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CSIRO

Integrated Urban Water Management Planning Manual

Subject Area: Water Resources and Environmental Sustainability

Integrated Urban Water Management Planning Manual

About the Water Research Foundation

The Water Research Foundation (formerly Awwa Research Foundation or AwwaRF) is a member-supported, international, 501(c)3 nonprofit organization that sponsors research to enable water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers.

The Foundation's mission is to advance the science of water to improve the quality of life. To achieve this mission, the Foundation sponsors studies on all aspects of drinking water, including resources, treatment, distribution, and health effects. Funding for research is provided primarily by subscription payments from close to 1,000 water utilities, consulting firms, and manufacturers in North America and abroad. Additional funding comes from collaborative partnerships with other national and international organizations and the U.S. federal government, allowing for resources to be leveraged, expertise to be shared, and broad-based knowledge to be developed and disseminated.

From its headquarters in Denver, Colorado, the Foundation's staff directs and supports the efforts of more than 800 volunteers who serve on the board of trustees and various committees. These volunteers represent many facets of the water industry, and contribute their expertise to select and monitor research studies that benefit the entire drinking water community.

The results of research are disseminated through a number of channels, including reports, the Web site, Webcasts, conferences, and periodicals.

For its subscribers, the Foundation serves as a cooperative program in which water suppliers unite to pool their resources. By applying Foundation research findings, these water suppliers can save substantial costs and stay on the leading edge of drinking water science and technology. Since its inception, the Foundation has supplied the water community with more than $460 million in applied research value.

More information about the Foundation and how to become a subscriber is available on the Web at www.WaterResearchFoundation.org.

Integrated Urban Water Management Planning Manual

Prepared by:
Shiroma Maheepala, **Jane Blackmore**, **Clare Diaper**,
Magnus Moglia, **Ashok Sharma**, and **Steven Kenway**
Commonwealth Scientific Industrial and Research Organisation (CSIRO), Australia
Highett, Victoria 3190, Australia

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FOREWORD

The Water Research Foundation (Foundation) is a nonprofit corporation that is dedicated to the implementation of a research effort to help utilities respond to regulatory requirements and traditional high-priority concerns of the industry. The research agenda is developed through a process of consultation with subscribers and drinking water professionals. Under the umbrella of a Strategic Research Plan, the Research Advisory Council prioritizes the suggested projects based upon current and future needs, applicability, and past work; the recommendations are forwarded to the Board of Trustees for final selection. The Foundation also sponsors research projects through the unsolicited proposal process; the Collaborative Research, Research Applications, and Tailored Collaboration programs; and various joint research efforts with organizations such as the U.S. Environmental Protection Agency, the U.S. Bureau of Reclamation, and the Association of California Water Agencies.

This publication is a result of one of these sponsored studies, and it is hoped that its findings will be applied in communities throughout the world. The following report serves not only as a means of communicating the results of the water industry's centralized research program but also as a tool to enlist the further support of the nonmember utilities and individuals.

Projects are managed closely from their inception to the final report by the Foundation's staff and large cadre of volunteers who willingly contribute their time and expertise. The Foundation serves a planning and management function and awards contracts to other institutions such as water utilities, universities, and engineering firms. The funding for this research effort comes primarily from the Subscription Program, through which water utilities subscribe to the research program and make an annual payment proportionate to the volume of water they deliver and consultants and manufacturers subscribe based on their annual billings. The program offers a cost-effective and fair method for funding research in the public interest.

A broad spectrum of water supply issues is addressed by the Foundation's research agenda: resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide the highest possible quality of water economically and reliably. The true benefits are realized when the results are implemented at the utility level. The Foundation's trustees are pleased to offer this publication as a contribution toward that end.

Roy L. Wolfe, Ph.D.
Chair, Board of Trustees
Water Research Foundation

Robert C. Renner, P.E.
Executive Director
Water Research Foundation

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EXECUTIVE SUMMARY

Many towns and cities are running short of water, water that we currently take for granted; in many places, urban water management practices are causing irreversible damage to the environment. If our urban water management is to become sustainable we must adopt an integrated approach that considers all aspects of the water cycle and all of its impacts. Embedded in city planning, an integrated approach can provide sustainable water services to communities and to the environment, despite growing populations and uncertain climate. Such an approach takes time to plan and implement. It is never too soon to begin, but in many cases it may well be too late. By the time disaster can be spotted on the horizon, it is generally too late to enact anything other than mitigation strategies. Introducing an integrated approach is, however, outside the scope of any single organization. Water supply utilities must therefore combine forces with wastewater, stormwater and city planners to find practical, sustainable ways of supplementing supplies, controlling demand and meeting the needs of future generations. Regulators, funding organizations and the local community must all become involved. Adopting an integrated approach to urban water management is complex and difficult, and needs a structured approach from planning to operation and maintenance.

The Water Research Foundation and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, have joined forces to describe a generic process (or a framework) for towns and cities around the globe to follow, to help them through the challenges of transitioning to an urban water management practice that is truly integrated. We call it "Integrated Urban Water Management (IUWM) planning process." This manual describes that process.

A number of terms with similar definitions to IUWM can be found in the literature, applied to water management in an urban context. These terms include integrated water cycle management, total water cycle management and total water management. The processes and systems to which these names apply have much in common with IUWM. Integrated Water Resource Management however, addresses integrated water management across the whole-of-catchment (or watershed).

THE IUWM PLANNING PROCESS

IUWM is an approach for urban water utilities to plan and manage urban water systems (i.e., water supply, wastewater and stormwater systems) to minimize their impact on the natural environment, to maximize their contribution to social and economic vitality and to engender overall community improvement. The IUWM planning process described in this manual was developed by the research team and draws upon state-of-the-art knowledge and practice in North America and Australia. It has many aspects in common with integrated urban water management practices already in place.

The IUWM planning process described in this manual has three phases (see Figure ES.1), each with distinct outcomes. The aim of Phase 1 is to develop a strategic direction for IUWM that has potential to meet the needs of the town or city under consideration. For example, strategic direction might include recycling to reduce wastewater discharges to sensitive environments, supplement potable water supply with desalination or the development of new groundwater sources. The output of Phase 2 is a shortlist of portfolios. A portfolio is a set of complete schemes or urban water servicing options that are in line with the strategic directions identified in Phase 1, and that show promise of meeting IUWM objectives. For example, one option might address the introduction of

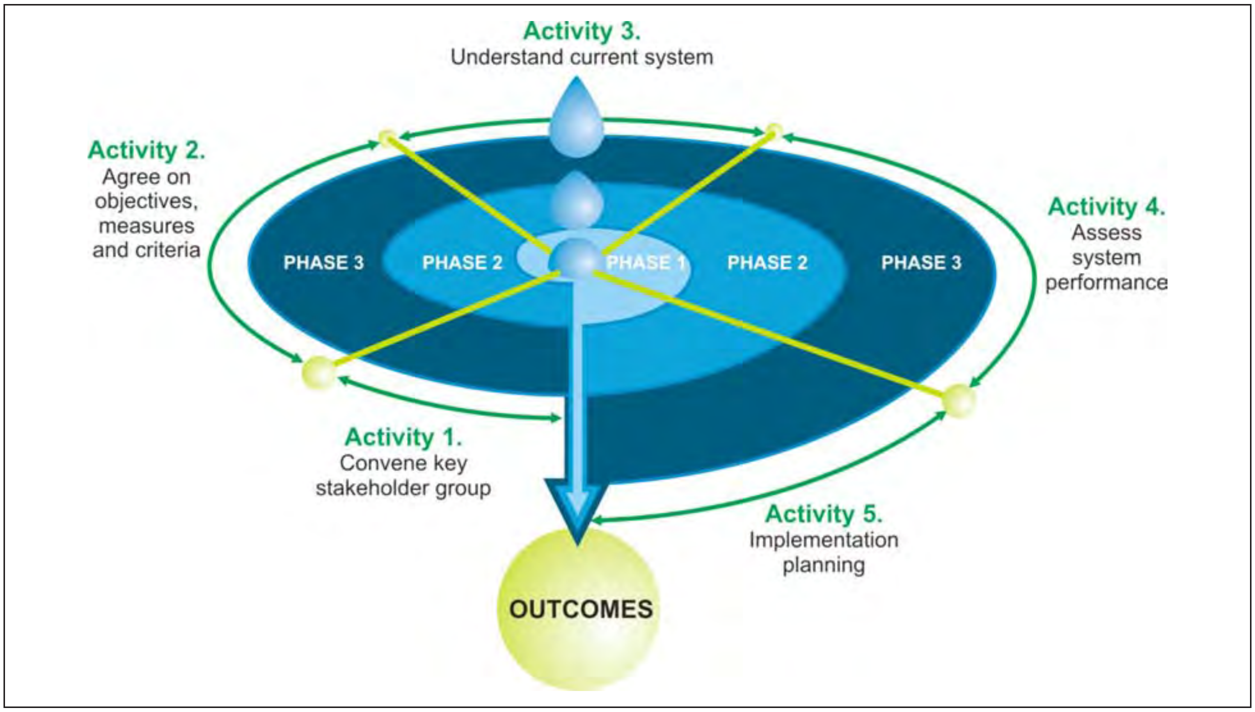

Figure ES.1 The IUWM planning process

greywater reuse and rainwater capture at household scale, while another might include recycling at whole-of-city scale. In Phase 3, shortlisted portfolios are analyzed in more detail and compared, and a preferred portfolio is selected for final implementation.

The activities undertaken in each phase are similar, and learnings from each feed into subsequent phases. Activity 1 in each phase is to set up a key stakeholder group, which is responsible for overseeing the IUWM planning process and is made up of representatives from critical organizations. Activity 2 is to reach agreement on IUWM objectives, how the success of the project will be measured and the methods of analysis to be used, and articulate minimum standards of compliance that meet all needs and expectations. IUWM objectives generally address sustainability as well as site-specific problems. Activity 3 involves understanding the current system, so that analysis can be undertaken (in Activity 4) to assess system performance in terms of the agreed measures. The data and level of analysis in each Phase is that required to produce the necessary outcomes, and it might draw upon analysis conducted in earlier phases together with additional knowledge that exists within the utilities. During Activity 4, whole-of-urban water system and integrated systems analysis methods are used to quantify the physical, social, economic and environmental performance of alternative portfolios of urban water management; stakeholder preferences are taken into account and multi-objective decision processes are used to select preferred portfolios. Finally, in Activity 5, each Phase is documented and plans made for implementing the outcomes.

As IUWM planning process progresses through the three phases, additional aspects of system performance will be taken into account and the depth of analysis will increase. The process is therefore, illustrated as a spiral that is traversed from the centre. The increasing width of the spiral indicates an increasing level of understanding of the urban water system as the project progresses.

IUWM stands a much better chance of acceptance and successful implementation, if not only key stakeholders, but also the wider stakeholder community, are consulted and their views are taken into account throughout the process. Understanding the concerns of the wider stakeholder group, mapping their needs and keeping them informed and involved is essential. The nature of the involvement depends on the complexity of the project. Advice on suitable methods for stakeholder participation is given within the manual.

Six case study sites, four in North America and two in Australia have been used to test alignment of the IUWM planning process with current practice. The case study sites are San Francisco, Santa Clara, El Paso and Calgary in North America, and Canberra and South East Queensland in Australia. All case study sites have begun transitioning to IUWM. Hence planning processes currently in place demonstrate some elements of IUWM, generally for only one aspect of the water cycle, in Phase 1 or Phase 2. In no case has IUWM yet been fully implemented.

All case studies follow the five activities included in the IUWM planning process. There is generally no clear distinction of phases, although the detailed study undertaken in preparing this manual showed that phases can, in fact, be identified. Lack of recognition of phases has at times led to an inefficient use of funds and resources, undertaking technical analysis that is not essential for making relevant decisions.

The case studies show the importance of having a dedicated project champion, and illustrate how water resource management plans and other urban water management plans (e.g., water supply strategic plans, sewerage strategic plans and recycling strategic plans) contribute to the IUWM planning process. The case studies also provide practical examples of how different levels of existing planning knowledge and analysis can be used within the IUWM planning process.

CONCLUSIONS

IUWM is a comprehensive water management approach that demands consideration of the whole urban water system, from supply catchments to receiving waters and all physical and non-physical influences on its performance. System boundaries spread far beyond town or city limits, and outcomes affect a multiplicity of stakeholders.

Transitioning to IUWM can be initiated by anyone, and can start at any time, using existing planning knowledge of the urban water system. Successful adoption, however, needs commitment to change from all parties involved. To do this a key stakeholder group that steers the IUWM planning process and decides what is, and what is not, relevant is essential. The key stakeholder group, together with the project champion, carry the process through to the creation of implementation plans. Since the aim is to achieve sustainability, even after construction and implementation are nominally complete, IUWM plans should be reviewed and updated on a regular basis.

Some towns in both North America and Australia are well advanced in their thinking, while others have a way to go. This manual provides a process that will encourage those who are part-way there to continue, and assist those who have yet to begin to assimilate their needs and knowledge into their first steps. We believe that the results will manifest themselves in a more sustainable future for all.

RECOMMENDATIONS FOR FURTHER RESEARCH

A wider adoption of IUWM for urban water planning requires methods and software tools, where possible, to aid the planning process and assist in the participation of key stakeholders in several ways. For example, methods and software tools are required for setting problem-specific objectives and assessment criteria within a sustainability context; multi-objective decision making;

accounting for uncertainty in underlying data and methods, and risks of failure; and quantification of the physical and non-physical total water cycle influences and impacts, that feed into the decision making process.

At present, there is no standard set of methods and software tools to support the adoption of IUWM for planning. Therefore, it would benefit the urban water industry as a whole to undertake a review of existing and emerging methods and tools that have the potential to provide such support and fund research to fill any gaps.

Further, the current governance models for planning, operation and maintenance do not fully support IUWM. For example, many water suppliers in the U.S.A. do not have responsibility for management of wastewater and stormwater generated from urban areas, yet such water streams and their interactions with water supply must be considered under the IUWM approach. Similarly, water agencies generally do not have the authority to influence land use decisions. Hence it is recommended that a review be undertaken to assess the adequacy of current governance structures to support successful implementation of IUWM. If current structures are found to be inadequate, it will be essential to develop new governance structures if the IUWM approach is to be accepted by the community.

Since IUWM is an emerging water management method, individual water utilities may or may not be fully aware of the benefits of adopting this approach, how it can be incorporated to existing planning processes and state-of-the-art knowledge of methods and tools to support its adoption. Development of an industry-wide training program and an information support system, possibly with web access for IUWM, will help alleviate any misconceptions and raise awareness. It is essential that the training programs be developed with varying complexity because some water utilities are well advanced in their IUWM thinking, while others have a way to go.

CHAPTER 1
INTRODUCTION

PURPOSE, STRUCTURE, AND USE OF THIS MANUAL

Water scarcity and increasing demand for water for both human consumption and meeting environmental needs are forcing many towns and cities to reconsider the ways in which they provide water services. An integrated approach to urban water management is one such approach being considered in many cities around the world. Integrated Urban Water Management (IUWM) can be applied to any urban area by any water utility that is wishing to make the most of its water resources while minimizing impacts on the environment. At the time of writing however, no jurisdiction is yet undertaking fully comprehensive, integrated urban water management that looks at all aspects of the water cycle and its integration with urban form and planning. Nonetheless, many aspects of IUWM are being introduced throughout the world, and many exciting initiatives are underway. These activities show distinct similarities, especially in the steps which jurisdictions are following in their planning processes.

This manual describes a generic process for undertaking IUWM for strategic planning of urban water systems, which includes water supply, wastewater, stormwater systems and the surrounding environment. The process has been developed by the project research team, based on experience in Australia and North America, and enhanced by the valued input of specialists and practitioners in the field of water management on either side of the Pacific Ocean.

A number of case studies are presented in the manual which illustrate the process and provide examples and inspiration to those wishing to transition to IUWM. They provide a practical illustration of how the process steps are being applied in different environments and under different management structures; they show how the current activities of water utilities and other organizations can be integrated into a planning framework that uses the IUWM approach; and they illustrate the benefits of even a partial approach to adopting IUWM, providing food for thought on matters such as "Who should we appoint to our key stakeholder group?," and "What might be reasonable, and achievable, objectives?"

The manual has four chapters:

Chapter 1 presents the background to the project, and defines IUWM: what it is, drivers for change, benefits and constraints

Chapter 2 provides a structured process for applying IUWM for strategic planning of an urban water system

Chapter 3 describes a number of case studies that illustrate how aspects of the process are being undertaken in North American and Australian cities and towns

Chapter 4 draws conclusions and makes suggestions for further developments needed to improve the adoption of the IUWM planning process

BACKGROUND TO THE PROJECT

This manual is the outcome of a project that was jointly funded by the Water Research Foundation (WRF) and the Commonwealth Scientific and Industrial Research Organisation, Australia (CSIRO). The aim of the project was to develop guidance to assist urban water utilities in adopting an IUWM approach for strategic planning of urban water systems. This manual helps water utilities to understand:

- The principles and benefits of adopting IUWM
- Links between IUWM and the processes currently being used for strategic planning of urban water sub-systems, i.e., water supply, wastewater and stormwater systems
- The IUWM planning process

There were three major components to the project:

- Development of, and incremental improvement to, the IUWM planning process. The process underwent many iterations as new information and ideas were introduced
- A workshop attended by representatives from twenty water-related utilities across North America, which was held in Boulder, Colorado in June 2007. The workshop provided valuable input to the manual, and helped identify potential case studies
- In-depth consideration of the application of IUWM to a number of case study areas (described in Chapter 3). The case studies provided insights into different drivers, responsibilities and opportunities for IUWM across North America and Australia, and real-life illustrations of IUWM activities

INTEGRATED URBAN WATER MANAGEMENT—WHAT DOES IT MEAN?

Definition

IUWM is an approach for urban water utilities to plan and manage urban water systems (i.e., water supply, wastewater and stormwater) to minimize their impact on the natural environment, to maximize their contribution to social and economic vitality and to engender overall community improvement (Maheepala and Blackmore, 2008). IUWM considers (Mitchell, 2006):

- All parts of the water cycle—natural and man-made, surface and sub-surface, and recognizes them as an integrated system
- The full range of demands for water, both anthropogenic and ecological requirements
- The impact of water cycle management on the overall planning and management of towns and cities
- The full range of water supplies available over time
- The practices which can provide water fit for purpose both in quality and quantity, and reduce the demand for potable water
- The sustainability of water service provision
- The local context and stakeholder views
- The scale, engineering and functional aspects of the water system
- The means by which transition from current practice can be achieved

IUWM fosters security through diversity and provides better resilience to climatic and economic change for urban water systems. It demands cooperation between government and utility sectors and assists in informing decisions in urban planning and water management based on overall sustainability, rather than single-sectoral, short-term planning and management goals.

A number of terms with similar definitions to IUWM can be found in the literature, applied to water management in an urban context. These terms include Integrated Water Cycle (NSW Department of Utilities, Energy and Sustainability, 2004; Coombes et al., 2003), Integrated Urban Water Resource Management (Global Water Partnership, 2007) and Total Water Management (Jeffcoat et al., 2009). The processes and systems to which these names apply have much in common with IUWM. References for further reading are provided in Appendix B for those interested in learning more about IUWM.

System Boundaries, Scales, and Methods of Analysis

IUWM recognizes that the physical urban water system sits within an organizational framework and a broader natural landscape (Mitchell, 2006). Hence the scope of IUWM necessarily involves considerations that spread far beyond town or city limits. While a detailed understanding of everything that influences system performance within the urban area assists the transition to IUWM, water sources, receiving waters, treatment plants and other physical components of the system often lie outside the urban boundaries. Non-physical influences, such as state and federal legislation, operational aspects of district water supply and water demands for rural use will also impact on the urban water system performance. IUWM involves understanding all that influences the system performance; reaching agreement on what is, and what is not, relevant; and deciding on an urban water system that provides outcomes that are acceptable to all.

The application of technologies and initiatives can occur at many different scales, from individual behaviors, through household, development and suburb to whole-of-city. Technologies applied at one scale to one situation might not be beneficial in another. Further, aggregating the performance of systems at small scales is unlikely to provide an accurate prediction of performance at whole-of-city scale since an integrated urban water system is complex, involving thresholds and feedbacks that can lead to unexpected outcomes. The impact of different strategies is not always immediate. Phasing, technology take-up rates and response to changes in climate and other long-term influences need to be analyzed if system performance over the long term is to be understood. Analysis involves understanding responses at different time scales, varying from minutes (for small-scale stormwater capture, for example) to tens or even hundreds of years (for environmental impacts on river morphology).

Two basic analysis approaches are essential to understanding the behavior of the integrated system and aiding decisions to optimize management (Bertrand-Krajewski et al., 2000). They are: (1) integrated systems analysis in time and space, and (2) multi-objective decision analysis. Integrated systems analysis involves analyzing the performance of the whole urban water system in multiple domains (e.g., hydrological, ecological, engineering, social, economic and environmental) by accounting for interrelations and feedback loops among sub-systems. Outputs of integrated systems analysis feed into multi-objective decision analysis, which links outputs with views and preferences of multiple stakeholders and enables decisions to be made that satisfy the objectives of all sectors. Multi-criteria assessment and optimization methods (Brans et al., 1986; Colson and Debruyn, 1989; Guitouni and Martel, 1998.) are useful tools for this activity.

Links With Integrated Water Resource Management

The IUWM approach emerged from the perception that water is an integral part of the ecosystem, a natural resource, and a social and economic good (United Nations, 1992). This perception has been reinforced with the release of a report (Millennium Ecosystem Assessment, 2005) in which more than 1360 experts worldwide have assessed the condition of ecological services of the globe and their links to human welfare, and have concluded that human activities have taken the planet to the edge of a massive wave of species extinction which now threatens our own well-being.

A related approach to IUWM also emerged from the United Nations (1992). This approach, called Integrated Water Resource Management (IWRM), is commonly used in planning at river basin level (Jonker, 2007; Davis, 2007; Jønch-Clausen, 2001). IWRM is defined as a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership Technical Advisory Committee, 2000). As described in Maheepala and Blackmore (2008):

> *The IWRM approach deals with the water allocation problem at regional and/or river basin level. A region might include a number of urban areas as well as rural, hydro-electricity and agricultural users. The IWRM approach helps in making decisions on regional water allocations by considering the needs of all the competing users. IUWM can be viewed as a subset of IWRM that is concerned with the management of water supply, wastewater and stormwater in urban areas within the boundary conditions set as part of the IWRM process (such as total annual urban water allocation). Close interaction and communication between IWRM and IUWM planning processes is critical if each is to be successfully implemented.*

DRIVERS OF IUWM

The overarching driver for adopting IUWM is to provide a sustainable urban water service to the community, which improves human welfare while maximizing ecological integrity of the surrounding environment. There can be other site, utility, county, state or country specific reasons that sit within this overarching driver. These include rising demand for water due to population growth, diminishing traditional surface and groundwater supplies due to a drying climate or simply due to over use, degrading of the surrounding environment due to pollutants in stormwater and wastewater discharges, and declining quality of source water due to drying climate or urban, agricultural and industrial activities in supply catchments.

For example, in Australia, capital cities and major towns have traditionally been almost totally reliant on surface water and groundwater supplies. This traditional approach has served the country well over the last one hundred years. The combination of the current drought, the effect of climate change and significant population growth in urban areas has resulted in a crisis in water supply in most cities and major towns (Australian Government, 2007). Most urban water utilities have responded to the current water shortage by imposing restrictions on water use and managing demand through the use of demand management practices such as water efficient appliances. However, such solutions have now reached the point of diminished returns. Ongoing harsh water supply restrictions are now being recognized as a failure of planning (Australian Government, 2007). Understanding the need for a long-term solution for better managing the uncertainty in water supplies in a fragile ecosystem has led urban water utilities in Australia to consider holistic solutions to water servicing problems. The IUWM approach is seen as one solution.

