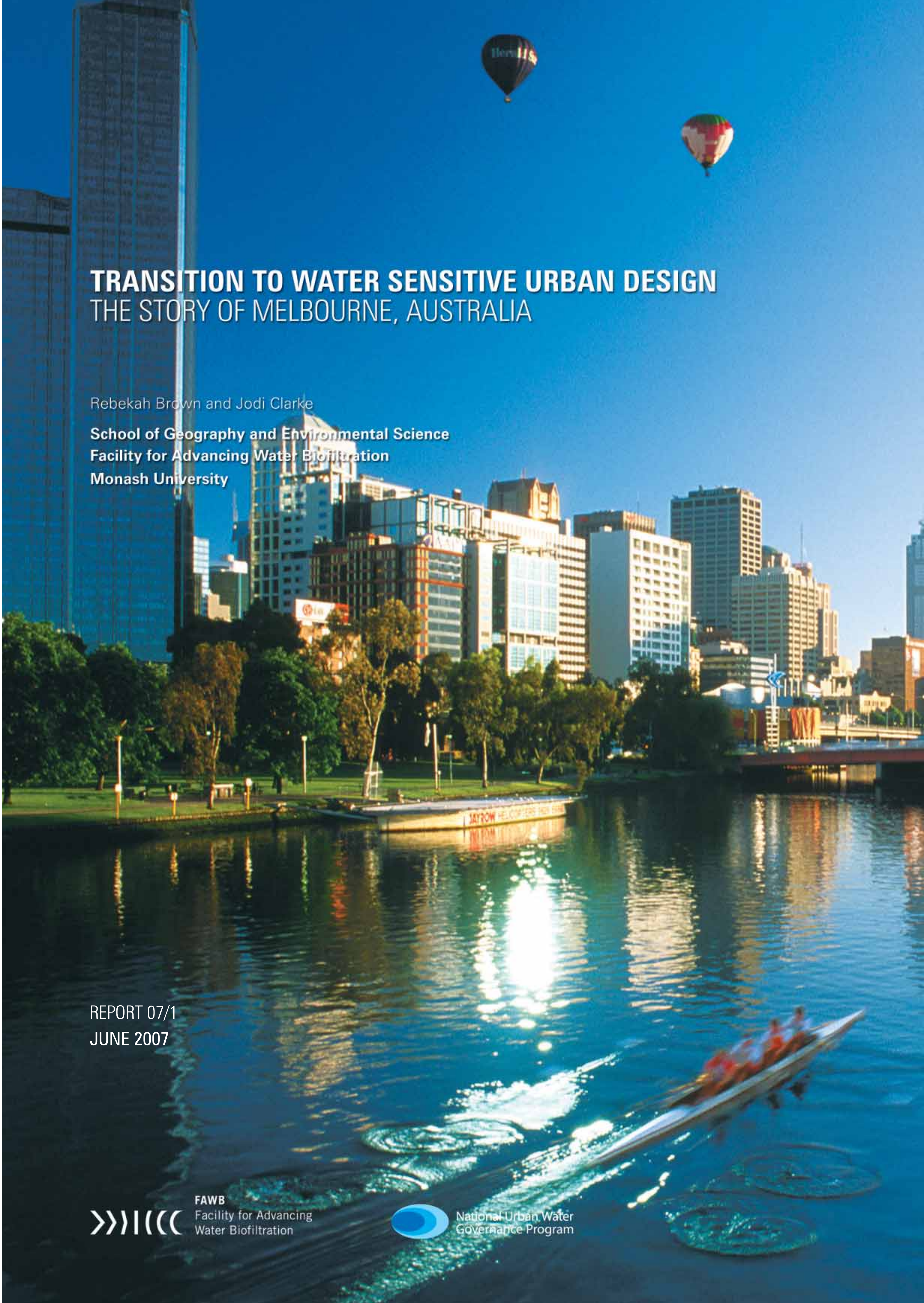

TRANSITION TO WATER SENSITIVE URBAN DESIGN
THE STORY OF MELBOURNE, AUSTRALIA

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FOREWORD

This report on the *'Transition to Water Sensitive Urban Design: The Story of Melbourne, Australia'* is an initiative by the Facility for Advancing Water Biofiltration to publish its research work. Research studies undertaken at the Facility for Advancing Water Biofiltration (FAWB) are aimed at facilitating more sustainable management of urban water through socio-technical initiatives including urban water governance reform and innovative technologies, particularly water biofiltration.

The main aims of FAWB are to:

- Provide scientific "proof of concept" for the application of stormwater biofilter technologies so that greater certainty is afforded to all stakeholders in relation to the choice and design of such technologies
- Facilitate industry-wide adoption and implementation of the technology after proof-of-concept is established

This study and report undertaken in collaboration with Monash University's National Urban Water Governance Program is, I believe, an important contribution to advancing our knowledge on institutional reform for sustainable urban water management. The report presents an analysis of the social and technical aspects associated with making the transition in Melbourne from traditional urban stormwater management towards a more sustainable Water Sensitive Urban Design (WSUD) approach.

The focus of this social research needed to be on the broader WSUD agenda to understand the transitioning qualities and future opportunities for change. Its focus is therefore much broader then on a single technology type such as water biofiltration systems. The insights gained are nevertheless of direct relevance to our efforts in facilitating the industry-wide adoption of water biofiltration technologies. By identifying and understanding key principles around technology diffusion, we can more readily apply these learnings to the objectives of FAWB for expediting the uptake of water biofiltration technologies.

It is hoped that the report findings will be of particular benefit to industry in providing key insights into the social and related aspects that enable technology adoption. It is envisaged that these insights will further enable Melbourne, and other cities, to ultimately transition to being water sensitive. The 'water sensitive city', is the product of city-wide commitment to WSUD with a sophisticated approach to the integrated management of the urban water cycle addressing such issues as water supply security, alternative sources of water, fit-for-purpose use of water, and waterway rehabilitation and aquatic ecosystem protection.

I am privileged to be working with a team that is so committed to sustainability, particularly advancing WSUD by bringing research closer to practice and we would welcome further opportunities for collaboration with industry. For more information about this research and the FAWB project, please visit our website (www.monash.edu.au/fawb).

Tony Wong
Chief Executive Officer
Facility for Advancing Water Biofiltration

EXECUTIVE SUMMARY:

This report presents the findings of a social research project focussed on identifying the key institutional change ingredients that will lead to the mainstreaming of the water sensitive urban design (WSUD) approach across modern cities. One of the most significant challenges facing urban water managers and policy makers today is the shortage of reliable knowledge and guidance on how to effectively institutionalise, and therefore mainstream, the WSUD approach. To date, numerous commentators have suggested that progress towards the widespread practice of WSUD has, at best, been slow. Some of the impediments to change appear to include insufficient professional skills and knowledge, organisational resistance, lack of political will, limited regulatory incentives, and unsuitable institutional arrangements. It is also well recognised that mainstreaming the WSUD approach is challenging, and often unsuccessful, because the transformation required is highly dependent on successfully establishing new cultures across multiple organisations, professions and tiers of government.

The WSUD approach is yet to be mainstreamed anywhere, and it is not an approach that requires a simple adaptive technological change from the current practice. In addition, there are few cities, if any, that have adopted effective governance regimes for the management of such complex, multi-sectoral issues, such as urban water. WSUD requires new technologies and approaches that are often radical to the status quo, demanding fundamental changes in institutional capacity at various levels including new knowledge and skills, organisational systems and relationships, policy frameworks and regulatory rewards and penalties.

This research draws from a retrospective analysis of the key factors that has led to the successful institutionalisation of 'urban stormwater quality management' (USQM), as an essential component of WSUD, across metropolitan Melbourne so far. Presented in this report is an analysis of the key factors over the last 40 years that have enabled this transition across Melbourne to date. This research attempts to draw on the Melbourne case as a proxy for addressing this significant knowledge gap, notably the process of 'change' that results in the implementation of new technologies and processes within the urban water system.

While WSUD requires greater levels of change to the urban form and the community's relationship with their physical environment than the USQM approach, it is the proposition of this research that there are likely to be substantial and beneficial insights and lessons for advancing WSUD through investigating the relative success of the USQM approach. This is because the mainstreaming of USQM demands the robust institutionalisation of 'aquatic environmental protection' and 'waterway amenity' values into current governance structures, as well as significant change in current management and operational responses. The report adapts the case study insights to develop recommendations for how urban water strategists could more efficiently and effectively pursue the mainstreaming of the broader WSUD agenda across modern cities.

One of the central propositions of this research was that if WSUD is to ever be fully realised, there is a strong need to change the underpinning institutional cultures that support the day-to-day practice of urban water management. The Melbourne USQM case study supports such a proposition as it is essentially a story of how the value of environmental protection of waterways has been institutionalised over the last 40 years. Making the transition to the mainstream practice of WSUD across cities requires a sophisticated program for strategic institutional change.

THE MELBOURNE CASE STUDY

Metropolitan Melbourne is identified as an important case study as it is often informally acknowledged as a leading international city in the area of USQM for aquatic ecosystem protection. While the on-ground implementation of USQM technologies is yet to become mainstream practice for all stakeholders,

the city is on an important change trajectory towards institutionalising USQM. Melbourne's progress is sufficiently developed to allow for a critical examination of the important ingredients that have enabled this transition to date.

This research involved recording oral histories from 28 expert interviewees representing multiple sectors of government, the market, academia and the community who collectively revealed a number of drivers and events that have underpinned the USQM transition over four decades. A series of facilitated group interviews were also conducted with local professionals, to generate improved understanding of the urban stormwater transition. This data was cross-referenced with secondary sources and existing scientific literature in the field.

MELBOURNE'S USQM TRANSITION PHASES

Overall, this case study has revealed an experiential process of how a new value of environmental waterway protection has been institutionalised across metropolitan Melbourne. Drawing from transition theory, four inter-dependent transition phases where identified, which involved a number of complex change processes, and include:

- **Phase 1: Mid 1960s-1989 'Seeds for Change'** – In this period, rapidly growing social activism emerged which challenged the government to improve the protection and rehabilitation of waterways and their passive recreation opportunities. This stimulated a number of key events and developments that seeded the USQM transition, including strategic responses from government policy makers and local scientists.
- **Phase 2: 1990-1995 'Building Knowledge & Relationships'** – In response to the high level socio-political shift experienced in Phase 1, a new institutional working space between key stakeholders developed which allowed the USQM niche area of practice to emerge. This was principally due to a bridging organisation that fostered improved relationships across the sector and helped to build a base of trusted and reliable science. The innovation of new activities and technologies (such as gross pollutant traps and stormwater treatment wetlands) began to evolve.
- **Phase 3: 1996-1999 'Niche Formation'** – This period witnessed the formation of the USQM niche, with a strong and active connection between key stakeholders and technological research and development activities. There were expanded and new relationships and coordination for USQM across the urban water sector. The formation of the USQM niche was collectively galvanised in Melbourne through the establishment of a nitrogen reduction target and the subsequent creation of an inter-agency committee for stormwater; the production of best practice guidelines that were incorporated into policy; rapidly emerging science and its practical demonstration; and additional strategic funding opportunities.
- **Phase 4: 2000-2006 'Niche Stabilisation'** – Here, the niche becomes stable and starts to attract important mainstream institutional legitimacy. In this phase, USQM is recognised but still not fully integrated into the mainstream priorities of all dominant stakeholders, such as all local government authorities across Melbourne. The stabilisation of the USQM niche was supported through a range of initiatives such as: a strategic state-wide funding source; a 'deemed-to-comply' assessment tool for designers, planners and regulators; the launch of the first national WSUD conference series; the production of local, state and national guidelines; an innovative market-based offset scheme; and dedicated industry training. A critical initiative was the recent imposition of new regulatory requirements in late 2006, directing both state and local government agencies to ensure that residential subdivisions meet stormwater quality targets and that any subdivision provisions include WSUD criteria. This provided the final reinforcement for stabilising the USQM niche.

While the USQM transition is yet to be completed, this case analysis provides an example of an ongoing and effective reform agenda that is 'currently in practice'. Progress so far includes the institutionalisation of a new value set for the environmental protection of waterways, and acceptance of a new urban development philosophy by a traditionally conservative industry that is accustomed to privileging conventional flood protection, economic efficiency and maintaining the status quo. Overall, from an institutional perspective, the progress of this transition has, to date, occurred over a relatively short period given what is already understood about transitioning periods.

KEY RESEARCH FINDINGS: CHAMPIONS & CONTEXT VARIABLES

This Melbourne case study has demonstrated the value of using transition theory to provide insights into this complex change process. Such an analytical approach can be used to help guide future strategic initiatives focussed on enabling change with some confidence. This is through guiding technology diffusion and stimulating the emergence of niche development in socio-technical environments that are in the early transitional phases. In addition, the application of transition theory provides a basis for envisaging future transition scenarios and pathways in order for policy and decision-makers to modulate and shape the direction of existing transition processes.

While the historical case study research revealed a range of interconnected activities and initiatives that on the surface seem to represent an organic development pathway, there has been a critical, and in many ways opportunistic, *interplay* between industry champions and important context variables that has provided the structure and catalyst for the transition so far. This has been instrumental to the development and stabilisation of a USQM niche that enabled the social embedding of new thinking, governance and technical practice. The case study showed how the interplay between the 'champions' and the 'enabling context' was critical to providing the ongoing catalyst and a level of niche resilience to conventional practice. Through the institutional learning fostered through the niche development processes, many of the potential threats and impediments to change were minimised.

The results of the Melbourne case study provide a useful set of transition indicators for stimulating and stabilising a niche, as shown in Table (i). These indicators can be used as a guiding template by urban water strategists to identify current transitioning deficits to improve the design, investment and outcomes of current policies and programs.

An important driver of Melbourne's transition was the legacy of a committed and innovative group of associated champions working across multiple sectors to advance change. The case study revealed the significant potential for a small network of champions across sectors to create positive change. Sharing common qualities, the characteristics of these champions included strong environmental values, a public good philosophy, active promotion of best practice ideology, having a 'learning by doing' approach to their work, as well as being opportunistic, innovative and adaptive. The presence of an organisational champion, Melbourne Water, was also instrumental to the transition. The agency was acknowledged for its dedicated leadership, resource allocation and proactive interpretation of its formal accountabilities in relation to urban stormwater management and waterway health.

While these champions were responsible for many of the on-ground successes in this transition to date, it has been the 'enabling context' that has shaped, constrained and provided the opportunities for these champions' transitioning aspirations. This research proposes that this *interplay* between the champions and the context has been the vehicle for addressing, and at times significantly minimising, many of the anticipated and experienced impediments to change. The research reveals that this *interplay*, including fostering the development of social capital for waterway protection, and creating and supporting bridging organisations that provide a coordination point for local champions across the science, policy and private domains, has been essential for enabling the 'niche' transition processes. The are variables in addition to the role of champions for enabling the transition. There are important enabling context variables that allow champions to emerge and/or be sustained over time. Urban water strategists and policy-makers can potentially expedite transitioning processes through identifying where the 'enabling context' deficits are and targeting their strategic work to shape a more enabling context.

KEY TRANSITION FACTORS **Champions** ⟵ *INTERPLAY* ⟶	**The Enabling Context**
1. Vision for waterway health A 'common vision' for protecting waterway health through pursuing a largely cooperative, rather than directive, approach for enabling change.	**1. Socio-political Capital** Aligned community, media and political concern for improved waterway health, amenity and recreation.
2. Multi-sectoral network A network of champions interacting across government, academia and the market.	**2. Bridging Organisations** Dedicated organising entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry.
3. Environmental Values Strong environmental protection values with a 'genuine' agenda for improving Melbourne's waterways	**3. Trusted & Reliable Science** Accessible scientific expertise, innovating reliable and effective solutions to local problems.
4. Public Good Disposition An orientation to advocating and protecting 'public good'	**4. Binding Targets** A measurable and effective target that binds the change activity of scientists, policy makers and developers.
5. Best Practice ideology Being more pragmatic and finding ways to help industry implement best practice thinking	**5. Accountability** A formal organisational responsibility for the improvement of waterway health, and a cultural commitment to proactively influence practices that lead to such an outcome.
6. Learning by doing Wanting to foster and trial new ideas, and valuing the rapid adoption of ongoing scientific insights	**6. Strategic Funding Points** Additional resources, including external funding injection points, directed to the change effort.
7. Opportunistic Continually thinking ahead and creating opportunities through strategic advocacy and practice	**7. Demonstration Projects & Training** Accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives.
8. Innovative & Adaptive Prepared to challenge the status quo, and concentrating efforts using an adaptive management philosophy	**8. Market Receptivity** A well articulated business case for the change activity.

Table (i): Key Transition Factors in the Melbourne Case Study

COMPLETING THE TRANSITION FOR MELBOURNE

Melbourne now needs to focus on niche diffusion which should be underpinned by a program of industry capacity building.

This approach is to ensure that there is dedicated attention to enabling the necessary knowledge, skills and organisational systems, particularly for local government and those involved in constructing and maintaining new technical systems. There needs to be effort spent on articulating common objectives of the niche with other fields that are also undergoing phases of transition leading towards WSUD.

The most immediate areas that present some common objectives and current reform activity that are recommended for expanding the current USQM niche in the direction of the broader WSUD approach are: 1) creating urban environments that are resilient to climate change, and 2) the use of alternative water sources. Expansion and integration with these areas will need to recognise and continue to reinforce the USQM transition value of improved stormwater quality and waterway health.

The insights from the Melbourne case study provide an important basis for other cities, and other sectors of activity, to learn from. While the institutional dynamics of the WSUD approach may be more complex than those for the USQM approach, the Melbourne case study provides a solid platform of evidence for how institutional change can successfully occur and identifies key factors that underpin such change. It is hoped these findings will also contribute important insights for urban water managers and policy makers that attempting to mainstream the WSUD approach.

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List of Acronyms

ARI	Average Recurrence Interval
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CRCCH	Cooperative Research Centre for Catchment Hydrology
CRCFE	Cooperative Research Centre for Freshwater Ecology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DVA	Dandenong Valley Authority
DWR	Department of Water Resources
EPA	Environmental Protection Authority
MAV	Municipal Association of Victoria
MLP	Multi-Level Perspective
MMBW	Melbourne and Metropolitan Board of Works
MPW	Melbourne Parks and Waterways
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NHT	Natural Heritage Trust
NSW	New South Wales
SEPP	State Environment Protection Policy
SI	Stormwater Initiative
SIA	Stormwater Industry Association
SIAV	Stormwater Industry Association of Victoria
UDIA	Urban Development Industry Association
URLC	Urban and Regional Land Corporation
USQM	Urban Stormwater Quality Management
VSAP	Victorian Stormwater Action Program
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

This report presents the findings of a social research project focussed on identifying the key institutional change ingredients that will lead to the mainstreaming of the water sensitive urban design (WSUD) approach across modern cities. The WSUD approach is yet to be mainstreamed anywhere, therefore this research draws from a retrospective analysis of the key factors that have led to the successful institutionalisation of 'urban stormwater quality management' (USQM), as an essential component of WSUD[1], across metropolitan Melbourne so far. Presented in this report is an analysis of the key factors over the last 40 years that have enabled this transition to date. The report adapts these insights to develop recommendations for how urban water strategists could more efficiently pursue the mainstreaming of the broader WSUD agenda across modern cities.

WSUD reflects a new paradigm in the planning and design of urban environments that is 'sensitive' to the issues of water sustainability and environmental protection. As defined by Wong (2006a), WSUD is focussed on the synergies within and between the urban built form and landscape, and the urban water cycle, recognising that community values and aspirations play an important role in urban design decisions and water management practices. Therefore it challenges conventional urban water servicing by inter-linking the management of urban water streams (potable supply, wastewater and stormwater) with the goals of minimising and treating pollution discharges, reducing potable water use, and efficiently matching different water sources (such as recycled water and treated stormwater) to 'fit-for-purpose' uses. These aims are met through the urban design process (the planning and architectural design of urban environments) by: the provision of integrated urban water management infrastructure; reintroducing the aesthetic and intrinsic values of waterways back into the urban landscape; and promoting new forms of urban design and architecture within the built environment (Wong, 2006b).

While WSUD requires greater levels of change to the urban form and the community's relationship with their physical environment than the USQM approach, it is the proposition of this research that there are likely to be substantial and beneficial insights and lessons for advancing WSUD through investigating the relative success of the USQM approach. This is because the mainstreaming of USQM poses a significant challenge to the status quo as it demands the robust institutionalisation of 'aquatic environmental protection' and 'waterway amenity' values into current governance structures, and the already well-entrenched values of flood protection, public health and economic efficiency. It also demands a significant change in current management and operational responses from a narrow technical approach dedicated to the efficient hydraulic conveyance of stormwater away from urban areas towards an approach that embraces the broader sustainability qualities of water management and urban design (Brown, 2005).

Currently, the mainstreaming of WSUD will require a more complex multi-sectoral governance approach that is dedicated, proactive and strategic in its pursuit of WSUD. This is because there is currently an absence of an overriding and galvanising socio-political driver or 'crisis' to lock in the necessary change. For example, the mainstream concern about the cholera and typhoid epidemics in the early 1800s was the key public health driver for the substantial investment in constructing sewage reticulation, treatment and disposal systems over the last two centuries. The more recent extended drought conditions across Australia is a significant water supply security driver resulting in significant investment in developing new and alternative water sources from technologies such as desalination and sewage recycling.

It is well accepted that transforming dominant management cultures is particularly challenging when the change required is highly dependent on successfully establishing a new vision and value set across multiple organisations, professions and tiers of government. This is further compounded by the lack of practical city-wide case studies that can demonstrate an effective governance regime for managing diffuse issues such as urban

1. See Wong (2006a) *'Water Sensitive Urban Design – the journey thus far'* for on overview of the historical development of the WSUD concept and its approach. Wong's review reveals how the WSUD approach in its initial conception was focussed on integrating across the urban water cycle and urban design. However, the first 10 years of its application was largely advanced by the urban stormwater professional community, and therefore WSUD was sometimes considered synonymous with the more narrow practice of urban stormwater management. More recently the original understanding of WSUD is being pursued, and applied to the urban water cycle and landscape.

stormwater runoff. It is also well acknowledged that the complex, multi-sectoral governance approach presents numerous technical, regulatory, policy and administrative challenges to current governments (Saleth and Dinar, 2005). This research aims to contribute to the shortage of reliable knowledge and guidance for urban water strategists (Brown *et al.*, 2006a) on how to effectively institutionalise change through an in-depth examination of the metropolitan Melbourne case study.

Metropolitan Melbourne is identified as an important region for analysis as it is often informally acknowledged as one of the leading international cities in the area of USQM for aquatic ecosystem protection. Through various forums, Melbourne is recognised for the innovation of technical solutions[2], progressive stormwater management performance targets and industry focussed capacity building initiatives. Indeed Melbourne was the founding city of the International WSUD Conference Series in 2000, hosting the 2000 and 2006 conference events.

While the on-ground implementation of USQM technologies is yet to be fully mainstreamed across all stakeholder groups, the city is on an important change trajectory towards institutionalising USQM. Melbourne's progress is sufficiently developed to allow for a critical examination of the important ingredients of the transition to date, which could potentially assist other cities with expediting USQM and the broader WSUD agenda. The relative maturity of this change trajectory is more recently demonstrated through the formalisation of two consecutive initiatives designed to institutionalise stormwater quality treatment practices across Melbourne.

The first of these is the introduction of a market-based *'Stormwater Quality Offset Strategy'* by Melbourne Water in July 2005. This Strategy provides a mechanism for Melbourne Water to require developers to meet best practice stormwater quality treatment objectives[3] by either implementing best practice treatment measures onsite or by contributing an offset payment for works undertaken elsewhere in the catchment. The contribution funds a rolling annual program of regional water quality works. By meeting all or part of the onsite performance objectives, a developer's water quality offset can be reduced.

The second is the Victorian State Government's amendment to Clause 56 of the Victorian Planning Provisions. As set out in the government's Department of Sustainability and Environment's *Victorian Provisions Practice Note* (DSE 2006a, p1), the initiative 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, and
- use best practice water sensitive design techniques to conserve, reuse and recycle water and manage the quality of stormwater run-off[4].

It is important to note that the metropolitan Melbourne region confronts many of the pressures typically faced by modern cities today, such as: rapid population growth, decreasing household occupancy ratios, ageing infrastructure, water supply stress, degraded waterway health, complex and sometimes unclear administrative configurations, and variable levels of commitment to environmental management across key stakeholder organisations. This challenging regional context shared by numerous cities worldwide also indicates the value of Melbourne as a case study.

