrient loads and slow stormwater velocities in Augustenborg, have had a similar affect. Results include an improvement in habitat values and the attraction of water birds back to historically waterlogged areas that had been drained<sup>91</sup>.

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86 Stahre & Geldof (2003)

87 Naumann B. [City of Salisbury] pers. comm., April 2009

88 Mitchell (2006)

89 Garde *et. al* (2004)

90 City of Salisbury (n.d.b)

91 Stahre & Geldof (2003)

## Part Two:

Exploring the benefits of distributed water systems.

Significant potential exists to build synergies between different service and infrastructure systems that use water in some way.

**Source control measures can reduce environmental impacts.** At a smaller scale in Seattle, significant environmental benefits have resulted from treating stormwater at source through the use of roadside swales and vegetated drainage basins. Due to a 98% reduction in stormwater runoff, the nutrient, heavy metal and hydrocarbon pollutant loads entering natural waterways have been substantially reduced. The scheme has also helped replenish groundwater and reintroduce native habitat back into urban environments<sup>92 93</sup>. Vegetated stormwater infiltration swales at WestWyck do a similar job on a smaller scale.

In addition to the aesthetic, habitat and pollution reduction benefits stemming from these examples, a strong sense of community ownership of the sites has developed in Augustenborg, Salisbury and Seattle<sup>94 95 96</sup>. These examples suggest that by designing ecosystem elements into constructed water systems, we can increase public interaction, understanding and care of natural environments.

## F. REDEFINING TRADITIONAL WATER SYSTEMS

Water plays a critical role in most technical, social and ecological functions. Significant potential exists to build synergies between different service and infrastructure systems that use water in some way. The following examples illustrate how designing water systems for a local context can create complimentary structures and produce multiple positive outcomes. These outcomes redefine traditional concepts of what water systems look like and deliver.

**On-site technologies can leverage multiple positive outcomes.** One of the simplest yet inspiring examples of a localised approach to a water problem generating multiple benefits is the green roof. One location where these are being mainstreamed is in Chicago where the local authority has championed and subsidised green-roof construction. Icon projects are demonstrating how green roofs can reduce stress on the city's combined sewer systems by modifying peak stormwater runoff. These roofs are simultaneously improving amenity and air quality, reducing urban heat, cutting energy use for building climate control and extending roof lifespan. Green roofs can therefore be integral to a city's sewer and stormwater system, play an important role in the quality of life for residents and be an extra tool for building managers to save on energy and maintenance<sup>97 98 99</sup>.

**A focus on matching local resources with local needs can open-up cross-sector synergies.** In Stockholm, designers of the Hammarby Sjöstad district have integrated water systems with the energy, aesthetic, housing and cultural aspects of the area. This has generated positive outcomes that extend well beyond the suburban boundary. At the building scale, water efficient appliances and greenroofs are reducing the volume and peak flows of wastewater and rainwater runoff. At the street level, separation of

92 Horner (2002)

93 Seattle Public Utilities (n.d.)

94 Naumann B. [City of Salisbury] pers. comm., April 2009

95 Stahre & Geldof (2003)

96 Vogel (2006) [www.planetizen.com/files/21901.pdf](http://www.planetizen.com/files/21901.pdf)

97 Ker (2009)

98 Kloss & Calarusse (2006)

99 Stahre & Geldof (2003)

roof from road stormwater is cutting total polluted water volumes - enabling easier treatment. Roof runoff is also dealt with close to source via infiltration or directed through a sculptured channel to the adjacent lake. Polluted stormwater is treated onsite through wetland biofiltration areas that form attractive vegetated features<sup>100</sup>. The 'eco-cycle' infrastructure model used in Hammarby Sjöstad highlights the synergies possible by utilising local resources close to their source. Household wastewater sludge is digested to produce biogas, which is then fed back into 1000 homes for cooking and also used to help run local taxis and buses. In a return loop that links water, agriculture and energy systems; nutrient rich residue from the wastewater digestion process is applied as a fertiliser for plant biomass production. This can then be burnt in the district heating and cooling plant<sup>101</sup>.

## IN SUMMARY

The examples and research explored in Part Two demonstrate how distributed water systems can deliver positive outcomes that extend well beyond those offered by conventional centralised systems. In addition to providing critical water services, the examples have reduced or delayed infrastructure investments, cut demand for water and energy, improved environmental conditions and strengthened local communities. These outcomes are attributable to common structural characteristics (as summarised in Figure 3). In particular:

- The design of systems to take advantage of resources where they occur
- Feedback and transfer links between systems
- Close proximity and interaction between actors and technical elements
- Incorporation of biological, low-tech and telemetry systems where feasible
- A diversity of supply and treatment options.