On the other hand, urban water systems in Western Europe and some parts in North America (e.g., eastern and northern U.S.A.) seldom suffer from an acute water supply crisis (Malmqvist et al., 2007). In many water-stressed areas (e.g., California and south-western U.S.A.) there is still the option to buy in water from outside the district or region. Nevertheless, there is an imbalance between the need for sustainable water systems and implementation. The high costs involved in water infrastructure rehabilitation and the upgrades to wastewater treatment necessary to maintain receiving water quality often preclude the integration of urban water management with ecological requirements (Malmqvist et al., 2007). Some specific problems in North America include:

- Overuse of groundwater for urban and agricultural purposes—in general, groundwater is being used 25% faster than it is being replenished; hence restrictive withdrawal policies are being applied to groundwater in nearly every state (American Water Works Association, 2007).
- Overuse of the Colorado River has reached the point where it no longer consistently reaches the ocean in Mexico, which has caused tension between the U.S.A. and Mexico (American Water Works Association, 2007).
- In the past, water utilities relied on federal agencies such as the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation and a state agency to build water supply projects by giving priority to economic benefits of water projects. Environmental needs were considered, but not given as high priority as today (American Water Works Association, 2007). Water utilities now have to plan for growing water needs including environmental needs. However, it is difficult to achieve sustainability objectives if the focus is too narrow, such as when individual water utilities take responsibility for balancing supply and demand within their own boundaries. This is because local water utilities cannot use their rate payer-generated funds to benefit others outside their jurisdiction, or to achieve objectives outside those authorized.
- Individual water utilities and communities see wastewater recycling, stormwater use and indirect potable recycling as potential sources of supply in urban areas. However, in many cases wastewater and stormwater streams are owned by cities that do not have responsibility for sourcing supplies. Similar situations can be seen with utilities that are involved in managing wastewater and stormwater discharge to sensitive environments. Nutrient recycling and reductions in diffuse pollutants to waterways can be achieved by integrating supplies with waste streams, but institutional structures currently in place do not support linking water supply management with management of the waste stream.
- Reduced snow pack and earlier snow melt due to warming climate can have a significant impact on previously reliable surface water supplies in some states, in particular water utilities in California.

Undoubtedly, principles of IUWM have the potential to provide solutions to the above-mentioned problems. It is a promising approach to achieving a balance between environmental, social and economic aspects of urban water management and reducing the dependence on traditional groundwater and surface water sources that are under threat due to warming climate.

Furthermore, growing populations, diminishing groundwater reserves and surface water supplies, environmental water needs including the protection of receiving environments, a desire to create "green" cities, the need to make more water available on the wholesale market and flood reduction are all potential drivers for adopting IUWM in any city.

BENEFITS OF IUWM

While providing clean water for all demands, a traditional "pipe in, pipe out" approach in which water is taken from the environment, treated, used once, treated again and then discharged back to receiving waters is not always an efficient approach. By integrating all aspects of the water cycle and taking into account all actions and changes that influence the performance of the water system, there is potential to greatly increase efficiencies and reduce adverse impacts, thus increasing sustainability. Concepts such as "water fit for purpose," in which water is reused, maybe several times, by matching source quality to its intended use and treating water only to the required level, "low impact development" whereby the impact of development on runoff is reduced by a variety of environmentally friendly practices, and "water sensitive urban design" which is about integrating water cycle management into urban planning and design, are just a few of the approaches that are being used to increase overall efficiencies.

An integrated approach not only increases efficiency; it also permits greater flexibility in water management. By considering all possible approaches to meeting water service needs, some of which will be outside the responsibility of any single organization, different ways of achieving outcomes are properly evaluated and viable alternatives can be readily identified and implemented. Techniques such as "day-lighting," or returning previously enclosed water courses to their natural state, can bring added benefits by creating outdoor recreation areas within cities that improve health and amenity as well as increasing property values.

Therefore, the overall benefit of adopting the IUWM approach is its potential to provide solutions to common challenges faced by the urban water industry such as climate change, population growth, rising costs for new infrastructure and meeting ecological requirements. Some specific benefits of the IUWM approach include:

- **Providing water security**—One key feature of IUWM is that it seeks to provide water security through diversification of sources and efficient demand management. Security is enhanced by use of a variety of supply sources such as surface water, groundwater, recycled water, stormwater, roof water, grey water and desalinated water to meet urban demand in a fit-for-purpose manner. Some sources such as recycled water and grey water have potential to provide a reliable water supply even in times of prolonged drought, because of their non-dependence on rainfall; others, such as stormwater and roof water, can reduce demand for fresh water as well as reducing nutrient, sediment and contaminant discharges to receiving waters. Demand management involves use of both structural and non-structural measures to reduce water use, including installation of devices and appliances that increase efficiency, education programs, water pricing, incentives and regulations. By promoting the use of a broad range of components that can be mixed and matched to provide water, wastewater and stormwater services in ways that are appropriate for local conditions, greater security can be achieved than by relying on only conventional sources such as surface water and groundwater.

- **Reducing impacts on the environment**—the IUWM approach considers urban areas as catchments, managing the urban landscape to improve habitat for native flora and fauna in urban waterways and estuaries by using approaches such as day-lighting, low impact development (LID), sustainable urban drainage systems (SUDS) and water sensitive urban design (WSUD). All these approaches have the potential to reduce the impact of urbanization on the environment and enhance urban amenity.
- **Improving governance**—IUWM requires cooperation between key stakeholders to make multi-objective decisions that are aligned with the principles of sustainability. This requires co-ordination, collaboration and participation in the management of water supply, wastewater, stormwater and receiving waters in urban areas, potentially resulting in better long-term decisions that provide inter-generational equity.
- **Improving system-wide performance**—management of the total water cycle involves accounting for interactions between sub-components of the system and understanding system dynamics, rather than focusing on the behavior of individual components. Short-term, localized and single-sector-based decisions, which often result in undesirable performance at the system level, are more readily avoided.

NEED FOR A MANUAL

Linking With Strategic Planning

As discussed earlier, the IUWM approach is an emerging and alternative approach to urban water management. It has the potential to provide solutions to current urban water challenges, but basic question are: how do we incorporate IUWM into current urban water management practice, and what is an appropriate process?

Since IUWM is a new approach, the obvious starting point is at the strategic planning phase, where long-term goals are set, the best approach (or strategy) to achieve those goals is identified, and resources (e.g., capital, equipment and people) are allocated to implement the chosen strategy.

The strategic planning process currently in place in many water utilities is designed to achieve the goals of traditional urban water management, that is, to supply water of drinking quality to all users and manage wastewater and stormwater to improve public health from waterborne diseases and floods. Current strategic planning processes consist of three parallel activities that independently address planning of water supply, stormwater and wastewater systems, to meet the traditional goals. Even in areas with combined sewer systems (i.e., one system for both wastewater and stormwater) the current strategic planning process is generally considered as two processes, one for water supply planning and another for combined-sewer planning. For example, *Water Resources Planning: Manual of Water Supply Practices M50* (American Water Works Association, 2007) describes a process to be followed for water supply planning in the U.S.A. context.

The process of incorporating IUWM principles into existing strategic planning is not a trivial task because it demands taking a holistic view of the urban water system and bringing the concept of sustainability to urban water management which includes, amongst other considerations, the health of the surrounding environment and integrating water management into urban landscapes. Little has been written on processes or frameworks that enable application of the IUWM approach to strategic planning. One approach, called the strategic choice approach (Friend and Hickling, 2005), consists of four steps. In Step 1, strategically relevant questions are selected to define the problem. In Step 2, potential strategies to address the problem are designed. In Step 3, performance of the potential strategies are evaluated and compared with each other. In Step 4, a preferred strategy is selected in participation with relevant stakeholders.

While the strategic choice approach is a valid approach for applying IUWM principles, it provides only basic and fundamental steps and does not fully describe processes to be followed in each step in detail. For example, Step 2 is for designing strategic options, but this step requires guidance on setting objectives that satisfy multiple stakeholders, measures to assess the degree of achievability of objectives and a good understanding of the existing system to identify opportunities for improvement. Given that IUWM is a new approach; such details should be transparent and explicitly stated in sufficient detail to avoid misinterpretations.

The purpose of this document is to describe a process for applying IUWM principles to strategic planning. We call this process "IUWM planning process." The emphasis of the IUWM planning process is not only on the technical and economic aspects of urban water management, but also on integrating public participation, limits of the surrounding environment, appropriate governance and needs of the community into urban water management.

Jeffcoat et al. (2009) reported a process for adopting IUWM principles into planning of urban water systems. The process described in this manual and Jeffcoat et al. (2009)'s process are developed in parallel, but independently. Interestingly, both processes have some similarities in terms of key activities of the process, but the process described in this manual is much more comprehensive than the process described in Jeffcoat et al. (2009).

We view IUWM-based strategic planning as the next generation of strategic planning for urban water systems. While the approach must include ways to account for interactions between all the sub-components of the urban water system and system-wide implications, it can be initiated from within any sub-system, focusing on, for example, water supply. This manual gives guidance to water utilities on processes to be followed for IUWM-based strategic planning.

Phases and Levels of Analysis

The process for adopting the IUWM approach for planning, generally progresses through several phases, each phase requiring different and generally more detailed analysis than the last. In the first phase, possible directions that might satisfy the principles of IUWM are identified. In the second phase, a number of alternative approaches are evaluated in more detail, leading to the third phase, selection of one system or a set of specific urban water management options for application throughout the town or city.

Analysis needs to be at a level appropriate to the end point—that is, for general strategies, analysis of whole-of-city water balances and broad-brush approaches to costing provide sufficient information, while for detailed option selection, the performance of individual strategies in different suburbs or developments will be needed. Final implementation requires analysis at the level of detailed engineering design. Good IUWM involves performing analysis at a level that suits the required outcomes, so time spent articulating outcomes and agreeing on appropriate levels and methods of analysis will be time well spent.

Starting Point

There is no defined point to commence adopting the IUWM approach for strategic planning of urban water management. In fact, *IT IS NEVER TOO EARLY TO START!* If disaster is looming on the horizon, it is probably too late to plan, and relief will only be possible through mitigation strategies.

The actions you have undertaken, your knowledge of your town's urban water management practices, and your understanding of the history, values and problems encountered in your local area, are all part of the process. Doubtless your knowledge is far wider than this; as you document all you understand, and how it feeds in to each step of the process, you'll be surprised how far along the path you have travelled. Doubtless there will be gaps, and it is likely that you have not yet undertaken integrated analysis of different aspects of the water cycle. The impacts of social mores and economic incentives might not yet be quantified, and key stakeholders might not yet be working together to integrate IUWM into town planning. Whatever the gaps, you are certainly not starting from a clean sheet, and we would like to wish you success as you open your mind to the possibilities of a truly integrated approach to IUWM.

Funding, Constraints, Opportunities

The transition to IUWM is a process that takes commitment, time and considerable investment. From preliminary discussions to implementation and operation, support for the process is essential. Sources of funding must be sought and secured.

There are many possible sources of funding. In jurisdictions where one water utility has control of the city's water supply, planning and distribution, it might be sufficient to convince the utility's board of directors of the benefits of IUWM to undertake at least Phase 1, if not all the phases of the process. In other cases water districts, water utilities or local authorities might be willing to contribute time and resources, share data and expertise and make joint submissions for state or federal grants.

Whoever provides funding, evidence is needed to demonstrate the benefits of the proposed system. Impacts, costs and benefits, including externalities such as social costs and benefits, will need to be carefully evaluated. Participation of key funding bodies in the IUWM planning process itself is strongly recommended, so that requests for funding are well understood, and do not come as a surprise to anyone. This advice applies to construction and implementation, as well as planning; where expenditure on capital works will be required. The sooner proposals are incorporated into the organization's capital expenditure budget planning the better. Many schemes have failed to reach the construction stage due to lack of funding for capital works.

SCOPE OF THE MANUAL

Chapter 2 of this manual describes a process to be followed to apply IUWM principles to strategic planning. The process is structured into three phases and five activities for each phase. For each phase, we describe the purpose of undertaking it, its outputs and how the outputs feed into the next phase. For each activity, we describe the purpose of undertaking the activity and how it links with other activities, and provide guidance on key factors to be considered and relevant and generic methods and approaches to be used to achieve its outcome. It is important to note that this manual does not recommend any particular models or approaches to aid the analyses. The final output of the process is a preferred portfolio of urban water management options for detailed engineering design and implementation and a set of actions to carry the project through to completion. The preferred portfolio has the potential to achieve the agreed objectives.

CHAPTER 2
THE IUWM PLANNING PROCESS

In the previous chapter, we described the potential benefits of IUWM and the issues that it could address. Here we describe a formal process for adopting the IUWM approach for strategic planning of urban water systems (referred to as IUWM planning process). Development of the IUWM planning process is based on current experiences in both North America and Australia. The process can be used to assist in uniform implementation in a multi-stakeholder environment.

IUWM requires collaboration and cooperation between previously independent entities and organizations. Applying IUWM principles into practice becomes more complex as it progresses; starting from the perception that a problem exists, or that "there must be a better way of doing water management," it is an ongoing journey of learning, sharing, consulting, analyzing, agreeing and implementing. New partnerships and collaborations are formed along the way, in an environment of ever-increasing knowledge and changing perceptions. The urgency of implementation varies with changing climate, supply availability and usage. Barriers are encountered and perspectives, attitudes and policies need to be adjusted if practical and practicable solutions are to be found. The key focus of IUWM may transmute from time to time with changes to key drivers. Hence there is a need for regular revisits to various aspects of the planning process. Also, there is an ongoing need to communicate any changes to data and knowledge, and consult with all those who might be affected. Hence a formalized framework is needed to ensure the planning process is conducted efficiently and openly.

In writing a manual that is applicable in such a complex environment, the authors were faced with a communication challenge. How could a manual be created that is easy to use and at the same time allows users freedom to start at any point, move through the process at a speed and in a sequence appropriate to their needs, that acknowledges an increasing understanding of the issues at hand, and that provides flexibility to go back and fill in gaps or make adjustments as necessary?

The communication challenge was addressed by perceiving the process of applying IUWM principles to urban water planning as a journey with the path marked by signposts. Travellers should understand what lies around the corner, and be well equipped to face the next challenge. Their whereabouts and planned route should be communicated to all stakeholders. Aspects of the journey should be repetitive, and lessons learnt along the way should be carried forward, each time providing a better understanding of the task at hand.

The structure of the IUWM planning process developed by considering these factors is shown in Figure 2.1. It is a cyclic process represented as a spiral. It consists of five main activities and three phases, with each activity leading into the next. The five main activities are repeated in each phase, but the depth of analysis of each activity increases as the process progresses from the centre of the spiral to outwards. The five main activities in the IUWM planning process are as follows:

- ***Convene a key stakeholder group:*** The key stakeholder group (KSG) is responsible for overseeing the IUWM planning process, and is made up of representatives from critical organizations. The activities of forming, constituting and funding this group,

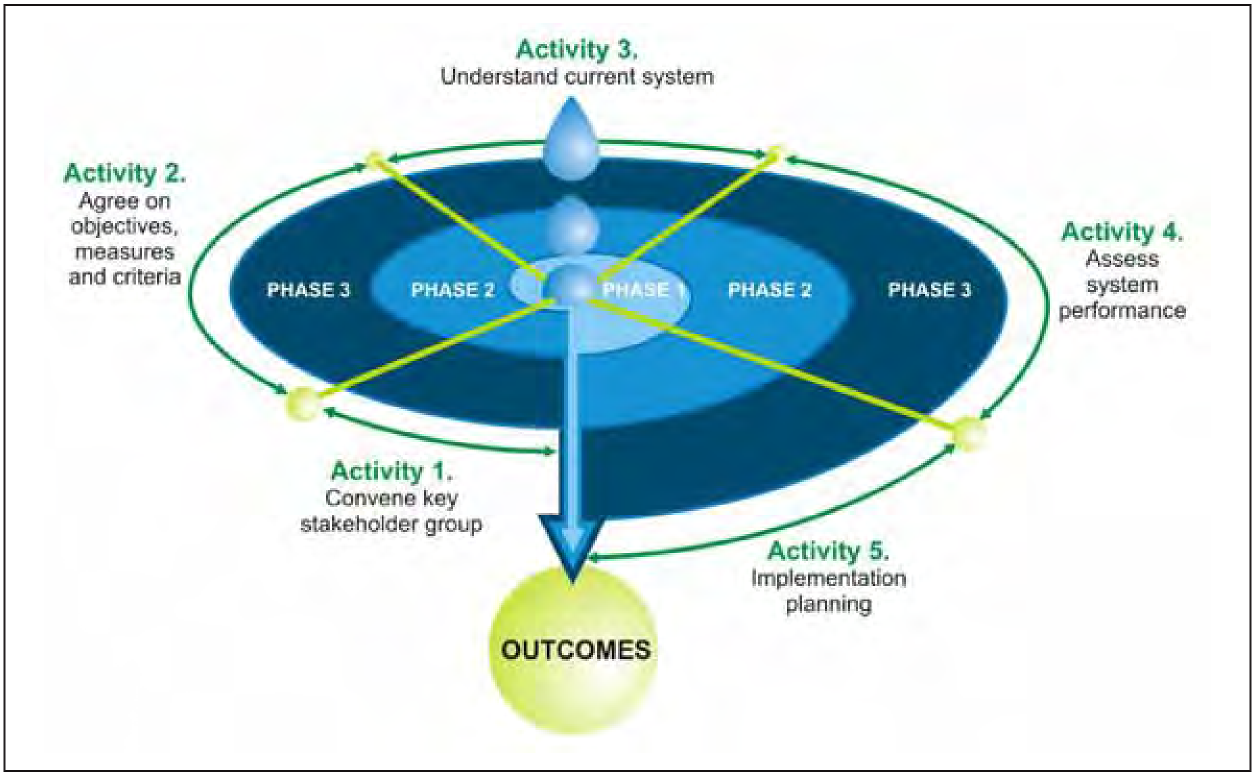

Figure 2.1 The IUWM planning process

and ensuring that it is effectively run and that its constitution remains relevant is essential to the success of the process.

- ***Agree on objectives, measures, criteria and methods:*** Agreement on IUWM objectives in terms of qualitative or quantitative parameters provides robust measures of the success of the project. Measures alone are insufficient; however, methods of analysis, and minimum standards of compliance, need to be articulated to ensure that any proposed system meets all needs and expectations.
- ***Understand the current system:*** Everything starts from the current system. Understanding all aspects of the system, including all elements of the water cycle, legislation, climate, demographics, social, economic and environmental considerations is essential in identifying potential strategies and developing viable alternative configurations.
- ***Assess system performance and select portfolios:*** Transitioning to IUWM requires understanding how different strategies and components function together into the future. Many areas of science, including social, environmental and economic analysis, are drawn together to provide an understanding of how proposed systems might function, and to assist the decision makers in selecting the best option.
- ***Implementation planning:*** Many major decisions must be made before the practice of IUWM becomes a reality. Long before the engineers start construction, strategies,

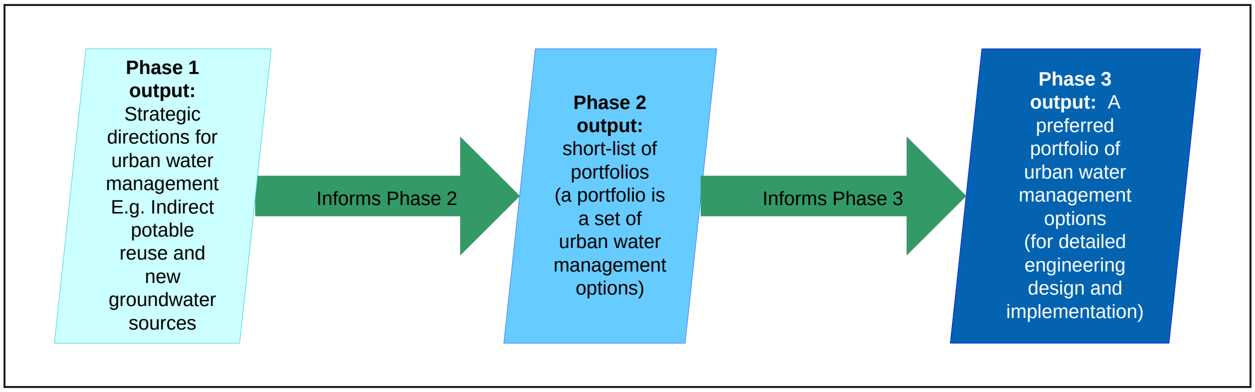

Figure 2.2 Outputs of each phase in the IUWM planning process

portfolios and aspects of the design must be confirmed and agreed on, determining subsequent directions for the planning process.

The three phases are identified by their distinctly different outputs (see Figure 2.2):

- ***Phase 1:*** Output is preferred strategic directions for urban water management, such as recycling, stormwater reuse, desalination, which will be considered in Phase 2 for more detailed analysis. During Phase 1, the analysis is appropriate to understand whole-of-city water and contaminant balances and identify opportunities for integrated management of the urban water system.
- ***Phase 2:*** Output is a shortlist of portfolios or components based on the strategic directions agreed on in Phase 1, and from which a preferred portfolio will be selected in Phase 3. During Phase 2, analysis is in sufficient detail to generate a plausible set of portfolios that are in line with the agreed strategic directions, and select a shortlist of portfolios by eliminating unfeasible options.
- ***Phase 3:*** Output is one preferred portfolio, suitable for undertaking detailed engineering design and implementation. Phase 3 provides sufficient detail to compare the performance of all the shortlisted portfolios, and select a preferred one. During this phase, the concerns of the multitude of stakeholders are addressed.

In each phase, activities build upon experience from previous phases. For example, system performance assessment for selecting potential strategies for the whole town or city will be less detailed than, but contribute to, the assessment used for comparing the benefits and pitfalls of each of a number of shortlisted portfolios.

Details of the activities and phases are described below. The presentation of this manual (i.e., activities and phases) follows the spiral from its centre outwards. Each phase is discussed in turn, describing how each of the five activities leads into the next, first at Phase 1, then at Phase 2 and finally at Phase 3. Since stakeholder consultation occurs throughout the process, guidance is given in a separate section entitled "Considering and Engaging Stakeholders."

PHASE 1—SETTING STRATEGIC DIRECTIONS

Phase 1 is the start of the IUWM planning process, in which the possibilities of potential new sources, demand reduction approaches and ways of overcoming environmental and broader sustainability concerns are explored, and those that show potential are identified for further analysis. Many jurisdictions have already undertaken aspects of Phase 1; but even if planning in Phase 2 or Phase 3 is well-advanced, everyone who is considering undertaking IUWM should revisit Phase 1 activities.

Phase 1 Activity 1: Convene Key Stakeholder Group

The key stakeholder group (KSG) has overall responsibility for the effective carriage of the transition to IUWM. Although IUWM is often initiated by a single champion or organization, effective planning requires committed participation from many organizations. Objectives are more likely to be achieved if key stakeholders are engaged early in the process, and if these critical players are involved in providing advice on strategic decisions. This section describes the formulation, responsibilities, relationships and activities of the KSG.

The principle roles of the KSG are to (1) manage the IUWM planning process; (2) provide authoritative advice to the decision makers on issues of strategic importance; and (3) manage and facilitate engagement of other stakeholders as necessary. In some circumstances the KSG will itself be the decision maker, but generally this will not be the case, and strategy and investment decisions will be made by utility boards, local councils or other groups with responsibility for allocating funds. At the planning stages (Phases 1–3 in this manual), advice to the decision makers from the KSG addresses the selection and conceptual design of urban water servicing configurations; in the later stages (not addressed in this manual), the KSG might also be responsible for ensuring that the system is constructed and continues to meet agreed objectives throughout its life.

In all phases of IUWM, the responsibilities of the KSG include overseeing (at a strategic level) the management of the IUWM planning process, identifying potential sources of funding, making well-informed recommendations to those with the power to implement, assigning responsibilities within and between organizations and informing those involved with technical and other aspects of the project of decisions and agreements which affect their assessments and activities. Agreed objectives, measures, preferences, constraints and opportunities, shortlists of portfolios for detailed evaluation and other critical issues recommended and communicated by the KSG become the rules of engagement for the IUWM planning process. Since the focus of the project changes as it progresses, the constitution of the group should be reviewed from time to time, to ensure that representation is appropriate for the tasks at hand and that participation of the full range of relevant stakeholders has been considered. Stakeholder mapping is discussed in detail in the section entitled "Considering and Engaging Stakeholders."

During Phase 1 the focus of the KSG is on ensuring that its structure, terms of reference and funding are firmly based, and that the objectives have been clearly articulated. It then concentrates on identifying feasible strategies, and recommending the most promising strategies to the decision makers.