In summary, while the institutional dynamics of the WSUD approach may be more complex than those for the USQM approach, this case study intends to provide a solid platform of reliable evidence for how institutional change can successfully occur for USQM. Therefore it is hoped that this research will contribute useful insights for urban water strategists in facilitating the successful mainstreaming of the broader WSUD agenda.

2. For example, the leadership of the highly regarded work of the (former) CRC for Catchment Hydrology's 'Urban Hydrology' and 'Urban Stormwater Quality' Programs was based in Melbourne between 1991 and 2005. Additionally, in 2005, the United Kingdom's 'House of Lords' Science and Technology Committee identified Melbourne and Sydney as their preferred cities to visit to improve their understanding of techniques and processes associated with advancing more sustainable urban water management.

3. The objectives are to retain 80% of the suspended solids annual load, 45% of total phosphorus and 45% of total nitrogen annual loads associated with urban stormwater runoff. More information on Melbourne Water's strategy is available at: http://ouryarra.melbournewater.com.au/content/melbourne_waters_vision/improving_our_rivers_and_creeks/stormwater_quality_offsets.asp

4. All new residential sub-divisions must achieve the best practice stormwater performance objectives, in addition to a 70% reduction of the typical urban annual litter load. More information is available at: http://www.dse.vic.gov.au/CA256F310024B628/0/B94519854FA94273CA257213000126AD/$File/VPP_Clause_56_4-Intwaterman.pdf

2. THE WSUD TRANSITION CHALLENGE

The practice of WSUD is still largely in its infancy, and many governments, organisations and communities are still operating within the traditional urban water management approach. The traditional approach typically includes a linear system of collecting, storing, treating and then discharging water, within a framework of expansion and efficiency (Newman, 2001). Following a review of 'integrated urban water management' (IUWM) practices[5] across Australia, on behalf of the CSIRO and the Australian Water Association, Mitchell (2004, p13) concluded that "there is a long way to go before IUWM could be considered a mainstream practice within the water and development industries". This is despite the widespread recognition that urban water managers around the world face enormous challenges with addressing waterway health vulnerabilities, water supply limitations and providing flood protection (Butler and Maksimovic, 1999). It is now well accepted that these issues cannot be adequately addressed by the traditional urban water management approach. However, many cities are faced with ongoing investment in the traditional approaches which will perpetuate a significant delay in the widespread diffusion of WSUD and the propagation of the existing institutional processes.

The urban water issues experienced in Australian cities are relatively representative of urban water issues faced by other developed countries. For example, Australian cities face increasing populations and higher proportions of single occupancy households (Birrell *et al*., 2005), ageing and degraded water infrastructure (Engineers Australia, 2005), climate change impacts (Howe *et al.*, 2005) and ongoing waterway degradation. These issues are in addition to the vulnerabilities of cities with providing a reliable water supply source given the ongoing drought conditions across Australia. Currently in progress at the national level is a review of the administrative arrangements and assessment of industry capacity development and training needs for advancing WSUD across Australian cities. This is in response to Clause 92 of Australia's 'National Water Initiative' which outlines action directed at 'Innovation and Capacity Building to Create Water Sensitive Australian Cities'[6].

2.1. Institutional Impediments to WSUD

Several commentators have attempted to explain the impediments to change towards WSUD within an Australian context. For example, Hatton MacDonald and Dyack's (2004) review of 'institutional impediments' to water conservation and reuse found that the 'overarching' issue is a lack of coordination of the policies and regulations that govern water conservation and reuse. Brown (2005) highlights the fragmented administrative framework in which urban water management is implemented, suggesting that this can perpetuate a lack of attention to institutional learning within the urban water sector. Wong (2006b; p1), suggests that "institutional impediments are not well addressed, and are often beyond current concerns of many sectors of the urban water industry, which are more concerned with strengthening technological and planning process expertise." This is a concern given that Mitchell (2004; p16) has observed that current institutional structures are "known to constrain integration and innovation". The national environmental industry lobby group has also identified a 'lack of trust' and 'inappropriate risk transfers' between stakeholder organisations, as key factors retarding the implementation of WSUD across Australia (The Barton Group, 2005). These institutional impediments observed in Australia are not uncommon to what has been observed elsewhere.

Overall, the review of the reported impediments to change highlights that insufficient skills and knowledge, organisational resistance, lack of political will, limited regulatory incentives, and unsuitable institutional capacity and arrangements, are significant

5. When combined with the field of urban design, 'integrated urban water management' (IUWM) is central to the WSUD approach. As defined by Cowie and Borret (2005), IUWM is 'a framework to understand, control, and optimise elements of the urban water infrastructure as an integrated system'.

6. The National Water Initiative is an intergovernmental agreement formalised on the 25th June 2004 between the Commonwealth Government and State Governments, available at: http://www.coag.gov.au/meetings/250604/iga_national_water_initiative.pdf. (Clause 92 is located on page 20)

impediments to institutionalising WSUD (see for example, Mouritz, 1997; Mitchell, 2004; Brown, 2005; Saleth and Dinar, 2005; Wong, 2006b). In addition, there is an increasing and diverse group of international commentators identifying the problem of institutional inertia and its significant impact on the transition towards WSUD (see for example, Mouritz, 2000; Lundqvist *et al.*, 2001; Vlachos and Braga, 2001; Hatton MacDonald and Dyack., 2004; Saleth and Dinar, 2005; Brown *et al.*, 2006b).

A number of these issues are encapsulated by Serageldin's (1995) identification of the 'silo effect', which describes the separation of responsibilities among organisations, and their inability or unwillingness to consider their mandate relative to those of other organisations. This is often expressed as 'vertical fragmentation' between levels of government and 'horizontal fragmentation' across levels of government. In Bruce Mitchell's (2005) review of the results of integrated water resource management efforts over the last 30 years, he suggests that aspiring to remove these silo-based boundary effects through structural reorganisation often proves 'futile' and that more productive outcomes will result from efforts that are focussed on enabling institutional learning and improving coordination between stakeholders.

Researchers who specialise in observing the social dimension of large technical systems consider that impediments such as these should be expected when attempting to advance significant programs of change, such as WSUD (Walker, 2000). This is due to what some social researchers call the 'entrapment' effect which describes how technical infrastructure (for example, a drain and the associated maintenance) is a physical representation of historical and deeply embedded administrative, political and economic investments. These investments collectively present a significant force in supporting the status quo (Moss, 2000; Walker, 2000). Within the urban stormwater context, this is often most evident when new ideas (e.g. the implementation of stormwater biofilters) cross jurisdictions (e.g. between road design and drainage standards), producing numerous conflicts between design and authorisation processes (i.e. those between planning and building approvals). Therefore the 'entrapment' effect often retards innovation and change, through reinforcing the historical and deeply embedded administrative, political and economic values.

The field of innovation studies also offers useful insights to the series of impediments that have been reported in the literature so far. The technology diffusion concept provides a conceptual basis for understanding how new and alternative technologies break through into the mainstream market. As discussed in Baptista's (1999) review of different diffusion processes and concepts, this area of scholarship has a long history and spans numerous disciplinary perspectives from sociology, geography, through to marketing and consumer behaviour. However, as shown in Figure 1, the technology diffusion S-Curve (see Mansfield, 1968) forms a central feature of this concept, characterising the shape and pattern of technology diffusion. As highlighted by Rip and Kemp (1998), van der Brugge *et al.* (2005) and others, there are a number of phases that a technology or product experiences during the development and diffusion processes.

As shown in Figure 1, the 'pre-development' phase involves the early design and associated entrepreneurial activity with the technology and therefore the broader institutional system does not visibly change. In the 'take-off' phase the system is starting to shift and the technology is supported through system activities such as development investment and other resources. If the take-off phase is successful, there are structural changes taking place within the institutional system and the diffusion of the technology moves through a relatively faster phase of 'acceleration' with many new players involved in the uptake and application of the new technology. This momentum is maintained if the technology faces little resistance to its adoption and/or this is minimised through dedicated strategic management programs. The technology is widely accepted as 'mainstream' practice when the pace of institutional change starts to slow down and a new equilibrium is reached. These phases reflect a process which is often called the 'diffusion pathway'.

However, research from sustainability studies reveals that many emergent sustainability technologies face significant resistance to change, and while some technologies progress through the *take-off* phase and may experience some *acceleration*, they often hit a critical point where they lose momentum and therefore struggle with being mainstreamed (see Berkhout *et al.*, 2004; Smith *et al.*, 2005; Smith, 2006). As also shown in Figure 1, this point is where sustainability technologies can follow the diffusion pathway and then reach a point of deviation from the pathway process resulting in a range of possible outcomes from never becoming mainstreamed through to being on 'hold' for a later time as part of an alternative diffusion process. An example of such a deviation is when a promising sustainability technology is integrated into a set of iconic government sponsored industry demonstration projects, but is then not replicated by industry in other similar projects in the future.

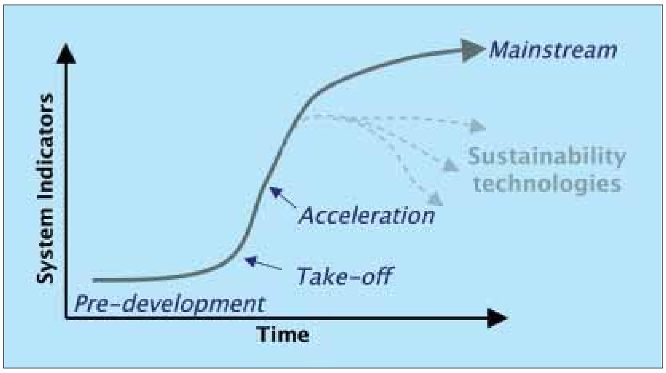


Figure 1. The Technology Diffusion S-Curve (adapted from Rip and Kemp, 1998)

Berkhout *et al.* (2004) and others argue that the key attribute preventing the mainstream adoption of sustainability technologies is the lack of acceptance across the broader range of stakeholders and institutions. Full diffusion is also further constrained for sustainability alternatives because they necessarily straddle multiple sectoral areas (such as transport, environment, land-use planning, building, water services, community health) and typically have implications for broader operational areas of government and industry. Berkhout (2002) argues that this broader stakeholder and institutional environment needs to view the proposed change as "necessary, feasible, and advantageous" in order for the technology to reach full diffusion.

Given that many of the major technological changes in the urban water area have been driven by a reaction to a 'crisis' event, it is the proposition of this research that with the current absence of such a powerful and galvanising driver for WSUD, there is a strong need to invest in strategic policy and program interventions. These need to focus on proactively influencing the underpinning institutional cultures and knowledge of stakeholders that support the day-to-day practice of urban water management if WSUD is to be effectively mainstreamed. Perhaps at the heart of the issue is the need to substantially improve the power of the institutional value of 'environmental protection' of waterways, so it is considered with equal prominence to the much-longer established institutional values of flood protection, public health protection, water supply security and economic efficiency within current decision and policy-making processes.

2.2. Socio-Technical Systems and Transitions

An important point highlighted in sustainability studies relates to the need for new sustainability technologies and initiatives to be supported by strategic programs that focus on embedding them within the social and institutional context to improve their chances of becoming mainstream practice (Elzen and Wieczorek, 2005). Contemporary research focussing on how to enable the transition of large technical systems such as water, transport and energy systems to more sustainable systems argues that these change strategies are essential because the social and technical infrastructures surrounding sustainability technologies are co-dependent and require an interdisciplinary and integrated perspective (Berkhout *et al.*, 2004).

Socio-technical systems[7], such as urban water or transport systems comprise a host of interconnected components such as technology, science, regulation and policy, user practices and markets, cultural memory, infrastructure, construction and maintenance networks, manufacturing and supply networks and industry associations. Collectively, these component systems typically support a largely stable area of practice that is subject to incremental adaptation and change over time, with the occasional major system-wide change often called a system-wide 'transition'. Such a complete transition involves replacing the old socio-technical system with a new system state that embodies significant change within each of the socio-technical system components.

Examples of studies involving historical system-wide transitions include changes in: urban transportation from the 'horse and carriage' to the automobile (Geels, 2005a); and in shipping practice from sailing-ships to steamships (Geels, 2002). The introduction of modern sewage systems as part of the 'sanitary engineering' response some 150 years ago would constitute a transition that was driven by a critical public health situation and the social cleanliness movement (see Melosi, 2000; Geels, 2006). Studies such as these reveal important insights into the transition process through identifying and mapping the outcome of deliberate interventions and fruitful accidents that together enabled the complete socio-technical transition.

Recent socio-technical models demonstrating the co-relationship between the technical and social systems, and how they change over time, have emerged to assist with analysing socio-technical systems. These are now being used to assist with addressing many of the observed impediments to mainstreaming alternative sustainability technologies as highlighted in the previous Section. The Multi-Level Perspective (MLP) framework is one such model which attempts to simply characterise the overall architecture of socio-technical systems and system-wide changes, recognising that there are significant complexities, cross-linkages and inter-dependencies within the overall change processes (Rip and Kemp, 1998; Geels, 2005b).

As shown in Figure 2, the MLP describes the interrelationships between three different levels of social structure (the macro, meso and micro) which can stimulate, adapt to and/or retard socio-technical change. These levels of social structure can be considered as a nested hierarchy so that changes within one or more levels have the potential of stimulating change at the other levels. The levels of social structure include the:

- **Macro-level:** represents the broad socio-political and bio-physical systems in which significant changes can occur. This includes changes that impact on dominant cultures and ideologies such as globalisation and environmentalism, as well as changes in the large physical systems that support society such as the infrastructural and spatial arrangement of cities (e.g. highways and water systems).
- **Meso-level:** represents changes within the institutional regime which includes the stakeholder organisations, and the formal and informal 'rules', across civil society, government and market sectors that have a role in shaping the management of the urban water environment or other institutional areas of practice. Organisations that collectively form the meso-level typically include: water authorities, regulators, state policy makers, local government agencies, land developers, consulting organisations, academic institutions, community groups and professional bodies.
- **Micro-level:** represents changes occurring at the technical or product development level where innovations that can be substantially different from the status quo are developed. Examples of these include the recent innovation of sewer mining technologies, and the innovation of stormwater gross pollutant traps in the early 1990s.

7. See Geels 2004, for an in-depth explanation on 'socio-technical systems'.

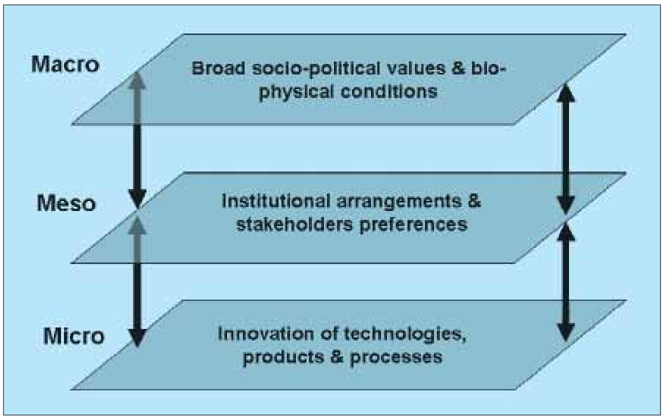


Figure 2: The Multi-Level Perspective (adapted from Rip and Kemp, 1998)

Over the last five years, sustainability researchers have increasingly utilised the MLP framework as a starting point for common analysis and communication of studies of transition processes across different areas and sectors around the world (see Elzen *et al*., 2004; Geels and Schot, 2007). In the past, researchers and practitioners have focussed their attention at different levels of the change process and often have not commented on the other levels of social structure and how they stimulated and/or constrained the change process. The value of using the MLP framework for analysis is in the integration of the various change processes to assist with developing an improved insight into transition processes and how they may be influenced in the future for enabling more sustainable futures.

2.3. The Transitioning Process

Transitioning to a new socio-technical state involves a process of substantial and mutually reinforcing change across the macro, meso and micro levels. Current research reveals that there are likely to be multiple change scenarios and change occurring at different points across these levels of social structure. While the mapping of overarching transitioning pathways is the subject of current research[8], it is broadly agreed that change at the macro-level is beyond the direct influence of individuals and organisations and thought to evolve over decades and generations. Changes at the meso-level are thought to move in decades, and changes at the micro-level can move in months and years. It is acknowledged that timeframes for transitioning from one socio-technical state to another can vary considerably and are considered to occur over long timeframes. Studies suggest transitions can take anywhere up to 100 years or so.

There have been a number of significant transitions that have been enabled in the past through a crisis-based driver at the macro-level. For example:

- the deaths of urban populations in London in the early 1800s due to water-borne diseases such as cholera and typhoid led to the then London Commissioners (at the meso-level) calling for proposals for a sewage system design at the micro-level. This led to the reorganisation at the meso-level to incorporate sanitary engineering thinking and practice and a new regulatory and policy arena for urban water management. It also stimulated entrepreneurial activity at the micro-level with a range of different options from sewage recycling systems through to sewage disposal systems being proposed. The Commissioners chose to support the sewage disposal system.[9]
- the London industrial air pollution disaster of 1952 known as the 'Great Smog of 1952' resulting in over 4000 deaths was the macro-level driver for the formation of new legislation (meso-level) banning emissions of black smoke and decreed that residents of urban areas and operators of factories must convert to smokeless fuels – prompting a range of micro-level innovations.

Research on the architecture of change across the three levels within the MLP reveals the significance of the formation of a niche area for clinching and enabling a system-wide transition, as shown in Figure 3. A niche forms when there has been mutually reinforcing change at the meso and micro-levels[10] which is often stimulated by a macro-level driver. The

8. See Geels and Schot (2007) for an overview of possible overarching transition pathways that draw on a number of historical transition case studies.

9. For a very brief history see Girardet (2003, p 18) Creating Sustainable Cities, *Briefing No. 2 for The Schumacher Society,* Green Books, UK.

change at the meso level would typically involve the development of the new alternative sub-regime of representatives across stakeholder organisations that are interested in the innovation, but this interest does not necessarily reflect their organisation's priorities at the time. The changes at the micro-level could include entrepreneurial activity with developing new products and processes for the market and new technologies being developed by scientists through research institutions. It is when these change processes start interacting and becoming mutually reinforcing that a niche area forms and gains more influence across the MLP.

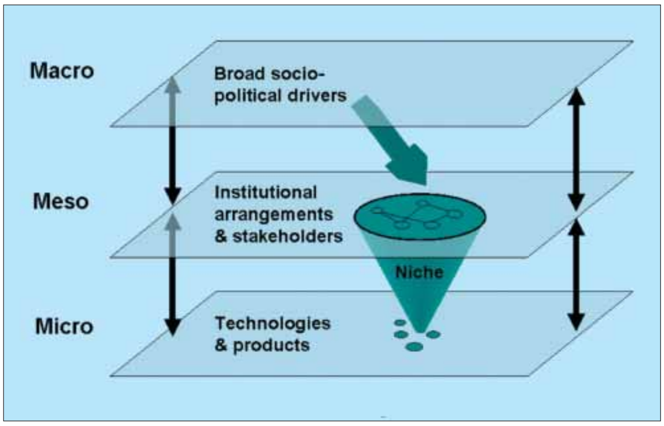


Figure 3: The Transitioning Process (adapted from Geels, 2002).

An example of a niche area forming is the response to the recent extended drought conditions in Australia (a bio-physical macro-level driver) where there have been technology and product-based developments at the micro-level (e.g. sewer mining) and new policy directions and organisational interests at the meso-level (i.e. new regulations, water recycling targets and new professional groupings for alternative water sources). Collectively, these complementary micro and meso-level changes have led to the formation of a niche area that is fostering the growth of alternative water sources across Australia.

The niche shields new practices and thinking that is alternative to the mainstream market forces by providing a 'protective space' in which dedicated experimentation and demonstration can occur through means such as research investment, regulatory incentives and proactive corporate activity. Therefore the niche acts as an incubator for institutional learning by coordinating and strengthening new social networks at the meso-level, and by supporting technological development and refinement at the micro-level (Figure 3). The next critical stage in the transition process is the diffusion of the ideological constructs and the technical knowledge embodied within the niche across the meso level (Geels, 2004). It is thought that a system-wide transition occurs once the three levels of social structure across the MLP all mutually support the workings of the niche.

Some of the sustainability research is focussed on determining the necessary conditions that can form and stabilise a niche as part of the proactive and strategic sustainability transitioning agenda. While there are no definitive answers at this point, it is hoped that this case study provides a valuable contribution to this effort. From an evaluation perspective it would seem most likely that a niche could be considered formed and stable when it is resistant to 'threats', such as changes to influencing sectoral policies, redirections in governmental interests, and evolving professional capacities that do not support the activities of the niche.

While the growing alternative water sources niche is offered as a recent example in Australia, it must be emphasised that these developments at the micro-level have been incrementally evolving for some time. They have been largely pursued from an environment protection and water conservation perspective, but have not found the necessary momentum (or macro-level driver) to be part of a niche. This new niche has been stimulated by the existing macro-level driver of maintaining water supply security combined with the new 'limits to growth' (i.e vulnerable potable water supply availability) macro-level driver. However, it is

10 Some transitions scholarship refers to the technologies or products developed at the micro-level as 'niches' or 'niche technologies'. Here the term niche is used specifically to describe an innovation arena that has evolved between mutually reinforcing changes within the micro and meso levels.

anticipated that this niche will face potentially less market resistance (acknowledging that the macro-level driver of public health protection may present some resistance) in comparison to attempting to institutionalise the practice of USQM and WSUD. This is because these areas depend on the wide-spread institutionalisation of the value of environmental protection associated with waterway health, whereas the value of water supply security is well established. It is also interesting to note that the legacy of past decisions responsible for centralised infrastructure for water supply and sewage systems in Australia has contributed to strong advocates today campaigning for a similarly centralised approach to (for example, seawater desalination and indirect potable reuse schemes).

It is a proposition of this research that the field of USQM, with some exceptions, generally lacks a galvanising macro-level crisis-driver for stimulating sufficient proactive change at both the meso and micro levels across modern cities. It is proposed that this study of the institutionalisation of USQM across Melbourne so far is likely to provide a fertile opportunity for understanding some of the ingredients for proactive transitioning.

2.4. Making the WSUD Transition

Overall, it is clear that pursuing WSUD in the hope of enabling a socio-technical transition is a far more difficult prospect than would normally be the case for successive and adaptive technological developments, as the former requires significant cultural change and alteration of the social embedding of technologies (Elzen and Wieczorek, 2005). Furthermore, socio-technical transitions are highly dependent on the broad range of stakeholders within the meso-level recognising that the proposed change is necessary, feasible, and advantageous (Berkhout, 2002).

Therefore, making the transition to the mainstream practice of WSUD across cities is likely to require a sophisticated program for strategic change that, as a first priority, focusses on the development and stabilisation of a WSUD niche. The diffusion of the WSUD niche is likely to require the well-planned facilitation of widespread reform across the meso-level that will enable the social embedding of new thinking, governance and technical practice. As set out by Brown *et al.* (2006a), institutionalising the practice of WSUD will require changes to institutional capacity at various levels, such as enabling new knowledge and skills, organisational systems and relationships, policy frameworks, and regulatory rewards and penalties.

3. SOCIAL RESEARCH: DESIGN AND METHODOLOGY

This social research project is based on the qualitative case study method (Yin, 1994; Stakes, 1995) and used the Multi-Level Perspective (MLP) as an analytical framework. The research was focussed on retrospectively producing a reliable historical account and analysis of the development and institutionalisation, so far, of USQM – a fundamental part of pursuing WSUD – across metropolitan Melbourne. Originally, it was an expectation of the researchers that the last two decades would sufficiently provide the temporal scope for the project, given that the majority of stormwater treatment technologies and policy developments were conceptualised during this period. However, it was soon realised that the USQM transition has been underpinned by a number of drivers and events over the last four decades. Therefore, the period of analysis spans from the mid-1960s to 2006.

The research drew on the collection and synthesis of multiple sources of evidence including both primary and secondary data, as outlined in Brown (2007a). The primary data involved recording oral histories and conducting group interviews with individuals involved with urban stormwater management[11]. The secondary data involved a process of searching and reviewing historical documents including previous policy materials, media campaigns and reports, organisational literature from key stakeholders, peak industry and professional association literature and in addition to the available scientific literature.