These characteristics give distributed systems an advantage in managing risk and uncertainty. Cases demonstrated how structural diversity builds adaptive capacity. In some examples, the presence of multiple water supplies and different pathways for delivering water services improved the ability of customers to respond to disruptions and the rationing of mains water supplies. In others, links between water and energy systems illustrated how increasing system diversity in novel ways can help against fluctuations in energy price and availability. These outcomes show how system design choices from the household-to-regional scale offer opportunities to reduce the vulnerability of our water services to threats from climate change and energy supply shocks.

System design choices  
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<sup>100</sup> GlashusEtt (2006)

<sup>101</sup> *Ibid.*

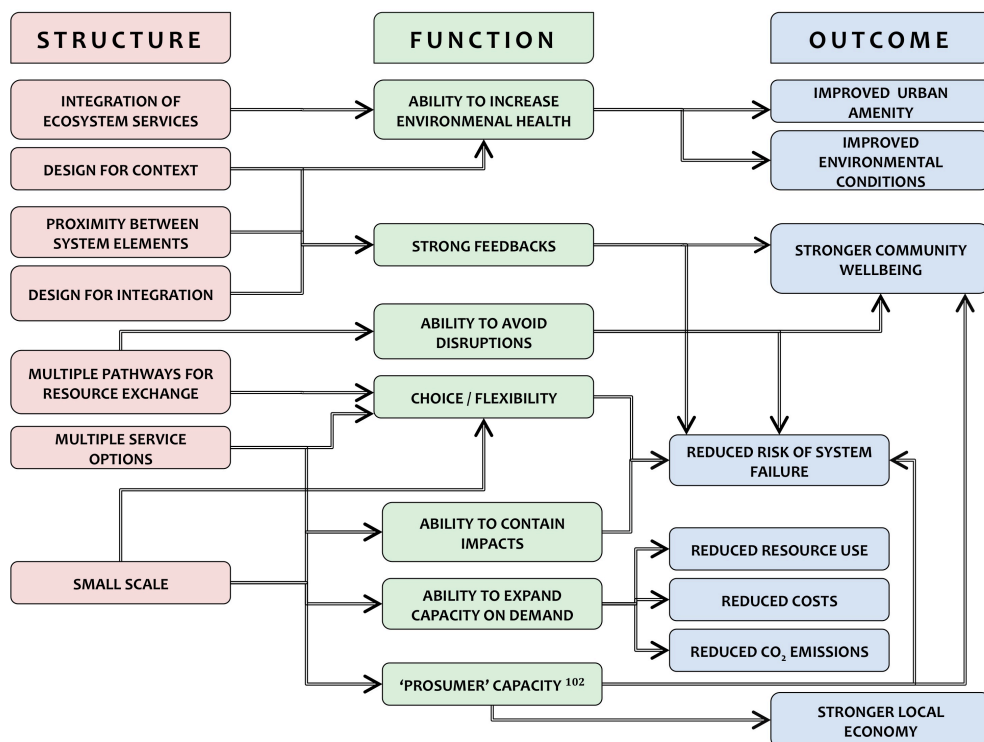


## Part Two:

Exploring the benefits of distributed water systems.

**Figure 3: Summary of the relationship between key structures, functions and outcomes in distributed water systems.**

This figure illustrates how factors such as size, design and integration of water systems can influence outcomes as diverse as carbon emissions, business opportunities and community wellbeing.



<sup>102</sup> The capacity of people or organisations to produce some of the goods and services they consume (in this case related to water) (Kotler, 1986).

## Conclusions:

### Making the most of distributed water systems

#### Where do we go from here?

Securing Victoria's water future requires highly informed decisions and further investment. The wrong choices can reduce long-term water options at a time of high future uncertainty. An effective response to ecosystem failure, climate change and energy scarcity requires a widening of response options. The distributed systems approach for delivering water services is capable of building this diversity. Examples demonstrate how many opportunities exist to improve current water infrastructure using localised 'context-specific' systems and how the distributed model has exciting potential to transition water systems onto a sustainable path.

The continuing evolution of a more adaptive, distributed systems approach to water management needs visionary leadership and bold decisions. The urgency of the water crisis requires that we increase our understanding and support for new approaches and be mindful of decisions that could slow further innovation.

#### Reconsider the role of big projects:

**Diverse solutions can build resilience.** One clear message in this paper is that risk and uncertainty are best met by building adaptive capacity, not just supply capacity. Greater effort is needed to ensure customers, utilities and governments have the freedom to choose how they respond under difficult water conditions. We need to urgently build flexibility into water systems - not limit future options by opting for rigid 'one-size-fits-all' solutions. Distributed systems offer a positive model for adding resilience and reducing risk but can be undermined by large supply-oriented projects.

- Emphasis on using single large projects to solve water problems can cut resources available to smaller projects and shift the focus away from the myriad of less costly local opportunities for improving the diversity and security of water services.
- Smaller projects incur lower opportunity costs. If conditions change or results don't meet expectations, less investment is wasted. Emphasising smaller projects allows new technologies to be adopted more frequently as they emerge. Changes in supply and demand can also be responded to more flexibly - as they happen.
- Big projects aimed at significantly boosting supply capacity may not necessarily improve long-term water security if they rely on the stability of external variables (eg. energy supply or environmental conditions). Providing services to hundreds of thousands of people through a single pathway can represent higher risk during conditions of uncertainty.