Project Champion

Despite the responsibilities of the KSG, the IUWM planning process typically needs the inspiration of an active and involved project champion to make things happen. In many cases, the IUWM planning process is initiated by a voluntary project champion, who seeks strategic support for the project within their own organization and through consultation with government and key players, identifying suitable people to participate in an initial meeting. At this meeting critical members of the KSG are selected, who then take overall responsibility for managing the IUWM planning process. In some cases an organization might actively seek a champion to initiate the IUWM planning process; a champion might be found from within or outside the water industry. Their allegiance is less important than their ability to raise enthusiasm and funding for transitioning to IUWM. The project champion might also take action to obtain funding and support from government and other bodies. Examples of project champions include:

- In El Paso, Texas, much of the success of adopting the IUWM approach is attributed to the championship of the General Manager, who has remained with the water utility for many years and has a deep understanding of local conditions and all aspects of water management. His organization has a close relationship with the City Council, but there is no formal KSG.
- In South East Queensland (SEQ), Australia, the Government formed the Queensland Water Commission, to integrate a multitude of players in urban water. The head of the Queensland Water Commission is now the champion of change.

The vision and energy of the champion is instrumental in ensuring buy-in from relevant parties, good communication between the organizations involved and a positive public image to assist progress towards implementation. While the champion does not necessarily lead the KSG, it is important that he or she gains their support. The champion is the public face of the KSG, and their role continues throughout the life of the project; plans should be put in place for replacement should the champion leave or be unable to continue in the role. Properties of an effective project champion include:

- Is enthusiastic and dedicated to IUWM
- Has support of his/her organization
- Has demonstrated support of key stakeholder group
- Is able to adapt to a changing role
- Ensures continuity and succession plans are in place

KSG Membership

A functional and effective KSG of around six to ten people is selected from all possible participants who are interested in IUWM. In the early stages representation is usually suggested by the project champion, and is limited to organizations which play a leading role in water planning and management, such as the local water supply utility, the water district, wastewater and stormwater utilities and the local council. As likely strategies for IUWM emerge, the KSG might choose to extend its constitution beyond planners and managers, to include relevant individuals or organizations that are motivated to participate.

For example, if there are large losses from leaks and aging infrastructure, it might be expedient to include a representative from asset management on the KSG. Consultants who specialize in particular aspects of analysis, representatives of university research departments, and others with specialist knowledge might also be selected. Whichever organizations are involved, the KSG is in a better position to achieve the desired outcomes if members have close links with the decision makers, and include representation from senior management of relevant organizations. Consideration might also be given to including representation from funding organizations and regulators, or obtaining their support in a less onerous role. A list of organizations whose participation might be considered on the KSG is given in Table 2.1.

Members need to be at an appropriate level of authority and expertise within their organization; their role is professional, requiring time commitment and continuity. Key stakeholders need to develop a detailed understanding of IUWM issues, both the general principles and local conditions and constraints. Members should be cognisant of their own organization's policies and objectives, and have access to strategic decision makers within their organization, should changes to company policy or commitment of resources be required. See Table 2.1 for possible members of the KSG. In order to manage the IUWM planning process, they also need to have some understanding of the rights, responsibilities and roles of each organization involved. The KSG must act as a professional body, and membership requires time, dedication and the ability to work together constructively.

Roles and Responsibilities

Success of IUWM lies squarely in the KSG's hands. The KSG is responsible for managing the IUWM planning process, and for ensuring that results are communicated to relevant parties. Over time, the KSG learns to work together to become an effective force. The KSG must spend adequate time on understanding and learning about each other's strengths and capabilities. This will assist in developing good group dynamics.

Early in the process the constitution, terms of reference, roles and responsibilities of the KSG are agreed on and articulated. This includes the relationship of the KSG to the ultimate decision makers, which in some respects resembles the relationship of a company executive to its board. The KSG should follow general rules of good business practice, ensuring that there is no ambiguity in the roles of individual members or how decisions are made, and that any conflicts of interest have been openly declared. Governance structures are put in place, and officers appointed to oversee its activities including, at least, a chairman and an administrative assistant. Regular meetings, good record keeping, transparency, accountability and follow-up on agreed actions are essential. Dispute resolution procedures should be agreed on. Funding arrangements for KSG activities are agreed on by all participants and confirmed with participating organizations. The roles and responsibilities should be reviewed from time to time.

During Phase 1, the role of the KSG is to ensure that all potential water sources have been identified, and that a comprehensive range of urban water management options has been considered. At the end of Phase 1, the KSG recommends a strategic direction for the urban water management to the decision makers, with suggestions on how the second phase of the project will be conducted. Throughout Phase 1 communication and engagement with the wider community, including the general public and special interest groups, is beneficial. More details on involvement of the wider community are given in the section on "Considering and Engaging Stakeholders."

Table 2.1
Possible members of key stakeholder group

Type of organization	Possible representatives
Water wholesalers, utilities and managers	• Utility managers • Utility operators • Local government stormwater managers/operators • Wastewater treatment plant managers/operators • City Councils • Private water purveyors outside city
Regulators	• Regulators (water quality, public health, supply) • Federal, state, local • Regional water quality control board • Public health officials • County stormwater (septics)
Industry	• Local industry (existing and new) • Energy industry • Chamber of commerce • Developers
Planners	• Local government planning • Upstream and downstream cities • Port representative
Funding groups	• State (grants for recycled water)
Users and special interest groups	• Rate payers/residents • Tribes • Species protection groups • Wetland champions • Recreational users • Agricultural users • Environmentalists • Downstream users • Fishery groups • Greenhouse gas groups

In summary, the KSG directs the IUWM planning process; discusses and ensures common understanding of objectives and agreed actions; clearly articulates key decisions and information to project participants; maintains focus of process on coordination and achieving common goals; and advises the ultimate decision makers on all strategic decisions and critical outputs, including: (1) objectives (set as part of Activity 2); (2) measures and criteria (set as part of Activity 2); (3) existing system constraints and opportunities (identified as part of Activities 3 and 4); (4) other issues that have been agreed on and will affect choices and outcomes and (5) a strategic direction for managing the urban water system (i.e., the outputs of Phase 1).

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

This activity is the touchstone of the IUWM planning process. During the objective development process, the essence of the problems to be solved is identified, and the way in which achievement of objectives is to be measured and calculated is agreed on. Any pre-defined performance criteria, such as water quality standards and minimum environmental river flows, are acknowledged. The resulting set of measures and methods provides the KSG with a common, clearly understood process for evaluating and assessing alternative solutions, and provides a technical basis for all the activities which follow. It is important that this information is recorded and referred to by all participants involved in the IUWM planning process so that a consistent approach is achieved.

During Phase 1, a first iteration of the overall objectives of the project is agreed on and appropriate measures, criteria and methods of analysis are chosen, for the purpose of selecting a strategic direction appropriate to local conditions.

Objectives

The ultimate success of adopting the IUWM approach depends upon setting clear objectives. The objectives of the proposed integrated urban water system will determine the suitability of alternative configurations of urban water servicing, and should be agreed on by all key players. The agreed objectives are critical outputs, and are referred to as a check throughout the IUWM planning process. Time devoted to articulating and agreeing on objectives is time well spent; although objectives, measures and methods are revisited and confirmed or adjusted during the course of the project, the objectives generally remain unchanged.

The process of agreeing on objectives starts with recognition of a problem, often the driver for considering IUWM, which is formulated into a *problem statement*. The problem statement is usually fairly specific, such as the possibility of running short of water if a certain source becomes unavailable. The problem statement is then generalized, to add context which assists in recognizing the full suite of benefits of IUWM, and allowing a wide range of solutions to be identified (such as reducing demand by using new technologies, as an alternative to providing more water). A set of objectives for IUWM is then derived from the problem statement (see Figure 2.3). For integrated urban water systems objectives generally address sustainability, and often include the need to solve site-specific problems, such as stormwater flooding or restoration of urban stream environments. Knowledge of the current system assists in formulating the final IUWM objectives (see Activity 3).

Generic factors to be considered when setting objectives in an IUWM context include:

- Sustainable urban water management
- Supply availability, reliability and continuity
- Level of service required by the community
- Living standards of the community
- Current water use and efficiency of water use
- Condition and value of the existing water infrastructure assets
- Water quality required for maintaining public and ecosystem health
- Sensitivity of the surrounding environment
- Impacts on city planning
- Energy consumption
- Greenhouse gas emissions
- Resource recovery
- Return on investment (profit/loss)

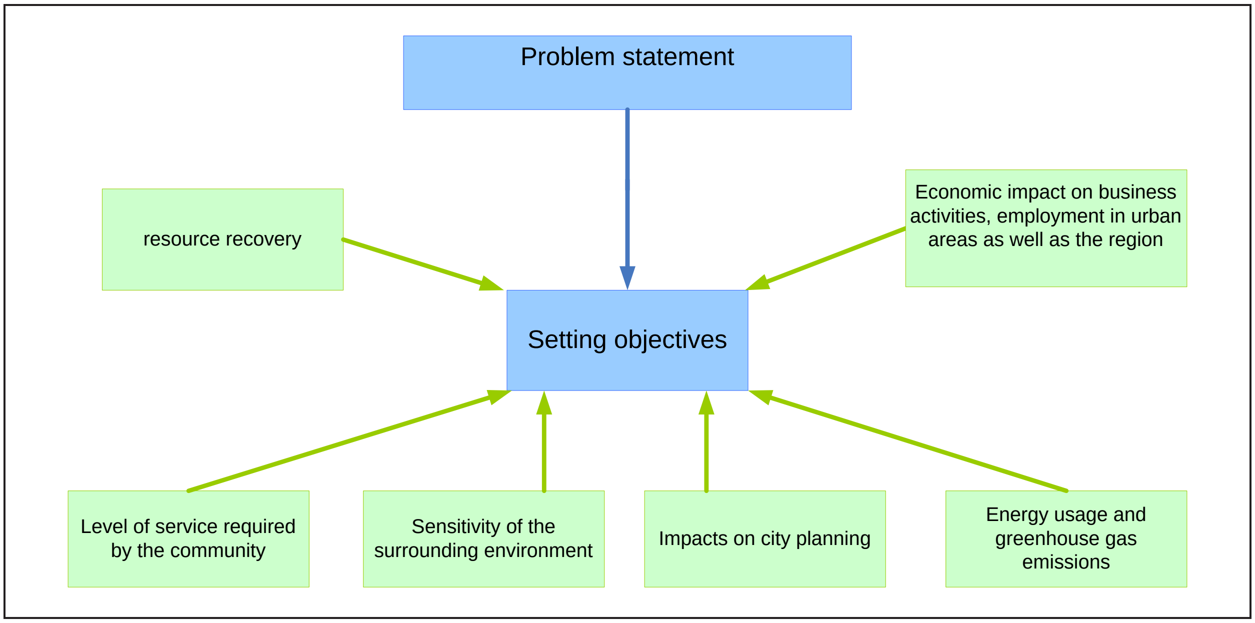

Figure 2.3 Deriving objectives from the problem statement and some factors to be considered when setting IUWM objectives

- Economic impact on business activities, employment in urban areas as well as the region

As clarification of the objectives is sought, different views are articulated and discussed to ensure that all members of the KSG have a common understanding. It is helpful to express objectives in a hierarchy or tree (see Figure 2.4), which generally includes "sustainable urban water management" as the primary objective.

Objectives do not offer specific solutions, but aim to express the performance required of the entire system. More specific objectives such as limiting the available supply, reducing consumption, extending the current system or recycling household greywater specify preferred solutions and restrict the approaches that can be adopted. While such prescriptive objectives might assist in specifying possible portfolios in Phase 2, they are not true performance objectives and should not be included in the higher levels of the objective tree. If they *are* included in the objectives at Phase 1, room should be left to expand them in future iterations, as new perspectives and greater understanding of the system identify alternative approaches. Specific objectives for individual sites or problems, however, such as reducing flooding in certain areas, or protecting critical habitats of endangered species, are important goals that must be met, and should be included in the objective tree.

Measures and Criteria

Once objectives have been agreed on, ways of determining whether, or how well, each high level direction (or strategy) meets the agreed objectives are sought. The performance of each proposed strategy can be evaluated using models, consultation, expert opinion and other methods, each providing performance evaluation in terms of different measures. In order to arrive at a

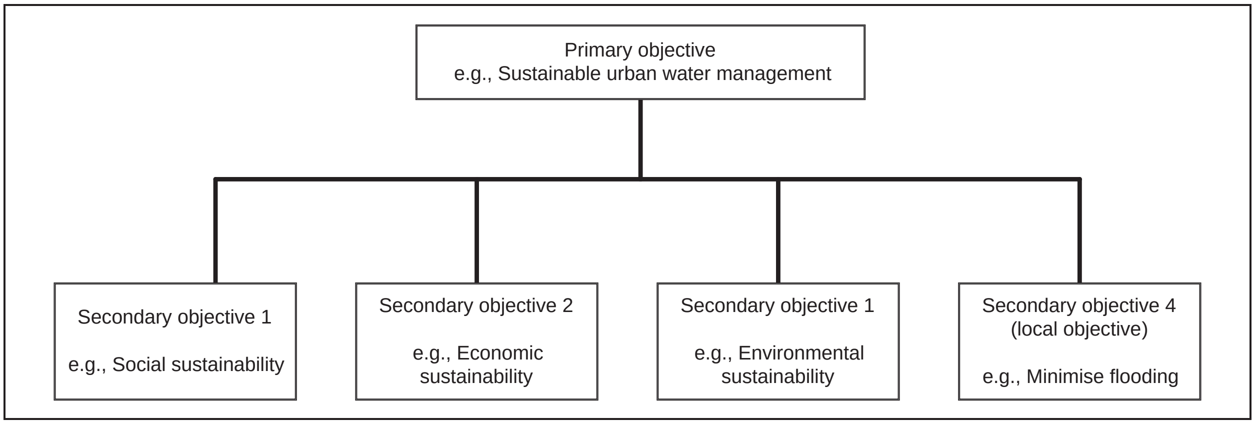

Figure 2.4 Objective tree showing primary and secondary objectives

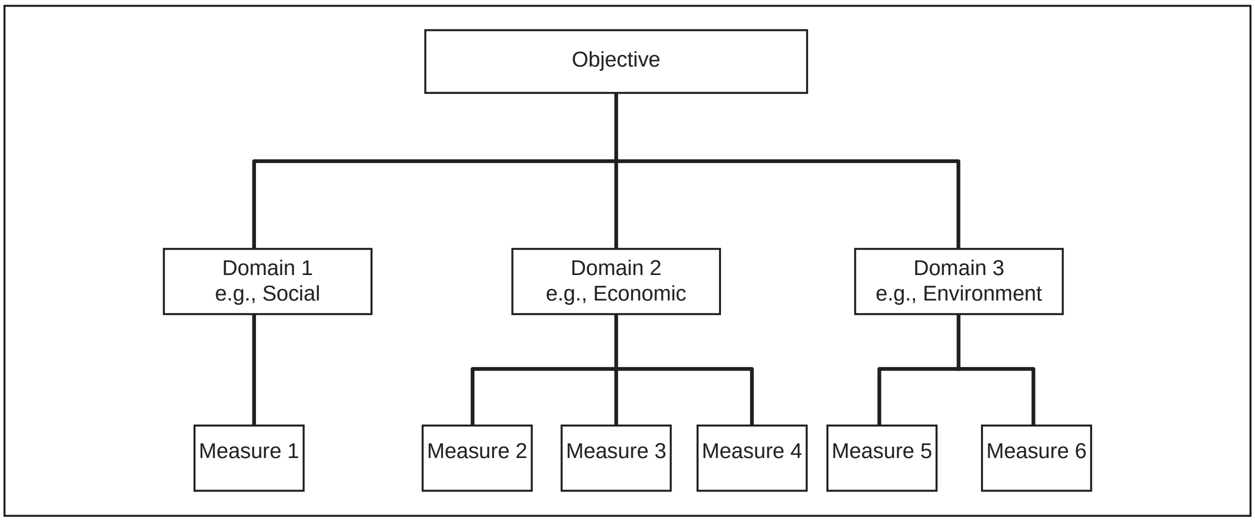

Figure 2.5 Objectives, domains, and measures for system performance evaluation

comprehensive set of measures for system evaluation, it is helpful to introduce the concept of "domains," which correspond to commonly understood areas of system performance. There are a number of domains associated with each objective (see Figure 2.5); for example, if the objective is to reduce flooding, the impact is in terms of social, economic and environmental damage (domains), which are commonly measured in terms of water volumes and frequencies, financial losses and human trauma and displacement.

A number of measures might be evaluated to assist in understanding system performance in each dimension (see Figure 2.5). It is not essential to have the same number of measures for each dimension (see Figure 2.5). Some examples of measures are given in Table 2.2. The economic dimension, for example, might be assessed using the measures of capital loss and losses in productivity.

Measures can range from a detailed numerical quantity (a water saving of 3 GL/year), through a semi-quantitative scale to a simple, qualitative expression (such as low, medium or high). Methods of evaluation are discussed in the next section, but when determining the measures to be used in the project, it is important to ensure that there *are* methods by which they can be

Table 2.2
Example measures in the economic, environmental, and social dimensions

Dimension	Measures
Economic	• Net present value • Annualized value of capital • Operating, maintenance and replacement of infrastructure • Costs and benefits to the community, which include externalities, regional economic growth and returns on investment
Environmental	• Environmental flows in waterways and rivers in urban areas • Quality of water levels of pollutants in waterways and rivers in urban areas, • Changes to habitats and biodiversity of the surrounding environment • Energy usage • Greenhouse gas emissions
Social	• Drinking water quality • Degree of flood protection and mitigation • Sanitation • Supply reliability, affordability and equity • Wastewater and stormwater service provision • Amenity and recreation aspects of waterways and green spaces • Home gardening • Degree of public participation in decision-making

evaluated. The preference of the teams working on the project to use particular models might well determine what are, and what are not, appropriate measures. And if there is a need to prepare environmental impact statements (EISs), for example, during portfolio selection and implementation, including measures that match the EIS requirements will save duplicated effort.

In some cases, the KSG or other organizations require that certain levels of performance *must* be met. These levels are commonly called criteria. While some criteria are set by legislation (such as minimum acceptable water quality standards), others are set and agreed on by the KSG. For example, the KSG might agree that one objective is a reduction in drinking water usage, measured in ML/annum, with a target of a 20% reduction by the year 2020. These then become the measures and criteria against which the success of different portfolios is assessed. Criteria are not required for each measure of system performance, as relative values might be sufficient to inform the portfolio selection process. For example, one option might be more socially acceptable than another, although no absolute level of social acceptance has been set. The resulting tree of objectives, measures and criteria should form a consistent set (see Figure 2.6).

During Phase 1 the objectives for the entire project are set. The dimensions, measures and criteria developed during this phase are, however, those needed for Phase 1 analysis, for setting the strategic management direction for solving the problem stated in the problem statement. Typically, these include whole-of-city water and contaminant balances, indicative pricing, general social acceptance and impact on threatened species. Phases 2 and 3 will require additional measures and criteria to be evaluated. Examples of dimensions, measures and criteria for different levels of analysis are included in the case studies described in Chapter 3.

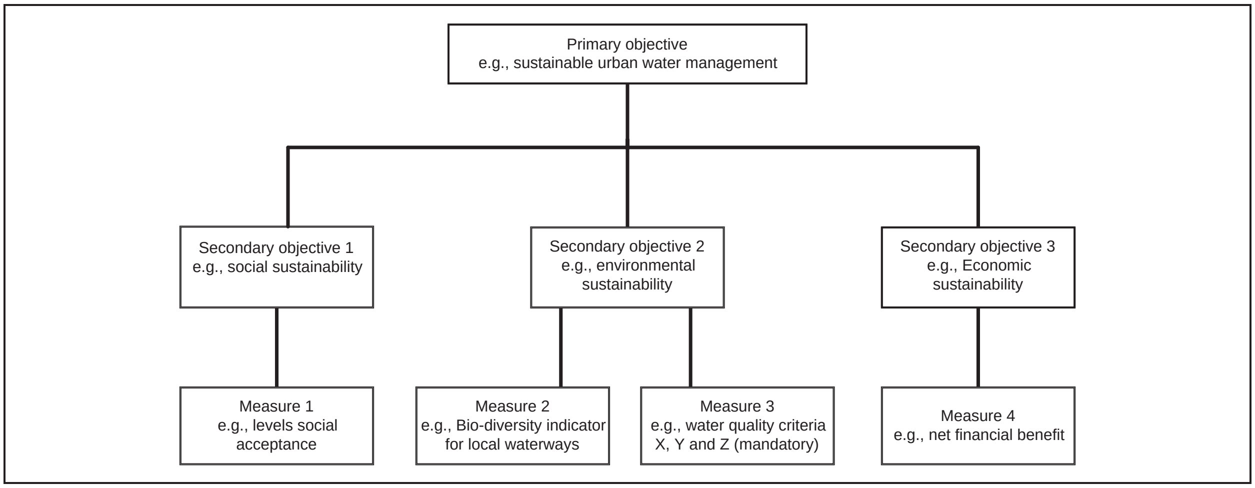

Figure 2.6 Objective tree showing measures and criteria

Methods of Analysis

The methods used to analyse system performance at each level is closely linked to the agreed performance measures. Often, available models and methods determine which measures are evaluated.

During Phase 1, the KSG is seeking to understand whole-of-city performance such as overall water balances, to identify possible new water sources and savings, and to gain a broad understanding of the potential cost and reliability of different approaches. For these evaluations, catchment-scale water and contaminant balance models, simplified economic assessments that examine generic plant, infrastructure and energy costs and the inherent reliability of different supply sources under a limited number of climate scenarios might suffice.

The performance of the system can be analyzed in many different ways, ranging from complex, geographically explicit computer models, through simple lumped models to surveys, consultation and expert opinion. It is the appropriateness of the approach to provide a relevant level of understanding that matters, not its ability to mimic reality. Methods will be limited by the skills available to undertake the analysis, which might involve hiring consultants. If the stakeholders' analysts are familiar with one particular flow model, and already have data on significant catchments available, it might be wise to continue with the familiar method. Examples of measures, criteria and assessment methods are given throughout the case studies described in Chapter 3.

Phase 1 Activity 3: Understand Current System

The purpose of this activity is to understand the current system in sufficient detail to enable the identification of potential opportunities, and to resolve the problem identified as part Activity 2. It is important to note that the data and level of detail depends on the objectives, measures and methods of analysis agreed on in Phase 1 Activity 2, and only data for the agreed methods is required.

Data and knowledge can be sourced from different utilities and organizations; where data is not in the public domain, access is negotiated as necessary. A structured approach to knowledge management assists the KSG in ensuring that consistent and agreed data sets are used throughout the project. This activity provides the input to the analysis that will be conducted in Activity 4.

System Boundary

An essential part of this activity is defining the system boundaries. The IUWM requires consideration of the whole urban water system including social, economic, regulatory, institutional and legislative structures that affect performance of the urban water system.

The physical system boundaries encompass the urbanized area and include system components that lie outside the urban area such as sources, discharge points and receiving waters. Potential impacts and potential solutions to the problem might extend well outside the immediate catchment: for example, stormwater discharge from a neighbouring catchment might provide water for irrigating parks and sports fields. This is true even if the focus of planning is on one particular aspect of the water cycle, such as water supply planning.

The non-physical system boundaries relate to social and economic activities of communities served by the urban water system, and regulatory, legislative and institutional structures currently in place. For example, legislative boundaries might extend to federal or even international limits.

The purpose of Activity 3 is to understand both physical and non-physical influencers that lie within the system boundary to a sufficient extent to develop strategic solutions to the problem defined in Activity 2. Brief descriptions of physical and non-physical influencers shown in Figure 2.7 are given below.

Demographic Projections

Demographic data include population, types of households, household income and number of occupants. Demographic data are needed to understand population-related factors that influence water consumption, and to project historical demographic patterns into the future. These in turn provide a basis for future water demand projections. Demographic data can be obtained from city planning departments or state or federal government organizations involved in collating, analyzing and forecasting demographic trends, e.g., Australian Bureau of Statistics.

Phase 1 analysis does not require detailed demographic projections. Population projections are sufficient in this phase to provide per capita average water consumption projections. However, depending on the problem, Phase 2 analyses may require detailed demographic projections. For example, spatially explicit demographic data might be needed to estimate local availability of water "fit-for-purpose," and hence to reduce resource use.

Climate Projections

The impacts of climate variation and climate change will vary for different regions. Understanding current trends in temperature, rainfall, wind and humidity, and how these compare to past records, gives an indication of values and extremes that might be expected (without climate change). On top of these variations, climate change scenarios provide projections, albeit with a degree of uncertainty, into the future. The selected strategies need to provide robustness against these extremes. The KSG will need data on extent and likelihood to agree on which climate patterns and climate change scenarios to use in their assessments.