Primary historical data was collected through recording oral histories from 28 interviewees that were identified as having first-hand involvement throughout major periods of the USQM transition period. These individuals were identified through a process of historical industry literature searching and a snow-balling process of peer recommendation. The interviewees represented multiple sectors (some were retirees), working across government, the market, academia and community. They predominately held (or formerly held) mid to high level hierarchical positions from the executive decision-maker through to the technological expert and stormwater project manager. The oral histories were recorded as free flowing narratives with the interviewee asked to give their personal account of the USQM transition, from when they were first involved in the urban stormwater area through to the present. This data was cross-referenced with data from other primary sources and with secondary sources including historical policy, media, organisational and other forms of industry literature, in addition to existing scientific literature in the field.

Primary data focussing just on contemporary USQM issues was also collected through six facilitated group interviews comprising four individuals per interview. Each group interview included mid to senior-level representatives working in the urban water area from different sectors including state government, local government, developers, consultants, academia, and the water industry. These group interviews involved asking a set of semi-structured questions designed to generate discussion on the current status of the USQM transition, perceptions of the current impediments and opportunities for mainstreaming USQM practices, and views on what interventions were needed to advance the broader practice of WSUD across Melbourne.

The analysis process began with the continuous thematic and theoretical assessment of data throughout the data collection process. This process involved the authors' developing multiple and ongoing accounts of the possible USQM transition process with the objective of actively seeking contradictory evidence and alternative meanings to emerging explanations and findings. Each of the oral histories, and then group interview results, were contrasted and compared in terms of key themes that arose, and on perceptions regarding the levels of influence attributed to key transition factors and events. This process allowed for disparities in the accounts to be further investigated and clarified.

11 None of the interviewees are identified in this report, respecting the research confidentiality agreement.

Recognising that the data generated from a retrospective case study will always be subject to a number of potentially significant limitations, a series of external verification processes were also employed during the research project. The validation processes included:

1. At the middle phase of the case analysis, 12 of the individuals who provided historical accounts conducted an individual review and critique of a written case report of the authors' tentative historical account of the USQM transition.
2. Towards the end of the data analysis, the authors' published a 'working document' which included the full historical account and analysis of the USQM transition. This was presented and discussed at an industry workshop which included over 40 participants representing all key sectors. The research was presented which then enabled group discussion and reflection, as well as further refinement of the analysis. The presentation was followed by facilitated small group validation sessions where participants were encouraged to critique and identify gaps in the historical account and/or analysis.
3. The final validation process involved synthesising the specific feedback on the 'working document'. Over 22 industry professionals submitted formal feedback on the historical account and presentation style of the 'working document'.

At the conclusion of the validation processes there was an overall high level of agreement on the historical account. However, the authors had to accept that it is nearly impossible to reach complete agreement among all participants on the historical account, particularly when historical records are sparser in some years. This meant that the authors had to rely on the individuals' memories alone in some cases. In particular there was some debate in relation to the strength of some key events and influencing factors occuring between 1989 and 1994, a frenzied period of institutional change in Melbourne. Some of this debate related to the relative significance of some champions and organisational departments identified with advancing the USQM agenda. This issue was addressed in multiple ways, including the re-interviewing of some individuals about this period and speaking with other professionals peripherally involved in USQM during this time.

The following historical representation reflects the application of the validation processes and social research principles.

4. TRANSITION PHASES: URBAN STORMWATER QUALITY MANAGEMENT

This part of the report presents the findings of the USQM transition to date across Melbourne. The results are presented in a chronological grouping of the activities, events and outcomes in four transition phases that have been identified between the mid 1960s and 2006 as shown in Table 1. The timeframes of each transition phase represent a broad marker between the differing transition processes.

It is acknowledged that there will be different views on the proposed dates for these transitioning phases, as experienced throughout the external research validation processes. These differences in views among the participants and observers of this transition largely related to suggested adjustments of up to one or two years either side of the periods that are adopted here. These differing perceptions are to be expected when the boundaries between these phases necessarily overlap and individuals are positioned at different stages in the transition.

Therefore, the phase periods have been matched as closely as possible to distinct features of socio-technical change in accordance with the MLP framework and transition theory. However, it is yet to be determined whether Phase 4 is close to completion; the available evidence suggests this is the case, but this cannot be confirmed at present. Therefore, the timeframe for Phase 4 may be longer than the 2000-2006 period.

Table 1. Melbourne's USQM Transition Phases

TRANSITION PHASE	DESCRIPTION
1 mid 1960s-1989 (Section 4.2)	**'Seeds for Change'** A macro-level socio-political shift and physical environmental response
2 1990-1995 (Section 4.3)	**'Building Knowledge & Relationships'** New meso-level protective space and micro-level novelty developments
3 1996-1999 (Section 4.4)	**'Niche Formation'** Critical linking of meso and micro-levels forming the USQM niche
4 2000-2006 (Section 4.5)	**'Niche Stabilisation'** New focus on niche knowledge-brokering and policy diffusion leading to niche stabilisation

4.1 Melbourne Case Context

Melbourne is the capital city of the State of Victoria and was subject to European settlement in the 1830s. It is the second largest city in Australia with a population of 3.6 million, which is expected to increase to 4.4 million by 2030. Located on the south eastern coastline of Australia, the city sprawls around Port Phillip Bay (Figure 4), with the Central Business District situated about 5 km inland from the Bay. Metropolitan Melbourne encompasses a developed urban area of approximately 1,500km^2. The major urban waterways are the Yarra and Maribyrnong Rivers.

Unlike many European systems, Melbourne's stormwater drainage system is separate from the sewage system and typically discharges stormwater runoff directly to the extensive network of local rivers and creeks and to the Bay. Melbourne's stormwater infrastructure is based on the minor/major approach (Pilgrim, 1987), where the formal drainage system is the minor system consisting mainly of pipes and drainage channels which convey frequent flood events. This is to eliminate nuisance flooding and the capacity of these systems is based on the economic risk assessment associated with flood events exceeding this capacity. The major systems are predominantly overland flow paths (roads, easements and designated floodways) that are designed to safely convey higher flows to receiving waterways. Whilst essentially separate, there are also pressure-relief cross connections between the sewage and stormwater systems which can result in local waterways receiving sewage overflows.

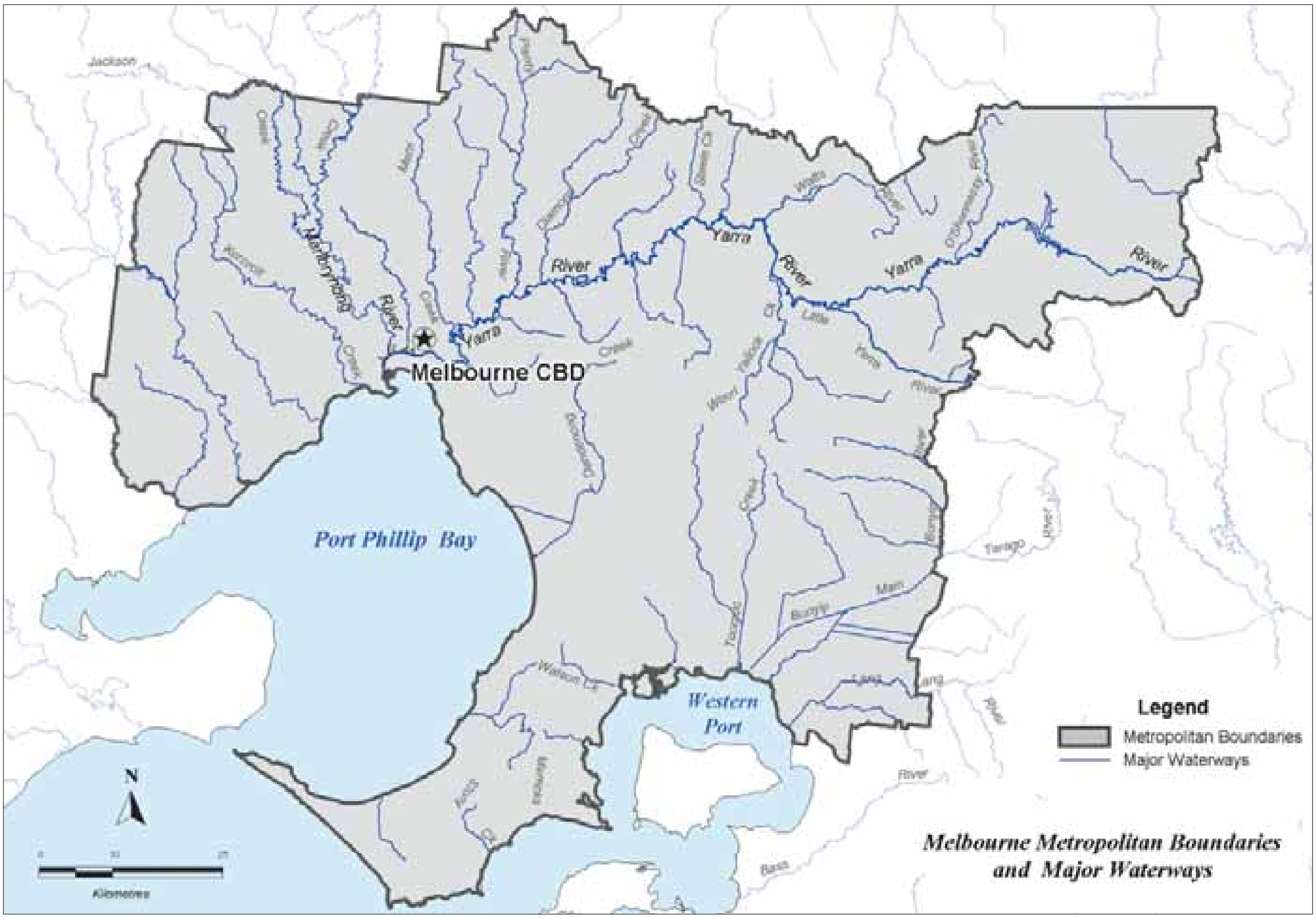


Figure 4. Metropolitan Melbourne and Major Waterways (courtesy Melbourne Water).

The incidences of sewer overflows to local waterways increases with ageing infrastructure, where cracks and open joints in the sewage infrastructure increase the volume of infiltration inflow into the sewer during high rainfall events and extended wet weather periods.

In the metropolitan Melbourne region, 45% of rivers and creeks are in poor or very poor water quality condition, while 30% are in moderate to very poor condition and 25% are in good or excellent condition (Melbourne Water, 2006a). The water quality in waterways located in Melbourne's water supply catchment areas and other forested areas is high, but generally deteriorates downstream towards the coastal, more heavily urbanised areas (Melbourne Water, 2006a). The city's main waterway, the Yarra River, experiences moderate to poor water quality in its lower section (Melbourne Water, 2006b).

Since the late 1980s to early 1990s, urban stormwater has been broadly recognised as a significant source of pollution to Melbourne's waterways, triggering a range of responses from community groups, the media and government to achieve improved quality and protection of these waterways. However, there has been a long history of waterway degradation and public concern over the health of Melbourne's waterways. While this issue dates back to the 1860s in the first 'boom development' period with industrial effluent being directed to Melbourne's waterways, it wasn't until the 1960s and 1970s that such pollution started being actively addressed. During the 1970s, the government encouraged all new properties to be sewered, and industrial effluent to be directed to the sewage system, resulting in significant improvement in the health of urban waterways. With a history of addressing these sources of pollution, the impact of urban stormwater runoff has progressively become more prominent.

Urban stormwater runoff, and in particular the associated nitrogen loads, have been identified as having significant impacts on the health of Port Phillip Bay (Harris *et al.*, 1996)[12]. With the sewering program removing sewage and industrial effluent from waterways, urban stormwater now ranks as one the greatest source of pollutants to the Bay, contributing approximately 75% of toxicants, 70% of nutrients, 50% of E. coli (a faecal bacteria indicator), and 70% of sediment inputs to the Bay (McAlister, 2006). It has been estimated that around 500GL of untreated urban stormwater runoff is generated from urban areas and discharged to the Bay each year (DSE, 2006b). This also equates to approximately half of the Port Phillip catchment's average annual rainfall and 10% more than the region's total potable water demand (Kay et al., 2004). It is anticipated that there will be increasing nitrogen loads entering the Bay with the expected population growth and projected level of dense in-fill developments.

While there are numerous organisations involved in USQM, those with the most significant operational responsibilities for addressing urban stormwater quality include Melbourne Water as the regional drainage authority, and the 31 local government authorities across Melbourne. In Melbourne, a simple delineation of drainage responsibility between local government and Melbourne Water has been set at a catchment area of 60 hectares, where local government authorities are responsible for catchments less than 60 hectares.

4.2 Mid 1960s-1989 Seeds for Change

This phase marks a macro-level shift in the MLP, related to growing environmental concerns that provided the necessary underpinning to the USQM transition, the early 'seeds for change'. In response to this concern there were a number of micro and meso-level developments that challenged the then well-entrenched agenda of traditional waterway management and rapid urban development, an agenda that did not set a priority to maintaining and protecting the environmental protection and social amenity values of waterways. Many commentators describe how the social changes, during this period, were common throughout much of the developed world as they were part of the world-wide awakening to environmentalism (Harding, 1998). As shown in

12. In addition, discharges from one of Melbourne's two major sewage treatment plants, the Western Treatment Plant, have been identified as a major source of nitrogen to Port Phillip Bay, resulting in a dedicated upgrading program for this plant.

Figure 5, this macro-level shift stimulated a range of key events and developments that contributed to seeding the USQM transition. This phase starts around the mid-1960s as it seems to be a time that reflects the coincidence of a number of social, managerial and scientific changes.

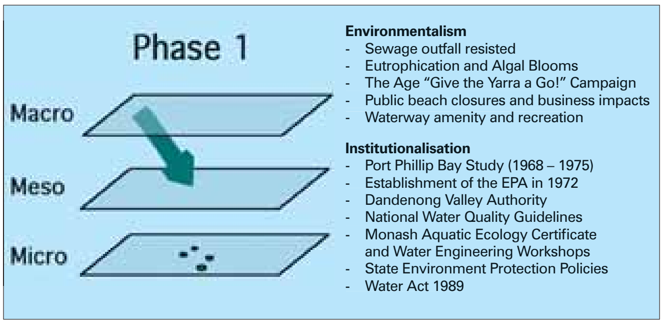


Figure 5. Phase 1 of the Transition: Seeds for Change (1965-1989)

From the 1950s onwards septic tanks[13] were used extensively throughout Melbourne and while they were better than the pan system (where a nightsoil operator had to empty the pan weekly), they were a major cause of the increasing pollution of Melbourne's rivers and creeks that threatened the health of Port Phillip Bay. In 1967, the then Melbourne and Metropolitan Board of Works (MMBW) unsuccessfully proposed to construct an interim sewage outfall from the South Eastern Purification Plant[14], three kilometres offshore from the bayside suburb of Carrum, to Port Phillip Bay. This proposal was to accommodate the sewage from Melbourne's rapid expansion during the post-war economic boom of the 1950s and 1960s with the then (and now unrealised) growth prediction of 5 million people living in Melbourne by 2000.

This outfall was part of a transitional plan and was to be later moved to Bass Strait when there were sufficient funds. As reported by Dingle and Rasmussen (1991; p293), a confidential report on this scheme was "leaked to the Sun newspaper" and was met with a public outcry over the potential risk to the Bay (see Figure 6) that was acted upon by local conservation groups, trade unions and local councillors from around the perimeter of the Bay.

It is likely that this event substantially fuelled the growing activism during this phase which sought to fundamentally challenge the dominant waterway management and urban growth planning agenda. The public outcry over the proposed sewage outfall triggered a governmental response, with the MMBW and the then Fisheries and Wildlife Department of Victoria agreeing to conduct an environmental assessment of Port Phillip Bay as reported in the first Environmental Study of Port Phillip Bay (1968-1973). However, it was noted that there was limited local scientific expertise to conduct such a study and therefore international experts were engaged, as well as applying learnings from other international studies (such as the Chesapeake Bay study in the USA) (Melbourne and Metropolitan Board of Works, Fisheries and Wildlife Department of Victoria and Port Phillip Authority, 1973). The outcomes from the study showed that sewage effluent and associated nutrient loads were having a significant impact on the health of the Bay and causing algal blooms. These findings provided a basis for the development of the first Victorian State Environment Protection Policy (SEPP) that was released in 1975, known as the 'Port Phillip Bay SEPP'. It is also worth noting that during this time there were frequent observations of algal blooms across the country, particularly in rural water supply reservoirs with an increasing acceptance that nutrients from sewage inputs were the major cause.

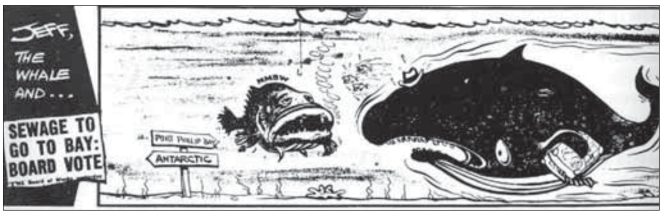


Figure 6. Newspaper cartoon depicting poor water quality in Port Phillip Bay; "You're not leaving our effluent society?" *The Sun*, 13 July 1967 (Dingle and Rasmussen, 1991; p294)

13. A typical septic tank consists of an enclosed watertight container with one or 2 compartments. It collects sewage and provides primary treatment by allowing solids to settle out from the water that is then disposed of through absorption trenches, irrigation or other approved systems.

14. The South Eastern Purification Plant is now known as the Eastern Treatment Plant.

The significance of this community activism is evidenced by the publication *Port Phillip Bay: The Case for Alarm* (Birrell *et al.*, 1974) (see Figure 7). This report highlights how the Victorian Government and the MMBW were criticised by a community advocacy group for allowing rapid urbanisation into environmentally sensitive areas, such as the Mornington Peninsula. They were also criticised for allowing unsewered developments to be built and industrial effluent to enter the drainage system, factors which were highlighted as degrading Melbourne's waterways and making some 'stagnant' (it is worth noting that there were still some industrial effluent discharges to waterways occurring into the 1980s). The 1968 'Melbourne Planning Scheme' had already issued planning directives requiring new property subdivisions and development to have adequate sewage infrastructure to prevent the growth in backlog sewer properties. However, it was not until 1973 when the MMBW issued a planning directive requiring all new subdivisions and developments to contain their waste on-site or they must connect to a reticulated sewage system (as part of then MMBW's 'Water and Sewage Backlog Program' now referred to as the Metropolitan Sewage Backlog Program) that this initiative really took hold.

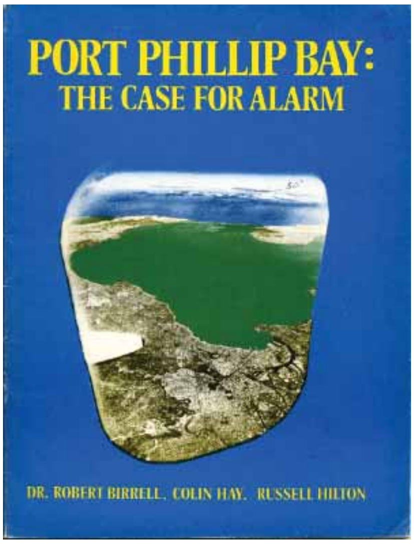


Figure 7. Front Cover of "Port Phillip Bay: The Case for Alarm" (Birrell *et al.*, 1974)

Blyth (2002) highlighted that during this period the state of Melbourne's waterways was a source of public ridicule and attracted significant media attention. For example, in Prince Charles' visit to Melbourne in 1970 he was quoted for associating the waters in Port Phillip Bay at Elwood Beach with "dilute sewage" (Dingle and Rasmussen, 1991; p295). Furthermore, during the 1960s and 1970s, the Yarra River attracted the euphemism that the waters were "too thick to drink and too thin to plough" (Blyth, 2002; p5). It is clear in this period that the community was starting to concede that little value had been formally placed on the environmental and social aspects of waterways, and that these waterways were essentially managed as conduits for flood conveyance (which often resulted in waterways being treated as waste dumping grounds). See Figures 8 and 9 for examples of public signage that the community were exposed to at this time.

This phase also reflects global changes in the evolution of the new disciplinary area of environmental science, including the more specific water quality sciences. Locally, a new Graduate Diploma in Water Science from the (former) Caulfield Institute of Technology, then followed by Melbourne University and later Deakin University, provided the first significant training ground for industry specialists, while the outcomes from the 1968-1973 environmental study of Port Phillip Bay were being generated. Also at this time, the first *National Water Quality Guidelines* were produced by the Australian Water Resources Council in 1974 and subsequently developed into a series with publications in 1982, 1992 and 2000. These developments reflected the national scientific awakening, and subsequent work with waterway quality issues.

In 1976, the Monash University's Department of Civil Engineering commenced offering a masters-by-coursework program in Water Resources and Environmental Engineering. This course ran for some 20 years, and was acknowledged for demonstrably helping 'lift the skill base of water engineering in Victoria' in catchment drainage[15]. From 1975 this

15. For a brief history on this program in Monash University's Department of Civil Engineering (1961 – 2000) see: http://civil.eng.monash.edu.au/about/history/water

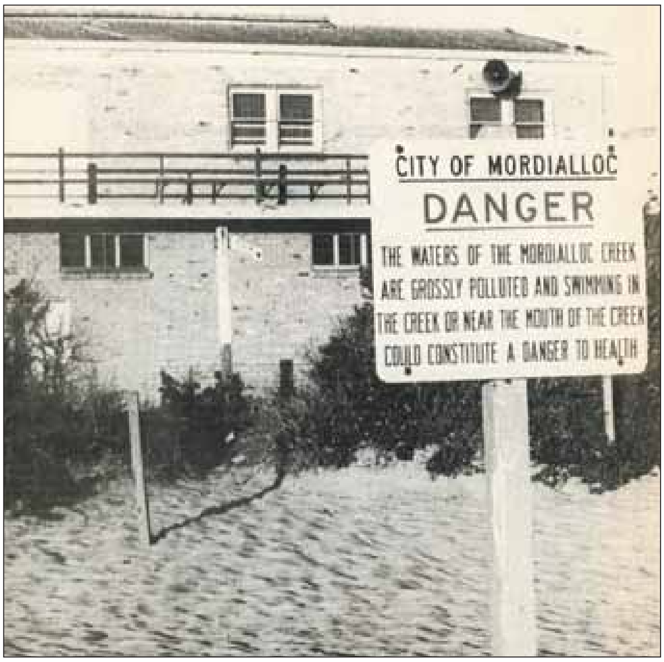


Figure 8. Danger sign at Mordialloc Life Saving Club (Birrell *et al.*, 1974; p27)

Figure 9. MMBW sewerage overflow point at Hampton (Birrell *et al*., 1974; p14)

Department also ran a successful series of Water Engineering Workshops for practising engineers. These workshops, initially of 6 days duration, had the explicit objective of having industry practitioners ready to apply the new methods, with their own data sets, as soon as they returned to their offices. This was considered a key factor in attracting a large number of participants from Melbourne and Australia-wide. The workshops also underpinned the subsequent development of highly effective academic-practitioner relationships across Melbourne that were later instrumental to the USQM transition (as discussed in the following Sections). It is also worth noting that training in urban hydrology at this time was at a premium and UNESCO had just completed its 'International Hydrological Decade' (1965 to 1974).

The Victorian Environment Protection Authority (EPA) was established (the first within Australia) under the *Environment Protection Act 1970* against the backdrop of this widespread environmental concern. The initial focus of action was industrial pollution and other point source pollutants, a focus which consumed a significant majority of the EPA's attention in its first 20 years. However, an important step in addressing diffuse sources of pollution entering waterways came through the EPA's pioneering work in setting up catchment management committees with community and other representatives, particularly in the Dandenong Valley and Western Port catchments. These committees provided the first opportunity and practical mechanisms for bringing key stakeholders together and seeking cooperative efforts to address the diffuse sources. This led to the later establishment of formal Catchment Management Advisory Committees throughout Victoria which were later transformed into Catchment Management Authorities.

Also at this time, the (now former) *Dandenong Valley Authority* (DVA) (1963 to 1989), a delegated agent of the EPA, was one of the most progressive organisations across Australia in terms of leading innovation in drainage planning and floodplain management, providing improved waterway amenity and waterway health protection[16]. The DVA was formally constituted in 1964 as a catchment-based organisation in response to the rapid development within the Dandenong Creek catchment located

16. The organisational framework of DVA was inspired from visits to the North American Tennessee Valley Authority, which is perhaps the best known catchment-based organisational model for integrating water and related resources at a catchment scale.