#### Realise the rules of the game are changing:

**New technologies are radically changing what is possible, cost effective and safe.**

The development of new modelling tools and technologies means smaller systems can provide the health protection and security of supply that centralised networks were designed to deliver. Such technologies are also reducing the customer base needed for water systems to operate cost effectively; reducing the need to pursue a centralised 'expand and supply' approach in order to keep service costs low. For example:

- Remote telemetry technologies are cutting water service costs and can give local communities, utilities or local governments the ability to monitor, synchronise and control system performance in real time.
- Modelling tools such as geographic information systems are enabling a better understanding of the factors that influence water system efficiency. This is

helping identify areas for targeted system intervention using small-scale water technologies.

- New appliances and treatment technologies are changing economies of scale and even how services are delivered. As a result, the functional value of water can be multiplied many times over by efficient localised use, treatment and reuse while cutting risks to public health and the natural environment.

### Find the opportunities in complexity:

**Complexity represents an opportunity, not a threat.** Distributed systems are capable of delivering a variety of positive outcomes in addition to traditional water services. However, many of these benefits are difficult to quantify in ways that assist decision makers compare system designs. In order to see the opportunities rather than the threats presented by water sector innovation, more integrated and flexible assessment processes must be embedded in decision-making. This will involve a broadening of evaluation criteria and a greater recognition of the roles experimentation and diversity play in adapting to change.

- Sustainable, cost effective water systems will not evolve by continuing to follow the well-beaten path set by centralised water systems. We need to learn from the successes of existing distributed water systems and test new concepts. Many of the water systems presented in this paper evolved through a learning-by-doing process.
- Tools such as life-cycle analysis, risk assessment, sustainability appraisal and scenario planning offer some help to compare complex system outcomes but can be slow and expensive. They also fail to effectively consider non-financial benefits such as community empowerment, security of non-essential services and the personal value of reducing environmental impacts.
- Utilities and governments will only gain the skills and experience to compare alternative designs and measure complex outcomes by supporting, being involved in and sharing lessons gained from innovative projects.
- Because distributed systems are complex and adaptable, many of the positive outcomes from adopting such an approach will remain unknown until systems are operating.

### Support innovation with new models of governance:

**Models of governance can do more to support innovation.** The range of organisations, technologies and new partnerships involved in distributed water systems present a unique challenge for regulators. The emergence of distributed systems in multiple sectors<sup>103</sup> (not just water), suggests that existing models of governance should be reviewed.

- The creation of new organisational roles and responsibilities reflects a broadening of opportunities for commercial, government and community actors into new territory. We are seeing new possibilities for consumers to

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<sup>103</sup> The first paper in this series by McCormick (2008) on distributed energy systems can be found here: <http://ecoinnovationlab.com/publications/45-briefing-notes/141-briefing-paper-an-overview-of-development-in-distributed-energy>

become producers, communities to have greater ownership of the water systems they rely on and new, creative partnerships to develop.

- The development of more diverse and empowered local actors may be key to the flexibility and health of water service systems, but must also be managed; greater localisation is not without its own potential pitfalls<sup>104</sup>.
- Experimentation in governance structures and regulations will be required alongside innovative water projects.

## RECOMMENDATIONS FOR GOVERNMENT

1. **Value the emergence of distributed systems.** The evolution of critical systems based around a networked and localised model is occurring in multiple sectors globally. Ignoring this trend or treating it as a niche movement may lead to disruptive consequences for critical systems based on traditional infrastructure models.
2. **Strengthen funding programs for building and assessing innovative water projects.** These should aim to stimulate a re-think of water system designs and roles, develop new synergies between industry sectors and embed active community participation in system functions.
3. **Consider the impact of major infrastructure decisions on the design and emergence of smaller, innovative water projects.**
4. **Prioritise water service solutions that can supplement and fill local unmet demands as existing infrastructure systems age and reach capacity.**

## RECOMENDED DIRECTIONS FOR RESEARCH

1. **How do different governance models and emerging technologies affect the scale, design and outcomes of new water service systems?** Issues to consider could include the role of new governance structures and new developments in information technology on the viability of distributed systems at different scales, on community ownership of water systems or the potential for small water producers to trade across local networks.
2. **What kind of tools can best help water strategists, utilities and governments calculate the relative benefits of water system options?** Greater capacity is needed to integrate existing assessment tools and incorporate the non-financial outcomes of adopting innovative water systems.
3. **Where are the greatest opportunities for creating synergies between the water sector and other critical service systems?** Examples have shown the possible links between energy and water systems. Valuable synergies can also be expected between water and other sectors (eg. agriculture).

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<sup>104</sup> For example regarding the maintenance of equity, liability and transparency.

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