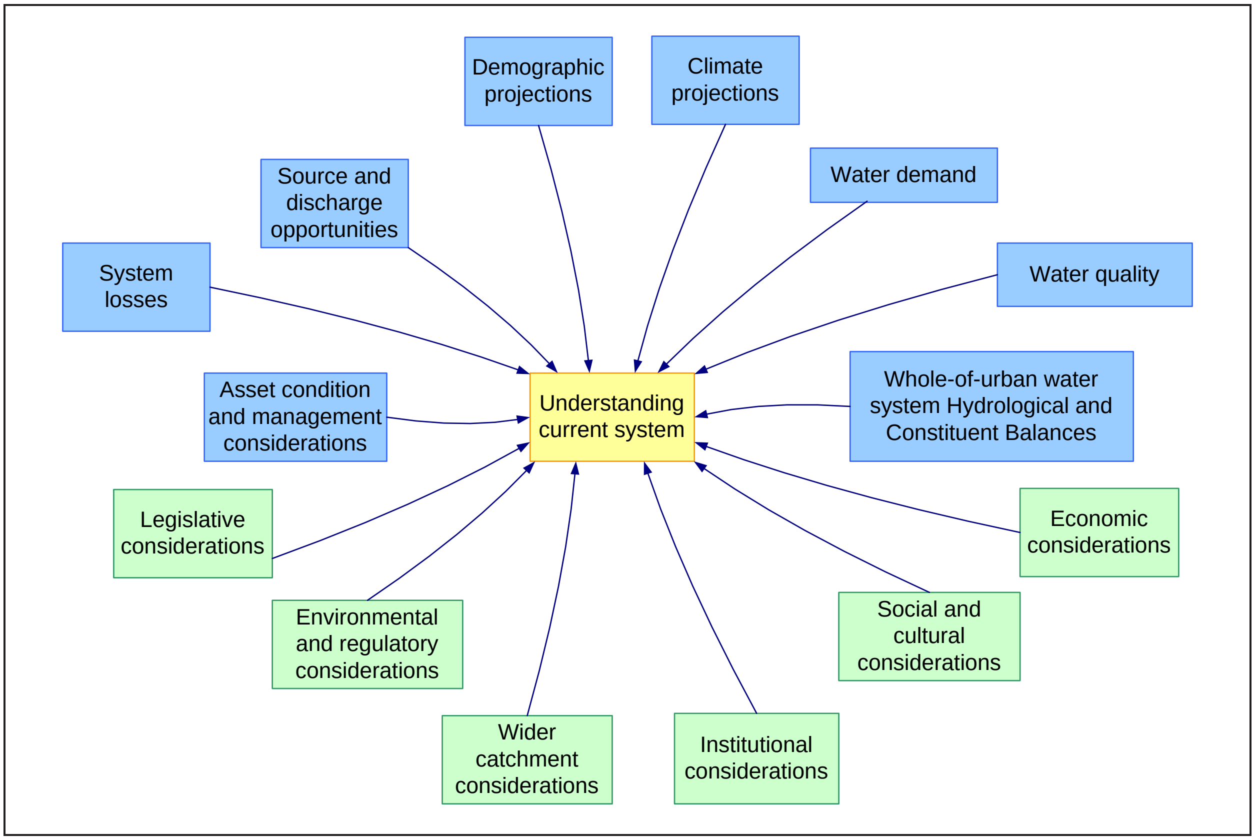

Figure 2.7 Physical influencers and non-physical influencers that should be understood as part of understanding the current system

Water Demand

The starting point for understanding user needs is understanding details of current water demand, which requires analysis of metered data, where possible, to identify current consumption patterns of various sectors such as residential, industrial, etc., and spatial variations of consumption across the system. However understanding the current water demand alone is insufficient to identify alternative strategies. Linking of historical water use with historical demographic patterns and climate data help to identify key influencing factors (e.g., population growth, changes to housing stock and demographics, climate variability and change) and develop consumption projections based on key influencing factors, which in turn help explain any anomalies and assist in forecasting future demand. Demand forecasting is a mature area of science and an essential component of water supply planning. A comprehensive guide to demand forecasting is given in American Water Works Association (2007).

A key feature of IUWM is to provide water fit-for-purpose, which requires understanding the consumption of residential, commercial and industrial sectors, and disaggregating the consumption of each sector into individual end uses. For example, end uses for the residential sector include kitchen, bathroom, shower, etc. Consumption of each end use is analyzed to understand trends, consumption patterns and the quality of water required to meet the demand. However, detailed end use data is generally not available (unless a monitoring program is in place).

As mentioned in the section on "demographic projections," in Phase 1 demand can be analyzed as average per capita demand, and then disaggregated into sectors and end uses using typical or assumed data (e.g., consumption of the residential sector is assumed to be 70% of total demand; outdoor water use in the residential sector is assumed to be 30% of residential consumption). In the U.S.A. context, typical end use data at a national level is available from the American Water Works Association, the Water Research Foundation, or the U.S. Environmental Protection Agency. In Australia, typical end use data are available from the Water Services Association, Australia.

Supply Sources and Discharge Opportunities

The starting point for understanding availability of water to meet needs of existing, new and potential uses is, understanding the yield of existing sources as well as potential new sources. Potential sources include: surface water, groundwater, stormwater, rainwater, greywater, recycled water and sea water. In Phase 1, temporal and spatial characteristics of all sources are quantified, which include possible capture locations (for new and potential sources), inflow characteristics and the yield. A guide to yield estimation is given in American Water Works Association (2007).

If the main driver for considering IUWM is water scarcity, a comprehensive assessment of all water sources will be required. Otherwise it is sufficient to quantify spatial and temporal characteristics of water streams sourced from urban catchments, i.e., stormwater, rainwater, greywater and recycled water, and to identify optimal discharge opportunities.

New strategies will affect the quality of water discharged (for example, sewer mining will reduce the water content of the waste stream, which could affect sewage treatment processes), as well as the quantity (lower discharge levels from sewage treatment plants will reduce water available to the environment). New discharge opportunities, such as enhancing flows in urban streams to improve the urban environment, should be considered along with source opportunities.

Water Quality

The meaning of water fit-for-purpose is that operational efficiency is achieved by using water that has not been over-treated. The quality of water, in both the supply stream and the discharge stream, will impact on infrastructure and the environment, and is therefore critical in deciding suitable strategic solutions to the problem defined in Activity 2.

In Phase 1, it is sufficient to understand typical water quality characteristics of both supply and discharge water streams (e.g., such characterizations as "drinking water," "class A recycled water" and "class B recycled water"), unless water quality issues have been identified as a particular concern in the objectives. This understanding will assist in identifying "fit for purpose" opportunities and potential damage (or improvement) to the environment and human health, if new strategies are adopted.

System Losses

Water is lost from the system through evaporation, seepage, leakage from pipe infrastructure and percolation into deep aquifers. The magnitude of these losses depends on local conditions, including climate, the condition of infrastructure assets and geological structures. A general understanding of the magnitude of these losses will indicate their significance.

Whole-of-Urban Water System Hydrological and Constituent Balances

Whole-of-urban water system hydrological and constituent balance calculation methods, which can quantify volumes and associated constituent loads in all flow paths within the physical system boundaries, are possibly the most powerful methods to be used in Phase 1 to identify opportunities to create a sustainable urban water system. This method allows accounting for interactions between the urban water system with the surrounding environment (i.e., extractions from the environment for sourcing water and discharging wastewater and stormwater to inland and marine receiving waters) and feedback loops within the urban water system due to recycling, stormwater use, etc., when simulating flows and constituent generation, runoff and transportation processes within the physical system boundaries. Outputs include spatial and temporal distribution of flows and constituents at any defined point within the system, which enables identifying flow paths and the volumes and quality of water available for capture and use for either human consumption or as environmental flows.

Analyzing water balances requires data on all inflows, demands and outflows from the system, for stormwater, groundwater, potable water and wastewater. During Phase 1, a general understanding of the quality of water in flow paths based on typical data and an annual water balance are adequate for identifying alternative strategies that meet objectives defined in Activity 2. An accurate simulation of flows and constituents based on site-specific data is appropriate for Phase 2 and Phase 3.

Asset Condition and Management

Urban water infrastructure is characterized by long lifetimes and high investment costs; once built, financial and technical considerations make it hard to change. IUWM will, in all probability, involve changes to the use of the infrastructure. For example, recycling will reduce volumes of wastewater and increased storage in reservoirs will put additional loads on dams. If the system is aging and has high losses through leaks, IUWM might include a leak reduction program. The condition of the current infrastructure and its ability to meet new storage and transport needs will influence the final choice of portfolios.

If major capital works are scheduled to replace aging infrastructure, or funding is available to construct a new sewage treatment plant, this might be an opportunity to consider change, or influence the acceptability of certain strategies. Management policy can also play a major role in reducing leakage; a risk-based replacement strategy can reduce leakage substantially.

Legislative Considerations

Consideration of legislation and policy frameworks ensures that the chosen strategies comply with relevant water-related acts and policies. Regional development plans, water resource plans, current strategic plans on water supply, wastewater and stormwater and guidelines on drinking water quality and recycled water use could limit the adoption of some strategies, and changes might need to be initiated.

Legislative requirements related to urban water systems are generally country specific and in some cases State specific. For example, in North America, there is no national water rights system (American Water Works Association, 2007).

Social and Cultural Considerations

An aim of IUWM is to provide a service that is equitable and acceptable to the community. Therefore, IUWM takes account of preferences of the community, the cultural needs of different groups, preservation of sites of historic or cultural value, traditional fishing rights and other social and cultural considerations. It takes account of requirements or policies for community consultation, and the current level of understanding of water issues in the community. It also investigates the community issues and concerns and the effectiveness of educational programs that are in place. The organizations represented on the KSG might have documentation on past interactions with community groups. Community consultation is strongly recommended during all phases, to ensure that issues are raised and addressed. A detailed description of community consultation and stakeholder interaction is given in the last section of the process.

Levels of service for water supply, wastewater and stormwater services (e.g., reliability of water supply; frequency, duration and severity of water restrictions in drought periods; sewer overflow volumes, events and frequency; frequency of floods of various magnitudes) provide an indication of the service expected from water utilities, state of the current system, and where services can be improved. Public attitudes to the adequacy and acceptability of current levels of service provide insight into where improvements are needed, and could result in changes to the project objectives and performance measures agreed on in Activity 2 (and hence the assessment methods described in Activity 4).

Protecting public health is a key influencing factor for accepting any water management option. Therefore, it is essential to ensure that the introduction of IUWM does not pose any threat to public health. Drinking water quality standards, water quality reuse and discharge standards, and the role of water in maintaining public health must not be compromised. An understanding of any past issues, the attitude of the community to water reuse and recycling, and understanding the suitability of using stormwater or recycled water on local crops, for fire fighting and for other services will assist in selecting appropriate strategies.

Institutional Considerations

IUWM involves a number of utilities and organizations working together to achieve common goals. It is important to understand each organization's responsibilities and institutional arrangements, and to recognize any potential barriers to implementation. For example, where a stormwater system is managed by the town council, the council might currently have responsibility for approving any changes; this could cause unacceptable delays and possible failure for the overall IUWM plan, and responsibilities might need to be reassigned or strategies reconsidered.

Economic Considerations

The economic implications of IUWM can be considered under the categories of (a) microeconomics and (b) macro-economics. Micro-economics includes capital expenditure (including budgeted capital expenditure), operation and maintenance costs, infrastructure replacement costs, revenue from selling water to customers, repayment commitments, grants and the externalities of urban water management. Bond histories and opportunities are also relevant, as well as financial incentives, such as rainwater tank subsidies. Macro-economics includes flow-on regional economic implications of urban water management such as growth in industries and regional employment due to efficient management of water.

Data for micro-economic analysis generally exists within the utilities, except for information on externalities. Quantified information on externalities is not generally required until Phases 2 and 3. A high level understanding of macro-economics is sufficient for Phase 1. Typical relevant questions are: Are there high water use industries, and what is their contribution to the regional, state and national economy? How much water is needed to produce one unit of product? Is it economical to sustain high water use industries in the region in the long run if water is scarce? What opportunities are there to include economic subsidies or incentives to encourage sustainable water practices?

Environmental and Regulatory Considerations

The urban water system interacts with the environment by extracting water from rivers, aquifers and other sources, using it and discharging it back. This impacts on the environment, depending on the volumes extracted, changes to flow patterns, and quantity and quality of discharges; impacts will be influenced by the geology and topography and the sensitivities of the biological species of the region. IUWM can play a role in improving the urban environment by creating opportunities to building wetlands and day-lighting streams and increasing water availability to water parks and green spaces. Such opportunities must be considered as part of Phase 1.

However, IUWM opportunities must be identified within the limits of the surrounding environment. Compliance with existing environmental regulatory requirements is a starting point for these considerations. For example in North America, the National Environmental Policy Act (NEPA) specifies policies and goals to protect the environment and authorizes the U.S. Environmental Protection Agency to implement NEPA. NEPA requires all projects and discretionary actions that may directly or indirectly change environmental resources and land use patterns to develop an environmental impact statement (EIS) supported by an environmental impact assessment (EIA) conducted by a suitably qualified organization (American Water Works Association, 2007).

Although further work including development of a detailed EIS will be required once the IUWM planning process has been completed, it is relevant to consider existing environmental regulations and aspects to be evaluated for an EIS in Phase 1. Qualitative evaluation of these considerations and impacts can then be included in Activity 4 analysis. Indeed, the needs of the EIS can be used to derive quantitative measures for evaluation in the environmental domain in Phases 2 and 3, thus avoiding duplication of effort and any unnecessary complications in acceptance of the final IUWM strategy.

Wider Catchment Considerations

Although this manual addresses urban water management only, inevitably activities outside the urban area will impact on supply and discharge opportunities. Bushfires, which might impinge on the urban fringe and require water for fire fighting as well as affecting supply, and other activities in the supply catchments such as forestry activities, logging and farming practices, might all need to be taken into account at a qualitative level during Phase 1. In addition, it would be desirable to include the following interrelationships and account for them in the performance assessment in Activity 4, in particular in Phases 2 and 3:

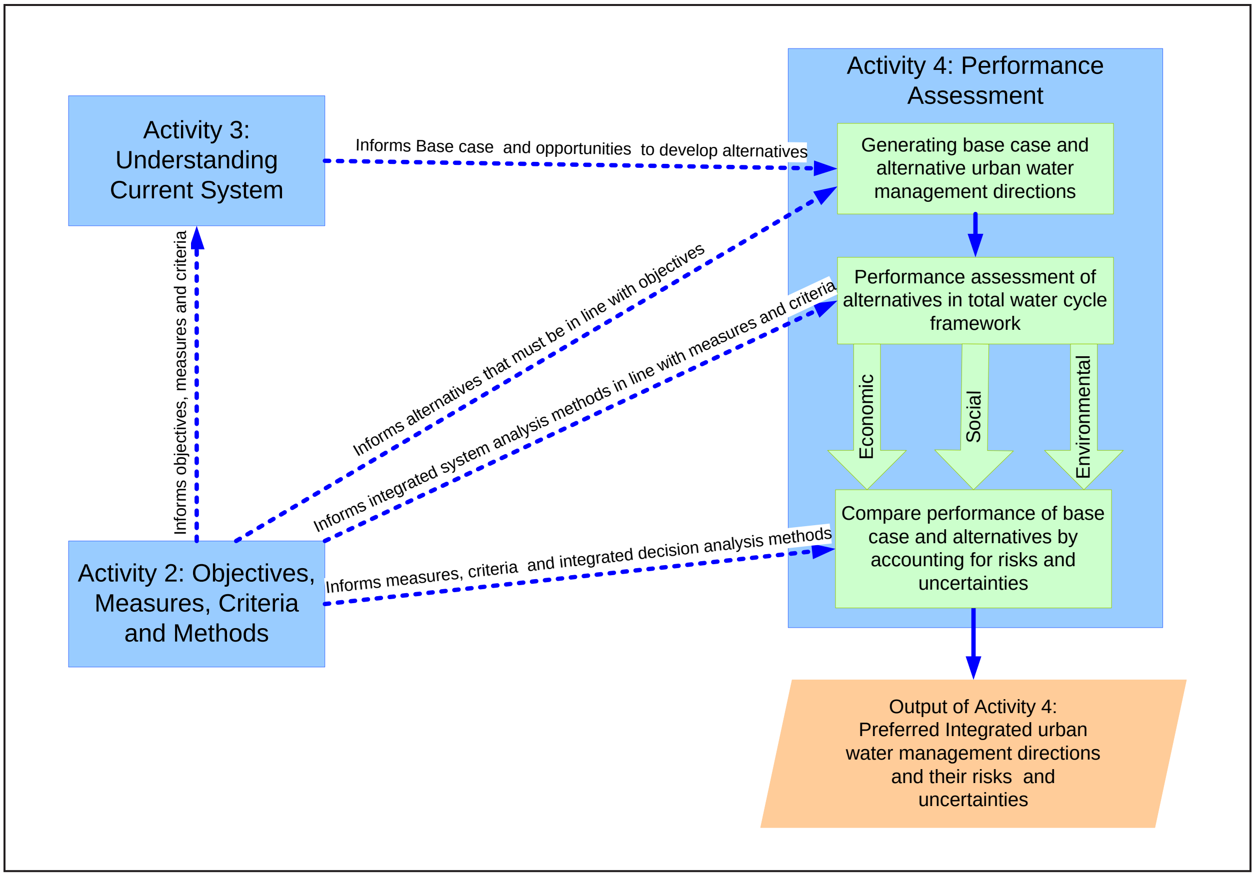

Figure 2.8 Information provided from Activity 2 and Activity 3 to Activity 4; analysis undertaken as part of Activity 4 and overall output of Activity 4

- The urban heat island effect and impacts on water use
- Water and energy interactions in urban water context, e.g., energy use for cooling and heating, energy or resources recovery from waste streams
- Water and greenhouse gas emissions in the urban water context

In Phase 1, the above could be qualitatively quantified using expert opinions and typical data.

Phase 1 Activity 4: Assess System Performance

The purposes of this activity are to: (1) define a base case; (2) define alternatives to the base case; (3) quantify the performance of the base case and alternatives against the measures defined in Activity 2; and (4) compare performance of the base case and alternatives in an appropriate decision-making framework. Components of this activity are shown in Figure 2.8.

The base case is generally the business-as-usual case. Often, it represents the current urban water management approach. In Phase 1, alternatives to the base case represent possible and strategic urban water management directions that are in line with objectives defined in Activity 2. It is important in this phase to consider all possibilities and only reject those which are unequivocally unfeasible, because some high-level options which at first seem implausible might later be shown to have merit. If in doubt, leave as many alternatives as possible in the mix.

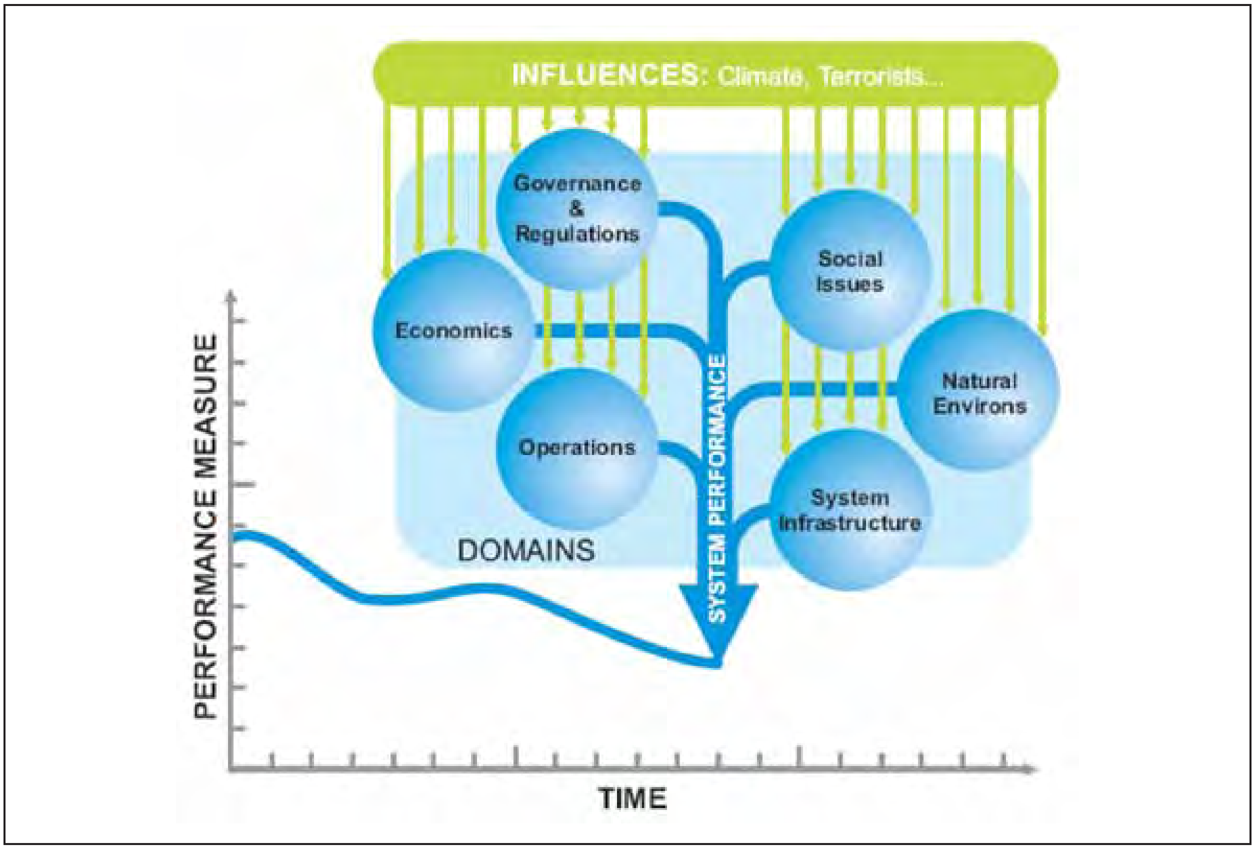

Figure 2.9 Depiction of an Integrated Urban Water System for performance assessment under the IUWM approach

Performance of the urban water system is influenced by both physical factors (e.g., infrastructure sizes and locations) and non-physical factors (e.g., social and economic factors). Figure 2.9 depicts this by representing the system as a series of different domains (shown as balloons). Performance is controlled by activities within each domain, which interact to determine the current state of the system, in terms of the agreed measures. As change occurs within each domain, the performance of the system changes, "moving" the point of the arrow and adjusting its location on the graph. Quantification of the effect of change on system performance is the endeavour of specialists and specialized models (for example, economists evaluate economic impacts, social scientists have models and processes to evaluate social interactions, hydrologists model water flows). The influences of all domains (and additional influences, see below) are combined to generate performance in terms of each measure.

System performance is further influenced by forces that lie outside the controlling mechanisms of each domain. These influences include climate change, demographic change, terrorist activities and natural disasters such as earthquakes, storms and cyclones, which again might require specialized analysis, and which determine scenarios to be evaluated (for example, average annual rainfall, climate change extremes, high population growth or the event of a terrorist attack contaminating water supplies).