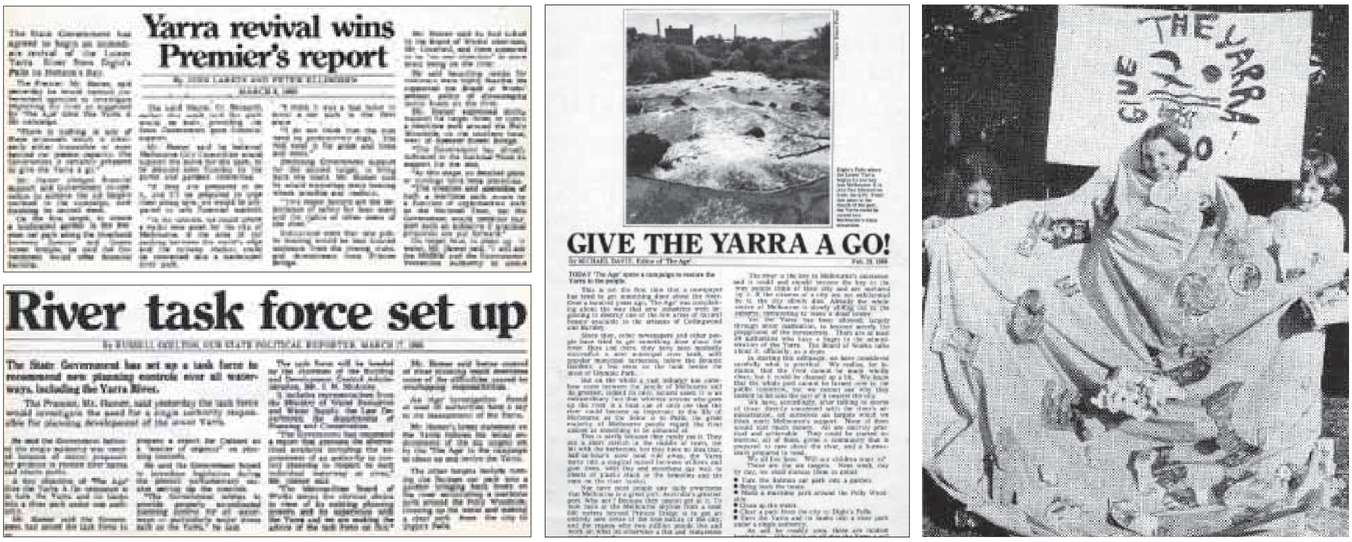
within the south-east part of Melbourne. The DVA was responsible for the "drainage of the waters of the Dandenong Creek and its tributaries, channels and watercourses, the improvement of lands within the catchment thereof and for the prevention of flooding, pollution and other purposes" (DVA Act, 1963). Amongst a host of other activities during the 1970s and 1980s, this organisation worked closely with the community, 'friends of' groups and formal advisory committees related to waterways. They also undertook pollution licensing and enforcement, together with pollution control activities and waterway health research and quality sampling.

The DVA quickly became recognised as an organisational leader in waterway health and protection, trialling new waterway rehabilitation and protection techniques and investing in the training and science to support this work. The DVA worked with the local universities to improve knowledge of the environmental protection of receiving waterways, and in particular worked with various science and engineering departments of Monash University. For example, as early as 1983, the DVA and the City of Frankston jointly commissioned Monash University Graduate School of Environmental Science to undertake a comprehensive environmental study of the Seaford Swamp, with the objective of producing recommendations for future management of the environmental and public open space aspects (DVA, 1984).

In addition, the DVA developed a new 'contributory drainage scheme' program for the administration of their drainage works, which was set up on a sub-catchment basis in newly developing areas. The schemes identified drainage and flood prevention infrastructure required on proposed new development sites and apportioned costs between developers. Importantly, this innovation laid the groundwork for the subsequent work by Melbourne Water in the late 1990s to include developer charges for water quality works. These schemes provided a mechanism to incorporate a developer charge that could be used to mitigate the downstream water quality impacts from developments. Towards the period of the merger of the DVA with Melbourne Water Corporation between 1989-1990, the DVA ran extensive programs of waterway rehabilitation including what were then termed 'soft engineering works' and active 'greening' to make waterways more 'environmentally-sensitive'.

In 1980, the then Editor of *The Age* newspaper, Michael Davie, initiated the "Give the Yarra a Go!" campaign, which has been identified by The Age as perhaps their "most successful local campaign for the last 50 years" (O'Regan, 2004) (see Figure 10). The campaign criticised the MMBW for officially referring to the Yarra River "as a drain", and that "largely through sheer inattention" it has "merely become the playground of the bureaucrats" (Davie, 1980; p3). The focus of the campaign was principally on the lower Yarra catchment and six "practical and achievable" targets were proposed by The Age "to restore the Yarra to the people". These targets included initiatives such as providing public access and recreational space, and cleaning up the waters of the Yarra. This media activism was the driver for the then Premier of Victoria, Mr Dick Hamer, to pledge financial support and government cooperation to address the restoration of the Yarra River. The Premier in 1980 announced that the Victorian Government would produce a detailed feasibility study for the construction of a 12km pedestrian and cyclists' path along the Yarra River bank from Princes Bridge to Dight's Falls, which was to address one of the six targets from The Age's *Give the Yarra a Go* campaign.

In 1985, a number of projects for the Bicentennial Commonwealth/State Commemorative Program were approved by the Victorian and Commonwealth Governments, which included the 'Melbourne Waterways Program' (ABA, 1985). Funding of $12.8 million was provided to "clean up, beautify and restore" creeks and rivers in Melbourne, particularly in the western and inner suburbs (ABA, 1985). This also resulted in the construction of the major bicycle and walking trail network along the Yarra River and other waterways (DSE, 2006b). In 1988 the DVA


Yarra revival wins Premier's report

River task force set up

GIVE THE YARRA A GO!

Figure 10. Examples from The Age newspaper "Give the Yarra a Go!" campaign (David Syme & Co Ltd., 1980)

was also successful in securing government funding to construct a 13km bicycle path for the community along Dandenong Creek from Dandenong to Port Phillip Bay at Carrum, and was called the 'Bay to Bush' bicycle path.

The investment in bicycle trails is considered by many urban water leaders across Melbourne as a critical driver for building mainstream social capital for waterway health and amenity. When the trails were accessible they had a significant effect on engendering greater community support for improved waterway health, as previously waterways were largely out of sight. It soon became clear that people were not happy with the state of local urban waterways with the EPA recording a significant increase in community complaints related to the health of urban waterways in the late 1980s. In 1988 the new SEPP (Waters of Victoria) was launched, clearly stating the importance and significance of protecting and restoring waterways and their beneficial uses across Victoria.

This was followed by the passing of the *Water Act 1989* developed by the Department of Water Resources (DWR). This Act was a result of a review and consolidation of the previous *Groundwater Act 1969* and the *Water Act 1958* during the mid 1980s. The new Act listed 13 'purposes' that focussed around improving water management to meet contemporary social, economic and environmental expectations, for example, "to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses" (Victorian Government, 2006; p2). Having had a policy and planning focus, the DWR is today recognised for its role in initiating the thinking behind what might be termed the first 'sustainable water management policy' for Australia with a strong focus on 'integrated catchment management'. The DWR, together with the Australian Water Resources Council, hosted the first National Workshop on Integrated Catchment Management in Melbourne in 1988, which highlighted the need for cooperation, integration and a sequencing framework for catchment management.

Throughout the 1980s, a number of significant algal blooms occurred in Port Phillip Bay, events which assisted in maintaining the social and political profile of the earlier activism. This resulted in the closing of suburban beaches following rainfall events, which attracted a significant negative reaction from the community and thus provided further momentum to start addressing stormwater issues. The business community was also affected; when in

1987, harvesting and marketing by mussel farmers was suspended during most of the season, resulting in losses in the order of $1 million at that time (Winstanley, 1996). In 1988, toxic algal blooms were officially recorded in Port Phillip Bay following heavy rainfalls in summer and autumn. This resulted in the issuing of public health warnings against eating shellfish from the northern areas of the Bay, further exacerbating the impact on the business community.

This snapshot of early conditions and drivers during the 'seeds of change' phase has underpinned the institutionalisation of waterway health, and recreation and amenity values at the meso-level as observed today. Overall, this phase characterises an important shift in local social capital towards the city's waterways, which mutually stimulated and reinforced significant media activism in relation to improving Melbourne's waterways. There were many drivers for this, notably an unsuccessful proposal for a wastewater outfall to be constructed in Port Phillip Bay and high levels of concern with the degradation of urban waterways. This grassroots activism enabled broad questioning of the validity of the traditional urban waterway management approach and revealed how the waterway values of passive recreation, amenity and ecological integrity were being compromised. The formalisation of environmental and water engineering knowledge, and effective academic-practitioner relationships were also critical during this period, in addition to the investment in environmental studies of Port Phillip Bay. The introduction of an environmental legislative framework in 1970 created the space for subsequent waterway protection policies. These were followed by a number of strategic government funding opportunities that assisted with reconnecting the community with urban waterways.

It is important to note that in this phase, while sewage and trade wastes are now understood as significant issues to be managed, the community still generally perceived urban stormwater runoff as a flooding nuisance, and implicitly considered it environmentally benign (Wong and Eadie, 2000). This perception is widely challenged in the next phase.

4.3. 1990-1995 Building Knowledge & Relationships

This phase marks the development of a new institutional working *space* within the existing meso-level, which is in response to the events in the previous phase. This new space was established against a broader backdrop of a government-wide corporatisation agenda[17] with the aim of creating more efficient and accountable government operations. It involved key champions from across different stakeholder organisations working together in different ways to create new learning opportunities and to promote the practice of USQM. This evolving meso-level activity fostered the development of an improved and common understanding about the urban water problem, which subsequently became the incubator for the formation of the USQM niche (which is described in the next phase).

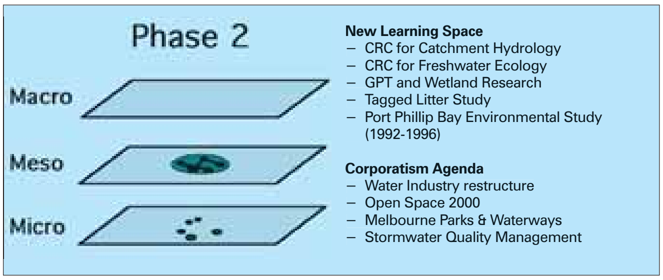


Figure 11. Phase 2 of the Transition: Building Knowledge & Relationships (1990-1995)

In the early 1990s, the Commonwealth Government initiated a new science development program involving the funding and establishment of Cooperative Research Centres (CRCs) around Australia for advancing science and policy adoption through strengthening links between industry and universities. The CRCs were to address current problems across Australia where scientific insight could be rapidly transferred into practical action that met the needs of industry partners and the Australian community.

The proposals for establishing a CRC for Catchment Hydrology (CRCCH) and CRC for Freshwater Ecology (CRCFE) were successful in 1992 and 1993

17. See Colebatch (2006) for a discussion on the rise of corporatism and the new public management agenda during this period.

respectively[18]. The stated vision of the CRCCH was the *"sustainable management of the nation's water resources through adoption of an integrated approach to land-use, water allocation, hydrologic risk, and environmental values"*, with a mission to *"deliver to resource managers the capability to assess the hydrologic impact of land-use and water-management decisions at whole-of-catchment scale"*. The stated vision of the CRCFE was the *"improved condition of Australia's inland waters"*, with a mission to *"provide ecological understanding to improve and protect Australia's inland waters by collaborative research, education, resource management, policy advice and community liaison"*.

Developing the CRC proposals between 1990 and 1992 involved significant engagement among multiple industry and research organisations as contributing partners, with a focus on industry partners defining their research needs. With particular reference to the topic of this study, there was a strong representation in the process from Melbourne-based stakeholders including Melbourne Water, Monash University and The University of Melbourne. This engagement work resulted in waterway health and urban hydrology being identified as a priority research area. In particular, these CRCs included specific program areas dedicated to monitoring waterway health and developing stormwater quality treatment technologies.

Figure 12. Logos for the Cooperative Research Centres for Catchment Hydrology and Freshwater Ecology

Both of the CRCs had a very strong local presence in Melbourne. As indicated by a number of interviewees, before the creation of CRCs and notwithstanding the industry engagement training activities of local universities (as highlighted in the previous Section), it was not common practice for a government official to proactively contact a university scientist or vice versa unless as part of a formal process. However, it is important to note that there was relatively regular interchange across industry and science prior to the formation of the CRCs amongst those individuals and organisations who were key champions. The CRCs worked as 'bridging organisations', bringing together researchers and industry stakeholders, so that ongoing research efforts could better reflect the needs of industry.

During this transition period, primary research into issues such as the generation of gross urban stormwater pollutants and water balance models emerged. This is in addition to a number of other initiatives at the micro-level including a period where gross pollutant trap technologies (GPTs) were rapidly developed (see Figure 13). In particular, the Continuous Deflective Separation technology[19] was developed in Melbourne in 1992 (Wong and Wootton, 1995), which led to the establishment of a publicly-listed international company (as described in Monash University, 1996). Furthermore, there was also early research into stormwater treatment wetlands (see for example, Wong, 1993; Wong and Somes, 1995; Lawrence and Breen, 1998), and assessment of stormwater and urban development impacts on urban waterways (Breen *et al*., 1994; Allison and Chiew, 1995).

Interestingly, the public perception of waterways in Melbourne was assessed in 1993 through a social study conducted by 'TQA Research' (TQA, 1993). The outcomes revealed that the public perceived litter as an indicator of poor water quality and gross pollutants as the greatest threat to waterway health.

18. **CRCCH** was a cooperative venture between: Brisbane City Council; Bureau of Meteorology; CSIRO Land and Water; Department of Infrastructure, Planning and Natural Resources (NSW); Department of Sustainability and Environment (Vic); Goulburn-Murray Water; Grampians Wimmera Mallee Water Authority; Griffith University; Melbourne Water; Monash University; Murray-Darling Basin Commission; Natural Resources, Mines and Energy (Qld); Southern Rural Water; and The University of Melbourne.

CRCFE was a cooperative venture between: ACTEW Corporation; CSIRO Land and Water; Department of Infrastructure, Planning and Natural Resources (NSW); Department of Natural Resources and Mines (Qld); Department of Sustainability and Environment (Vic); Department of Water, Land and Biodiversity Conservation (SA); Environment ACT; Environment Protection Authority (NSW); Environmental Protection Authority (Vic); Goulburn- Murray Rural Water Authority; Griffith University; La Trobe University; Melbourne Water; Lower Murray Urban and Rural Water Authority; Melbourne Water; Monash University; Murray-Darling Basin Commission; Sydney Catchment Authority; The University of Adelaide; and University of Canberra.

19. The Continuous Deflective Separation (CDS) screening technology was developed in Australia by CDS Technologies Pty Ltd. The CDS technology is reported as providing efficient separation of settleable solids and achieves 100 percent capture of floatable material >1mm. For more information, see http://www.cdstech.com.au/.

Figure 13. CRCCH Research into Urban Stormwater Gross Pollutant Composition and Trap Technology (courtesy Dr Robin Alison)

Considerable media coverage and community involvement in the previous 'Tagged Litter Study' probably helped influence this perception, in addition to the success of the Clean Up Australia Campaign in the late 1980s and early 1990s, where gross pollutants from the stormwater drainage system were identified as a major threat to waterways. This is likely due to the fact that, unlike other pollutants such as toxicants and nutrients, gross pollutants are visually obvious to the public.

More broadly, professional expertise and attention was starting to accumulate in the area of stormwater quality management, evidenced by the First International Symposium on Urban Stormwater Management, held in Sydney in 1992, and the Second in Melbourne in 1995. However, this was not always received well by all stakeholders such as the previously-established Stormwater Industry Association (SIA). The SIA was established in the mid-to-late 1980s; an era active in promotion of on-site detention systems, and was designed to address the effects of urban consolidation on peak stormwater discharges in developed catchments. At the time, the promotion of alternative vegetated systems, such as stormwater treatment wetlands, was viewed by some members of the SIA as jeopardising the flood security of urban environments. However, today the SIA is a prominent advocate of such approaches.

While urban stormwater quality was increasingly considered an environmental problem in scientific circles and amongst some industry protagonists, it posed a significant dilemma for attracting government attention and priority. Due to the diffuse nature of urban stormwater, it did not clearly fall under the formal jurisdiction of any one government agency or sector. Diffuse sources of pollution presented a major handicap to better management, because unlike point sources, traditional statutory notices and control process could not be easily served and policed. A major barrier to tackling these sources of pollution was the absence of widely accepted technology and practice which could, if needed, be able to be upheld in legal proceedings.

Managing diffuse pollution sources and waterway health did not sit well also with the new corporatism agenda as reflected in the Council of Australian Governments (COAG) agreement for water reform. At this time State government agencies were principally focussed on downsizing and outsourcing 'non-core business' (which often included environmental matters), and local government authorities across Victoria were subjected to an unprecedented process of amalgamation from 210 to 79 municipalities. In particular, Melbourne Water was subject to a process of disaggregation into a wholesale water, drainage and waterway authority and three new retail water supply and sewage businesses (Yarra Valley Water, City West Water and South East Water). Furthermore, in January 1993, the government established the former Melbourne Water Corporation's - Melbourne Parks and Waterways (MPW) division into a separate enterprise encompassing the parks, waterways and environmental operations of the former Melbourne Water Corporation in the Lower Yarra Region.

During this period, stormwater management lost the significant organisational attention that it was starting to gain in the late 1980s. It was suggested by numerous interviewees that no-one wanted to take the lead for urban stormwater management mainly because they could see the significant challenge of trying to work across the separate administrative areas of drainage, floodplain and waterway management. At this time, the former Department of Conservation and Environment led an informal review of institutional responsibilities for drainage and waterway management. The department initially unsuccessfully proposed that local government authorities should assume full responsibility for the engineered drainage and waterways and that MPW take responsibility for so called 'natural surface waterways' and litter in the Lower Yarra River. This proposal was opposed by local government authorities and others based on the view that because local government boundaries were not based on catchments and without the coordinating authority of Melbourne Water, local governments were at risk of discharging stormwater runoff within their respective jurisdictions with limited regard for any downstream consequences. Interestingly there was some debate at this time as to the need for creating definitions as to what was a 'drain' and what was a 'waterway' so that responsibilities could be allocated appropriately.

One of the issues that further delayed the overall effort to address urban stormwater quality was whether Melbourne Water had the legal right under the Melbourne and Metropolitan Board of Works Act (1958) to spend money in this area. The Act gave specific powers in relation to flood protection, and there were words in the Act relating to 'river improvement works'. However, there was no mention in the Act of stormwater quality. At this time, many thought spending money in this area was potentially acting outside the legal scope of Melbourne Water. Eventually, this was overcome and codified when water quality costs were starting to be included in drainage scheme charges in the late 1990s.

Ultimately MPW only took responsibility for monitoring and reporting on waterway health through the 'Streamwatch Program' and in 1997 this responsibility reverted back to Melbourne Water. However, with the launch of the Open Space 2000 program in 1991 by the former Department of Conservation and Environment, there were significant operational implications for MPW, Melbourne Water, local government and the community. The program sought to improve the social amenity of waterways over a 10 year period involving the expansion of the existing network of parks, and bicycle and walking trails, and improving access to river frontages and beaches. The program was essentially open space strategic planning and this initiative provided significant funds to implement these strategies, often providing resources to local government and for community grants.

With the newly formed MPW in 1991, the 'Tagged Litter Study' in Port Phillip Bay was initiated. This study involved an experiment of dumping 1,307 items of 'labelled' or 'tagged' litter (four types of buoyant non-degradable items) across Melbourne and measuring what was collected in the waterways and Port Phillip Bay (McKay and Marshall, 1993). This experiment was designed to trace the pathways of gross pollutants through the urban drainage system. The findings of the study were highly publicised at the time and resulted in estimates that up to 95% of litter that pollutes the Bay and its beaches is transferred by the drainage system that serves Greater Melbourne (McKay and Marshall, 1993). This study was one of the catalysts for the future market response with development of the GPT industry as highlighted previously.

In 1992, the third[20] Port Phillip Bay Environmental Study was funded at a cost of $12 million, and was conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) from 1992-1996 in order to learn more about the Bay[21] (see Harris *et al*., 1996). The key driver for the study was to ensure that the Bay could sustain the continued input of treated effluent from the Western Treatment Plant, given that the construction of an ocean outfall from the Werribee sewage treatment plant was a multi-million dollar alternative. Consequently, the stormwater aspects of the study were secondary to the impacts of sewage effluent on the Bay. However, in trying to understand all the inputs to the Bay and their effects, the significance of the Yarra River and urban stormwater was substantiated.

During this transition period, scientists and industry champions were increasingly adapting the existing scientific knowledge of wetland design for sewage treatment to the relatively new science of addressing stormwater quality. While early demonstrations of treatment ponds and wetlands were trialled by the DVA in Melbourne and by other organisations in Canberra in the late 1980s, wetland science formed a core activity of the CRCCH and CRCFE as well as other CRCs (such as the CRC for Waste Management and Pollution Control), and the CSIRO during this period. This focus was also gaining traction in the land development market place. Some of the larger developers, particularly the then 'Urban and Regional Land Corporation' (URLC) (now VicUrban) were starting to recognise the improved market value of water features and more green space for prospective homebuyers (this market recognition was seen as an important opportunity by industry champions and is discussed in the next transition phase).

The willingness of the development industry to embrace stormwater treatment technologies was also seeded by a number of factors including the active encouragement from pivotal Melbourne Water staff advocating the business opportunity to differentiate their developments from the general market as well as contribute to improving the health of waterways. The naming of subdivisions to reflect the prominence of the stormwater wetlands provides evidence of this phenomenon. The interest of the development industry in stormwater treatment technologies was matched with an increasing demand to acquire knowledge and skills in stormwater management, particularly constructed wetland design. This was first addressed through creating informal design partnerships between developers and Melbourne Water staff by which they could collectively scope out the design of treatment wetlands. This work was later supported and advanced by the research and design guidance produced by the science of the CRCs (see Wong and Somes, 1995; Lawrence and Breen, 1998; Wong *et al.*, 1998). The CRCs stormwater management and wetland design course offered to industry from 1997 onwards was highly regarded by both Melbourne Water and Industry and led to an increased number of stormwater wetlands being incorporated into developments around Melbourne.

Towards the end of this phase the language of Water Sensitive Urban Design (WSUD) had emerged as an outcome from work in Perth, Western Australia (see for example, Whelans *et al.*, 1994) which reflected a broad and alternative integrated planning approach to the whole water cycle. As set out by Wong (2006a) this then 'radical' approach did not gain mainstream acceptance in the early 1990s, and it was not until the

20. A second, lesser well known, environmental study of Port Phillip Bay was conducted in the 1980s.

21. The final report of this study was released in 1996, and therefore the key findings and recommendations are discussed in the next transition Phase.

mid 1990s that stormwater aspects of WSUD gained favour in Melbourne. The Perth WSUD guidelines were acknowledged as an important development by local stormwater champions across Melbourne, even while these guidelines did not manage to change practice in Perth at that time. By 1995, the WSUD language started to infiltrate the Melbourne stormwater management professional circles and was used interchangeably by many to describe the practices of USQM. In addition, towards the end of this phase there was another major concept that started to have an impact on the practitioner language of the USQM field. This involved key champions highlighting the limitations of treating the stormwater problem at the 'end of the pipe', advocating the need for preventative practices and addressing stormwater quality at its 'source' through 'non-structural measures' and 'source-control' such as education and planning techniques. This activity started gaining momentum in terms of scientific publication in the late 1990s and early 2000 (see for example Nancarrow *et al.*, 1997; Brown, 1999; Brown and Ryan, 2001; Taylor and Wong, 2002).

This phase, 'Building Knowledge and Relationships' marks the early formation of a new 'bridging organisation' within the existing meso-level and tracks a growing number of developments in new USQM technologies at the micro-level. The combined CRCs as a bridging organisation brought about the formation of new and mutually beneficial relationships (which remain highly active today) between local scientists and managers, allowing for the innovative bridging of emerging scientific and policy work. Land developers, and others, clearly identified that communities wanted aesthetically pleasing and robust waterways. These expectations, in turn, influenced the priorities of developments, and supported the early business case for USQM treatment techniques.

4.4. 1996-1999 Niche Formation

This phase involved the formation of the USQM niche (see Section 2.3) across Melbourne. Perhaps the best way to describe this period is a series of frenzied and interconnected activities being initiated, tested and implemented to advance the practice of USQM. The protective space developed within the meso-level during the previous phase ensured the growth of new relationships and increased collaboration and coordination among stakeholders, particularly between Melbourne Water and the CRCs. This space expanded and strengthened during this period through the active inclusion of developers, planners and local government authorities. With additional strategic funding opportunities and rapidly developing scientific knowledge emerging from the CRCs, the USQM niche was formed during this period. It is important to note that during this phase the language of WSUD was increasingly being adopted across Melbourne's urban stormwater industry.