Hence performance assessment of options requires (1) appropriate systems analysis methods to quantify measures defined in Activity 2 and, (2) appropriate methods to integrate the

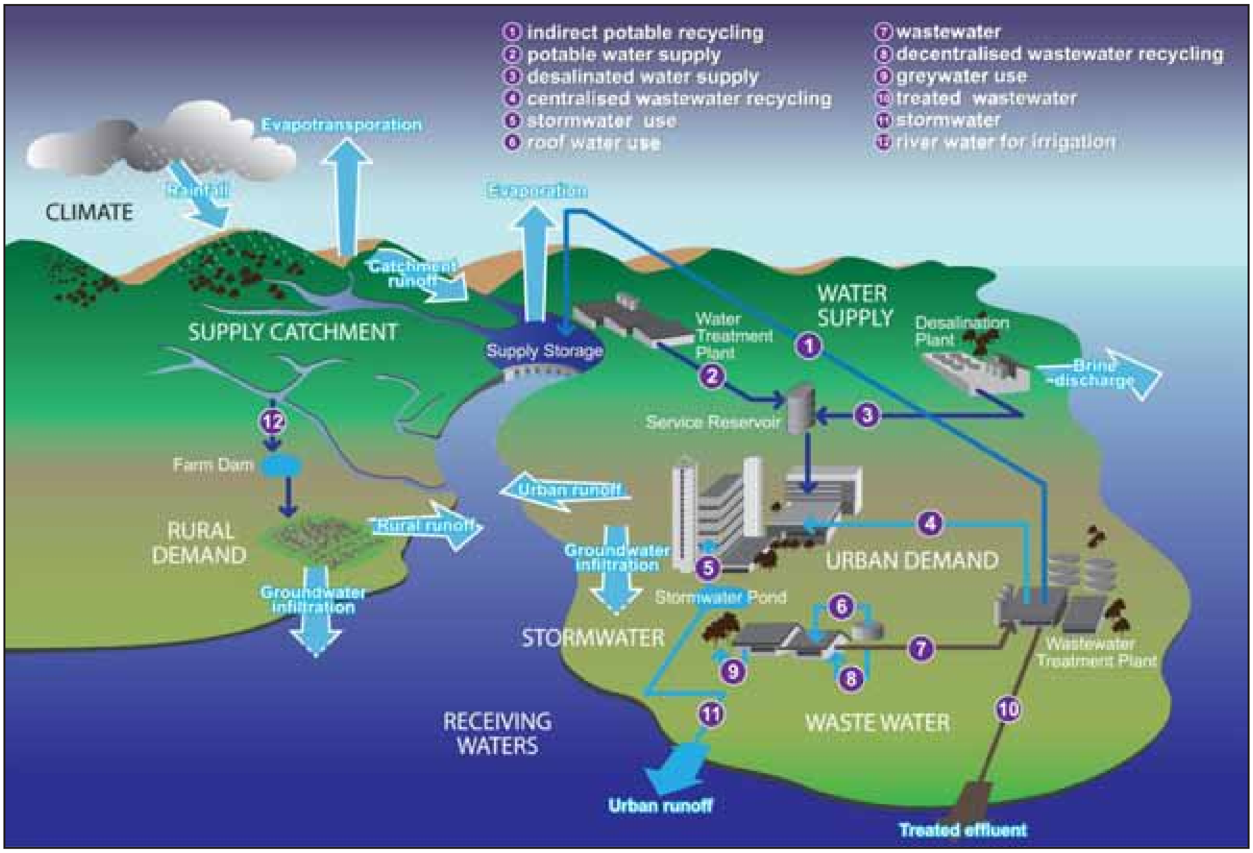

Figure 2.10 Components of total urban water cycle in urban context

knowledge captured in each measure, in order to make sensible decisions. Multi-criteria assessment is commonly used for the latter.

There is no standard set of systems analysis methods that can be recommended for each domain. Selection of suitable methods for each particular case will depend not only on the required measures (which should match capability), but also on the availability of data, time and resources. Therefore, this manual does not attempt to compare systems analysis methods or provide recommendations on which method to use. Methods to quantify measures are categorized into four basic domains: bio-physical, environmental, economic and social. Bio-physical methods generally examine hydrological and water quality aspects of the urban water system, which provide a sound basis for undertaking analysis in the environmental, social and economic domains.

Integrated Bio-physical Assessment

Integrated bio-physical assessment methods take a holistic view of the urban water system and provide insights to fluxes of water in terms of temporal and spatial variability of volume and quality.

Figure 2.10 shows elements of the total water cycle that must be considered in integrated bi-physical assessment. Whole-of-urban water system quantity and quality modeling is an appropriate method for assessing the performance of the urban water system in bio-physical terms. This method considers urban areas as sub-catchments of larger catchments which supply water and are the recipients of stormwater and wastewater. These models include hydrological processes, water quality constituent (i.e., pollutants, contaminants and pathogens) generation and routing processes and water extraction and allocation processes. In addition, they account for feedback flows from reclaimed water use (i.e., recycling, stormwater harvesting, rainwater tanks and greywater use). Emerging tools in this context include HydroPlanner (Maheepala et al., 2005; Grant et al., 2006 and Maheepala et al., 2007), Water Evaluation and Planning or WEAP (a U.S.A.-based model; Purkey et al., 2008; Assaf and Saadeh, 2008) and URWARE (a Europe-based model; Karrman et al., 2007).

Data on sources, demand, water quality, climate projections and demographic projections described in Activity 3 are inputs to the bio-physical assessment, which balances inputs and outputs (e.g., stormwater and wastewater leaving the system) and quantifies the system deficit. The deficit represents the sum of the water evaporated and the water lost through seepage, leakage from pipe infrastructure and percolation into deep aquifers. A good understanding of these losses indicates which are significant, and if so which control strategies are plausible.

Integrated bio-physical assessment models can be used to quantify the integrated urban water balance described in Activity 3. During Phase 1, it is not necessary to undertake detailed bio-physical assessment; a spread-sheet based annual water balance model of the whole urban water system for quantification of flow paths and a general understanding of the quality of water in flow paths based on typical data is adequate for identifying alternative strategic water management directions.

Environmental Performance Assessment

Environmental performance assessment methods quantify environmental implications of alternative strategies. Some common measures in the environmental dimension are: use of fresh water; discharges to waterways; ecosystem health and emissions to air such as greenhouse gases and gases that cause odor and pollution.

Some environmental measures can be quantified using integrated bio-physical assessment, for example fresh water use and discharges to waterways.

Life cycle assessment methods can be used for tracking material usage and greenhouse gas emissions. Life cycle assessment methods have been used widely in the construction, agricultural and production sectors for identifying major energy consumption and emission sources that are amenable to greenhouse gas mitigation, regardless of where they lie in the production chain. However, this is a relatively new approach in the urban water context.

Methods for assessing ecological impacts on urban streams and waterways involve understanding the hydrological flows (both quality and quantity) and changes that can be expected with IUWM. Knowledge of river health indicators and aquatic ecosystem responses to flow and material fluxes, including identification of essential aspects of habitat and flow life-history processes, are then used to assess ecological impact.

Economic Performance Assessment Methods

Economic assessment methods suitable for IUWM include financial cost benefit analysis (CBA) and full economic CBA. Financial CBA includes direct financial costs such as capital, operation, maintenance, administration, rehabilitation, replacement costs and benefits such as revenue from the customer, tax deductions and grants. Economic CBA includes financial, resource scarcity, environmental and social costs and benefits. Evaluation of hydrological, environmental and social costs and benefits will depend upon hydrological, environmental and social impacts, and tools from these specialist domains should be used to provide input to the economic models.

Performance assessment methods for economic impacts include returns on investments and the potential implications of urban water management on regional growth.

Social Performance Assessment Methods

Social aspects of performance assessment generally seek to quantify social outcomes such as public health and safety, level of service, recreation and amenity values, equitable water sharing, technical function aspects (e.g., odor and overflows in sewers and infrastructure failures), cultural aspects of water use and the institutional structures in place for providing a reliable urban water service. They also seek to understand the influence of behaviors (such as the uptake of water-saving shower heads) on other measures of performance. Most of these are difficult to measure using models or in monitory terms. Carefully designed questionnaires and focus groups, as well as historic data, can be used for quantifying social measures.

Methods for Integrating Knowledge in Multiple Domains

Knowledge generated from bio-physical, environmental, social and economic assessment for each alternative is in the form of measures defined as part of Activity 2. Since this knowledge is in multiple domains, comparing alternatives requires multi-criteria decision aid (MCDA) methods. There are a number of MCDA methods; some are available as commercial software. Readers wishing to read more on MCDA are referred to: Kain et al. (2007); Guitouni and Martel (1998); Colson and Debruyn (1989); Massam (1988) and Brans et al. (1986). Commercially available MCDA software include: Decision Lab 2000 (<http://www.visualdecision.com/dlab.htm>); MCAT software (Marinoni et al., 2009).

All MCDA methods require either quantitative or qualitative measures and, preferences for each measure in the form of weightings. Measures (which can include risks) are quantified using the assessment methods described above. Preferences are determined either qualitatively, by the key or wider stakeholder group, or quantitatively, by using deliberations, which combine the facilitation, interaction and consensus building features of the Citizens' Jury process (Crosby, 1999; Dienel and Renn, 1995) with the structuring and integration features of Multi-criteria Evaluation (Proctor and Dreschler, 2006, Massam, 1988, Munda et al., 1994). The output of the MCDA analysis is a uniform comparison of alternatives in multiple domains and a ranking for each alternative.

In Phase 1, it is essential to consider all domains shown in Figure 2.9, but it is not essential to undertake a rigorous quantification for measures in each domain because the intended output is a set of strategic directions to enable generating of a short-list of options. A qualitative assessment of measures using a three-point scale (representing low, medium or high) or five-point scale (representing low, moderately low, medium, moderately high, high) is sufficient in Phase 1. All assumptions made during the analysis should be documented and reviewed during subsequent phases of the process. Outputs of qualitative or semi-quantitative assessments are then fed into a MCDA method to undertake a high-level multi-criteria assessment. Preferences on individual measures may be sought at this phase using deliberations, but it is not essential.

Risk of System Failure

The risk of a system failing to meet anticipated expectations of performance is often as important as the expectations themselves, and should be evaluated and taken into account in any decisions that are made. Risk involves understanding not only the consequences of system failure, but also its likelihood. Ideally, risk assessment is incorporated into analysis of all measures, providing understanding of the risk of failure for each portfolio under each measure. However, in reality there is rarely the data or the time to undertake detailed risk analysis, and risk workshops or expert opinion are used to provide semi-quantitative values. In Phases 2 and 3, outcomes of risk assessment should be included in the MCDA.

It is hard to make decisions when confronting uncertainty; it is easier when those uncertainties have been translated into risks. Risks can be incorporated alongside other performance measures in MCDA. Inclusion of risk assessment into system performance evaluation has the advantage that it gives meaning to the uncertainties in data and modeling assumptions, and in extreme values inclusion of risk analysis will not only influence system selection, but also provide the basis for pre-empting failure and hence managing the system appropriately.

Phase 1 Activity 5: Implementation Planning

Once the systems assessment has been completed, the findings (i.e., a matrix showing values of measures in each domain for each alternative; comparison of alternatives against measures; and ranking of alternatives) will be presented to the decision makers (DM). Implementation at Phase 1 requires that the DM reach agreement on strategic IUWM directions for urban water management. The MCDA model may be used in a workshop setting with the KSG to reach an agreement. The selected strategic IUWM directions for urban water management will be used in Phase 2 to generate alternative portfolios. Some alternatives (such as rainwater capture) might be suitable for immediate introduction while others will require long-term planning. Implementation planning for Phase 1 should ensure that all stakeholders, including the wider stakeholder community, understand (and generally accept) the proposed strategies. A plan for Phase 2 is then agreed on.

Communicating Outputs

In Activity 4, the performance of the current system was assessed and potential strategies for IUWM identified. This information is now communicated to the DM. The form in which the information is presented depends on the requirements of the DM. In some cases the KSG will make a substantiated recommendation to the DM, which will be endorsed for future action without further analysis. In other cases the DM will wish to draw its own conclusions from the submitted information, and might conduct multi-criteria analysis or use other methods to reach a decision. In some cases the DM will be seeking short-term strategies for immediate implementation, as well as a long-term plan. It goes without saying that the long-term impacts of any short-term strategies will be well understood before they are adopted, and that any implemented short-term strategies are included in portfolio generation and analysis in Phase 2 (often referred to as a “no regrets” portfolio).

Communication is not only between the KSG and the DM. Where short-term strategies are selected, details of their proposed introduction, including their benefits, are communicated to councils, utilities, householders, industry and other bodies as appropriate. Benefits of all selected strategies are also communicated, not only to potential users but to relevant funding organizations, upper management and all those whose support will later assist in achieving change.

Finally, details of the assessment of system performance are documented in reports and communicated to relevant stakeholders, for use in later phases of the IUWM planning process.

Planning the Next Phase

The final activity for Phase 1 is to plan Phase 2. In some cases the plan will form part of the submission to the DM from the KSG. Even if this is not required, documentation of Phase 1 is incomplete without a draft plan, which provides a practical start to Phase 2 and a helpful reference should there be a change in personnel or break between phases. Where short-term strategies are to be implemented, details of how and when these are to be implemented will be included in the plan.

Phase 1: Summary

A summary of Phase 1 activities is given in Table 2.3.

PHASE 2—PORTFOLIO SHORTLIST DEVELOPMENT

Phase 2 involves considering how the strategic IUWM directions for urban water management (i.e., outcomes of Phase 1 analysis) will be applied across the town or city. The effectiveness of different strategic directions will vary from place to place, and in Phase 2 a shortlist of portfolios is selected from the multitude of possibilities. *A portfolio is a set of urban water management options in line with the strategic directions agreed on in Phase 1*.

As in Phase 1, some jurisdictions will have already undertaken aspects of Phase 2. If this is the case, one of the first activities of the KSG will be to understand just where these activities sit in the overall process, share the knowledge and fill in any gaps.

Phase 2 Activity 1: Convene Key Stakeholder Group

The purpose of the KSG described in Phase 1 continues throughout its lifetime. During Phase 2, its role turns more towards understanding the system and undertaking more detailed assessment of system performance. The main purpose of the KSG during Phase 2 is to agree on a short list of IUWM portfolios. The KSG ensures that the IUWM planning process progresses smoothly, and that suitable consideration has gone into developing the list of portfolios. It is therefore necessary for the KSG to maintain the interest of stakeholders and decision makers, and to continue to hold meetings on a regular basis. At the end of Phase 2, the KSG will have developed a plan for Phase 3 that is supported by the decision makers.

Project Champion

The project champion continues to be the chief advocate for IUWM. During Phase 1, activity focused on gaining buy-in from the key stakeholders. During Phase 2, involvement of a wider audience is important. The project champion (together with the KSG) needs to ensure that all organizations, individuals and issues that are impacted by the multitude of possible alternatives are considered, and, where appropriate, consulted. The champion needs to build up enthusiasm and

Table 2.3
Summary of Phase 1 activities

Activity	Summary
Activity 1—Key stakeholder group	• A key stakeholder group (KSG) is formed. The KSG manages the IUWM planning process. It consists of six to ten members from all key organizations and includes an enthusiastic and committed project champion. The role of the key stakeholder group is: • To engage key stakeholders • To ensure that the IUWM planning process is followed • To define and agree on objectives, measures, criteria and performance assessment methods • To agree on a set of strategic directions for urban water management in line with IUWM principles • To ensure documentation of assumptions, outcomes and the process followed in Phase 1 • To plan for the next steps, which could be to undertake Phase 2 or to stop the IUWM planning process due to funding constraints
Activity 2—Objectives, measures, criteria and methods	• Define the problem and develop a problem statement • Develop an agreed understanding of the objectives, derived from the problem statement • Identify regulatory and other performance criteria that must be met • Agree on how achievement of the objectives will be measured and calculated for the purpose of selecting strategic directions for urban water management in line with IUWM principles
Activity 3—Understanding the current system	• Identify and articulate the boundaries of, and interactions between, key components of the system • Collect data and understanding of the current system • Start developing community involvement • (System boundaries extend beyond the urban boundary. Data and understanding is as needed for evaluation of the measures agreed on in Activity 2.)
Activity 4—Assess system performance	• Define a base case (i.e., business-as-usual solution) and alternatives to the base case, using knowledge gained as part of Activity 3 • Quantify measures using suitable bio-physical, social, environmental and economic assessment methods. During this Phase, it is sufficient to quantify measures qualitatively using expert knowledge and typical local data • Undertake high-level MCDA analysis and risk assessment to outrank and compare social, environmental and economic performance of the base case and alternatives • Identify strategic IUWM directions for urban water management as the basis of Phase 2 portfolio development
Activity 5—Implementation planning	• Clearly state the outcome, i.e., **a strategic IUWM direction for urban water management**, and the process and assumptions used to develop the outcome • Ensure stakeholders are well-informed and understand and accept outcomes of Phase 1 • Document outcomes and prepare an implementation plan for Phase 2

support to ensure a smooth transition for the changes that are in store. He or she will also need to seek out sources of financial support for the proposed changes.

KSG Membership

Membership of the KSG during Phase 2 remains fairly constant, although membership is reviewed on a regular basis and additional participants appointed as new activities are identified.

During this phase, expert groups are set up to perform specific tasks; these report directly to the KSG, and involve experts and specialists from outside the KSG. Specific groups might be set up to evaluate modeling, manage decision processes or to address communications, for example. The roles, responsibilities and ambit of each group should be clearly defined, and limits of their considerations, including the time frame for their activities, explicitly stated. Resourcing arrangements are agreed on; during this phase involvement might be sought from universities, consultancy companies or others with expert knowledge. A list of expert groups that might be considered is given under Phase 1.

Roles and Responsibilities

As the IUWM planning process progresses, the KSG needs to maintain a well-informed position, and requires support in understanding and implementing its recommendations. The KSG seeks and receives advice and support from many sources; their role is not to undertake technical analysis of the IUWM systems, but to ensure that all feasible options are considered, that relevant information is brought to bear on the process and that decisions are made in an open and explicit way in full knowledge of all relevant impacts. Expert groups serve as a knowledge broker to the KSG, receiving and analyzing information (much of which might exist within the utilities, councils and participating organizations) and feeding it through in a suitably processed form to the KSG.

At each stage of the IUWM planning process, the main activity of the KSG is to negotiate solutions that meet the multiple and conflicting needs of the stakeholders, make recommendations to the decision makers and communicate with the project participants. There are many ways in which such agreements can be reached. Where the impact of different portfolios is clearly understood and performance is based on a single assessment criterion, group discussion and voting usually provides a suitable path forward. As the move towards IUWM progresses, the complexity of recommendations is likely to increase, together with the knowledge needed to inform the recommendations. Decisions based on evaluation of system performance against multiple criteria need to be made. For such complex and critical issues the group might consider the use of formal decision tools such as Multi Criteria Decision Aid tools (see Phase 1 Activity 4), both for their own activities and to assist the decision-making authorities.

While the KSG provides the overall strategic direction for the IUWM planning process, it is by no means the only channel for stakeholder consultation. Stakeholder acceptance is vital for successful introduction of new technologies, changes in long-accepted water management processes and the successful implementation of the proposed system; stakeholders can also provide valuable input and ideas. The KSG will ensure that the views of stakeholders, including (but not limited to) the general public, minority groups, legislative representatives, management, operational staff and others are taken into account in the design of the system. Throughout the process, consultation with those affected by the proposals is a priority (see the section on "Considering and Engaging Stakeholders" at the end of Chapter 2).

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The overall aim of Phase 2 is to develop and agree on a shortlist of portfolios that are further analyzed in Phase 3. Activity 2 therefore focuses on agreeing on measures and methods to be used in developing the shortlist. During this phase the KSG needs to agree, not only on how the performance of different portfolios is to be evaluated, but also on the approach they are going to take in selecting which portfolios are to be included in the shortlist. This process might reuse or extend the analysis undertaken in Phase 1. As with Phase 1, measures and criteria for selecting the shortlist are developed concurrently with selection of the methods used for evaluation.

Objectives

The KSG now has a greater understanding of the system and the potential opportunities and challenges of IUWM. The objectives agreed on during Phase 1 are reviewed, although there is likely to be little major change. It is possible that the analysis undertaken in Phase 1 demonstrated that certain objectives are unachievable (for instance, the cost of supplementing supply from certain sources might have been shown to be prohibitively expensive), or new objectives might have come to light with the identification of potential new sources.

There is a growing understanding of the potential for certain portfolios, and opportunities for developing specific portfolios are identified. This leads to the generation of portfolio-specific objectives, that help identify which portfolios should be included in the shortlist. While general objectives are kept as general as possible to allow for multiple alternative strategies, portfolio objectives limit the strategies that are included in any one portfolio. For example, if a current centralized system requires major infrastructure replacement in the near future, the opportunity to decentralize might be considered and a portfolio objective developed around this. On the other hand, if infrastructure has recently been replaced, then decentralization might not be considered feasible for all or part of the city.

Alternatively, portfolios might be developed around "themes," in line with the strategic directions agreed on in Phase 1, such as minimizing demand or maximizing recycling, or hybrid themes, that, for instance, protect the natural environment. The KSG might wish to include portfolios to illustrate their *lack* of viability. For example, analyzing a least-cost portfolio might demonstrate the limitations imposed by such an approach on future growth of the city. Finally, if there is need for immediate action, a "no regrets" portfolio of strategies that can be implemented immediately and at low cost might be included. Portfolio objectives set the direction for the shortlist. Examples of portfolio objectives include:

- Improve stormwater management
- Protect groundwater recharge
- Protect receiving waters and improve receiving water quality to protect local habitat, e.g., particular fish population, frogs or otters
- Provide reliable wastewater system
- Reduce combined sewer overflows
- Protect wetlands

- Provide reliable water delivery infrastructure
- Reduce system losses
- Reduce industrial waste
- Reduce per capita consumption
- Improve cost efficiency
- Maximize cost effectiveness/value
- Minimize financial risks
- Protect public health
- Maximize communication and information sharing
- Minimize greenhouse gas emissions
- Provide adequate stream flows for salmon at a minimum to maintain tribal fishing quotas

Measures and Criteria

As in Phase 1, dimensions, measures and criteria need to be agreed on to illustrate that the objectives are being met. The general process is the same as that described in section Phase 1 Activity 2.

In Phase 2, however, a more detailed evaluation of system performance is needed than in Phase 1, although the evaluation will be quicker and more broad-brush than the final selection process of Phase 3. A simple approach to analysis might assume that conditions will remain steady throughout the lifetime of the system; however, understanding system performance under current conditions is generally insufficient at this level. If a system is to be sustainable we need to understand how it will perform, and its risk of failure to perform, not only now but into an uncertain future. A high risk of failure might make an otherwise preferred portfolio unacceptable.

While measures and criteria for developing the shortlist are being considered in Phase 2, it is also advisable to consider measures for the final selection processes. This will ensure that evaluations conducted in Phase 2 feed directly into the final selection process. As with Phase 1, all measures should relate directly to the objectives. Measures can range from broad, qualitative statements to precisely quantified numerical values. Measures might correspond to more than one objective (for example, volume of tank water consumed might correspond to objectives relating to both reduction in potable water use and human health), but each objective should be associated with a unique set of measures. Development of the list of measures should accommodate stakeholder views, as well as consideration of the scientific capability for quantification. As with Phase 1, a preliminary knowledge of the methods and tools available to predict system performance assists in developing a suitable set of measures. In Phase 2 it is important to ensure that the needs of, and measures for, any system evaluations that are required to gain acceptance of a preferred option have been included. These include measures needed for environmental impact assessment.

During Phase 2, analysis criteria, especially those imposed by legislation, are increasingly important. From the range of options available, many will be dropped because they fail to meet the necessary levels of performance. For example, a portfolio that fails to provide for environmental flows in local rivers, or that obviously violates greenhouse gas emission targets, will not be considered for further analysis. These imposed criteria, however, are unlikely to reduce the multitude of possible portfolios to a manageable list of six to ten alternatives for detailed analysis, and additional selection criteria will be needed. Various methods of selection are described in the next section. For example, for supply diversification, San Francisco formed five portfolios (note: see the section on 'San Francisco case study' in Chapter 3 for details):

- Status quo
- More affordable
- More reliable
- More responsible to entrusted resources
- Balanced objectives

Methods of Analysis

In Phase 2, the KSG is seeking to understand how various strategies selected in Phase 1 perform under local conditions, so that a shortlist of suitable portfolios can be developed for analysis in Phase 3. Methods of analysis are more detailed, drawing on local knowledge at the suburban or cluster scale and taking into account a wider range of possible futures.

During this activity the method used to select the shortlist is chosen. The method might involve workshopping to develop a set of "portfolio objectives." This approach is especially beneficial if different factions of the KSG or wider stakeholder community have very strong views on what strategies should be used. An alternative approach is to select the "best performing" portfolios, based on limited analysis. This approach has the advantage that several seemingly good portfolios will be analyzed in detail, but it might not provide the evidence to convince a sceptical community, and it might well overlook an "outside" good performer. Consultative processes can be used to develop multi-criteria assessment priorities, and modeling used to evaluate actual performance measures.

Phase 2 Activity 3: Understand Current System

The purpose of this activity is to understand the current system in sufficient depth to identify a shortlist of IUWM portfolios. Additional data and knowledge is needed so that the impacts of the strategies selected in Phase 1 can be assessed (see Phase 2 Activity 4). During Phase 2, additional knowledge and data is sought, to assist in understanding interactions and feedbacks between system components and risks of system failure.

As in Phase 1, the data and level of detail depends on the objectives, measures and methods of analysis agreed on in Phase 2 Activity 2, and only that data needed for the agreed methods should be collected.