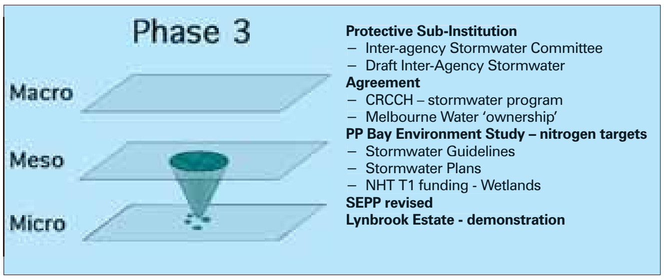


Figure 14. Phase 3 of the Transition: Niche Formation (1996-1999)

The outcome of the third *Port Phillip Bay Environmental Study* was formally released in 1996, and proved to be an important stimulus for galvanising the legitimacy and political importance for advancing USQM across Melbourne. While the study concluded that the Bay had remained relatively resilient at the time, it identified nutrient loads from the sewage treatment plant at Werribee and urban stormwater runoff as key threats to maintaining this health (Harris *et al.*, 1996). The study recommended a high priority policy target of reducing annual nitrogen loads entering the Bay by 1000 tonnes from 1993 levels (Harris *et al.*, 1996).

The State government endorsed this finding and the State Environment Protection Policy (Waters of Victoria) was subsequently amended to incorporate 'Schedule

6 (Waters of Port Phillip Bay) which has a stated aim of achieving a nitrogen load reduction of 1000 tonnes from 1993 levels by 2006. Melbourne Water was responsible for determining the allocation between the nitrogen sources under its jurisdiction. This resulted in an initial decision by Melbourne Water to reduce annual inputs from the Western Treatment Plant by 500 tonnes from 1993 levels, and reduce annual inputs from catchment sources by 500 tonnes from 1993 levels.

Catchment-based water quality modelling completed in 2000 by Melbourne Water and others, identified that regional wetland sites are capable of reducing annual nitrogen loads by 100 tonnes from the 1993 levels (or 20% of the 500 tonnes reduction from stormwater nitrogen). This target was then adopted in Melbourne Water's 2000 corporate plan and was allocated in excess of $60 million over 10 years. The setting of this scientifically informed policy target and Melbourne Water's leadership to reduce nitrogen loads from catchment sources provided the necessary momentum behind a host of subsequent initiatives that underpinned the formation of the USQM niche, and continues today to be a significant driver throughout Melbourne Water's capital works program.

The disaggregation of the former Melbourne Water Corporation in 1996 resulted in three separate water and sewer retailing businesses. The relative organisational profile of drainage and waterways in Melbourne Water was consequently heightened with a significant focus on meeting the catchment-based nitrogen target, as well as responding to the increased community advocacy for improved waterway health, amenity and recreation values. With the incorporation of the former DVA into Melbourne Water in 1989-1990, many of the innovative ideas and experience of key waterway professionals influenced new practices during this period. The 'contributory drainage scheme' thinking (discussed in Section 4.2) allowed for whole catchments to be planned, and development contributions levied equally on a whole-of-catchment basis; these schemes were rolled out across Melbourne. With Melbourne Water having a critically important role as a development referral authority, the organisation had the power to place conditions on developments relating to drainage and water quality, and local government authorities were legally obliged to write these conditions into planning permits. While Melbourne Water had this power for some time, it was only during the 1990s that the organisation's executive encouraged their staff to actively exercise this power. Prior to this, there was less confidence in taking such an approach and concerns existed relating to potentially not being able to withstand a legal challenge by developers.

Given this context, Melbourne Water's 'Waterways and Drainage Division' proactively designed and promoted a new Stormwater Initiative (SI) to facilitate improved cooperation and commitment to stormwater quality issues across industry sectors, including local government and the EPA. The SI, as depicted in Figure 15, formed the basis for the important institutional innovation of the inter-agency Stormwater Committee[22] in 1996. The purpose was to steer implementation of the initiative and the establishment of the draft inter-agency Stormwater Agreement. The Committee was convened by the EPA which also provided the secretariat. However, in operation it was very much a partnership effort between the EPA and Melbourne Water. What is important to note, as expressed by a number of interviewees, is that a number of the committee members were highly passionate and committed to advancing improved urban stormwater quality management.

The Stormwater Committee produced three key outputs:

1. the *Stormwater Agreement* which articulated the responsibilities and relationships between the EPA, Melbourne Water and local government for improved USQM[23];

22. The Stormwater Committee was a partnership between the Environment Protection Authority, Melbourne Water Corporation and Local Government aimed at improved urban stormwater quality. Committee members represented the City of Kingston, the City of Monash, Australian Conservation Foundation, Department of Infrastructure, Environment Protection Authority, City of Hobson's Bay, Urban Development Institute of Australia, Local Government and Planning Advisory Council, Municipal Association of Victoria, City of Wyndham, Port Phillip Catchment and Land Protection Board and Melbourne Water Corporation.

23. The Stormwater Agreement, which was an attempt at articulating the responsibilities of EPA, MW and Local Government in relation to urban stormwater management, remained in draft until 2003. It was only after a host of ongoing initiatives including the $20 million Victorian Stormwater Action Program launched in 2000 that there was sufficient support across all of the CEOs that all organisations signed off on this agreement.

2. the *Urban Stormwater Best Practice Environmental Management Guidelines*, and
3. a *Stormwater Management Planing Framework* which was published in the best practice guidelines and piloted with five councils.

Figure 15. Stormwater Initiative depicting the goals and relationships of the Stormwater Committee (Courtesy Mr Chris Chesterfield, Melbourne Water)

A major objective of the Committee was developing "shared responsibility" and achieving "cultural change in local government" for improved USQM. A view held by a number of representatives on the Committee at that time was that the obligations set out in the SEPP (Waters of Victoria) were too difficult for developers and others to demonstrate compliance, and therefore there was a strong need for the Committee to prioritise capacity building initiatives.

This activity also spurred a significant debate amongst the Committee members and local scientific experts associated with the CRCCH and CRCFE on whether setting sustainable stormwater quality runoff loads or setting receiving water quality objectives would be the most productive for changing industry practice. While the approach of setting of receiving water quality objectives was seen by some as more comprehensive, it was also considered by many as a more ideological rather than pragmatic approach that would drive practice. Therefore, it was soon agreed that taking a best practice philosophy in attaining sustainable pollutant load reduction would be the more practical approach for improving rates of uptake and implementation. Subsequently, one of the initial tasks of the Committee was the preparation of the *Urban Stormwater Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee, 1999), or informally, 'The Blue Book', which was drafted in 1997 and formally released in 1999 as shown in Figure 16.

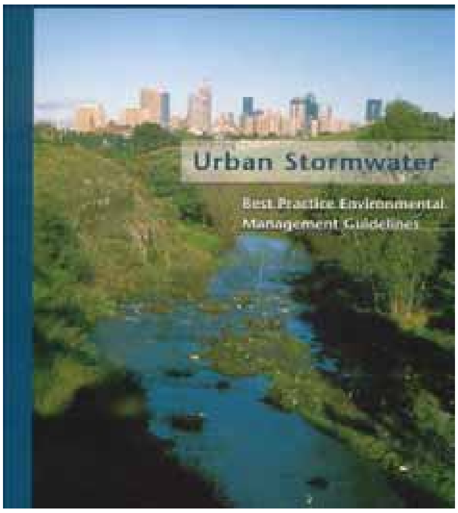


Figure 16. Stormwater Committee's *Urban Stormwater Best Practice Environmental Management Guidelines* (1999).

The Stormwater Committee worked with the Committee's Technical Working Group, in addition to representatives from the CRCs and other organisations, to determine some practical, achievable and measurable targets that could provide what was perceived as a 'level playing field' for the industry. This involved a substantial analysis of international studies of stormwater pollutants (see Duncan, 1997) combined with a series of workshops between Melbourne Water, the EPA, the CRCCH and CRCFE and representatives from other relevant agencies including the NSW EPA. This process resulted in the agreement on best practice performance targets to be achieved by developments across Melbourne. This activity was very important as it meant that the resource manager (Melbourne Water) and the regulator (EPA) agreed to a set of objectives that were considered to satisfy the statutory requirements of the SEPPs and be delivered through improved management of the resource.

These objectives require an 80% retention of the annual load of Suspended Solids, a 45% retention of Total Nitrogen and a 45% retention of Total Phosphorus that are tipically generated from an urban catchment (locally referred to as the '80:45:45' principle) (Victorian Stormwater Committee, 1999). This '80:45:45' target was advocated as achievable in all new developments, and developers were encouraged to either find a way to meet these targets through their own means or it would be acceptable to adopt the deemed-to-comply alternative through the construction of stormwater treatment wetlands that are at least 1% of the land area of the development[24]. These principles and insights have now become an industry standard in a number of other Australian states, and Melbourne is now perceived as leading the way in stormwater management (DSE, 2006b). It was recognised that Total Nitrogen loads from urban development were still increasing, and that application of the broader WSUD approach could achieve higher environmental outcomes in new developments. It was also recognised that if WSUD was applied to tackle existing urban development through retrofits, it would provide a means to further negate the increasing nitrogen loads conveyed to the Bay.

In 1997, the Australian Commonwealth Government launched the Natural Heritage Trust (NHT), as "the largest environmental rescue plan ever undertaken in Australia" (NHT, 2006). The main source of funds in the NHT Reserve was from the partial privatisation of Telstra (NHT, 1998), called "T1 money". This money funded a number of environmental improvement projects, including the 'National Wetlands Program' and the 'Clean Seas Program' (NHT, 1998). Opportunistically, key champions associated with the Stormwater Committee informally approached the Commonwealth Component of Coastal Catchments Initiative for additional funding for urban development, expressing the need to build urban wetlands that would reduce nitrogen loads entering Port Phillip Bay.

This proposal, later formally submitted by the then Environment Minister for Victoria, Marie Tehan, was successful, with Melbourne Water being a joint funding partner in the launch of the 'Healthy Bay Initiative'. The Healthy Bay Initiative was a $130 million program aimed at improving the health of Port Phillip Bay by reducing nutrient loads from the Western Treatment Plant at Werribee and from stormwater run-off. The urban wetlands project was a component of this initiative and was supported with the T1 money, involving $7.5 million for the construction and monitoring of 10 separate wetlands over three years (Melbourne Water, 1999a). Figure 17 presents an example of one of the 10 wetlands that was constructed. These activities demonstrated the significance of the policy target for reducing nitrogen loads to the Bay as a driver for action.

The wetlands were constructed in Melbourne's 'South East Growth Corridor', as it was expected at the time that the next decade would see approximately 200,000 additional people settle in the area, and that this would lead to a potentially significant source of stormwater pollution, as the entire area drains to Port Phillip Bay (Melbourne Water, 1999b). It is important to note that the proposal for these 10 wetlands was based on the experiences of a wetlands project that Melbourne Water staff had been working on since 1994 and was constructed in 1998 as part of 'The Waterways Estate', which is a residential subdivision with 45% of the area devoted to constructed wetland environments. The Waterways Estate was a major sales success and went on to win the Urban Development Industry Association's (UDIA) national award for Environmental Excellence in 1999. While this wetland ended up being incorporated into the portfolio of 10 wetlands, it provided the necessary impetus for the promotion of a large wetlands construction project across Melbourne.

It is also important to highlight that at this time Melbourne Water's then General Manager of Waterways and Drainage recognised that "by any measure, this is an ambitious project, and we believe it will become the benchmark for Australia" (The Source Magazine, April 1999, p 8-9). He went on

24. Duncan's (1997) analysis published in the CRCCH report 'Urban Stormwater Quality Treatment by Storage' showed that the allowance of a 1% wetland area for developments could be expected to achieve the 80:45:45 stormwater quality performance target in metropolitan Melbourne.

Figure 17. Hampton Park Wetland, an example of a constructed urban wetland built by Melbourne Water

Figure 18. An example of the signs erected by Melbourne Water near the wetlands built in the 'Healthy Bay Initiative' (Courtesy Mr. Graham Rooney, Melbourne Water)

to observe that there had "been a renaissance in people's attitudes to our waterways" and attributed much of this change back to the mid-eighties at the start of the investment in public bicycle and walking trail networks around waterways. Each of these 10 wetlands today is marked with Melbourne Water's organisational emblem (the Growling Grass frog; see Figure 18) on a sign nearby to indicate that the wetland is helping to protect ecosystems and the Bay. This has since been acknowledged as an important step in the early stages of the cultural transformation of Melbourne Water, as reported in Brown (2006). The initiative further supported the ongoing collaborative research on wetland design and management between the CRCs and Melbourne Water with an implicit objective of encouraging developers to integrate treatment wetlands as a "new feature in sub-divisions" (Melbourne Water, 1999b).

In late 1997, influential staff within Melbourne Water and the CRCCH actively pursued the development of an innovative WSUD sub-catchment scale demonstration project. Their vision was to focus on constructing a 'treatment train' design at the streetscape level, as a way of building on the innovations with the regional wetlands treatment work. This group of project champions wanted to show developers and local government authorities that the USQM technology could be adapted to smaller development scales, as well as "to enable a better understanding of design and construction issues associated" with such technolgies (CRCCH, 2000). Melbourne Water approached the Urban Land Corporation (ULC) (a fellow state government corporation) appealing to their stated values of industry leadership, and asked them to nominate one of their development projects that could be used as a real life demonstration of WSUD principles. The URLC agreed and offered Lynbrook Estate as it was considered to be their "worst performing estate in Melbourne", posing limited economic risk to their operations if the development was to fail. A project leadership team was assembled, represented by Melbourne Water, CRCCH, CRCFE, KLM Development Consultants and Murphy Design Group to design and implement the project.

The innovation was through the construction of the 'treatment train' which linked new streetscape design including swales, bioretention systems (Figure 19), treatment wetlands (Figure 20) and a lake (see Lloyd *et al.*, 2002). In addition, the project also provided real costing data associated with design, construction and maintenance at a time when such cost estimates were exceedingly rare and highly valued across Australia. The design process was facilitated through a series of workshops led by the CRCCH. It is worth noting that the final innovative design plans were rejected by the local government authority which viewed the stormwater management strategy as too risky – it was perceived not to conform to the Council drainage standard. Melbourne Water then negotiated with Council and eventually "got Council over the line by underwriting the hydraulic design", and by guaranteeing to replace the WSUD infrastructure with a conventional approach (for example, kerbs and channels) if it did not perform as designed.

Fortuitously, this design was tested in its first year of operation through being successful at conveying the flows for the 5-year ARI rainfall event and treating the stormwater runoff as it was designed to. During this event, the Lynbrook facility was considered to have "performed [hydraulically] better than the other conventional drainage systems in the estate".

This finding was substantiated through postgraduate research undertaken through the CRCCH on this project (see Lloyd, 2004). Interestingly, the social market research conducted by Lloyd revealed that the local community found the development much more aesthetically attractive than the conventional approach.

The Lynbrook Estate project surprised proponents by dramatically improving the development's market performance. Accordingly, sale prices for subdivisions that incorporated WSUD reported increases in the order of 20% to 30%. While the developer of Lynbrook believed this was largely due to the substantially improved visual appeal of this particular development relative to others at that time, representatives from Melbourne Water took a broader view in attributing this sales success. They believed there were a number of additional reasons relating to market changes that contributed to the development's success in addition to the WSUD attributes.

Figure 19. Bioretention system at Lynbrook Estate (www.wsud.org)

Figure 20. Lynbrook Estate Wetland, built by VicUrban

25. It is important to note that the Lynbrook project was not the only project including USQM treatment measures at this time. However from the outset it was set up to be a reliable demonstration project including the implementation of a distributed treatment train approach, water and other monitoring, detailed infrastructure and maintenance costing, and social receptivity analysis of the innovative streetscape elements. It also applied all of the prescriptions as set out in the Urban Stormwater Best Practice Environmental Management Guidelines, so it ultimately demonstrated at a large real-life scale that that this type of USQM was not only feasible but also preferable from an economic and social perspective.

Overall, this initiative was very significant for completing the formation of the USQM niche[25]. It assisted with reinforcing the confidence of leading USQM and WSUD champions, as well as reinforcing, in a practical way, the working relationships across government, academic and industry sectors. The project demonstrated a range of novelties in a distributed treatment train approach to achieve improved stormwater quality management, and it also provided a real demonstration of how to meet the objectives of the newly established *Urban Stormwater Best Practice Environmental Management Guidelines*. The project also addressed the need to meet nutrient reduction targets. The Lynbrook Estate project was awarded the UDIA President's award for innovation in 2000. In 2002, the then Urban and Regional Land Corporation (URLC) made a corporate commitment to include such WSUD concepts in all future projects.

In parallel to the activities of guideline preparation, regional wetland construction and the Lynbrook Estate development that occurred during this four-year period, the CRCs and Melbourne Water facilitated a series of industry training workshops to improve adoption of this new science. The CRCCH[26] also hosted a series of bus tours for professionals to visit and inspect the Lynbrook Estate, and a number of other sites (including Hampton Park Wetland, Kinfaun Estate and Ruffeys Creek Wetland), which were offered as part of a five-day stormwater management course. This was in addition to a range of industry training workshops and seminars that were offered in all mainland capital cities (except Darwin) to educate the industry about WSUD, and in particular, the design of wetlands.

The industry seminar series, entitled "Managing Urban Stormwater using Constructed Wetlands" was held over 1998 and 1999 by the CRCCH and was highly successful, attracting over 220 participants from Melbourne and a total of over 1000 participants nationally. As part of this training the CRCCH's report with the same title as the workshops (see Figure 21), was launched. It is interesting to note that at this time, this CRCCH report was their most popular industry report ever prepared. Over 1200 copies in two editions were either distributed or downloaded from the world-wide-web. In 2001 the national CRC Association Award for Excellence in Technology Transfer was presented jointly to Melbourne Water, Brisbane City Council, Urban Land Corporation and the CRC for Catchment Hydrology for this work.

This training activity ended up involving a number of champions and was a key factor in not only creating industry legitimisation of the scientific concepts, but also assisted with improving the potential to meet the policy target of reducing nitrogen loads from stormwater runoff. Many of the interviewees who participated in this period talk about the level of energy, excitement and fun involved, as well as emphasising that they perceived they were "really contributing to improved environmental outcomes". In addition, a few interviewees suggested that "this was one of the most enjoyable periods" of their careers.

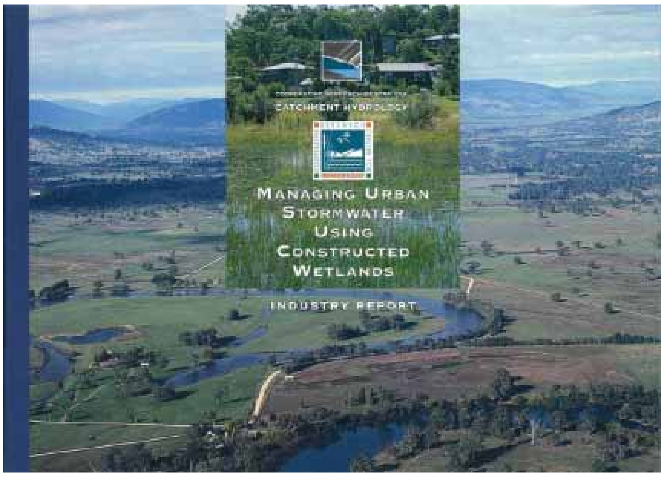


Figure 21. Cooperative Research Centre for Catchment Hydrology's Industry Report – *Managing Urban Stormwater using Constructed Wetlands* (1998 and 1999)

Overall, this transition phase (Niche Formation) witnessed the development of a philosophy shared by champions, and directed at advancing practical and achievable on-ground development of USQM (often referred to as WSUD) practices through providing both guidance and practical examples in the field, in addition to sophisticated industry training. This phase was energetic and exciting for those

26. Note that also at this time, the CRCCH program addressing stormwater quality was within the program area broadly titled 'Urban Hydrology' until 1999. It then became the 'Urban Stormwater Quality' program until 2005.

involved, and was characterised by fast-paced action and implementation, which is perhaps a fundamental requirement for forming an innovative niche.

4.5. 2000-2006 Niche Stabilisation

This phase was a period of initiatives that were focussed on diffusing the insights of the USQM niche and therefore ensuring the relative stability of the niche, in addition to improving its institutional legitimacy. This 'niche stabilisation' was enabled by, and supported through, a range of initiatives such as a strategic state-wide funding source dedicated to funding stormwater quality management practices and the development of a 'deemed-to-comply' WSUD assessment model for designers, planners and regulators (see Figure 22). The momentum gained throughout the last transition phase led to the launch of the first national WSUD conference in Melbourne in 2000, as well as the production of both state and national WSUD guidelines, as discussed later in this Section.

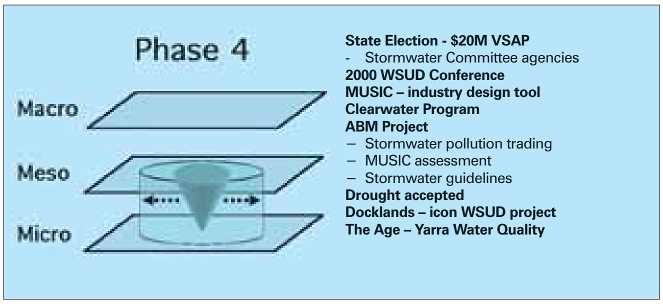


Figure 22. Phase 4 of the Transition: *Niche Stabilisation (2000-2006)*

The 1st National Conference on Water Sensitive Urban Design was hosted in Melbourne in 2000, sponsored by Melbourne Water, the CRCCH, the Australian Water Association, the Institution of Engineers Australia, and the Stormwater Industry Association[27]. The idea and planning for the conference was principally generated by the key champions involved in the Lynbrook Estate project. The aim of the conference was to bring practitioners, researchers and policy makers together to draw on their experiences and discuss key issues that support or impede the implementation of WSUD in urban catchments. The conference attracted over 170 participants representing a wide range of stakeholder groups from the development industry, government, and researchers that are involved in WSUD.

The conference also hosted an optional specialist workshop that examined case studies of WSUD and how the barriers experienced by practitioners could be overcome (Melbourne Water, 2000). The 2000 conference was well-received and was subsequently hosted in Brisbane (2002), in Adelaide (2004) and in Melbourne (2006).

The *Model for Urban Stormwater Improvement Conceptualisation* (MUSIC) (see Figure 23) was developed by the CRCCH as an industry capacity-building initiative for advancing WSUD initiatives, and was first released in 2001 for beta testing by Melbourne Water, Brisbane City Council and associated consultants. MUSIC is a software modeling tool which allows for the creation of alternative concept designs for managing urban stormwater, and for the benefits to be predicted, at a range of spatial and temporal scales. It was developed in response to the need for a more standardised and reliable approach by providing an agreed and uniform modelling basis for developers to demonstrate compliance with the urban stormwater quality performance targets as outlined in the Best Practice Guidelines and the SEPP. The algorithms in the model were drawn from the previous 10 years of research, including the monitoring results from the Lynbrook project. The algorithms were regularly updated to capture research outcomes from the CRCCH and three versions of MUSIC have been released since 2000 at a nominal charge to industry.

Melbourne Water supported the application of the MUSIC tool by industry, and released 'Guidelines for the use of MUSIC'[28] recommending input parameters and specifying the types of program output for determining compliance with developer agreements. Thus the use of MUSIC significantly contributed to

27. The outcomes of this conference are reported in Lloyd (2001), Water Sensitive Urban Design in the Australian Context – Conference Synthesis, Technical Report 01/7, Cooperative Research Centre for Catchment Hydrology.

the more efficient uptake of WSUD principles and practices. Of note, over 230 people attended the Melbourne launch and seminar on MUSIC which was an unprecedented level of interest and support shown by the industry for a new software tool. Owing to this substantial interest, the software was subsequently presented in Sydney, Canberra, Brisbane and Adelaide attracting a total of 685 seminar participants around the country. The support from Melbourne Water and Brisbane City Council was recognised as instrumental in generating the strong industry adoption of the model.