In Phase 2, more detailed analysis is undertaken, and it is now essential to quantify system interactions, which demands more temporally and spatially explicit local data than those used in Phase 1 analysis. In some cases the list of performance measures used in Phase 1 to select strategies will be extended. For example, in Phase 1 strategic directions might have been selected based on integrated water balances and social preferences, and economic considerations might be included in Phase 2. In other cases Phase 1 performance measures might be evaluated in more detail. For example, while a qualitative assessment might have considered water quality in Phase 1, a detailed water quality modeling might be considered in Phase 2 due to high environmental sensitivity of the receiving water bodies.

During Phase 2, there is need for a greater understanding of the sensitivities and resilience of new sources and discharge opportunities, and the potential impacts of different strategies on supply and receiving waters. Water quality becomes an important consideration, as the viability of different strategies in different parts of the city is explored. A detailed understanding of water quality, from both supply and demand perspectives, assists in identifying the level of treatment required for different sources and discharges, to ensure service delivery and reduce risks to human and environmental health. Understanding the spatial distribution of demand, as well as the minimum water quality that can be used in different locations, assists in identifying suitable portfolios.

Now that strategic directions have been identified, the acceptability of different strategies to the community becomes an issue. Health impacts relating to the use of non-potable water, risks and benefits of introducing new stormwater collection ponds, and many issues associated with specific strategies will need evaluation. Details of current practice and any past incidents assist in informing the analysis. Investment in community consultation to learn and inform will pay dividends. A detailed description of community consultation and stakeholder interaction is given at the end of this chapter. The reader is encouraged to revisit Phase 1 Activity 3 for a full list of the types of data that might be needed.

Phase 2 Activity 4: Assess System Performance

This activity involves (1) generating a manageable number of portfolios against portfolio-specific objectives defined in Phase 2 Activity 2; (2) quantifying the performance of each portfolio against measures defined in Activity 2 and (3) evaluating performance of portfolios using a relevant MCDA tool. A shortlist of three to six portfolios is selected on the basis of “best” performers for further analysis in Phase 3.

Performance assessment in Phase 2 might involve detailed assessment of a limited number of measures or a broad or approximate assessment of a wide range of measures, covering the whole social, economic and environmental spectrum. The depth or breadth of the analysis depends on the measures selected in Activity 2. The performance assessment methods used in Phase 2 are mostly similar to those used in Phase 1 (see Phase 1 Activity 4).

MCDA tools described in Phase 1 are employed in this activity to compare the performance of portfolios in different domains and provide a rank to each portfolio. There are many MCDA methods such as PROMETHEE, ELECTRE, REGIME, NAIADE, MCAT and STRAD. All of these methods use quantitative or qualitative inputs of measures, and rank alternatives by taking into account preferences of stakeholders.

Phase 2 Activity 5: Implementation Planning

As with Phase 1, the KSG informs the DM of the outcomes of systems assessment and selection.

This time, details of the method used to select the shortlist of portfolios and the results of assessments are reported, and a final list of portfolios for detailed analysis is agreed on.

Communicating Outputs

As with Phase 1, the KSG communicates the results of its assessments in a way that is suitable for the needs of the DM. Again, the DM might ask for a direct recommendation from the KSG, or they might choose to make the shortlist selection themselves, based on the results of analysis conducted in Activity 4. Whatever the needs of the DM, the KSG will provide the basis for the shortlisting process.

Informing stakeholders and the wider stakeholder community of the outcomes of the analysis and benefits of different portfolios is an ongoing process. At the end of Phase 2, the benefits of IUWM over the current situation are apparent, and alternatives analyzed in sufficient detail to convince funding organizations and upper management of the benefits of proceeding to Phase 3. Outlining the method that will be adopted for the final portfolio selection process will further help to secure the support of stakeholders.

Planning the Next Phase

The final activity for Phase 2 is to plan the next phase. In some cases the plan will form part of the submission to the DM from the KSG. Even if this is not required, documentation of Phase 2 is incomplete without a draft plan, which provides a practical start to Phase 3 and a helpful reference should there be a change in personnel or break between phases.

Phase 2: Summary

A summary of Phase 2 activities is given in Table 2.4.

PHASE 3—FINAL PORTFOLIO DEVELOPMENT

In Phase 3 one portfolio is chosen from the shortlist generated in Phase 2. Analysis is therefore in greater depth, and additional measures will be included. Again, detailed analysis that has already been undertaken within the various organizations involved might contribute to the analysis. It is unlikely, though not completely out of the question that the IUWM planning process will commence with Phase 3.

Phase 3 Activity 1: Convene Key Stakeholder Group

During this phase the focus is on detailed analysis of the shortlist of portfolios and providing recommendations for a preferred portfolio. Much of the work of evaluating system performance is undertaken by technical groups, overseen by the KSG and using measures and tools agreed on by the KSG. Technical analysis of aspects of system performance inform the decision process, which has itself been selected by the KSG. The KSG needs to ensure that the output of the expert groups is compatible with the selected decision process, and that all relevant influences on the system have been considered. Risk of system failure is analyzed for each portfolio. It is strongly recommended that an expert group on integration is established; this group needs to work closely with other expert groups, and might need special authority to influence the other expert groups to ensure that outputs are compatible.

At this phase of the project, activity is needed to gain and maintain support from all stakeholders for implementation of the selected portfolio. This might be assisted by the preparation of a strategic plan for the next stage of implementation.

Table 2.4
Summary of Phase 2 activities

Activity	Summary
Activity 1—Key stakeholder group	• The project champion continues as chief advocate for the project, taking the IUWM message to a wider audience and seeking financial support • The KSG constitution and membership is reviewed and if required, adjusted • The KSG continues to maintain a well-informed position, setting up expert groups to perform specific technical tasks • The KSG will recommend a shortlist of portfolios to the decision makers as the outcome of Phase 2 analysis. A portfolio is a set of urban water management options that collectively has the potential to achieve both portfolio-specific objectives and overall objectives in an optimal manner.
Activity 2—Objectives, measures, criteria and methods	• The overall objectives set in Phase 1 are reassessed to ensure that they are still relevant, achievable and comprehensive in the light of increased understanding of the system and needs • Portfolio objectives are developed that describe the aim of alternative portfolios • Measures, criteria and methods of analysis (including assessment tools) required to develop a shortlist of portfolios are developed and agreed on
Activity 3—Understanding the current system	• Data and knowledge on the current system is sought and collected to inform evaluation of measures agreed on in Activity 2. Data is generally more detailed and more spatially and temporally explicit than that sought in Phase 1. It might include new domains • Quantitative understanding of system interactions is evaluated
Activity 4—Assess system performance	• Develop all possible portfolios in line with portfolio-specific objectives • It is sensible to develop a "no regrets" portfolio, which encapsulates strategic directions that are seen to have no adverse impacts and that can be readily implemented in the short term • Performance of each portfolio is quantified in terms of the measures defined in Phase 2 Activity 2. Quantification usually includes analysis in social, economic and environmental aspects of urban water management, uncertainty identification and risk assessment and spatially explicit evaluation of parameters that vary across the town or city and a detailed bio-physical assessment • Measures that require detailed data for analysis for quantification, can be quantified qualitatively during this Phase and leave detailed quantification to Phase 3 • Multi-criteria decision aids are used develop a shortlist of portfolios (no more than six portfolios) out of all possible portfolios
Activity 5—Implementation planning	• Details of shortlisted portfolios, their benefits and risks are communicated to councils, utilities, householders, industry, funding organizations and upper management • Strategies for final portfolio selection are communicated to stakeholders and included in plans for Phase 3 • Provide decision support for a well-justified and agreed shortlist of portfolios from which the final option will be selected • Document outcomes and prepare an implementation plan for Phase 3

Project Champion

The role of the project champion during Phase 3 is to prepare the stakeholder and the community for the chosen portfolio, and pave the way to smooth adoption. The champion needs to play an advocacy role, with the support of the KSG, justifying decisions, demonstrating the benefits and disadvantages of the various portfolios and canvassing support of governments, utilities and the community in language that is clear and easily understood. The project champion plays a key role in ensuring that any legislative changes required by the selected portfolio are initiated.

KSG Membership

Phase 3 is one of detailed technical analysis, and the KSG should review its constitution to ensure that it has the capability to understand the outputs of the various expert groups who are undertaking detailed analysis of various portfolios, and the significance of their findings. At the same time, interaction with the wider stakeholder community will probably increase, and representation on the KSG from influential community groups might be considered.

Roles and Responsibilities

One activity in which the KSG is involved during this phase is that of ensuring the thoroughness, quality and consistency of the analysis and selection processes. By this stage the objectives, measures and assessment criteria, together with the models, algorithms and processes used in the analysis, have been agreed on. During Phase 3 the KSG keeps an eye on the progress of the expert groups to ensure that their activities are aligned with these objectives. This demands a detailed understanding of the implications of the analysis. The KSG should be in a position to provide peer review of all aspects of the analysis, either directly or by referral.

Although the KSG might not itself be the ultimate decision maker, its role is to inform and assist the decision makers. It thus needs to provide a method, supported by data, to compare the options on the shortlist. The selection process should be transparent and repeatable, and provide a fair means of addressing the views of all relevant parties. Possibly the decision makers will commission the KSG to run a decision-making workshop.

Phase 3 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

By the time the KSG considers Phase 3 Activity 2, they have an in-depth understanding of the system, and consideration is focused on the shortlist of portfolios selected in Phase 2. The aim of this activity is now to make sure that all objectives have been addressed, and ensure that the outcomes of the Phase 3 analysis really reflect those objectives. The activity thus needs to concentrate on the details of the final assessment measures and criteria, and the methods used to evaluate them. As with the shortlisting process of Phase 2, the method to be used for making the final selection needs to be agreed on.

Objectives

At this stage the objectives of the study are well understood, but as with Phase 2 they should be reviewed, adjusted and agreed on as appropriate.

Measures and Criteria

Phase 3 involves detailed technical assessment of all aspects of the performance of shortlisted portfolios. As well as agreeing on the measures and criteria for assessment, those working on the analysis will agree on which interactions are significant and should be taken into account. For example, social acceptance of the use of rainwater tanks might influence take-up rates, and hence the overall performance of the system. This might be influenced in turn by the introduction of financial incentives, which add to the cost of the portfolio.

It is appropriate to include EIS-related measures and accepted methods by environmental protection agencies to quantify them. A list of possible measures, criteria and interactions for evaluation is given in Phase 1.

At this level it is appropriate to consider evaluating various risks relating to each portfolio. The risks relating to each portfolio will be different—one might have a high risk of failing to provide the requisite amount of water, for example, while another might present a higher risk to human health or the environment. The importance of such risks, and the ease with which each could be mitigated, has an important bearing on the final selection. As in Phase 2, the final selection process and any weightings or priorities are agreed on during this activity.

Methods of Analysis

Methods of analysis required at this stage are much more detailed than those in Phases 1 and 2, and will include social, economic and environmental impacts and interactions. In addition, as mentioned above, it would be preferable to use the methods of analysis acceptable to any EIS assessments. Outcomes of all analyses must be included in a chosen MCDA method for identifying the final option for implementation.

Phase 3 Activity 3: Understand Current System

The purpose of Phase 3 Activity 3 is to understand the system in sufficient detail to select a preferred portfolio from the shortlist developed in Phase 2. The preferred portfolio will later undergo detailed engineering, economic and other design, before it is finally adopted.

This activity provides the understanding needed to compare the performance of different portfolios, in terms of the measures agreed on in Activity 2 and in sufficient detail to differentiate between them. During this phase, the current system is analyzed in much more depth than in Phases 1 and 2. Whereas analysis was limited to a few key measures in the earlier phases, a full suite of triple bottom line performance measures, together with other, project-specific measures and EIS-related measures, are evaluated for each of the shortlisted portfolios. This might require gathering data on aspects of the current system that have not yet been considered. If consideration of risk is to be included, data on probabilities of events will be needed to support the analysis.

In Phase 3, the performance of all aspects of the shortlisted portfolios is compared. As with Phase 2, this might involve a more detailed analysis of measures already evaluated, but additional measures will almost certainly be included. For example, the impact of flow changes on habitat and species lifecycle, potential health risks, greenhouse gas emissions and costing of externalities might be included. Additional data will include probabilities of events, a more detailed understanding of the preferences of the local community, and a deeper knowledge of local industry and its ability to change water consumption.

The reader is encouraged to revisit Phase 1 Activity 3 for a full list of the types of data that might be needed.

Phase 3 Activity 4: Assess System Performance

In this activity the performance of different portfolios (selected in Phase 2) is compared so that a final option can be chosen, taking into account any risks that might prevent implementation.

In Phase 3 methods of analysis will be similar to, but more detailed than, those used in earlier phases. Bio-physical models will include detailed hydrologic and water quality modeling approaches to simulate the behavior of the urban water system as accurately as possible. Models mentioned in Phase 1 Activity 4 are appropriate in this phase. Similarly, methods of analysis used for the social and economic domains should provide sufficient detail to reflect spatial and temporal differences.

Risk-based Integrated Performance Assessment

Methods of analysis must now include risk assessment, as well as detailed understanding of feedback between different components of the system. Like Phases 1 and 2, MCDA is used to compare the multiple performance measures of different portfolios, but almost all measures now have quantified values estimated using models calibrated and validated to local conditions. Preference of the MCDA method has to be estimated using a suitable method such as the deliberative MCDA approach described in Phase 1 Activity 4. This approach involves holding of series of workshops with a stakeholder group wider than the KSG. This is likely to be an iterative process, involving interaction between the technical analysts, the KSG, the wider group of stakeholders and the decision makers.

Detailed Economic Performance Assessment

A detailed economic analysis of portfolios may be required for funding purposes. Appropriate economic evaluation methods are required to quantify system performance in monetary terms. Nonmarket valuation techniques such as "revealed preference" and "stated preference" are frequently used to estimate the value of goods and services that are not commonly bought and sold in markets.

Methods include "revealed preference" (Kennedy, 2002), which identifies underlying preferences, and thus the demands of individuals, based upon the choices each reveals in their consumption. This method is generally preferred as it relies on real actions that people make that can be directly observed, and not on hypothetical situations (through subjective judgements). However, it can only be used where related market data exists.

"Stated preference" methods are used when actual data on behavior with regard to certain environmental goods or services is not available. This method estimates the "existence value" that individuals ascribe to resources that they will never see. Individuals are typically provided with hypothetical scenarios, based on plausible outcomes and options, and their choices are used to determine the value of the environmental goods or services in question. The Contingent Valuation Method (Rolfe and Prayaga, 2007) and Choice Modelling (Hatton MacDonald et al., 2005) are the key examples. However, these methods require carefully designed survey and sampling procedures and the employment of sophisticated data analysis. Obtaining reliable information requires a substantial investment of time and resources and makes these methods very expensive. Hence undertaking of a particular approach depends on funding availability.

Phase 3 Activity 5: Implementation Planning

By the end of Phase 3, a preferred portfolio is endorsed by the DM for construction and implementation. Selection of the portfolio is well justified and documented in sufficient detail to justify the choice to a wide range of stakeholders

Communicating Outputs

As with earlier phases, the KSG provides information to the DM in the required format. The DM then selects or endorses the preferred portfolio. In communicating the outcome of the final selection, details of shortlisted portfolios that were NOT selected assist in convincing stakeholders of the benefits of the preferred option. Buy-in from the wider community is essential at the end of Phase 3, as aspects of the preferred approach are soon to be constructed or implemented, and stakeholder support will greatly ease the transition; lack of support could prevent implementation.

Planning the Next Phase

Once Phase 3 is complete, the next phase is detailed engineering design and implementation. Thorough documentation of analysis conducted under Phase 3, and strategic plans for transitioning the system to the preferred portfolio, will assist in a smooth transition.

Phase 3: Summary

A summary of Phase 3 activities is given in Table 2.5.

CONSIDERING AND ENGAGING STAKEHOLDERS

IUWM will only succeed if the proposed changes are accepted and implemented by all relevant stakeholders (here defined as individuals, groups and organizations). Depending upon the strategies included in the final and preferred portfolio, this could involve every member of the community. Since stakeholder consultation and involvement occurs throughout the IUWM planning process, within all phases and each activity, consideration of ways in which it can be undertaken is included here as a separate section.

In recent years there has been an increased understanding of the importance of stakeholder involvement in sustainability issues, including IUWM. While in the past environmental and community values were not widely considered in the planning process, such values are now more often recognized. However, many institutions and organizations still have a way to go in recognizing the importance of interactions between departments, stakeholders and functions, and in developing a learning culture that values integration and participatory decision making (Brown, 2005). Values, cooperation and behavior will all impact on the success of the IUWM project.

Table 2.5
Summary of Phase 3 activities

Activity	Summary
Activity 1—Key stakeholder group	• The project champion adopts an advocacy role, ensuring that stakeholders and the wider community understand and support the chosen portfolio, canvassing support and ensuring that legislative changes have been addressed • The KSG constitution is reviewed, ensuring that membership has a suitable level of expertise to understand significance of expert group outputs • The KSG continues to manage the IUWM planning process, interacting with the wider stakeholder community, supervising expert groups and ensuring that analysis is thorough and complete, comparing options and negotiating solutions that satisfy multiple, conflicting goals
Activity 2—Objectives, measures, criteria and methods	• The objectives and portfolio objectives are reassessed to ensure they reflect the required outcomes of Phase 3 analysis • Measures, criteria and methods of analysis are agreed on for detailed comparison of portfolios, and include any critical interactions and any assessment measures and criteria that are required for system approval, e.g., EIS requirements • Methods to be used in the decision process are agreed on, including assessment of the relative importance of different variables
Activity 3—Understanding the current system	• The knowledge and data needed to undertake a full analysis on each of the shortlisted options, in terms of the measures agreed on in Activity 2, is gathered • Data and knowledge includes all data needed to understand the measures agreed on in Activity 2, including interactions and probabilities of events to support risk assessment
Activity 4—Assess system performance	• Each portfolio is analyzed in detail to understand hydrological, water quality, infrastructure requirement, financial costs and benefits, externality costs and benefits, social implications, energy usage, greenhouse gas emissions, resource recovery and other relevant environmental implications. All implications are quantified by considering latest climate change and demographic projections, and land use and urban development data. • Detailed modeling is undertaken to where applicable to quantify above-mentioned implications. All models are calibrated and validated to local conditions before they are used to quantify measures • Quantified measures are fed into a suitable MCDA method. Preferences on measures are quantified using a suitable method; methods based on deliberations with stakeholders, e.g., deliberative MCDA, may be appropriate • Detailed economic analysis of portfolios may be required for funding purposes. An economic analysis requires quantification of key measures in monetary terms using suitable economic approaches
Activity 5—Implementation planning	• Final outcome is a well-justified final portfolio of urban water management options for engineering, social and economic design and implementation • Outcomes are communicated to the decision makers and stakeholders (i.e., councils, utilities, householders and industry to: (1) assist them understand benefits of the selected portfolio over the current situation; (2) ensure that outcomes are included in capital works program, and (3) seek funding for detailed engineering design and implementation

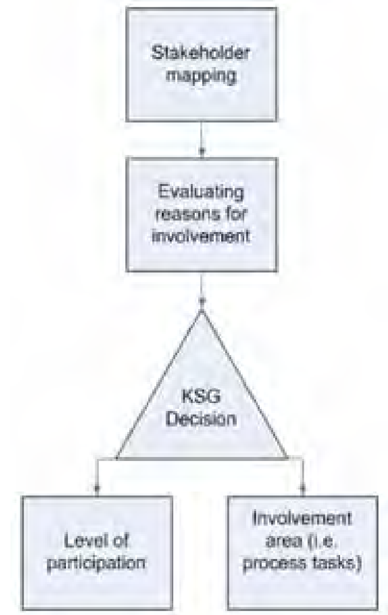

Figure 2.11 Assessment of stakeholder involvement by the KSG

As seen in the previous chapter, some stakeholders in the IUWM planning process will be part of the KSG, while others will be part of the wider stakeholder group (WSG); and the level of involvement of stakeholders will vary greatly. For example, participation of both the KSG and the WSG in the early stages of IUWM is important to understand requirements, constraints and behavioral complexities and to develop a sense of ownership and acceptance amongst all the stakeholders for the success of IUWM.

In order to manage stakeholder involvement, it is important to first undertake stakeholder mapping (see Figure 2.11), which in turn informs decisions about suitable levels and types of participation for each stakeholder or stakeholder group. This is an activity for the KSG. The level and type of participation will depend on the reasons for involvement. The KSG will need to decide which tasks each stakeholder should be involved in. The process starts with stakeholder mapping, which will include an evaluation of the reasons for involvement, and how critical each stakeholder is to the IUWM planning process. Based on this, the KSG will decide the level of involvement of each stakeholder in each phase of the process. Once the level of involvement has been decided, an appropriate method for engagement needs to be chosen.

Stakeholder Mapping

The stakeholder mapping process involves identifying each stakeholder and their values, perceptions, decision-making processes, relationships, and any conflicts. It is also important to know how they perceive the problem and what their concerns are. To identify the stakeholders, it is useful to start with a preliminary list of stakeholders based on general knowledge, reports, conversations, etc. The preliminary list indicates organisations that are relevant to IUWM. This can then feed into brainstorming sessions, interviews, or an iterative (and preferably social) learning

Table 2.6
Information to be collected from stakeholder

Information type	Description
Problem perceptions	How does the stakeholder perceive a particular problem? How do they make sense of the situation?
Stakeholder concerns	What are the particular concerns of the stakeholder? What are their values?
Relations between stakeholders	Are the relationships between stakeholder good or bad? Do they know each other?
Conflicts between stakeholders	Is there stereotyping, or personal conflicts? What is the level of trust between the stakeholders? Are there inherent conflicts in their concerns (i.e., environmental versus financial)?
Stakeholder resources	Information, skills, time, money, decision power, competencies, influence, etc.
Decision making	How does the stakeholder make decisions? What values and (legal) constraints are taken into account? What are the motivations? For KSG individuals, what organizational influence does the person have?
Responsibility	What is the responsibility of the stakeholder? And what responsibility may the stakeholder accept to take on?

process to identify right stakeholders. Table 2.6 describes the information that needs to be collected about the stakeholders.

Evaluating the Reasons for Involvement

The reasons for involving stakeholders in the KSG and WSG are as follows (HarmoniCOP, 2005):

- There is need for high levels of cooperation and there is considerable reliance on stakeholder behavior for success of IUWM. Cooperation can be achieved by involving stakeholders in decision making. This will improve the quality of plans, designs and projects, make implementation smoother (i.e., avoid delays, litigation, or blocking of projects) and help meet legal requirements.
- There are considerable disagreements about the issues at stake, i.e., to avoid conflict. Solutions to conflicts can be achieved by promoting active citizenship and reducing the gap between citizens and planners. This will improve smooth implementation and help find solutions that are acceptable and rewarding to the range of diverse stakeholders.
- The issues are important enough to motivate people to participate.

Selecting a Level of Participation

The level of participation can be classified according to the following modes (adapted from Biggs, 1989):

Table 2.7
Level of ownership required for different degrees of complexity in the KSG

	Level of ownership and acceptance required		
Complexity of issues	Low	Medium	High
Low	Peripheral/ Contractual	Contractual/ Consultative	Consultative/ Collaborative
Medium	Contractual/ Consultative	Consultative/ Collaborative	Collaborative/ Collegiate
High	Consultative/ Collaborative	Collaborative/ Collegiate	Collegiate

- Peripheral: stakeholder are kept informed about interventions.
- Contractual: stakeholders are contracted into the projects to take part in implementation planning (i.e., Activity 5).
- Consultative: stakeholders are asked for their opinions and consulted before interventions are made (and their input is considered during Activities 2, 3 and 4).
- Collaborative: KSG members and stakeholders work together on projects designed, initiated and managed by the KSG (i.e., participation in Activities 2, 3, 4 and 5).
- Collegiate: KSG members and stakeholders work together as colleagues with different skills to offer, in a process of mutual learning where stakeholders have control over the process (i.e., Activities 1 to 5).

The level of ownership will increase with the level of involvement, but a higher level of participation is also more demanding and time consuming for all involved. However, a collegiate or collaborative level of involvement is recommended for projects with a high level of complexity requiring considerable input from stakeholders in conceptual and design stages.

Based on an assessment by the KSG of the level of complexity and the level of ownership and acceptance required, a rough and ready rule system for selecting the level of participation can be used, see Table 2.7.

The process for creating ownership and acceptance, however, is more complicated than just involving people; it also depends on trust, and perceptions of risk, equity and fairness; which in turn depend on subjective assessments and personal values. Therefore, the above system is a relatively simplistic representation and should be treated with caution. The KSG will need to make judgments depending on the particular contexts and circumstances.