Figure 23. The *MUSIC* logo

In June 2000, the $22.4 million Victorian Stormwater Action Program (VSAP) was launched by the newly elected State Labor Government, and administered by EPA Victoria. The Labor Party's election platform in 1999 included this funding commitment, which was strongly encouraged through a range of innovative advocacy techniques by a couple of Melbourne's WSUD champions. The aim of the VSAP was to improve stormwater management in Victoria over the next three years to June 2003 (EPAV, 2005). As part of designing and administering this program, the senior management of the EPA wanted to strategically build on the technical work already done on stormwater pollution and focus on supporting initiatives that would lead to improved acceptance and uptake, particularly for local government. The EPA's background research revealed that within local government, there was developing interest at the officer level in the technical issues, but minimal awareness of urban stormwater issues amongst the locally elected representatives.

To address this need for broader inclusion and ownership, the EPA established the Victorian Stormwater Advisory Committee (VSAC) which had strong representation from: urban and rural councils (elected representatives rather than officers); the CEOs of the Municipal Association of Victoria, CMAs, and Melbourne Water; high ranking officers from planning and other agencies; as well as community and environmental group representation. This group was observed by some as the first group of champions for USQM at the decision-making level, rather than at the technical level within these major stakeholder organisations. The EPA worked with the VSAC members to prepare a multi-pronged strategy against which the $22.4 million program funds were allocated and distributed. The strategy was based on a model that focussed on building awareness, improving the knowledge base, providing a set of practical tools, and introducing mechanisms that were designed to maximise local government involvement, ownership and ongoing commitment.

The first of these mechanisms was the development of Stormwater Management Plans (SWMPs) that was partly funded by VSAP, requiring local government organisations to identify the priority sources of stormwater pollution in their municipalities and to prepare a plan to address these. The plan had to be signed off by the CEO and have council endorsement. A prime motivator for councils to do this was access to the $22.4 million of Government funding. They could not apply for funding to support USQM initiatives until they prepared and had EPA approval for their SWMPs. This action brought the issue before senior management and councillors of all councils in Melbourne, and Victoria, and required a formal commitment to action. At this time, it was considered that many local government organisations did not perceive USQM as their responsibility as it was typically considered then to be the responsibility of the State Government.

Another major program administration decision was to invite local government, via the Municipal

28. Melbourne Water also maintained that a variety of assessment tools could be used by the industry to demonstrate compliance with the stormwater performance targets (such as AQUALM, STORM and XP-SWMM modelling tools).

29. Details on the Clearwater program are provided at http://www.clearwater.asn.au/

Association of Victoria to submit a program for funding that would focus on delivering education, awareness building, training and engagement for local government. A significant proportion of VSAP's strategic budget supported a very successful initiative called the Victorian 'Clearwater Program'[29] (referred to as 'Clearwater'). This is an industry capacity-building program that was jointly funded between VSAP, Melbourne Water, the Stormwater Industry Association of Victoria (SIAV) and the Municipal Association of Victoria. Interestingly, many of the key players represented were associated with the inter-agency Stormwater Committee that identified the need for Clearwater, and proposed its design for addressing the growing demand for knowledge and skills for WSUD concepts within industry. The formal aims of Clearwater included providing education and training to local government and industry professionals on sustainable urban water management, and fostering partnerships across organisations and disciplines.

The Clearwater Program[30] delivered a range of capacity-building initiatives during this period. Such initiatives included a series of very popular bus tours that built on the success of CRCCH stormwater management course and associated technical tours conducted in the previous transition phase. These forums facilitated opportunities for industry/field inspections of practical WSUD projects, such as the Lynbrook Estate development, as successful examples of WSUD principles in practice (see Figure 24). Clearwater also identified other important capacity development needs across the sector for advancing WSUD across Melbourne, including the need for leadership training and getting organisations to showcase their 'secrets of success' for getting WSUD on the agenda within their organisations and implemented in practice (see Figure 24)

In 2002, construction commenced on Melbourne's prominent precinct development, the 'Docklands', by the then Melbourne Docklands Authority. This project included the redevelopment of 200

Figure 24. The Clearwater Program: Industry Capacity Building Events

A: Bus tour stop point – bioretention systems at streetscape scale
B: Field training – apartment block greywater recycling
C: Participants in one of the many seminar series held by Clearwater

30. Keath and White (2006) provide an overview of the Clearwater Program presenting the progressive evaluation results of the different initiatives implemented and how they influenced the learning needs of local urban water professionals.

Figure 25. Victoria Harbour, Melbourne

Figure 26. NAB Building Forecourt Wetland, Melbourne Docklands

Figure 27. Cremorne Street, Richmond, City of Yarra.

hectares of government-owned land – a former port and rail area – into a new inner urban precinct (VicUrban, 2004). The opportunity to develop the Docklands along the principles of WSUD came about through the advocacy of one of the WSUD champions from the CRCCH, at a workshop organised for the design of the Victoria Harbour precinct area.

The decision to incorporate WSUD features was made by the then developer before its merger with URLC and ultimate formation to VicUrban.

The Docklands development is considered a landmark feature of Melbourne's public space and a key demonstration site for innovative WSUD features (see Figures 25 and 26). It is interesting to observe the progress of the transition by contrasting this development to Lynbrook Estate, which is located at the opposite end of the socio-economic spectrum and was not initially intended to succeed in contributing to improved social amenity values.

Interviewees identified Kingston Council as a leading local government organisation for advancing the WSUD approach during this phase. In particular, the organisation's innovative 'road reconstruction policy' provides many examples of WSUD streetscape applications across the municipality from which concepts were adopted by other councils, such as the City of Yarra's Cremorne Street bioretention raingardens (see Figure 27). This policy has not only provided evidence of technology advancement, but is often expressed as an excellent example of institutional change for advancing the WSUD approach at the local government level. In addition, there have been several other local government organisations and groups that have emerged as leaders in WSUD during this period, including the Association of Bayside Municipalities (ABM), which comprised the 12 local government authorities around the perimeter of Port Phillip Bay.

Another scientific development during this phase was the work of the CRCCH on 'non-structural' USQM measures and reported in Taylor and Wong (2002 and 2003). This research involved significant industry involvement, and was later extended into aspects of life cycle cost analysis and triple bottom line assessment. This work was some of the first publicly reported research in Australia on these aspects of USQM.

In 2003, the 'Waters of Victoria' SEPP was updated and released by the EPA. This revised SEPP, titled

Protecting our Bays and Waterways, was accompanied by the finalisation of the draft Stormwater Agreement, which had been in development since 1997 and was eventually signed by the EPA, local government authorities and Melbourne Water. The SEPP and the partnership agreement aimed to address the issue of urban stormwater pollution entering the creeks and rivers that feed into Port Phillip and Westernport Bays (EPAV, 2003). This partnership outlined, for the first time, the formal acknowledgement of shared responsibilities between these organisations for improving the health of the waterways and bays and also outlined resolution measures in the event that they were required (EPAV, 2003). The Chairman of EPA Victoria stated that "this agreement provides a robust framework for coordinating urban stormwater management to achieve State Environment Protection Policy (SEPP) objectives" (EPAV, 2003).

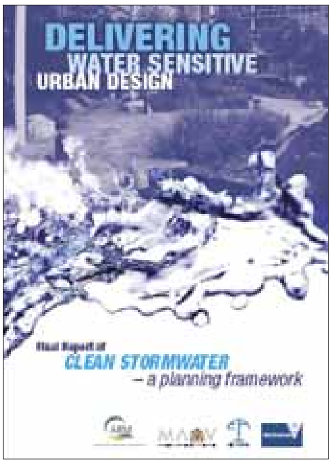


Figure 28. Association of Bayside Municipalities' *Clean Stormwater – a Planning Framework* (2004)

A relatively large-scale project titled *Clean Stormwater – a Planning Framework*[31] (see Figure 28), was being developed during this phase, designed to ensure that increasing growth and urban development has minimal impact on the Bay. Led by Bayside City Council and Melbourne Water, the federally-funded project was coordinated by the ABM councils, consultants Ecological Engineering, and Environment & Land Management Pty Ltd. The purpose of this planning framework project was to identify a means of using the statutory planning system to mandate WSUD in new urban developments, particularly redevelopment sites in existing urban areas. At this time, *Melbourne 2030* (a strategy for managing the future growth of Melbourne) was being developed, which involved some of the *Clean Stormwater* project design team. This strategic consolidation of the two initiatives with Melbourne Water fostered the development of a range of useful concepts, such as the scalability of stormwater treatment technologies, stormwater quality credits, and a planning framework for implementing WSUD in a consistent, transparent and equitable manner in both green field and brown field sites over the full range of development scales.

The *Clean Stormwater Framework* included the option of a market-based stormwater pollution offsets scheme as part of its overall planning. Under this scheme, the offsets could be assessed using a simplified rating tool based on meeting the urban stormwater performance curves derived using MUSIC for a number of standardised stormwater treatment measures. This initiative attracted unprecedented support from these local government organisations. The framework is still awaiting approval by the Minister for Planning as an Amendment to the Bayside City Council Planning Scheme so that the Clean Stormwater Planning Framework can be implemented. However, Melbourne Water, having the statutory capacity to implement the offset strategy, successfully launched its *Stormwater Quality Offsets Strategy* in 2005 to reduce pollution associated with urban developments. This strategy mandates the same simplified rating tool to be used to determine whether developers meet the best practice '80:45:45' targets for stormwater quality treatment in the catchments that Melbourne Water are responsible for, and determines an economic charge if targets have not been met (Melbourne Water, 2006c).

By 2003, the reality of the extended drought conditions in Victoria had been accepted politically. In 2004, the Victorian Government released the White Paper *Our Water Our Future,* and established the 'Stormwater and Urban Water Conservation Fund' to "support local scale

31. The Clean Stormwater: a planning framework project report (titled 'Delivering Water Sensitive Urban Design') was launched in December 2004 and is available at http://www.abmonline.asn.au/reports.cfm. The report provides a policy framework that can be incorporated into local planning schemes or broadly through the State Government's planning system. The project has shown that effective stormwater treatment can be achieved in virtually all forms of urban development, from single lot infill development, high density urban housing, through to larger green field sites.

innovative water sensitive urban development initiatives, stormwater conservation and water recycling initiatives across Victoria" (DSE, 2006c). Although the intent of these interventions was widely supported within the now rapidly-expanding WSUD community, there was significant disappointment at the time, expressed by industry champions, at the lack of emphasis on stormwater quality management. The White Paper and Fund were perceived as reflecting a political shift back to a relatively narrower water supply focus.

Engineers Australia (2005) highlighted that the White Paper needed to address a number of issues, including the desire to manage urban stormwater as a resource, continuation of the evolution of stormwater strategies to meet development growth, and that more extensive integration of water cycle management into urban design was required. Several interviewees felt that at this time WSUD faced a range of institutional risks associated with "quickly slipping off" the political agenda in the near future. Research by Ecological Engineering (2005), on behalf of the Victorian Government, also revealed how many of the local government practitioners that were involved in actively promoting the development of Stormwater Management Plans for their council were starting to feel unsupported, as the new strategic funding source (i.e. Stormwater and Urban Water Conservation Fund) was not permitted to fund stormwater quality management interventions associated with their new Plans, despite being encouraged to prepare them. This limitation is now partly being addressed through the *Yarra River Action Plan* funding launched in 2006, as discussed later in this Section. It is perhaps a testament to the achievements of VSAP, the key stakeholders involved, and the role of Melbourne Water in attempting to actively fill the breach and provide the momentum of past work, that this 'perceived' setback did not erode relationships or the will to keep the program going with base funding.

More recently, several industry guidelines have been produced. The City of Melbourne's Water *Sensitive Urban Design Guidelines* were produced in 2005

Figure 29. City of Melbourne's *Water Sensitive Urban Design Guidelines* (2005)

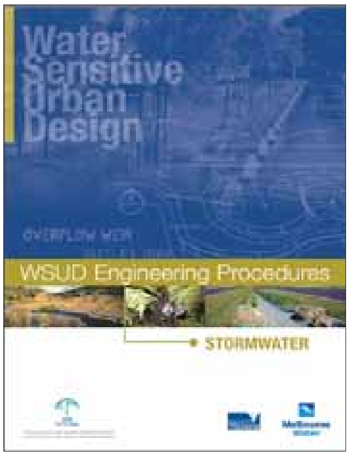


Figure 30. Melbourne Water's *Water Sensitive Urban Design Engineering Procedures: Stormwater* (2005)

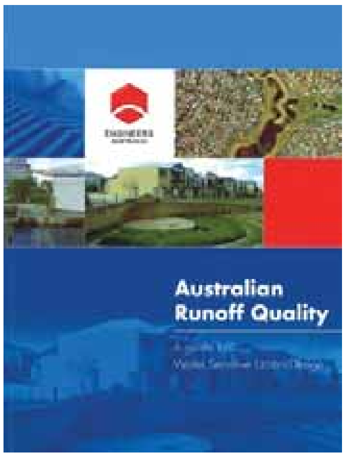


Figure 31. Engineers Australia's *Australian Runoff Quality* (2006)

(see Figure 29) addressing issues specifically relating to the local government adoption of WSUD and providing examples of opportunities for adoption across their municipality. Also in 2005, the *WSUD Engineering Procedures: Stormwater* manual (Figure 30) was produced by Melbourne Water, Ecological Engineering, WBM Oceanics and Parsons Brinkerhoff, to establish a consistent approach to WSUD throughout Victoria (Melbourne Water, 2005b). It was designed to give practical engineering guidance and included design and maintenance procedures, typical drawings, design checklists, landscape requirements, worked examples and case studies. In addition, the national guideline *Australian Runoff Quality: A guide to Water Sensitive Urban Design* was released in 2006 as an initiative of the Institution of Engineers Australia's National Committee on Water Engineering (see Figure 31). Over the last 10 to 15 years a number of the key champions across Melbourne have contributed to the science and writing of these guidelines. In late 2005, the CRCCH and CRCFE ceased operations and were succeeded by the much larger eWater CRC (CRCCH, 2006).

Currently, there is a well-stabilised USQM niche that has been the beneficiary of capacity-building initiatives and a number of other local strategies and innovations. For example, in the recent launch of the *Yarra River Action Plan* (2006) $20 million was allocated to build the capacity of local government authorities within Melbourne. It included an allocation of $10 million to four councils in the lower Yarra River region, for the implementation of new WSUD projects, and aimed to foster better relations between local government authorities and the Victorian Government (DSE, 2006b)[32].

The International WSUD Conference series was hosted in Melbourne again in April 2006 (Deletic and Fletcher, 2006) and involved the presentation of 156 papers, and attracted 405 participants with over one third of participants from overseas.

The WSUD concept gained international awareness through the establishment of an International Working Group on WSUD in 2005, under the auspices of the International Water Association and the International Association of Hydraulic Research. This international recognition wsa also evident in the recent enquiry and visit to Melbourne by the United Kingdom's House of Lords' Science and Technology Committee to learn from Melbourne's experience as a leader in addressing urban water issues. The nation of Singapore is now embarking on an ambitious programme of developing a WSUD framework for the metropolitan area of Singapore in conjunction with their scheme to harvest urban stormwater from a third of the metropolitan area through the conversion of Marina Bay from a marine environment to a water supply reservoir. Institutionalising WSUD in the metropolitan area is an essential element of their strategy in securing the water quality of the Marina Bay reservoir.

At the national level, recent Australian Government policy positions associated with the National Water Initiative, and the Urban Water Reform process, make reference to the 'Water Sensitive Cities' initiative.

Notwithstanding the positive momentum, there appears to be (as identified by the majority of the interviewees) a significant level of resistance to change, particularly at the local government level. Moreover, a perception exists that the coordination of WSUD is lacking at the State level and between State and local government. However, the relative maturity of this change trajectory and USQM niche was demonstrated through the formalisation of two consecutive initiatives designed to institutionalise stormwater quality treatment practices across Melbourne. The first of these was Melbourne Water's introduction of a market-based 'Stormwater Quality Offset Strategy' in July 2005. This Strategy provides a mechanism for Melbourne Water to require

32. The Age media campaign during 2005 highlighted the poor quality of the Yarra River, and a number of incidents where recreational users of the Yarra had allegedly fallen critically ill after coming into contact with the water were reported. The inference was that the kayakers were affected by a faecal-borne disease related to the sewerage system. This campaign generated enough attention to encourage a political response from the Victorian Environment Minister John Thwaites, with an announcement of a $300 million total investment package to address this problem, with $20 million specifically dedicated to the stormwater pollution reduction program within the Yarra River Action Plan in early 2006.

33. 80% of the suspended solid annual load, 45% of total phosphorus and 45% of total nitrogen annual loads associated with urban stormwater runoff are to be retained. More information on Melbourne Water's strategy can be viewed at: http://ouryarra.melbournewater.com.au/content/melbourne_waters_vision/improving_our_rivers_and_creeks/stormwater_quality_offsets.asp

developers to meet best practice stormwater quality treatment objectives[33] by either implementing best practice treatment measures onsite or by contributing an offset payment for works undertaken elsewhere in the catchment. The contribution funds a rolling annual program of regional water quality works. By meeting all or part of the onsite performance objectives, a developer's water quality contribution can be reduced.

The second policy initiative was the Victorian State Government's amendment to Clause 56 of the Victorian Planning Provisions. As set out in DSE (2006, p1), it 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, and*
- *use best practice water sensitive design techniques to conserve, reuse and recycle water and manage the quality of stormwater run-off* [34].

Towards the end of this transition period there are also observed changes in the disciplinary composition of the scientific community, which can be characterised as the mainstream introduction of the social sciences alongside the well-placed engineering and natural sciences. An example of this includes the recently established program at Monash University called the *Facility for Advancing Water Biofiltration* (www.monash.edu.au/fawb/) which is an integrated research initiative that focusses on both technology development and the social and institutional processes to advancing technology adoption. Another example is Monash University's *National Urban Water Governance Program* (www.urbanwatergovernance.com), principally funded by the urban water industry, which focusses on investigating how to improve institutional capacity and urban water governance at a metropolitan scale. While these recent programs and initiatives appear to be addressing the central challenges within the urban water industry, their outcomes are yet to be realised and cannot be measured in terms of their influence in advancing the WSUD transition. Importantly, however, they maintain strong links with many of the key individuals that have USQM champions over the last 10-20 years.

4.6. Reviewing the Transition Process: A Summary

This Section briefly reviews and summaries the four transition phases, as presented in Sections 4.2 to 4.5 and comments on the overall architecture of the transitioning process (i.e. the linkages between each transition phase) from a transition theory perspective as shown in Figure 32. The analysis of key factors that have underpinned this USQM transition to date is presented in Section 5 and a proposal of how to complete this transition is presented in Section 6. While the USQM transition is yet to reach completion, this analysis essentially reveals a process on how a new set of values relating to the environmental protection of waterways has been institutionalised across metropolitan Melbourne over the last 40 years.

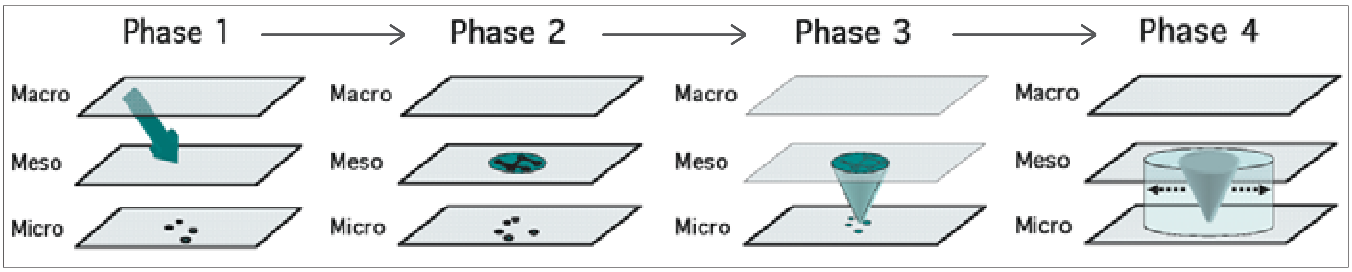


Figure 32. Transition Architecture of USQM across metropolitan Melbourne

34. All new residential sub-divisions must achieve the best practice stormwater performance objectives, in addition to a 70% reduction of the typical urban annual litter load. More information is available at: http://www.dse.vic.gov.au/CA256F310024B628/0/B94519854FA94273CA257213000126AD/$File/VPP_Clause_56_4-Intwaterman.pdf33.

From an institutional perspective, the progress of this transition has occurred over a relatively short period given what is already understood about transitioning periods (see Geels, 2002; Geels, 2004). While it is difficult to confirm the exact starting point of the seeding activity (presented in this report as the mid 1960s) underpinning the initial change process, the subsequent processes leading to the niche stabilisation have occurred within a relatively rapid timeframe between 1990 and 2006. Notwithstanding this positive transitioning momentum, as discussed in Section 6, there is still more work to be done so that USQM becomes mainstream practice for all stakeholders. The following discussion briefly outlines the transitioning between each of the four phases as identified in this case analysis.

The early macro-level shift in *Phase 1* (1965-1989) was critical to the destabilisation of the then traditional waterway management approach seeded by the rapidly growing social activism that challenged the government to improve the protection and rehabilitation of waterways and their passive recreation opportunities. This macro-level change stimulated a number of key events and developments that seeded the USQM transition, however, the community and other stakeholders still generally perceived urban stormwater as a flooding nuisance and implicitly environmentally benign at this time.

In response to this macro-level change, *Phase 2* (1990-1995) involved the development of a new institutional working space between key stakeholders within the existing meso-level (or institutional regime) as well as the innovation of new activities and technologies at the micro-level. It is important to note that this new activity acted as a 'protective' space (principally the relationship between Melbourne Water and the CRCs) with the focus on advancing learning and shielding the emerging research and associated technologies (such as gross pollutant traps and stormwater treatment wetlands) from the then mainstream priorities.

Phase 3 (1996-1999) witnesses the formation of the USQM niche, with a strong and active connection between key stakeholders at the meso-level, and the technological research and development activities at the micro-level. The 'protective space' at the meso-level had expanded with new relationships and coordination extended (through the leadership of individuals within Melbourne Water and the CRCs) to include developers, planners and some local government authorities.

The formation of the niche was collectively galvanised through the establishment of the nitrogen target and the subsequent creation of the stormwater inter-agency committee, the production of best practice guidelines that were incorporated into policy, rapidly emerging science and its practical demonstration (such as the Lynbrook Estate project), and additional strategic funding opportunities. It is important to note that during this period, the language of USQM was being reframed to the language of WSUD.

Phase 4 (2000-2006) witnesses the stabilisation of the USQM niche attracting important mainstream institutional legitimacy, meaning that it is it now recognised, but still not fully integrated into the mainstream priorities of all dominant stakeholders at the meso-level such as all local government organisations across Melbourne. The stabilisation of the niche was supported through a range of initiatives such as: a strategic state-wide funding source dedicated to funding stormwater quality management practices; the development of a 'deemed-to-comply' assessment tool (MUSIC) for designers, planners and regulators; the launch of the first national WSUD conference series; the production of local, state and national guidelines; an innovative market-based offset scheme, and dedicated industry training. The amendment to *Clause 56: Residential Subdivision* of the Victoria Planning Provisions and all Planning Schemes, under *Melbourne 2030*, in October 2006, provided the final component to the stabilisation of this USQM niche.

The outcomes of this case analysis strongly suggest that the effective progress with advancing USQM has been highly dependent on the activities relating to the nurturing of this USQM niche. While it cannot be confirmed at this point in time, it is likely that Melbourne may be entering the beginning of a new transition phase, involving the diffusion of the USQM niche across the meso-level through strategic institutional reform efforts. From a transition theory perspective, the stabilisation of the niche is not only very difficult, but a critical ingredient to substantially improving the chances of mainstreaming a new practice (or in transition language 'enabling a system-wide lock-in across the Multi Level Perspective (MLP)').

For a niche to be stable it needs to be able to withstand threats, such as the dominance of other priorities and sectoral issues that may arise, resulting in the redirection of limited resources (and sometimes professional interests) away from the focus of the niche. In this case, the phenomenon of drought (a macro-level driver) currently experienced across the nation, and the associated increased focus on alternative water sources and the recycling agenda, could be considered as presenting such a threat, as it essentially reinforces the already well-entrenched institutional value of providing water supply security. However, in Melbourne the USQM niche, perhaps in contrast to some of the other cities across Australia, has managed at this point to maintain its legitimacy and relative resource attention at this stage.

5. KEY TRANSITION FACTORS: INGREDIENTS FOR CHANGE

The four phases of Melbourne's transition, as described in Section 4, demonstrate the significant progress that has been made over the past 40 years towards mainstreaming the WSUD approach for addressing poor waterway health. While the USQM transition is still not complete (see Section 6), this case analysis provides an example of an ongoing and effective reform agenda in the absence of an overriding macro-level driver (which is the case for many sustainability initiatives). Therefore, this section is focussed on determining the key transition insights for enabling effective change within this context, using the analysis of the Melbourne case study and the transition factors, or 'key ingredients' that have underpinned this change so far. It is hoped that this will contribute important insights for urban water managers and policy makers in their efforts facilitating the successful mainstreaming of the WSUD approach. The following sections present the three key themes identified from the analysis, i.e. the 'transition interplay', the 'role of champions' and the 'enabling context variables'.

5.1 The Transition Interplay: Resilience and Institutional Learning

The case study analysis reveals that there has been a critical, and in many ways opportunistic, *interplay* between the 'champions' and the 'enabling context' that provided the ongoing catalyst, as well as structuring force, for the transition thus far (see Figure 33). It is proposed here that this *interplay* has been a vehicle for addressing, and at times significantly minimising, many of the anticipated and experienced impediments to change as outlined in Section 2.1.

For example, there were a number of significant events that could have substantially hampered the transition process, which were vulnerabilities or risks that were overcome through this *interplay* between champions and the enabling context. Some of these included:

- The corporatisation of the water sector across Australia, involving the introduction of efficiencies and outsourcing of non-core business which could have potentially included urban stormwater quality management. During the early 1990s, the USQM agenda lost some of its institutional status and attention, and the work of local champions and the CRCs were significant in keeping it on the agenda,
- Local government resistance to approving the implementation of the USQM features in the Lynbrook development, resulting in Melbourne Water responding by underwriting the potential financial liability of the project if it did not perform to design, and
- The recent extended drought conditions across Australia shifting the political focus away from urban stormwater and waterway health to the issue of providing water supply security.

  The previous scientific and policy development work, combined with the activism of local champions, has so far ensured that USQM has maintained its significance.

Figure 33. The Transition Interplay in the Melbourne Case Study

It is proposed here that this interplay provided a level of resilience to the risks of transition losing its momentum. For example, the operation of the CRCs as science-management bridging organisations allowed for trust to evolve between key organisations to the extent that Melbourne Water underwrote the risk of constructing the Lynbrook Estate project. The activism of key industry champions at both the project and executive levels ensured that research, and the application of research findings, in urban stormwater was well supported during the corporatisation phase and more recently during the

35. As reviewed by Taylor (2007), the literature on 'champions of innovation' distinguishes between two types of champions that may exist within organisations. These include the 'project champions' and 'executive champions'. The 'project champion' acts as a change agent on a daily basis within an organisation or broader institution, at any organisational level, and relies on personal forms of power. In contrast, an 'executive champion' is an executive who has influence over the resource allocation process and uses this power to channel resources to a new technological innovation, thereby reducing the risk of the project. Executive champions do not normally promote innovations on a daily basis and often act in tandem with project champions.

redirection of government attention to drought. However, the role of champions alone does not explain this resilience, as the interaction with the enabling context has allowed for a strong undercurrent of 'continual institutional learning' and the nurturing of 'multi-sectoral partnerships' throughout the Melbourne transition.

The analysis reveals how the 'institutional learning' was self-reinforcing. Local champions were responsible for progressively transferring the insights from the rapidly evolving science (e.g. water quality indicators and stormwater treatment technologies) into policy areas that they anticipated would drive practice more expediently (e.g. linking the 'blue book' to the SEPP or linking the stormwater performance objectives to Clause 56 amendments). Different opportunities (such as Commonwealth Government grants) provided the enabling context for champions to cause action that advanced the transition. Conversely, the case study also reveals how champions drove the 'enabling context' through actions such as delivering effective industry training and learning opportunities, and being catalysts through strategic advocacy for important demonstration projects, such as Lynbrook Estate. While many of the on-ground successes would not necessarily have been achieved without a number of committed individuals and organisations strategically weaving in and out of the transition context, it has been the 'enabling context' that has shaped, constrained and provided the opportunities for these champions' transitioning aspirations.

Given the above discussion, it is clear that it is difficult to artificially separate the role of the 'champions' from the 'enabling context' when assessing and determining the key factors that have underpinned the Melbourne transition. This interplay between 'champions' and the 'context' is crucial to understanding how this transition pathway has evolved. Notwithstanding this interdependence, the following two sections further explores the attributes of the 'champion' and 'enabling context' phenomena as essential ingredients of the transitioning process.

5.2 Role of Champions: Key Qualities

The case study findings identify what could be considered as the legacy of a committed and innovative group of associated champions who have focussed on driving the transition. These individuals largely started out as project-level champions and have progressively gained more influence as they have become a mix of senior project-level and executive champions[35] across government, academia and the market. Interestingly there has been ongoing interaction between these champions from across these sectoral organisations over the last two decades, as they have intermittently moved in and out of loose and close networks depending on the USQM project and/or initiative at the time. It is also important to note that some of these champions were interacting before there were more formal means for the interaction associated with the establishment of the CRCs and more formal USQM policy positions.

While this section reports only on observed and highlighted champion attributes revealed during the data collection and analysis, it is noted that there is an established body of literature on leadership theory, see for example Ottaway (1983) and Howell (2005). However, as highlighted by Taylor (2007), this is yet to be applied in any substantial way to the urban water field. Therefore, detailed testing of these champions' personality traits and leadership characteristics was not conducted in this research. Notwithstanding this, during the case study there were a number of strong and common themes that emerged which provide indicative insight into these champions' attributes and disposition as is generally perceived by many of their colleagues in this area. This information emerged from the multiple sources of evidence collected including the oral histories, focus groups and workshops where the role of key champions were continuously highlighted and discussed by participants (including fellow champions) as key drivers for Melbourne's transition.

35. As reviewed by Taylor (2007), the literature on 'champions of innovation' distinguishes between two types of champions that may exist within organisations. These include the 'project champions' and 'executive champions'. The 'project champion' acts as a change agent on a daily basis within an organisation or broader institution, at any organisational level, and relies on personal forms of power. In contrast, an 'executive champion' is an executive who has influence over the resource allocation process and uses this power to channel resources to a new technological innovation, thereby reducing the risk of the project. Executive champions do not normally promote innovations on a daily basis and often act in tandem with project champions.

Table 2. Qualities of Champions involved with the Melbourne USQM Transition

NO.	KEY VARIABLES	DESCRIPTION
1	**Vision for waterway health**	A 'common vision' for protecting waterway health through pursing a largely cooperative, rather than directive, approach for enabling change.
2	**Multi-sectoral network**	A network of champions interacting across government, academia and the market.
3	**Environmental values**	Strong environmental protection values with a 'genuine' agenda for improving Melbourne's waterways
4	**Public good disposition**	An orientation to advocating and protecting 'public good'
5	**Best practice ideology**	Being more pragmatic and finding ways to help industry implement best practice thinking
6	**Learning-by-doing philosophy**	Wanting to foster and trial new ideas, and valuing the rapid adoption of ongoing scientific insights
7	**Opportunistic**	Continually thinking ahead and creating opportunities through strategic advocacy and practice
8	**Innovative and adaptive**	Prepared to challenge the status quo, and concentrating efforts using an adaptive management philosophy

Table 2 presents a tentative list of the eight broad 'qualities' that emerged from the case analysis, and are proposed as being collectively instrumental to the role of a successful USQM champion, this is followed by a discussion of these qualities in relation to the case study.

The data analysis suggests an implicit 'culture' (or common philosophy) pertaining to this group of champions which is defined by a commitment and shared 'common vision' to pursing a largely cooperative, rather than directive, approach for enabling change. This also reflects their shared perspective that if an initiative is to be promoted it must be amenable to a 'best practice' ideology, meaning that there must be readily available and codified information that simply spells out what needs to be done as part of a development activity or planning process. Therefore champions seemed to place a high level of emphasis on promoting action that was practical, measurable, and amenable from the perspective of the market (particularly land developers) and local government agencies.

This disposition towards advocating for a best practice approach was reflected by initiatives such as the Lynbrook Estate project, which was facilitated by the alternative scientific 'adaptive management' model or 'learning-by-doing' approach. The high level of interaction, trust and shared vision that developed between different champions across the multiple sectors (in particular Melbourne Water employees, scientists within the CRCCH/CRCFE and the developer), resulted in Melbourne Water underwriting the potential financial loss of replacing the project with the conventional drainage infrastructure if the project did not perform to its agreed design specification. In addition, the commitment and outlook of key CRCCH and CRCFE scientists who saw significant value in rapidly implementing and sharing their emerging scientific thinking was significant. This presented an alternative to the traditional scientific model, where science would be expected to be subject to many more years (decades perhaps) of validation testing before being promoted for adoption. Therefore, the combination of a common philosophy, a shared commitment to advancing practical change, and a 'learning-by-doing' approach valued by industry champions appears to be instrumental to facilitating the transition process.

It is important here to acknowledge the ongoing role of Melbourne Water as an 'organisational champion' in this transition, particularly post-1995. The structural reforms between 1989 and 1995, which included the merger with the Dandenong Valley Authority (DVA) and the separation of retail water supply and sewage functions, assisted greatly in elevating the organisational priority and attention to USQM. The merger with the DVA led to internal diffusion of innovative thinking and experiential knowledge of the former DVA staff. This, in combination with the activism of existing project level champions in Melbourne Water and bold executive leadership for USQM within the organisation, proved to be essential in affecting and transforming the culture of the organisation. This led to a very proactive interpretation of their legislative base with respect to urban stormwater management, and the pursuit of being a leader in this field.

Today, Melbourne Water is relatively unique across Australian cities, being a State government-owned organisation that includes regional stormwater and waterways responsibilities. The organisation is acknowledged for its dedicated leadership, resource allocation and proactive interpretation of their formal accountabilities in relation to urban stormwater management. As discussed in the next section, Melbourne Water as an 'organisation' is identified as an important bridging agent for other organisations across all relevant sectors. For example, Melbourne Water's urban wetlands project, partly funded by the NHT in the late 1990s, supported collaborative research on wetland design and management by the CRCs with an implicit objective of encouraging developers to integrate treatment wetlands in subdivisions. Melbourne Water's corporate approach to this responsibility for technology transfer, capacity building of local government authorities and the industry, and initiation of numerous other strategies to promote WSUD, was instrumental to niche formation and stability. Had Melbourne Water as an organisation adopted a more compliance-focussed business model, as opposed to the current 'influencer' role they play, the formation of the USQM niche would have most likely experienced increased disruption and vulnerability and may not have transitioned as far as it has today.

The presence of this unique 'organisational champion' or bridging agent may be a key reason for Melbourne's comparatively advanced location within the WSUD transition. Fundamentally, much of the good research and effort undertaken by individual industry champions may never have resulted in such successful change had it not been supported by the organisational power of Melbourne Water. For example, only Melbourne Water had the power to impose conditions on developers and reject subdivisions on the basis of failure to meet best practice targets. The collaborative relationship between Melbourne Water and the research fraternity created an environment where the researchers were able to understand the tools Melbourne Water needed to improve stormwater outcomes, and hence, further facilitate the opportunity for some of the individual champions to be effective.

It will be interesting to observe whether professional power struggles between disciplinary groupings within the broader urban water community start to arise in the near future as many of these champions (and the urban stormwater professionals more broadly) are starting to actively encroach into the water reuse and other fields within the broader WSUD agenda. This is because moving into this space requires working with the ideology and priorities of the water supply and sewage professional communities that are now starting to move towards an integrated urban water management approach. These other professional groupings have traditionally been governed by the values of water supply security, public health and economic efficiency, rather than the prominent set of environmental stormwater-related values that have, so far, largely underpinned the focus of champions in this case study.

5.3 The Enabling Context: Key Variables

In addition to the 'champions', as discussed in Section 5.2, the transition was co-dependent on a range of enabling context variables. While there were numerous aspects about the social, physical, technical, institutional and economic contexts that enabled the transitioning process thus far, it was the eight variables listed in Table 3 that emerged throughout the data analysis and validation processes as the most significant to the formation and stabilisation of the USQM niche. While each variable is essential to the transition process in its own right, it is the 'package' of variables, in interaction with champions that is likely to represent the necessary ingredients for niche building and stabilisation within transitioning processes.

While, it is important to highlight that these context variables were interconnected, there did not appear to be an overriding sequence or ranking of importance between them. However, there did appear to be a temporal relationship between some. For instance, the existence of *socio-political capital* around the condition of waterways stimulated *market receptivity,* where 'early adopter' land development organisations in the late 1980s and early 1990s sought to incorporate water quality treatments to protect the new water features of their developments. Establishing the 'binding target' of reducing nitrogen loads to Port Phillip Bay by 1,000 tonnes from the 1993 levels, was a catalyst for both seeking and attracting *strategic funding* (such as the NHT and VSAP investments), as well as being a galvanising rationale for enabling *demonstration projects and training.*

While there does appear to be an indicative temporal relationship between some of these variables for the Melbourne case, without comparative case studies, the significance of this or any other particular relationship sequence cannot be verified. What appears most certain from a context perspective is that there needs to be a 'problem' in the first place to stimulate action and maintain attention on the transition process. For the Melbourne case, this attention was linked to waterways with the most prominent including Port Phillip Bay and the Yarra River.

Even without the advantage of direct comparative case analysis at this stage, it is anticipated that these 'enabling context variables' cover the breadth of the transitioning process to niche stabilisation and they should be considered by urban water strategists as a 'package'. Therefore, when analysing the scope of transitioning in other cities and places, these context variables could be used as a tool for diagnosing where the transitioning deficits are, and help direct change programs to build these capacities. For example, in the Melbourne case, Brisbane City Council joined the CRCCH and worked with Melbourne Water and research scientists with the objective of transferring the 'trusted and reliable science' and associated technologies that were produced in Melbourne to the Brisbane context, as this was their key capacity deficit to advancing the USQM transitioning process across Greater Brisbane.

The eight enabling context variables are discussed next, briefly drawing from aspects of the case study to demonstrate their significance in the Melbourne transition. It is important to highlight the significance of the 'interplay' with champions when considering each enabling context variable. Some variables such as socio-political capital and market receptivity enabled champions to emerge, while other variables such as bridging organisations and demonstration projects and training were enabled through the work of champions. Overall, each of these variables in one way or another contributed to enabling champions, and champions contributed to enabling and reinforcing the context variables.

Table 3. Enabling Context Variables for the Melbourne USQM Transition

NO.	KEY VARIABLES	DESCRIPTION
1	**Socio-Political Capital**	Aligned community, media and political concern for improved waterway health, amenity and recreation.
2	**Bridging Organisation**	Dedicated organising entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry.
3	**Trusted & Reliable Science**	Accessible scientific expertise, innovating reliable and effective solutions to local problems.
4	**Binding Targets**	A measurable and effective target that binds the change activity of scientists, policy makers and developers.
5	**Accountability**	A formal organisational responsibility for the improvement of waterway health, and a cultural commitment to proactively influence practices that lead to such an outcome.
6	**Strategic Funding**	Additional resources, including external funding injection points, directed to the change effort.
7	**Demonstration Projects & Training**	Accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives.
8	**Market Receptivity**	A well articulated business case for the change activity.

1. 'Socio-political capital': is the presence of a significant concern expressed by the community and media, and acted upon by politicians, for improving waterway health, amenity and recreation. This has continually evolved and been self-reinforcing, while it may have seeded the initial action, its evolution has sustained the progression along the transitional pathway. The start of this progressively built capital is evidenced by the early community activism around urban development (for example, *Port Phillip Bay: The Case for Alarm)* and media campaigns for improving the Yarra River (for example, *Give the Yarra a Go!)*. This capital was later reinforced through initiatives such as the construction of the Yarra trail network, because it brought the community even closer to the waterways. This capital is also evident through the strategic activism of champions in government lobbying for strategic funding leading to the construction of large-scale wetlands through to the funding of professional training programs. Port Phillip Bay and the Yarra River are the iconic waterways of Melbourne and have been the focal point for this activity and energy. This socio-political capital is significant as it provided the 'informal' impetus for action and maintaining pressure on government for protecting and enhancing Melbourne's waterways.

2. 'Bridging organisation': a bridging organisation is an entity that brings key stakeholders from multiple sectors together and facilitates collaboration and learning, including science and policy, agencies and professions, and knowledge brokers and industry. The formation of the CRCCH and CRCFE in the early 1990s, as part of the Commonwealth initiative to build relationships and partnerships between industry and academics through Cooperative Research Centres (CRCs), acted as important bridging units for facilitating new science/policy relationships around stormwater quality management. These CRCs had a 'public good' approach, which implicitly supported the adaptive scientific approach focussed on rapid adoption of science that met industry needs through implementation, training and capacity-building. Melbourne Water was a critical bridging agent through its participation in the establishment of the CRCs, contributing to the nature of the CRCs' research agendas and being ready to implement research insights and recommendations. The later, and separate formation of the interagency Stormwater Committee in 1996, was an additional bridging organisation assisting the ongoing development of a policy network across government and professional associations providing the initial vehicle for diffusing the scientific and technological insights from the CRCs into a policy framework. These bridging organisations were significant in building influential partnerships, creating a space of trust between managers and scientists, and identifying needs from a multi-sectoral perspective that assisted in building industry receptivity and commitment to best practice targets.

3. 'Trusted & Reliable Science': is the availability of scientific expertise and knowledge considered to be reliable and effective, leading to its ready application through technology and associated processes in practice. In the Melbourne case, scientists within the CRCCH and the CRCFE had the scientific and technical expertise to investigate, develop and/or refine a number of USQM issues. This resulted in providing the science to support a number of treatment technologies (such as GPTs, constructed wetlands, bioretention systems), and the development of a tool (MUSIC) that assisted practitioners with conceptualising the combined implementations of these techniques and regulators with assessing compliance for meeting urban stormwater quality performance targets. The significance of this context variable is highlighted when considered in light of the 'bridging organisation' previously discussed.

While the bridging organisation of the CRCs provided good support through financial and human resources, it also created an important level of 'trust' between these managers and the scientists. Therefore, it helped expedite the work of the scientists and further improve technology transfer and adoption, as evidenced by the series of national industry awards highlighted in the previous sections. An example of this trust is evidenced by an event in 2003, when a "bug" was discovered in the MUSIC software. While the CRCCH was rapidly undertaking a detailed investigation to correct the bug, Melbourne Water immediately issued an advisory statement to the broader industry to reaffirm their confidence in the software and that strategies previously developed with the software (containing the bug) would remain acceptable to Melbourne Water, although development proponents were advised to examine the implications of the bug on their WSUD strategy and the expected environmental performance.

4. 'Binding Targets': are targets that are scientifically informed, but stated in a policy framework. They are measurable and effective when they can 'bind' industry to a certain standard of practice. The scientific outcomes of the 1996 *Environmental Study of Port Phillip Bay* were communicated with a clear, unambiguous policy message to reduce annual nitrogen loads entering the Bay to 1,000 tonnes less than 1993 levels. As evidenced in the case study, this 'binding target' was a galvanising force for USQM activity. It was formally adopted by the Victorian Government with the decision, as advised by Melbourne Water, that the 1000 tonnes target be attained by reducing the annual nitrogen loads from urban stormwater by 500 tonnes from 1993 levels, and by reducing 500 tonnes of nitrogen discharged from the Western Treatment Plant from 1993 levels.

This binding target also contributed to enhancing the already developing business case for including water features in developments, by encouraging the application of wetlands and other stormwater treatment technologies to minimise nitrogen. Therefore, this binding target was a 'formal' impetus for action around the implementation of more water-sensitive developments across Melbourne. The setting of this higher order policy target also seeded the work behind the setting of the scientifically informed urban stormwater quality performance objectives (i.e. the '80:45:45' target) which were translated into a policy setting through the Stormwater Committee's publication of the Best Practice guidelines and later through the Clause 56 amendment.

5. Accountability: is an organisation's formal responsibility to the improvement of waterway health and a cultural mandate for influencing practices that led to such an outcome. The case study reveals that Melbourne Water's accountability for USQM arises from a proactive interpretation of their legal obligations[36] combined with the view that the management of urban stormwater issues are beyond any single local government boundary. Melbourne Water being a State-owned entity also allows for generating an income from the rating base to contribute to developing and implementing USQM practices. It is important to note that with this disposition to accountability, Melbourne Water's commitment in this area reflects an organisation that acts as an 'external influencer' across the industry rather than a compliance-focussed organisation. This accountability provided the impetus for the subsequent initialisation and support for important opportunities for demonstration projects (for example, Lynbrook Estate) as well as driving the establishment of State policy and regulation.

The incorporation of stormwater quality performance objectives in the SEPP and Melbourne 2030 policy positions, in combination with the other enabling context variables, laid the ground work for the later amendments to the Victorian State Government's Clause 56 obligations (as set out in the Victorian Planning Provisions) to strengthen the language in the clause that mandates the attainment of the urban stormwater best practice quality targets in all new residential developments. This is the most formal example of imposing (rather than proactively seeking) accountability on stakeholder organisations.

6. 'Strategic Funding': is the key injection of money that provided dedicated funding for critical research, technology development and a range of projects throughout this transition. There have been two types of strategic funding that have supported this transition. They are external resources and grants, and an 'internal' organisational-based strategic fund. The 'external' resources (recognising that external grants always require a level of co-investment by the proponent) were principally injections of Commonwealth and State Government grants which have been reasonably continuous throughout the transitioning period. The Commonwealth funds supported strategic projects including the bicentennial funding of the Yarra trail network and the NHT funding for the construction of stormwater treatment wetlands in the 'Catchment of the Future' project. These projects were instrumental to advancing the transition by contributing to the improved 'socio-political capital' as well as the professional momentum that was starting to build around stormwater quality treatment technologies. Investment through the CRCs into the research on wetlands, GPTs, and other USQM technologies has also been critical to the transition and enabling 'trusted and reliable science'. The Victorian Government funds, such as the $22.5 million pledged for the VSAP, and the $20 million directly allocated from the *Yarra Action Plan* to USQM have been instrumental in raising attention and skills in local government and other stakeholder groups for USQM.

The 'internal' strategic funding for USQM was achieved through the incorporation of USQM in Melbourne Water's drainage charges in 1997, and further enhanced through the innovation of Melbourne Water's Stormwater Quality Offsets Scheme in 2005. The strategic injection of 'external' resources throughout the transition process proved critical to mobilising USQM action. However, the 'internal' strategic funds have protected the niche from vulnerabilities associated with the 'boom and bust' trajectory that can be created by short-lived 'external' grant programs. Therefore these resource types have collectively provided a strategic funding base for Melbourne's transition so far.

36. It is important to note that when considering a strict definition of 'accountability' that presently there are no independent third-party auditing systems in place.

7. 'Demonstration Projects and Training': demonstration projects provide real examples of innovative technologies in practice, giving industry access to the design, construction and maintenance processes and the associated problems that can be experienced. Training programs provide the means to further diffuse this knowledge. A key demonstration project in Melbourne is Lynbrook Estate, which links WSUD technologies in a treatment train at the streetscape level. Lynbrook Estate was initiated by a group of champions that wanted to build the industry's knowledge and understanding of the technologies and their implementation.

The CRCs and Clearwater ran a series of strategic training programs, to further diffuse the knowledge of the scientific concepts, which capitalised on the interest from industry generated by the success of Lynbrook Estate. The development of successful demonstration projects and associated capacity-building programs, such as Clearwater, was a key factor in not only creating industry legitimisation of the scientific concepts of WSUD, but also assisted with building the market receptivity for meeting the policy target of reducing annual nitrogen loads from catchment sources.

8. 'Market Receptivity': is a clearly defined business case for the niche, which drives the change activity. The market success of Lynbrook Estate provided a business case in Melbourne for USQM features in residential developments at the streetscape level. Due to the existing 'socio-political capital', a few developers were starting to act upon homebuyers' preferences for water features, such as lakes, in their developments by the early 1990s. However, witnessing the transformation of the Lynbrook Estate project from the URLC's worst-performing estate to their best-performing estate, in terms of sales, provided an important marker to the land development industry of the financial value of integrating USQM streetscape features into developments. They also had the additional investment benefit of protecting the health of their water features. This receptivity was further evidenced by the incorporation of USQM and stormwater harvesting and reuse features in Melbourne's prominent Docklands development. Market receptivity and the business case were essential for diffusing the implementation of USQM practices, and were further enhanced by the UDIA's awards scheme for WSUD design excellence, distinguishing these development attributes as a point of difference and quality in the land development sector.