Engagement Processes

When stakeholder participation is sought, there are a wide range of engagement issues that must be considered, and it is critical that stakeholder expectations, scope of engagement and process facilitation are carefully managed. In choosing a level and type of engagement, key process decisions include the following considerations:

- What is the scope of the group? In other words, what problems are being addressed (and how are they defined), and is there disagreement about what needs to be addressed? Who has the final say about the scope?

Table 2.8
Some tools and methods for engagement

Engagement pattern	Description
Community of Practice (CoP)	A group of people who meet regularly to share ideas, find solutions, share stories and to learn together. Participation in the CoP is open to practitioners; and the CoP can play a key role in knowledge management as well as social networking.
Web site	Can be developed to identify stakeholders, provide a transparent information repository, communicate information as well as collect information. Web sites can be particularly useful to allow stakeholders to select their own level of involvement throughout a project.
Roundtable conference	Facilitated discussion between participants at a roundtable around a given topic. This provides an opportunity to share opinions and viewpoints; and to develop an understanding of other people's opinions.
Focus group	Where participants are asked to provide their opinion in a fairly free and open environment; while being observed. To be used for exploring the issues of most concern to the participants. The choice of participants will impact on the results; as will the information provided to them.
Delphi dialectic technique	An iterative learning process for mapping disagreements about an issue to arrive at a consensus through formal process.
Brainstorming	Participants are asked to come up with as many solutions as possible without consideration of constraints and feasibility; and without criticism. Applied to develop new ideas and solutions; and to break ingrained thinking that may hinder progress.
Fishbowl	An inner group in a roundtable format are questioned by an outer invited group. This technique aims to increase understanding of different perspectives on issues or on a proposal; and uncover hidden/implicit reasoning.
Expert panel	Applied when highly specialized knowledge is required for a project. Participants are invited to hear a range of informed perspectives based on which decisions and recommendations can be made.
Citizen juries	A number of randomly selected people representing the public attend, ask questions and participate at meetings. They can finally be asked to fill in a form and make judgements as in a legal jury.
Open space technology	A flexible facilitation methodology that allows outcomes to emerge through participants' interactions. It is particularly useful to generate new ideas and to develop trust between participants.
Group model building	Participants are facilitated through a process in which a model of a particular issue is being developed. This is particularly useful for developing systems understanding and to generate a discussion about underlying assumptions.
Role playing games	Game situation where participants play the real or taken roles. Particularly useful for uncovering behavioral aspects and institutional lock in situations. It also generates a shared understanding in a social learning experience. This activity also tends to generate constructive dialogue about interactions, rules and institutions; through which win-win situations can be identified.
Interviews	Interviews can be of many types, and can be very useful for collecting information about participants' knowledge and perspectives. Interviews can be lengthy or short depending on the target; and may be structured, unstructured, or involve drawing of sketches or responding to images.
Backcasting	Analyzing alternative futures by envisioning a desired future point; and then explore the feasibility of the measures and interventions that will lead to this goal.
Displays and exhibits	Can be used to raise awareness about certain issues; and to inform the community.
Citizens advisory committee	A consultative style of engagement aimed at feeding community information, attitudes and values into the decision making process, and to make implementation smoother.
Public workshops	Open invitation to the public to participate in workshops. Workshops can be used to distribute information, and/or to collect community information, values and perceptions.

Source: HarmoniCOP, 2005; Dick, 2002a; Dick, 2002b; Smith et al., 2003.

- Who should be included in the process? Does the stakeholder map need to be updated?
- Is there a need for a professional and neutral facilitator? Having a professional and independent facilitator is often seen as critical for ensuring legitimacy of the process.
- How is ongoing participation and momentum ensured? Is it appropriate to add incentives for critical stakeholders to participate? Are the participants sufficiently motivated to be involved in the long run?
- How to deal with surprises? It is important in participatory processes to adapt and learn from surprises rather than being rigid. In this way, threats can be turned into opportunities.
- What is the appropriate size of the group? Factors to consider here are diversity, learning capacity and the ability to make projects happen
- How is information and data to be stored? Engagement processes tend to generate large quantities of data such as notes, recordings, decisions and reports. A note taker needs to be assigned, and information management routines developed

A non-exclusive list of useful engagement patterns, tools and methods are described in Table 2.8. While the issues in this table also apply to the WSG participation, the level and type of participation will vary depending on the particular issues at hand.

CHAPTER 3
IUWM IN PRACTICE

The following case studies are based on discussions held with representatives from the case study sites and literature received from their organizations. Each illustrates how aspects of IUWM are currently being incorporated into urban water planning. Following a general description, progress within each phase and activity of the IUWM planning process is identified, and suggestions are made on how the process could be carried forward.

SAN FRANCISCO

The City and County of San Francisco's (the City) urban water system, incorporating water supply, wastewater and stormwater, is managed by San Francisco Public Utilities Commission (SFPUC), which is also a water wholesaler. The SFPUC control over all aspects of the water cycle, gives the City substantial freedom in managing its water supply. Around 85% of SFPUC's water comes from Hetch Hetchy Reservoir which is operated by the SFPUC's Hetch Hetchy Water and Power Project. The remaining 15% comes from Bay area reservoirs and the small remainder is sourced from local groundwater and recycled water. For the City approximately 96% of water is imported, while local groundwater provides the source for the other 4%.

The water supply from the Hetch Hetchy system is of high quality and there is local pride in having water sourced from a pristine environment. This does generate some community reluctance to accept other sources of water, which are perceived to be of lesser quality. There are other community sensitivities related to the location of wastewater treatment plants within the city boundary and associated odour and engineering aesthetics.

Water and wastewater infrastructure in San Francisco is aging and seismically vulnerable. Water demand is increasing in the wider water service area, but in the City, demand remains steady. The SFPUC watersheds are facing regulatory requirements to provide stream flows for fish and aquatic ecosystems. Stormwater quality is becoming an increasing issue and there are combined sewers and a number of stormwater overflows. There have also been recent natural events (e.g., droughts) which have impacted the water supply.

Within SFPUC, different aspects of the water cycle are managed by two different enterprises: the Water Enterprise which manages the water supply, the water system and the production of hydroelectric power, and the Wastewater Enterprise which manages the collection, treatment and discharge of stormwater and wastewater. A third enterprise, the Power Enterprise, provides electricity to municipal departments. At the time of writing, the impetus for IUWM is coming from champions within the different Enterprises. Until recently there has not been a specific drive for IUWM from upper management. Each enterprise within the SFPUC has individual sources of funding that can not be shared between enterprises. The capital works program for each enterprise is sourced from ratepayers and other contributors such as bond schemes that are floated from time to time and grants from various agencies.

The SFPUC's organization promotes individual planning within each enterprise and the development of capital plans that address the needs of each enterprise. Despite the fact that all aspects of the water cycle are managed by the SFPUC, the organizational structure does not lend itself to integrated planning across enterprises. The SFPUC recognizes the need for more integrated planning across enterprises to take advantage of the resources it manages and has begun a more focused effort to establish workgroups that cross enterprises to address the SFPUC objectives. The following discussion tracks a planning process conducted by the Water Enterprise to highlight some elements of IUWM. In more recent planning efforts, the SFPUC Water and Wastewater Enterprises are working together to identify ways to further use wastewater and stormwater as water supply sources for non-potable uses thereby reducing the amount of surface water used by the SFPUC to meet water demands in the City.

The SFPUC's Water Enterprise recently produced a water supply plan for meeting the City's demand, from which a report entitled *Diversifying San Francisco's Retail Water Supply Portfolio* (SFPUC, 2006a) was prepared by the Water Resources Planning Division. The process followed in this diversification report closely resembles the IUWM planning process, Phases 1 and 2. It primarily addresses water supply, but considers supplying water to fit for purpose by including options for wastewater reuse. In this report a number of options (or strategies) were selected, compiled options into five portfolios, and the performance of five portfolios were evaluated. The portfolios were assessed for comparative performance in terms of supply reliability, environmental impact and affordability. However, no selection process was undertaken. The process was also used to introduce ideas of sustainable water management to the community.

Other planning documents include an Urban Water Management Plan, which feeds into a Bay Area Integrated Regional Water Management Plan which, in turn, informs the California Water Plan. There are a number of other planning documents which have also informed or been informed by the diversification plan. These include:

- Recycled Water Master Plan (SFPUC, 2006b)
- San Francisco Bay Area Integrated Regional Water Management Plan (SFPUC, 2006c)
- Urban Water Management Plan for the City and County of San Francisco (SFPUC, 2005)
- Desalination and San Francisco Bay (San Francisco Bay Conservation and Development Commission, 2005)
- SFPUC Wholesale Customer Water Demand Projections: Technical Report (SFPUC, 2004a)
- SFPUC Wholesale Customer Recycled Water Potential: Technical Memorandum (SFPUC, 2004b)
- Water Supply Master Plan (SFPUC, 2000)

The key drivers for SFPUC to implement IUWM can be identified from their problem statement of 'how are we going to meet future demand?' SFPUC has considered a number of global, national and local drivers when addressing this question, including:

- Climate change and increased flooding and/or drought and/or reduced snow melt
- Population growth, demographics and retail versus wholesale demand
- Interruption of water supply due to seismic activity
- Community reluctance to use supply alternatives such as groundwater or recycled water or to reduce demand
- Lack of full intra-institutional integration in decision-making and funding
- Water quality issues including stormwater and sewer overflows

- Aesthetic issues of odour and visual impact
- Aging infrastructure
- Reduce reliance on imported water
- Reduce need for additional diversions from surface water supplies
- To contribute to San Francisco as a sustainable city

There are a number of IUWM options which have already been implemented in San Francisco. They include subsidies to encourage urban rainwater harvesting, 'Keeping Water out of Sewers' program, third pipe for recycled water in new buildings above a specified occupancy, use of 'Low Impact Development' principles and eco-roofs and eco paving.

The next section compares the processes used in SFPUC's *Diversifying San Francisco's Retail Water Supply Portfolio* (SFPUC, 2006a) (hereafter called "Diversification Study") with the IUWM planning process described in Chapter 2. It should be recognized that the diversification plan addressed water supply issues only, and did not incorporate options for wastewater or stormwater management unless wastewater and stormwater are seen as additional water supply sources.

Phase 1 Activity 1: Convene Key Stakeholder Group

For the Diversification Study, a key stakeholder group was established. Key stakeholders included members of the general public and of community organizations, representatives from the SFPUC Citizen's Advisory Committee, and staff from several City departments. The stakeholder group was brought together for a series of five public workshops that spanned the Study from start to finish.

Champions for IUWM exist within separate enterprises, and plans for integrated approaches are proposed from time to time. Currently, however, there is not a formal KSG that is focused on cross enterprise IUWM. In addition, initiatives that transcend enterprises are difficult to fund unless they are included in the capital expenditure budgets because cross-enterprise initiatives require a major commitment on multiple levels of organizational management. If a KSG was formed, it would include representation from the many divisions within the SFPUC Enterprises as well as across the City, including City Department of Recreation and Parks, City Planners and Public Works. It would also include representation from the decision makers of the many departments.

SFPUC generally uses a series of public workshops and forums with open invitations for stakeholder engagement. In general, stakeholder forums and workshops include representatives from the wholesale customer community, ratepayer advocate community, environmental community, environmental justice community, regulatory community and workforce community. Stakeholder participation varies based on the issues being addressed in the process. The SFPUC has several formal stakeholder groups such as the Citizen Advisory Committee, the Bay Area Water Stewards, the Revenue Bond Oversight Committee, and the Transparency Committee. These are utilized during a number of stages of a project, including planning, design, environmental review and implementation. In other words, these workshops feed into the activities 2, 3, 4 and 5, in an engagement style that is mainly consultative, bordering on collaborative. The participation is motivated by a combination of allowing stakeholders to contribute in decision making, making implementation smoother, promoting active citizenship, and finding solutions that are acceptable for a range of stakeholders. In particular, the workshops aim at modifying performance criteria, identifying key issues of concern and identifying future actions.

Table 3.1
Measures identified for SFPUC

Objective	Measures
Affordability	• Cost • Rate impacts • Implementation time
Reliability	• Flexibility • Potential implementation risks • Public acceptance • Reliability • Water quality • Yield
Responsible management of entrusted resources	• Efficient water use • Environmental stewardship • Sustainability

Source: SFPUC (2006a)

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

Objectives for IUWM have not been clearly stated and currently they are generated in separate departments and no formal process exists for setting integrated objectives, measures and criteria. Some objectives and measures have been developed for individual system components. For example, objectives included in the Diversification Study are as follows:

- Affordability—Meet the water supply needs of SF in the most cost effective way minimising the cost of water and fluctuations in water rates
- Reliability—Meet the water supply needs of SF in a way that minimises the potential for delivery reductions and outages and is of a quality suitable for its application
- Responsible management of entrusted resources—meet the water supply needs of SF in a way that reduces the use of natural resources, reduces the impacts to or improves the natural and aesthetic environment and is sustainable

Measures corresponding to these objectives are given in Table 3.1. The objectives were derived from the SFPUC mission statement. SFPUC believes that objectives should be clear and concise and should not limit available options. Also, these measures of system performance are developed to suit the particular application, and qualitative scales are used, informed by the results of quantitative modelling.

Phase 1 Activity 3: Understand Current System

SFPUC has completed capital improvement plans for most aspects of the water cycle for their current system, and the improvement plan for stormwater flows and the condition of the wastewater system is currently underway. Broader community perception is well understood through interactions with the SFPUC's External Affairs division, and involvement of the community is seen

Table 3.2
Ranking of individual water supply options for SFPUC Phase 1

	Water Conservation	Groundwater	Recycled water	Desalination	Rationing
Affordability	+	+	–	–	✓
Reliability	+	✓	✓	✓	–
Responsible management of entrusted resources	+	✓	+	–	+

+ More favourably, ✓ Moderately favourably,—Less favourably
Source: SFPUC (2006a)

as essential. This is achieved through technical advisory committees, citizen's advisory committees and public meetings.

In the Diversification Study*,* future water demands for retail water were obtained (SFPUC 2004a). Local water supply options of water conservation, groundwater, recycled water, desalination and rationing were identified and other reports were used to provide the background knowledge required in these areas. Some examples are given:

- ***Water Conservation***—The 38 programs identified in *City and County of San Francisco Retail Water Demands and Conservation Potential* study (SFPUC, 2004a) has the potential to reduce retail water purchases in the year 2030 by approximately 4.5 mgd
- ***Groundwater***—The *Final Draft North Westside Groundwater Management* Plan identified potential of 2.0 mgd new groundwater sources by 2012
- ***Recycled water***—Approximately 4.1 mgd recycled water available by 2012 identified in *Recycled Water Master Plan for the City and County of San Francisco* (2006b)
- ***Desalination***—The *Bay Area Regional Desalination Study* (San Francisco Bay Conservation and Development Commission, 2005) identified potential to produce approximately 38 mgd

For full IUWM approach, stormwater, rainwater, decentralised wastewater, greywater and other options need to be assessed. At the time of the study, these supply options were not fully developed, however, the SFPUC has, in recent months, begun to develop further information on these sources as potential water supply options. Further water supply planning underway will be incorporating these options.

Phase 1 Activity 4: Assess System Performance

In this first Phase, SFPUC utilised data and information from existing plans and strategies to develop five portfolios for further assessment in Phase 2.

The Portfolios were developed based on how each individual water supply option performed relative to the objectives. A qualitative and semi-quantitative assessment (where information was available) of individual components of the water system was undertaken and each option was ranked on a simple three point scale, (see Table 3.2) which determined whether an option performed more, moderately or less favourably relative to the objectives. Interactions between components, however, were not assessed.

Phase 1 Activity 5: Implementation Planning

Five portfolios were formed based on the performance of each individual option relative to the objectives. The portfolios are listed here:

- ***Status quo portfolio***—imported water, water conservation, groundwater and rationing
- ***More affordable portfolio***—imported water, additional water conservation and groundwater, rationing
- ***More reliable portfolio***— imported water, additional water conservation and groundwater, recycled water, desalination, rationing
- ***More responsible to entrusted resources portfolio***— imported water, additional water conservation and groundwater, recycled water, rationing
- ***Balanced objectives portfolio***— imported water, additional water conservation and groundwater, recycled water, rationing

In the more affordable scenario for example, individual options that performed more or moderately favourably against the objectives were included. Imported water was included in all the portfolios as none of the alternative sources are sufficient to offset use of imported water.

Phase 2 Activity 1: Convene Key Stakeholder Group

As stated in Phase 1, for the Diversification Study, a key stakeholder group was established. Key stakeholders included members of the general public and of community organizations, representatives from the SFPUC Citizen's Advisory Committee, and staff from several City departments. The stakeholder group was brought together for a series of five public workshops that spanned the Study from start to finish.

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

In Phase 2, further analysis was identified in addition to that required to evaluate the objectives and measures of affordability, reliability and responsible management identified in Phase 1. This analysis was not presented in a form of objectives and it included:

- Estimated retail ratepayer impact
- Amount of new water supply generated
- Estimated maximum projected rationing
- Time based examination to 2030 for normal and drought years

The Diversification Study was based on several analyses completed by the SFPUC regarding the SFPUC's available water supply, water delivery system and water demands throughout the SFPUC service area. Many of these analyses were documented through various studies identified above.

SFPUC utilise a number of modelling tools for more detailed analysis of their water system. For example, InfoWorks (from Wallingford Software) was used to investigate the use of low impact development (LID) to offset stormwater flows to sewers. Hydraulic models were used to identify distribution issues, and in-house spreadsheet based models were used for water supply system planning. Water demands were estimated using an end use model, which was developed based on Australian expertise. The model included the ability to forecast demand while taking into account the impacts of plumbing codes (e.g., low flush toilets) and breakdown of use by housing type, by industry/commerce/residential and for population projections. An Australian-based model was also used for asset management. Water quality was not modelled for the urban area, and climate change modelling is currently underway through the development of new models and alteration of existing hydrologic models.

The external affairs group provided assistance on community consultation. Stakeholder preferences and political influence were taken into account for the performance assessment. However, no formal decision making tools were used for ranking portfolios.

Phase 2 Activity 3: Understand Current System

A number of assumptions were identified and used to provide estimates for the additional analysis identified in Phase 2. Assumptions included:

- Hypothetical single-family customer uses 700 cubic feet per month
- Annual inflation rate 3%
- Annual rate of interest for bonds 5.5%
- Financing costs 10%
- 30 year payback
- Water cost projections

At this Phase of IUWM analysis, an improved understanding of all water system components is required and detail of the wastewater, stormwater, groundwater, other surface waters and evaporative streams should all be considered. In addition, detail of contaminant flows for these water streams should be incorporated in order to understand inter-relationships and interactions between the streams and their impacts on the whole of the system.

Detailed studies on different aspects of SFPUC's water system were not conducted as part of the Diversification Study. However, many studies regarding available water supply from the surface water system, demand projections, conservation potential, recycled water availability and groundwater availability were available at the time of conducting the Diversification Study. These provided the foundation for the Diversification Study. The studies on water demand and water supply availability provided the information to define the water demand and the current surface supplies available to meet the demand. The other studies identified the potential sources of supply besides surface water that could be analysed to meet the demand. The Diversification Study pulled all available and relevant information together and compared the different sources against each other and in portfolios using evaluation criteria.

Table 3.3
Example summary information from assessment of portfolios used by SFPUC

	Status quo portfolio	More affordable portfolio	More reliable portfolio
Impact of retail ratepayers (single family/month)	N/A	Reduces cost by $1.02	Increases costs by $7.85
Imported Water (normal year/drought year)	89.3 mgd/ 77.0 mgd	83.4 mgd/ 71.9 mgd	41.3 mgd/ 35.6 mgd
Water conservation	0.6 mgd	4.5 mgd	4.5 mgd
Groundwater	3.5 mgd	5.5 mgd	5.5 mgd
Recycled water	0 mgd	0 mgd	4.1 mgd
Desalination	0 mgd	0 mgd	38.0 mgd
Maximum projected rationing	12.3	11.5	5.7
New supply from local options	0.6 mgd	6.5 mgd	48.6 mgd

Source: SFPUC (2006a)

Phase 2 Activity 4: Assess System Performance

The five portfolios were assessed according to the measures and analysis outlined in Phase 2 Activity 2. Summary information of this analysis is given in Table 3.3. In addition to this quantitative assessment of water volumes, qualitative assessment of affordability, reliability and responsible management was undertaken.

Phase 2 Activity 5: Implementation Planning

SFPUC developed a list of recommendations as outcomes from their study. These recommendations provide a basis for planning for the next phase. Recommendations were:

- Continue to study the feasibility of additional water supply projects and programs and update existing study in light of new findings
- Revisit current allocation agreement for imported water between retail and wholesale customers during drought conditions
- Launch a comprehensive public education campaign in order to be proactive in addressing customer issues
- Consider adopting rate structure to provide customers incentive for conserving water

Phase 3: General

SFPUC is aware that the process followed in the Diversification Study needs to be broadened to examine water supply, wastewater and stormwater management in tandem in order to be in line with the IUWM approach. They are keen to incorporate new ideas and options and recognize the diversified portfolio they have developed could be expanded to include other sources of water supply. The process is seen as requiring continual update and review and, flexibility in being able to incorporate changes in technology or feasibility of other water supply options to integrate into implementation plans. The SFPUC prepares an Urban Water Management Plan every five years that requires updating water demand estimates for the next 20 years and identifying water supplies to meet those demands. As new water supply options emerge as feasible to meet demands, they become incorporated into such planning documents.

As with other case studies, this final section describing Phase 3 of the IUWM planning process, details some recommendations for SFPUC to continue their assessment in a more integrated manner.

Phase 3 Activity 1: Convene Key Stakeholder Group

For the Diversification Study, a key stakeholder group was established. Key stakeholders included members of the general public and community organizations, representatives from the SFPUC Citizen's Advisory Committee, and staff from several City departments. The stakeholder group was brought together for a series of five public workshops that spanned the Study from start to finish. It would be appropriate to continue engaging the same key stakeholder group for Phase 3. In addition, presentations to decision makers on the social, environmental and economic benefits of IUWM may encourage their involvement.

Phase 3 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

Objectives measures and criteria need to incorporate all aspects of the urban water system, including wastewater, stormwater, groundwater, surface water and evaporation and for social, economic and environmental dimensions. Measures needed for environmental impact assessment (EIA) are not incorporated into SFPUC's assessment and EIA is seen as a separate process that is applied when a preferred portfolio has been chosen. Although, SFPUC uses consultants for EIAs and other aspects of evaluation it would be useful to incorporate some of the requirements of EIA into Phase 3 of the IUWM planning process. The EIA is not then left as the final hurdle for a particular portfolio and many aspects will already be addressed prior to detailed design and implementation.

Phase 3 Activity 3: Understand Current System

A more thorough understanding of the current system is required in Phase 3. Use of more detailed information on water use and quality requirements may facilitate development of other fit for purpose supply, where water is not necessarily of drinking water quality. Understanding the contaminant flows for all these streams is necessary in order to assess potential environmental impacts and to assess possibilities of source recovery of nutrients from waste streams.

Even though SFPUC had not completed its stormwater or wastewater capital plans, it had conducted many studies regarding available water supply from the surface water system, demand projections, conservation potential studies, recycled water studies and groundwater studies which provided the foundation for the diversification study. In this phase, the existing studies can be updated, as required and new studies can be initiated, particularly for understanding interactions between stormwater, wastewater and water supply, to obtain a thorough understanding of the whole urban water system.

Phase 3 Activity 4: Assess System Performance

Portfolios developed have been evaluated for relative performance of the water supply component only. SFPUC utilizes some complex models for system assessment but, as with other case studies, the assessment of integrated performance is essential during this phase, which can be undertaken using whole-of-urban water system integrated modeling tools.

Phase 3 Activity 5: Implementation Planning

The SFPUC has adopted a plan to implement recycled water, groundwater and further conservation in the City to offset up to 10 million gallons per day of surface water currently used in the City to meet demand. In addition, some other components of IUWM have been implemented. Such components include:

- Subsidies to encourage urban rainwater harvesting in the San Francisco Area
- 'Keeping Water out of Sewers' program
- Constructing a third pipe for recycled water in new buildings above a specified occupancy
- Use of 'Low Impact Development' principles to reduce stormwater flows to sewers
- Eco-roofs
- Urban forestry
- Stream day lighting
- Eco paving.

Rainwater harvesting is ad-hoc, and approvals given on a case-by-case basis. A "no regrets" policy allows individual strategies to be implemented provided they can be shown to have only positive outcomes.