6. COMPLETING THE WSUD TRANSITION FOR MELBOURNE

It is unlikely that the WSUD transition for Melbourne will be fully locked-in until the broader WSUD reform agenda has been stabilised. The purpose of this section is to project the pathway for strategic planning so that both the USQM and the broader WSUD transition can be expedited across Melbourne. More generalised insights for urban water strategists and others are presented in Section 7.

6.1 The Next Transition Phases: Diffusing the Niche

Drawing from transition theory, it is anticipated that at least two more transition phases (Phase 5 and Phase 6) are required before the USQM niche is fully diffused across the MLP (as shown in Figure 34). Moving from the current phase (Phase 4) of 'niche stabilisation' into 'Phase 5' will require an explicit focus on realigning the meso-level to support mainstream diffusion of USQM practices across all players involved in water and land management. This will need to be supported by all relevant stakeholders involved in the design and implementation of new policy, with well-aligned regulatory instruments that reinforce this priority. Given the insights from the Melbourne case so far, this will also need to be underpinned by a program of industry capacity building to ensure that there is dedicated attention to enabling the necessary knowledge, skills and organisational systems to support the effective and wide-spread implementation of USQM. It is anticipated that once 'Phase 5' was

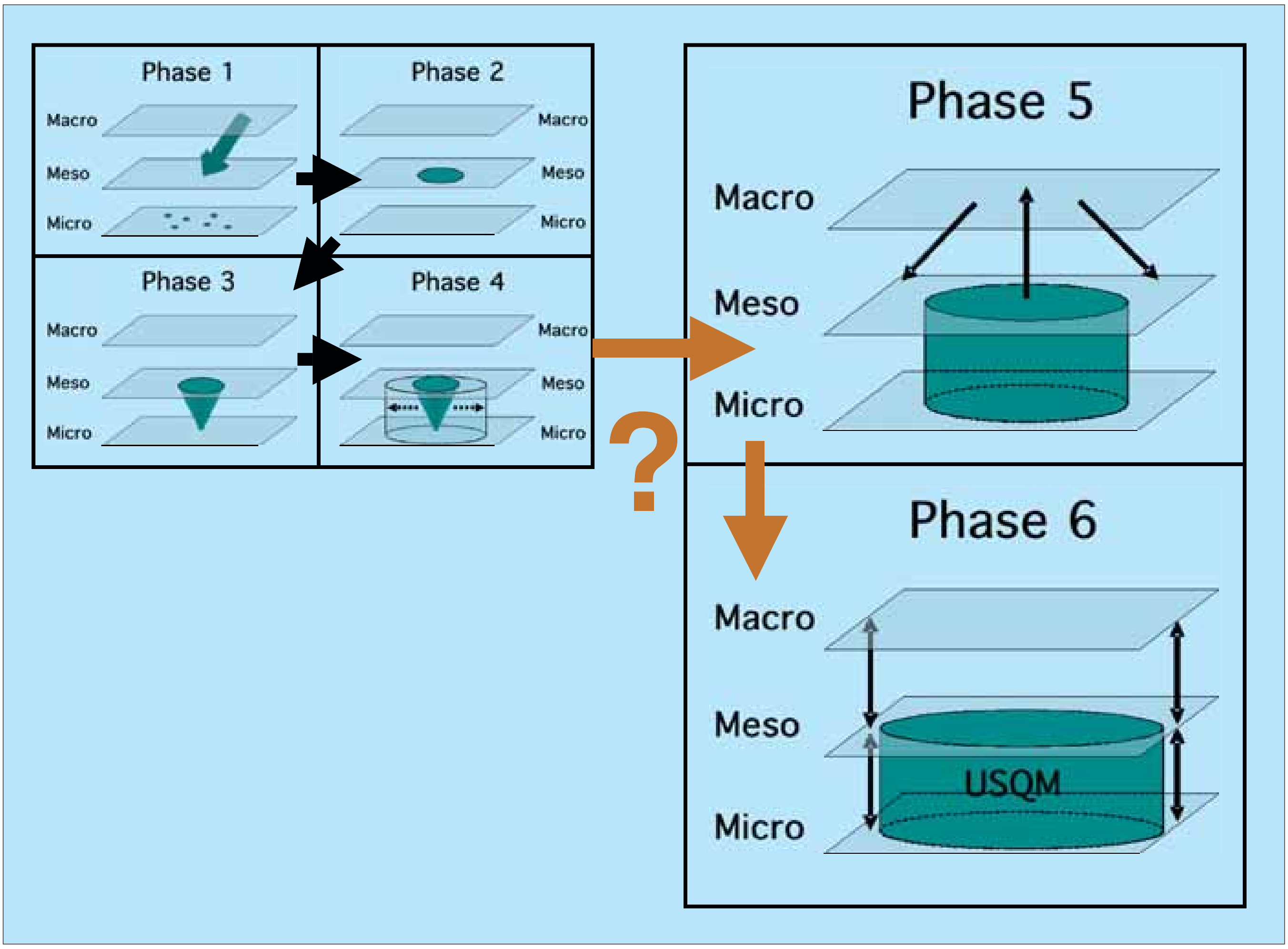


Figure 34. Possible scenario for the completion of the USQM Transition.

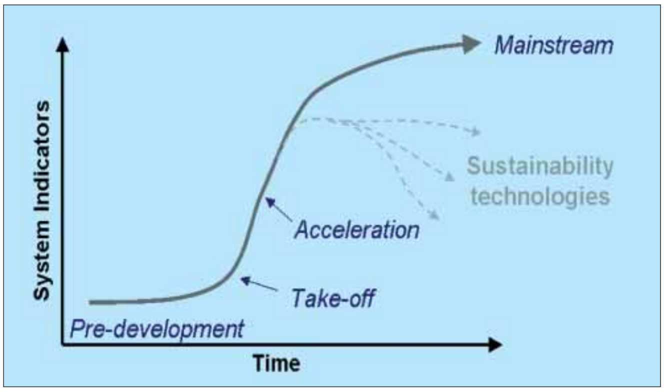


Figure 35a. The conceptual technology diffusion curve

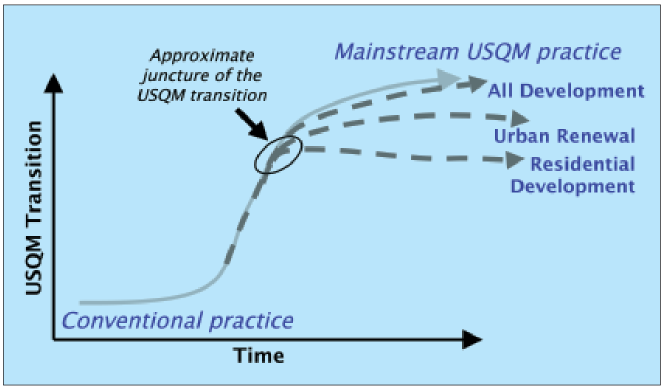


Figure 35b. Possible Transition Completion Pathways for Melbourne

successfully achieved, it would be followed by the final 'Phase 6', which would involve a system-wide lock-in across the MLP that reinforces the practice of USQM across the macro, meso and micro-levels. In this scenario, there would be no further mainstream use of components from the conventional urban stormwater approach that are in conflict with the ideology of the USQM niche. This final phase would result in the institutionalisation of the USQM niche, as stable mainstream practice across Melbourne.

The case study has revealed that a stable USQM niche exists, and is likely to start diffusing more rapidly following the recent amendments to Clause 56, the regulatory requirements for new residential subdivisions. This could possibly be a marker that Melbourne is entering into Phase 5 of the transition. However, the transition is at a critical stage. As shown in the 'technology diffusion curve' in Figure 35a, and the corresponding diffusion curve for the case study in Figure 35b, Melbourne's USQM niche has surpassed the transition 'pre-development' and 'take-off' stages and has been subject to an acceleration process, particularly over the last 10 years (as outlined in Section 4). Yet it has not reached the mainstream stage.

While reaching niche stabilisation is highly commendable for any sustainability initiative to achieve, as pointed out by Stirling (2003) this is often where transitioning of such innovations stops, with sustainability niches losing momentum (i.e. just before entering the mainstreaming stage as shown in Figure 35a). Perhaps this is because the full diffusion of the niche relies on integration with many other sectoral areas within the meso-level and in this case it would be related sectors such as transport, land-use planning, building, community health, finance and all activities related to the operations of local government agencies. Hence, there would need to be changes in these other related sectoral areas to improve their readiness for the incoming niche and its implications. Therefore, from a transition theory perspective, sustainability niches are likely to have little chance of becoming mainstream practice without proactive and strategic management, or what is termed in transition theory as 'strategic niche management' and 'transition governance'.

As shown in Figure 35b, Melbourne's USQM niche is at a stage where the meeting of best practice stormwater performance targets is mandated for new residential subdivision development. However, this does not encompass all other types of development, including industrial and commercial, and developments in urban renewal and retrofit projects. Therefore it does not encompass the full development spectrum, and still relies heavily on voluntary and sponsored initiatives in those projects not covered by Clause 56.

The renewal of Melbourne's stormwater infrastructure over the next 50 years requires a significant and dedicated investment of resources, and the mainstreaming of the niche will be threatened if this investment is directed at renewing and perpetuating conventional approaches. The recent legislative change (i.e. Clause 56 amendments) established the basis for a substantial component of this investment to be based along the philosophy of WSUD. It is hoped that subsequent endeavours would ensure that future investment in all other development scenarios follow this approach.

Early initiatives are already in place to continue this transition. For example there are a number of projects investigating the business case for incorporating WSUD requirements in all development projects. A Code of Practice for WSUD in industrial precincts is currently being developed as is a project examining the merit of using building regulations to incorporate WSUD in all developments. If realised, this would legislate the requirement for WSUD in all building types (both new development and redevelopment scenarios) and would provide a basis for ensuring Melbourne transitions into Phase 5. These projects are facing some challenges in the form of not having the attention or interest of all relevant government agencies owing to the current drought crisis faced by the city and state.

There is new local research currently underway with the view to revising current USQM guidelines through the development of ecologically-based targets as part of the 'continuous improvement' of the local science. This work could potentially connect local government more closely with the health of their local receiving waterways.

In summary, it would appear that the new regulatory obligations associated with the amendments to Clause 56 are an important step towards diffusing the USQM niche, suggesting that Melbourne may already be entering into the next Phase. However, the current overriding political focus on supply security (due to the recent extended drought conditions) does not guarantee a consolidation of government policy, attention and funding to USQM nor WSUD. Therefore these recent developments are more likely to mean that the necessary seeds are being put in place to potentially coincide with the next macro and/or meso-level event that will bring the necessary re-focus onto waterway health and urban stormwater quality impacts in combination with fit-for-purpose water supply. However, there does appear to be a number of potential risks that could significantly retard the diffusion of the already stabilised niche before the next window of opportunity presents itself as discussed in the next section.

6.2 Projected Transition Risks

As identified through the data collection and analysis of the Melbourne case study, there appear to be a number of potential risks to the 'diffusion' of the USQM niche and therefore the realisation of WSUD. These envisaged risks are focussed at the existing meso-level. At present, a majority of the USQM champions are at the management level, or are operating with good support from higher level management. Therefore, the next most significant challenge is making USQM and WSUD common knowledge and part of basic professional competence across all organisations and through all levels, particularly to individuals involved in the construction and maintenance of such technologies.

The research revealed that there was come concern amongst some of the more recent champions that while Clause 56 mandates stormwater quality performance targets for new residential subdivisions, the current insufficient knowledge and skills across the sector could lead to poor implementation practices and ultimately ineffective systems. It was the view of some that the most vulnerable included the other professions that needed to be involved such as landscape architects, those involved in constructing and maintaining the systems, and the more traditional engineering consultancies. It was perceived that there is the potential that poor implementation and maintenance practices may result in the USQM approach and techniques themselves being deemed unsuitable and ineffective by stakeholders, rather than questioning the potentially poor implementation and maintenance practices.

The current lack of political, human resource and financial capacity of local government (38 organisations across Melbourne) poses a significant risk to retarding the diffusion of the USQM niche. Despite the continued engagement and capacity building of local government organisations across Melbourne, some local governments have raised a number of concerns, and in particular the issue of 'cost shifting', in that the benefits of USQM were being perceived as accruing to Melbourne Water's organisational agenda while local government was responsible for the on-going and, in some cases, capital costs of the USQM initiatives. This type of response is indicative of a number of local government organisations only seeing USQM as a state government compliance issue rather than a social and environmental benefit that is instrumental to their organisation.

However, as highlighted in the research of Ecological Engineering (2005), local government is continuously subject to increasing environmental protection policies from higher tiers of government, but is not often supported with the necessary resources to undertake the new responsibilities. Compounding this issue is the reluctance of local politicians to raise taxes or property rates which could also subsidise USQM and WSUD practices. While local government is nominated as an agency for environmental protection in the SEPP (Waters of Victoria), there is no history of fines for non-compliance. Therefore, while the state government has not provided a sustainable funding mechanism for local government to undertake USQM and WSUD practices, the state also does not actively penalize local government either for poor performance in this area.

6.3 Future Transitioning: Opportunities and Linking with other Niches

It is clear that to advance the diffusion of the USQM niche, there needs to be a dedicated focus on institutional capacity building which involves the need to influence all stakeholders at the meso-level so that USQM is considered desirable and feasible.

There has already been considerable investment in urban water reform across Australia, but due to the lack of critical analysis of existing capacity and/or capacity deficits these reforms have often resulted in being less successful than anticipated. Understanding and assessing institutional capacity is crucial to forming coherent and demand driven capacity development strategies and therefore diffusing the USQM niche. As discussed by Brown *et al*., (2006a), institutional capacity includes the human resources, intra-organisational, inter-organisational and/or external rules and incentives capacity spheres. Therefore building the knowledge and skills of individual implementers as well as the organisational systems to support the new knowledge and skills is going to be a very important undertaking across Melbourne if the USQM niche, and ultimately WSUD, is to be successfully diffused.

Drawing from the limited literature available relating to the effectiveness of change programs in the water resources area, it appears that the elements of leadership and commitment are typically recognised as the most important ingredients for change and mainstreaming of new practices, independent of the policy or program implementation style (Brown, 2007b). For example, Mullen and Allison's (1999) comparative analysis of four different implementation models, including top-down, coordinated top-down, authority driven and locally driven/citizen-led/bottom-up, revealed three common factors for ensuring leadership and commitment to new programs and polices. These included: 1) the extent of stakeholder involvement; 2) the availability of social capital, and 3) the presence of real or perceived water resource concerns or problems. While each of these factors are evident in Melbourne's transition thus far, the case study also revealed the importance of a range of other enabling context variables (see Section 5.3) such as 'trusted and reliable science' and 'binding targets', and the interplay between the context and industry leaders or champions for streamlining the transition process.

Berkhout *et al*. (2004) argue that the key attribute for realising this next step is the enabling of 'cultural reform' at the meso-level, resulting in a substantial value shift within and across the prevailing institutional regime. This is because the mainstreaming of the niche is highly dependent on the broader range of actors and institutions within the meso-level recognising that the proposed change is "necessary, feasible, and advantageous" in order for them to support the transition (Berkhout, 2002). Therefore urban water strategists should not only focus on designing programs that facilitate cultural reform among extended stakeholders, but also identify potential synergies with other institutional programs of change and niches that potentially offer mutual transitioning benefits. These other change programs and niches could provide a broader base of interest and energy that can be applied to the transitioning objective. The rest of this section focusses on this last point and suggests how the USQM niche could be integrated with other fields in Melbourne attempting to advance alternative sustainability practices.

Given the preceding discussion, not only do the key change factors (as identified in Section 5) need to be further built upon in order to actively induce the completion of the USQM transition, there also needs to be effort spent on articulating common objectives of the niche with other fields that are also undergoing phases of transition leading towards WSUD. The most immediate areas that are recommended for expanding the USQM niche in the direction of the broader WSUD approach are: 1) creating urban environments that are resilient to climate change, and 2) the use of alternative water sources. Expansion and integration with these areas will need to recognise and continue to reinforce the USQM transition value of improved stormwater quality and waterway health.

The common objectives between the USQM niche and the related areas of 'creating urban environments that are resilient to climate change' and 'the use of alternative water sources' that contribute to the broader WSUD agenda include:

- providing urban environments with a level of redundancy in water sources that are both centralised and decentralised;
- the buffering of natural environments against the expected higher level of hydrologic variability associated with climate change;
- environmental protection of aquatic ecosystems in water supply catchments, urban waterways, and near (treated) sewage outfalls, and
- the integration of the above initiatives into the urban landscape and built form.

From the validation workshop, as highlighted in Section 3, industry participants highlighted a number of other niche areas that were considered potentially viable linkages for diffusing the USQM niche. Briefly these include the 'affordable housing' niche, which could incorporate innovative WSUD elements in both private and public developments. The current government and community niche focus on the notion of 'well-being' could be further expanded to the 'well-being' of waterways to improve human well-being. Evolving interest in urban and industrial ecology, means the perception of waste, such as sewage, from one activity is the resource for another. 'Public infrastructure design enrichment' was also highlighted in terms of producing more attractive and 'green' streetscapes that encourage communities to walk and interact in their streets meeting a range of other health, well-being and aesthetic goals while improving the health of the urban water environment.

These issues are currently the subject of ongoing research and consideration by a number of organisations across Australia. An expected outcome of these activities is the envisaging of what a fully transitioned state of each of these areas may look like. It is hoped that the insights in this report can inform the development of strategies and initiatives that assist in realising these anticipated end states.

7. IMPLICATIONS FOR URBAN WATER STRATEGISTS AND FUTURE RESEARCH NEEDS

This section provides a summary of the key implications for urban water strategists and enabling WSUD in the future. The starting point being that the practice of WSUD across modern cities is still largely in its infancy. Many cities are still operating and investing in the traditional urban water management paradigm, which is further perpetuating the delay in realising more sustainable urban water approaches. It is also clear that pursuing WSUD is significantly more difficult because it is not an approach that requires a simple adaptive technological change from the current practice. It requires new technologies and approaches that are often radical to the status quo, as well as fundamental changes in institutional capacity at various levels including new knowledge and skills, organisational systems and relationships, policy frameworks and regulatory rewards and penalties.

This Melbourne case study (and others) has demonstrated the value of using transition theory to provide insights into this complex change process. Such an analytical approach can be used with some confidence to help guide future strategic initiatives focussed on enabling change through guiding technology diffusion and stimulating the emergence of niche development in socio-technical environments that are in the early transitional phases. In addition, the application of transition theory provides a basis for envisaging future transition scenarios and pathways in order for policy and decision-makers to modulate and shape the direction of existing transition processes.

Making the transition to the mainstream practice of WSUD is likely to require a sophisticated program for strategic change that, as a first priority, focusses on the development and stabilisation of a WSUD niche that will enable the social embedding of new thinking, governance and technical practice. As shown in Figure 36, the results of the Melbourne case study provide

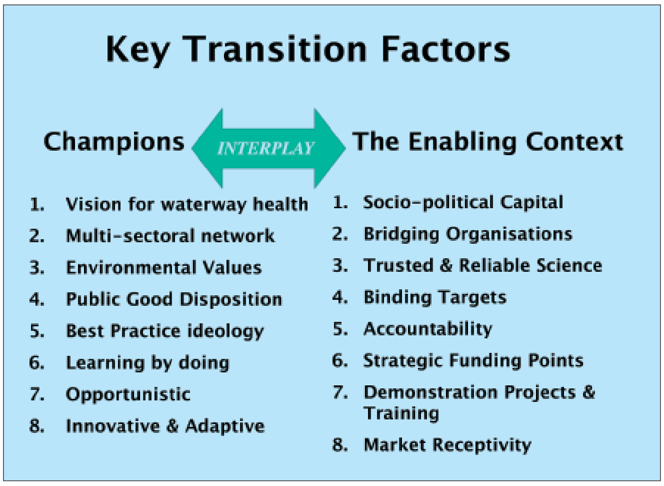


Figure 36. Key Transition Factors in the Melbourne Case Study

a useful set of transition indicators for stimulating and stabilising a niche through the appropriate intervention and seeding of the champion-enabling context interplay. The case study has revealed the significant potential for a small network of champions across sectors to create positive change. However, there are important enabling context variables that allow champions to emerge and/or be sustained over time. Urban water strategists and policy-makers can potentially expedite transitioning processes through identifying where the 'enabling context' deficits are. For example, questions that strategists could ask include:

- What bridging organisations exist and do they integrate across science and management?
- How are current demonstration projects proactively used to demonstrate compliance with policy targets, provide technical training and bring scientists and industry together?, and
- What leadership training and other opportunities exist to assist with nurturing and fostering champions?

Therefore the transitioning qualities identified in this case study can be used as a guiding template by urban water strategists to identify current transitioning deficits to improve the design, investment and outcomes of current policies and programs.
The case study showed how the interplay between

the 'champions' and the 'enabling context' was critical to providing the ongoing catalyst and a level of niche resilience to the transition. Through the institutional learning fostered through the niche development processes, many of the potential threats and impediments to change were highly minimised.

Melbourne now needs to focus on niche diffusion which should be underpinned by a program of industry capacity building to ensure that there is dedicated attention to enabling the necessary knowledge, skills and organisational systems, particularly for local government and those involved in constructing and maintaining these new technical systems. There needs to be effort spent on articulating common objectives of the niche with other fields that are also undergoing phases of transition leading towards WSUD. The most immediate areas that present some common objectives and current reform activity that are recommended for expanding the USQM niche in the direction of the broader WSUD approach are: 1) creating urban environments that are resilient to climate change, and 2) the use of alternative water sources. Expansion and integration with these areas will need to recognise and continue to reinforce the USQM transition value of improved stormwater quality and waterway health.

Finally, urban water history reveals the power of a 'crisis' to generate transitions. However, sustainability researchers and practitioners are concerned with how to prevent and/or minimise such crises (such as degraded aquatic ecosystems and vulnerable water supplies for humans and the environment). Therefore, sustainability champions are charged with a complex task of trying to proactively facilitate change based on a message of a potentially negative future. The next stage of this research (see Wong *et al.*, 2007) is focussed on envisaging different transition scenarios of a desirable 'water sensitive city' future as a potential basis for developing transition tools grounded in a positive and proactive change rationale. It is hoped that this type of activity will assist cities in taking advantage of the next macro-level change opportunity, when it arrives, for advancing WSUD.

8 CONCLUDING REMARKS

The purpose of this research was to determine the necessary ingredients for achieving effective institutional change that will facilitate improved ecological health in the waterways of Melbourne. One part of these ingredients is technology, including water biofiltration technology, and the diffusion of this technology requires complementary initiatives associated with the building of the socio-technical-political capacity of urban water governance. The insights from the Melbourne case study provide an important basis for other cities, and other areas of activity to learn from. Particularly since it is also well acknowledged that that there are few cities, if any, that have adopted effective governance regimes for the management of complex, multi-sectoral issues, such as urban stormwater and WSUD.

While the institutional dynamics of the WSUD approach may be more complex than those for the USQM approach, the Melbourne case study provides a solid platform of evidence for how institutional change can successfully occur and the key factors that underpin such change. It is hoped that these findings will also contribute important insights for urban water managers and policy makers to facilitate the successful mainstreaming of the broader WSUD approach.

One of the central propositions of this research was that if WSUD is to ever be fully realised, there is a strong need to change the underpinning institutional cultures (and those values, norms and beliefs that underpin such culture) that support the day-to-day practice of urban water management. The Melbourne case study supports such a proposition as it is essentially a story of how the value of environmental protection of waterways has been institutionalised through USQM over the last 40 years. Therefore, making the transition to the mainstream practice of WSUD across cities is likely to require a sophisticated program for strategic institutional change that include the capture of common objectives of the USQM niche with other fields that are also undergoing phases of transition leading towards WSUD. The most immediate areas that present some common objectives and current reform activity include creating urban environments that are resilient to climate change, and the use of alternative water sources. These areas contribute to the building of a water sensitive city. A further expansion of these areas would extend beyond urban water management to encompass the objectives associated with building sustainable urban environments.

The insights developed from this retrospective case analysis were drawn from information of a kind that is always incomplete - typical of the nature of this type of social research. This is being addressed through subsequent research on comparative case studies of other cities in different transition positions and institutional and physical contexts across Australia (see forthcoming report by Brown and Keath, 2007). The identification of the detail of champion attributes also remains tentative until subject to detailed and comparative analysis.

The follow-up to this research has already commenced (see Wong *et al*., 2007) and is focussed on using the insights of this case study to envisage the socio-technical characteristics of a ‘water sensitive city’ that Melbourne can ultimately transition to.

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