At present, initiating IUWM is seen as a major capital investment, requiring substantial capital works. Consequently, implementation plans for IUWM have not been included in future budgets as a single activity but rather a series of projects promoted by individual departments within the SFPUC in their budgets. This may not result in successful implementation of IUWM.

Discussion

In San Francisco, many studies and planning processes have been undertaken. There is in-depth understanding of many aspects of the urban water system, and the community is well-informed and aware of the issues, and community consultation is well accepted. Planning has generally followed the process outlined in this manual, particularly Phases 1 and 2, but the approach has always been applied to components of the urban water system, and not to the integrated system as a whole. If San Francisco chooses to take an integrated approach, there will be a wealth of experience to contribute to Activities 3 (understanding the current system) and 4 (system performance assessment). The Activities of formulating a Key Stakeholder Group, formulating objectives, measures and criteria and following through to final implementation will present more challenges in such an aware and active community.

As with other case studies there are many over-lapping plans and strategies which need to be combined to provide a better system understanding. An IUWM approach would integrate these plans, ensuring that various benefits of proposed initiatives are identified. Objectives for IUWM have not been clearly articulated, but San Francisco sees benefits of IUWM including flood reduction, "greening" the city, reducing abstractions, increasing available water supply from alternative supply sources and contributing to the water share balance. All of these are in line with the fit-for-purpose IUWM principle.

The SFPUC is only beginning to implement structured IUWM that crosses enterprises. In more recent planning efforts, SFPUC's Water and Wastewater Enterprises are working together to identify ways to further use wastewater and stormwater as water supply sources for non-potable uses thereby reducing the amount of surface water used by the SFPUC to meet water demands in the City. In this application, the SFPUC will be able to address the wastewater and stormwater collection system overflows and treatment plant issues while also reducing wastewater discharges. A key barrier for implementing a structured IUWM planning process in SFPUC is the way in which capital improvement programs are being funded. At present, each enterprise is allocated a set budget for capital improvement works and it can not be shared across enterprises. If San Francisco chooses to take an integrated approach, the current funding allocation method has to be changed in such away that projects which provide benefits to both enterprises should be funded by both enterprises. Some additional barriers include regulatory limitations in reusing greywater, stormwater and wastewater. The SFPUC will need to continue working with local and state regulatory agencies to advance their understanding of the reuse potential of these resources and develop appropriate regulatory strategies that encourage the use of these resources for non-potable needs.

SANTA CLARA VALLEY

The Santa Clara Valley Water District (SCVWD) is the water wholesaler for Santa Clara County in California. SCVWD manages water resources and provides treated water to local water retailers, who in turn provide to their retail customers. In addition to water supply, the SCVWD is responsible for flood management and stream stewardship of the county. The SCVWD Urban Water Management Plan (SCVWD, 2005) states in average years, 40% to 50% of water used in Santa Clara County is from groundwater, about 40% from treated water imported from the State Water Project and federal Central Valley Project, about 15% from San Francisco's Hetch Hetchy system and the remainder from local surface water sources and recycled water. The District also invested in out-of-county ground water storage or banking, where surplus imported water can be stored to allow carryover from wet years to dry years.

The first function of the district when it was formed in the 1920s was to "develop a reliable water supply, build reservoirs to store water and recharge the underground aquifer to halt subsidence." Subsidence was still an issue in the 1950s and 1960s when there was large population growth in the district. Diversifying their water resources through surface water importation from the State Water Project reduced groundwater extraction and halted land subsidence by the late 1960s. In late 1980s, the District started importation from the federal Central Valley Project to augment supplies to meet demand. In the 1990s, recycled water from the South Bay Recycling project was introduced for non-potable use and continues to become more prominent in the District's water supply portfolio. The late 1990s also saw issues arising with contamination in reservoirs and groundwater by MTBE (methyl tertiary butyl ether) and more recently perchlorate. By the 2000s, imported supplies from the State Water Project and Central Valley Project became increasingly constrained due to regulatory restrictions on exports from the delta. Current infrastructure projects include the Water

Treatment Improvement Project to upgrade the three treatment plants in the district, to meet increasing state and federal water quality standards and to perform seismic upgrades.

Governance of the SCVWD is by a seven member Board of Directors, five of whom are elected and two of whom are appointed by the County Board of Supervisors. The two appointed seats are due to be eliminated by December 2009. The Board sets policy and provides direction to the District's Chief Executive Officer through a set of board governance policies.

There are two planning documents that the SCVWD has completed since 2000, which are aligned with the IUWM planning process described in Chapter 2. The first is the Integrated Water Resources Plan (IWRP), first developed in 1996 and then reviewed and updated in 2003 (SCVWD, 2003). The second is the Urban Water Management Plan (UWMP) (SCVWD, 2005), which is prepared by all publicly and privately owned urban water suppliers every five years, as a requirement of The Urban Water Management Planning Act (UWMP Act). UWMPs are required by all water utilities in California. Whilst the UWMPs do not necessarily have implementation plans, they serve as guidance documents to water utilities and local governments in terms of water supply availability for the long-term as well as during short-term shortages.

The IWRP provides a planning framework and supporting modeling tools that enable the District to fairly compare investment options in an ever-changing environment. SCVWD's planning framework closely aligns with the planning processes described in Phases 1 and 2 of this manual, and plans to a horizon of nearly 40 years. The current IWRP was developed over a two-year period, involving both internal and external stakeholders. The objectives of the plan were based on the SCVWD mission statement and the Board's policies stated as Ends Policies. The impetus for the development of the IWRP was the need for evaluation of the multiple options for future investment in a complex and changing world.

The SCVWD prepared its first UWMP in 1985, with subsequent updates in 1990, 1996, 2001 and most recently in 2005. UWMPs are designed to provide information on the suppliers' service area, water use, supply and demand, water service reliability, water transfer and exchange options and water recycling and conservation efforts. As such they are not a planning framework but are a useful source of information for other local land use planning and water agencies, as well as cities and community members. The most recent UWMP incorporates the new requirements from the UWMP Act, which focus on coordination of water supply and land use decisions. These new amendments include detail of water planning for new development for three projected scenarios (normal, single dry and multiple dry years) over the next 20 years.

The SCVWD has a Water Use Efficiency Program, which was initiated in 1992 and incorporates water conservation in the home, landscape, business and agriculture, water recycling and desalination programs. In 2007, the programs included rebates for water efficient irrigation hardware for business and residential customers, workshops in water efficient landscaping and a Water Wise house call service for residential customers to replace showerheads and faulty toilet flappers and install sink aerators.

The SCVWD recognizes the cultural diversity in its customer base and provides educational publications in a number of different languages. Programs have been developed in collaboration with many other agencies and organizations such as: the Water Education Foundation, WaterReuse Association, Bay Nature magazine, the Alameda County Waste Management Authority and Alameda County Source Reduction and Recycling Board through the Stop Waste.Org, local schools through educational programs and the Sunset Publishing Corporation.

The SCVWD was involved in the development of the Integrated Regional Water Management Plan. This Plan was led by the Bay Area Water Agencies Coalition, which was formed in 2002 as a forum and framework to discuss water management planning issues and coordinate projects and programs that would meet regional objectives to improve water supply reliability and quality. The Coalition coordinated with other water management agencies and entities in the San Francisco Bay Area region to develop and implement the Plan. The Plan describes the projects and programs in managing water supply, water quality, waste water, recycled water, flood protection, storm water, watersheds and ecosystem restoration. A similar integrated regional water management plan was also developed for the Central Coast region. In addition to these, other SCVWD plans and programs include:

- A Drought Management Plan
- An Infrastructure Master Planning process which feeds into the Capital Improvement Plan
- A Groundwater Management Plan (SCVWD, 2001)
- An Asset Management Program
- An annual report on protection and augmentation of water supplies

In the broad range of programs and projects that the SCVWD is managing or involved in, it assists and advises urban users and retailers within the County on water management issues, encouraging cities to consider aspects of IUWM. Any city in the County wishing to develop an IUWM plan would doubtless seek the support of the SCWVD. As the SCVWD is not a water retailer and does not have direct jurisdiction and responsibilities for the total water cycle in cities, its ability to implement IUWM will be governed by its links and collaboration with retailers and councils in its region.

There are global, regional and local drivers for the initiation of IUWM in the SCVWD and amongst the district's retailers. On a global scale, the effects of climate change on the region are uncertain and there is a need to plan for a range of possible future scenarios, from prolonged drought to an increase in intense rain events and flooding. Regionally and statewide there is increasing competition for water among urban development, agriculture and environmental water needs and these requirements need to be balanced in the most equitable and sustainable way. Locally, increasing population in specific areas of the region, such as Coyote Valley, changes in housing density, and a shift from high water using manufacturing industry to lower water use service industries are all drivers for using an integrated approach to urban water planning. The conjunctive water resource approach adopted by the SCVWD would also benefit from an integrated approach, so that inter-relationships and broader impacts of different supply, distribution, storage and treatment measures can be understood. Other regional and local drivers for implementing IUWM in the region include:

- Threat to quantity and quality of imported supplies posed by algal blooms in San Luis Reservoir when water level is low
- Reduced imported supplies due to regulations to protect water quality and flow into the Bay Delta for endangered fisheries and other threatened species
- Threat to imported supplies due to unstable levees in the delta
- Need to concurrently balance/manage water supply and flood control.
- Earthquake adaptation
- Aging infrastructure

- Compliance with the California Environmental Quality Act and the National Environmental Policy Act
- Increased state and federal water quality requirements
- Security of facilities
- Emerging contaminants, for example pharmaceuticals in imported water and perchlorate in South County
- Protection of groundwater resources and minimizing subsidence

The following sections compare the two SCVWD IWRP processes to that of the IUWM planning process described in this manual and provide examples of specific outcomes of the IWRP processes in relation to the IUWM planning process. Where the IWRP process does not provide adequate demonstration of the IUWM planning process, examples from other SCVWD programs are presented.

Phase 1

The SCVWD IWRP (SCVWD, 2003) continued the approach from the previous plan in 1996 and many of the Phase 1 activities were undertaken and repeated. Objectives, performance measures, criteria and methods were defined through the District mission statement and Ends Policies and other regulatory requirements. There was already a solid understanding of the current system through previous planning efforts and there was extensive assessment of changes in planning assumptions, as well as updated water supply and demand management options to reflect changed conditions. The recommended key strategies or programs were implemented through the annual budget and water rates-setting processes.

Phase 1 Activity 1: Convene Key Stakeholder Group

In Phase 1, the KSG included a wide spectrum of external representatives from the retailers, business, community groups, agriculture, environmental community and local government. Internal stakeholders included the Board of Directors, the Chief Executive Officer and SCVWD managers with responsibility for different aspects of the water utility. As the SCVWD does not have direct responsibility for wastewater or retail customers, the incorporation of KSG members from cities and retailers with these responsibilities ensured that those perspectives were considered in the planning process.

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

During Phase 1, the objectives reflect the SCVWD's mission, which aims at providing "a healthy, safe and enhanced quality of living in Santa Clara County through watershed stewardship and comprehensive management of water resources in a practical, cost-effective and environmentally sensitive manner." This mission statement is reflected in the policies developed by the Board, specifically in the Ends Policy which incorporates intended results, organizational products, impacts, benefits, outcomes, recipients and their relative worth. Examples of Ends Policy are given:

- There is a reliable supply of healthy clean drinking water

Table 3.4
Example of state and federal drinking water standards considered by the SCVWD

Objective	Indicator	Criteria
Meet federal and state water quality regulatory standards	Drinking water MCL* for nitrate	45 mg/L
	Drinking water MCL* for arsenic	10 μg/L (under review 2005)
	California PHG† for perchlorate	6 μg/L

Source: SCVWD (2003).
*Maximum Contaminant Level
†Public Health Goal

- The water supply meets or exceeds all applicable water quality regulatory standards in a cost-effective manner
- The water supply is reliable to meet current demands
- The water supply is reliable to meet future demands in Santa Clara County, consistent with the County's and cities' General Plans and other appropriate regional and state-wide projections
- The groundwater basins are aggressively protected from contamination and the threat of contamination
- Water recycling is expanded within Santa Clara County in partnership with the community, consistent with the District's Integrated Water Resources Plan, reflecting its comparative cost assessments and other board policies
- Water conservation is implemented to the maximum extent that is practical

One of the End Policies states that "the water supply meets or exceeds all applicable water quality regulatory standards in a cost-effective manner" and the SCVWD incorporate relevant state public health goal and federal maximum contaminant level regulations governing water use or quality in its programs and projects to provide *a reliable supply of healthy clean drinking water*. Table 3.4 shows examples of these regulatory requirements.

Phase 1 Activity 3: Understand Current System

Prior to the IWRP (SCVWD, 2003) update, the SCVWD had undertaken its first IWRP in 1996 and master planning efforts in 1975 and 1983. These planning efforts and reports provided the impetus for water supply and infrastructure investments over many decades and resulted in the current water utility system. Information presented in the most recent UWMP (SCVWD, 2005) as well as IWRP (SCVWD, 2003) incorporated climate, geography, water history, reservoirs, groundwater, local water supplies, water use profiles, forecasting of future water resources and opportunities for water conservation, banking, recycling and transfer (see Table 3.5)

Some of the information is relatively detailed, for example the information on demographics and water use was expanded through the use of household water surveys, whereas other information is less well defined.

In addition to the above, in times of shortage the District produces a monthly water supply and use report that contains the following information:

- Monthly and season-to-date rainfall at four rainfall stations within the County

Table 3.5
Example information on current system in Phase 1

Water system component	Information
District profile	• Overview and governance • Water history of the valley
Water supply system	• Reservoirs and groundwater basin • Imported supply • Water treatment and distribution facilities • Historical supply sources and future trends
Water use	• Demographics and the economy • Historical water use and use by sector • Demand projections
Water supply outlook	• Characterizing supplies under different hydrologies • Local, imported and total water supplies
Water supply deficiencies and risks	• Water supply and demand comparison • Reliability, risks and uncertainties
Water shortage contingency planning	• Three dry years scenario • Shortage response guidelines
Demand management measures	• Water conservation programs • Water conservation achievements

Source: SCVWD (2005)

- Reservoir storages and capacities
- Monthly recycled water deliveries
- Monthly and year-to-date water use for each major water retailer in the County
- Groundwater basin condition (depth-to-water data)

Phase 1 Activity 4: Assess System Performance

As part of the IWRP (SCVWD, 2003), the SCVWD assessed the validity of baseline assumptions on water demand and supplies. The assessment included the following items:

- Reliability and capacities of local water infrastructure
- Progress on treated water improvements
- Historical water use trends versus projected demand
- Achievements in water conservation and recycling
- Local and imported water supplies
- District investment in out-of-county water banking
- Progress in state and federal programs and projects (such as CALFED) to address delta issues

Some of these assessments were quantitative, such as historical water use, whereas others were qualitative, such as progress in CALFED program implementation. Changes in planning assumptions and uncertainties were noted.

Phase 1 Activity 5: Implementation Planning

Whilst the UWMP does not have implementation goals in itself, the recommendations from the District's first Integrated Water Resources Plan in 1996 as well as the 2003 update were implemented through ongoing water utility programs and projects to protect and augment water supplies. Many Best Management Practice commitments, as defined in a Memorandum of Understanding Regarding Urban Water Conservation in California in 1991 were implemented through the District's Water Conservation Program which targets residential, commercial/industrial, and agricultural water use. Examples of Best Management Practice implemented in IWRP (SCVWD, 2003) are as follows:

- Residential water surveys
- Residential plumbing retrofit
- Water system audits, leak detection, and repair
- Metering with commodity rates for all new connections and retrofit of existing connections
- Large landscape conservation programs and incentives
- High-efficiency washing machine rebate programs
- Public information programs
- School education programs
- Wholesale Agency Assistance Programs

Some implementation targets from the IWRP (SCVWD, 2003) were described as core elements and relate to actions to ensure validity of baseline assumptions, actions to monitor and evaluate resource options and other actions to help meet objectives. The core elements include:

1. Actions to Ensure Validity of Baseline Assumptions
    - Achieve 46,000 acre-feet/year of water conservation by year 2020
    - Achieve 14,400 acre-feet /year non-potable recycling
    - Establish a municipal and industrial shortage policy for Central Valley Project supplies
    - Protect reliability of State Water Project, Central Valley Project and Hetch Hetchy supplies
    - Protect existing resources and monitor potential impacts
    - Implement programs to seek improvements in source water quality, protect quality of existing resources, and improve treatment capability
    - Improve data collection and evaluation
    - Expand and upgrade Rinconada Water Treatment Plant from 80 to 100 MGD to meet anticipated capacity requirements
    - Add recharge and/or treatment capacity for South County
2. Actions to Monitor and Evaluate Resource Options
    - Investigate statewide water market opportunities
    - Investigate future storage options
    - Investigate increased recycling opportunities and distribution of costs and benefits
    - Investigate opportunities to improve reliability of imported water supplies
    - Investigate other resource options that have been held for future consideration

3. Actions to Help Meet Objectives
    - Assess system vulnerability.
    - Continue public interaction.
    - Investigate system re-operation to improve efficiency.

Phase 2

Phase 2 of the IUWM planning process is best described by the second SCVWD IWRP (SCVWD, 2003), with additional system information obtained from subsequent UWMP (SCVWD, 2005).

Phase 2 Activity 1: Convene Key Stakeholder Group

In Phase 2 of the IUWM planning process, the SCVWD was developing its IWRP and was clearly the champion of this approach. The KSG consisted of representatives from the following:

- Academic community
- Agricultural community
- Business community
- County planning
- District agricultural water advisory committee
- District landscape advisory committee
- Santa Clara Valley Water Commission
- Environmental advocates
- Homeowners
- Other water agencies
- Public advocacy groups
- Wastewater/water recycling interests
- Water retailers

The KSG for the 2003 IWRP included many of those who participated in the development of the 1996 IWRP. The role of the stakeholder group is to represent respective interest, and to review the planning frameworks and technical analysis, as well as provide input and feedback.

The 2003 IWRP was developed over an 18-month period. During this time the KSG met six times to provide input to activities including setting objectives and measures, building portfolios, evaluating the performance of portfolios, determining the relative importance of objectives and developing and implementing an action plan. Four half-day workshops were included in the KSG activities at which the Ends Policies were reviewed to develop planning objectives for the IWRP (SCVWD, 2003).

The IWRP involves internal and external stakeholder participation and multi-objective planning, and the district staff, management, stakeholders and the board of directors all have distinct roles in the preparation of the planning study, and the level of stakeholder engagement was collegiate.

The external stakeholder identification and invitation is based on a basic stakeholder mapping exercise, and the reasons for involvement of stakeholders is mainly due to the overall complex and inter-related nature of the tasks, requiring considerable community feedback on values and acceptance of solutions. To deal with the constantly changing circumstances, the IWRP process is iterative and updated periodically.

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The IWRP (SCVWD, 2003) relates to Phase 2 of the IUWM planning process. From the Ends Policies seven main objectives were developed, and their relative importance to stakeholders was determined. The main objectives were:

- Ensure supply reliability
- Ensure supply diversity
- Ensure water quality required for public health
- Minimize cost impacts
- Maximize adaptability to prevent over and under investment for capital works
- Protect the natural environment
- Ensure the community benefits in terms of recreation, flood protection and prevention of land surface subsidence caused by over-pumping of the groundwater basins

Sub-objectives were then developed to provide guidance for identifying measures (or "predictive indicators"), so that the level to which objectives were met could be evaluated. Further details of objectives, sub-objectives and measures can be found in Table 3.6)

Methods in the form of modeling tools to be used for system assessment were identified at this stage. For example, CALSIM II (an operations model that simulates State Water Project and Central Valley Project supplies under different conditions) was selected to estimate future contract delivery allocations.

Phase 2 Activity 3: Understand Current System

Understanding the current system and uncertainties was an important element of the IWRP (SCVWD, 2003) planning framework and was used to define the baseline and risk factors, which feed into quantifying the extent of water shortage, community perceptions and environmental needs, and identifying opportunities to address problems.

Building on work performed in Phase 1, for some aspects of the baseline water system, risk factors were examined to establish the degree of uncertainties to the assumed baseline or base case. As an example, risks and uncertainties that could impact the baseline water supplies include:

- Hydrologic variations
- Random risks such as Delta infrastructure failure resulting in disruption of imported water supplies, Delta export interruptions to protect endangered fisheries, low-point in San Luis Reservoir that disrupts Central Valley Project supplies
- Delay or abandonment of planned improvements in statewide water supply facilities
- More stringent drinking water quality standards and emerging contaminants affecting both surface water and ground water
- Climate change resulting in decreased imported water deliveries and increased demands
- Greater-than-expected water demand

Table 3.6
Objectives and measures used in SCVWD IWRP

Objectives	Sub-objective	Measures
Ensure supply reliability	Provide for County water demands	Frequency and magnitude of unmet County's water demand
	Meet contractual obligations	Frequency and magnitude of unmet contract treated water
	Maximize SCVWD's influence	Degree of SCVWD's influence
Ensure supply diversity	Provide a variety of sources	Local supplies as a percentage of total supply
Ensure water quality	Maximize treatability	Daily variability and algae in surface water
	Meet or exceed water quality regulations	Levels of bromide in surface water
	Protect groundwater quality	Impact on groundwater
Minimize cost impacts	Minimize community costs	Total present value cost of supply portfolio to the community
	Minimize cost to the SCVWD	Total present value cost of supply portfolio to the SCVWD
Maximize adaptability	Maximize capital investment flexibility	Variable cost as a % of total (variable + fixed) costs
	Maximize scalability	Degree of phased expansion
Protect the natural environment	Maximize benefits to habitat and the environment	Degree of overall environmental habitat benefits
	Ensure environmental water quality	Impact on stream water quality
	Maximize efficiency of existing resources	Volume of County's water demand offset by water conservation
		Volume of County's water demand met by recycled water
Ensure community benefits	Increase recreational benefits	Degree of recreational opportunity
	Improve flood protection	Degree of flood protection
	Prevent land surface subsidence	Groundwater storage

Source: SCVWD (2003).

Baseline information was used to identify groups of building blocks (or Phase 1 strategies in this manual) and generate portfolios. Portfolios were developed around portfolio objectives that focused on individual strategies, as well as "hybrids." This process aligns with Phase 2 of the IUWM approach. Each portfolio was made up of relevant components (or building blocks) in line with the objectives. There were five categories of building blocks and from the five categories, forty-six building blocks were identified. The categories of building blocks were:

- All-weather supplies, which include water conservation, recycling and desalination
- Storage, which includes surface water storages, recharge to regional aquifer and water banking in out-of-county aquifers
- Dry-year transfers, which include spot market transfers

- Treatment of surface and groundwater supplies to make them reliable and safe to use
- Re-operations, which include inter-connections with neighboring water suppliers to increase system reliability

Six portfolios were developed, five of which have the potential to meet IWRP objectives. The sixth is a "no regrets" portfolio made up of components that ensure supply reliability in the short term or through 2010, with minimal vulnerability to stranded assets. Components are environmentally friendly and cost-effective, involving no major capital investment.

In addition to understanding the water flows for the current system SCVWD also has sound understanding of some of the contaminants that might impact surface or ground water quality. For example, the following emerging contaminants of concern have been identified and monitoring and assessment programs are being undertaken:

- Dioxane, a solvent stabilizer
- Trichloropropane, a fumigant and solvent
- Nitrosodimethylamine, liquid rocket fuel ingredient and disinfection by-product
- Trichloroethylene
- Perchloroethylene, a dry cleaning and electronic solvent
- Endocrine disruptors

Phase 2 Activity 4: Assess System Performance

Both quantitative and qualitative methods were used to evaluate measures. The quantitative methods use observed and modeled data, whereas the qualitative methods use expert opinion to reach consensus on values. An in-house simulation model called "Extend" is used to quantify water flows and an in-house economic analysis tool is used to quantify infrastructure life cycle cost implications and cost of shortages.

The portfolios were ranked using multi-criteria assessment, in which each measure is assigned a weight. For example, three measures were used to assess supply reliability: ability to meet County's water demand, ability to meet contract obligations and ability to maximize the SCVWD's influence on water supplies. The measures were given weightings of 70%, 15% and 15% respectively, which indicates that meeting the County's water demand is much more important than meeting current treated water contractual obligations. Both KSG and technical staff provided input to derive weightings.

Risks were identified and quantified for each portfolio. Risk scenarios included random catastrophic events such as a major incident resulting in disruption of imported water supply from the Delta, and climate change combined with accelerated and unexpected increases in water demand.

Outcomes of the portfolio analysis show relative strengths and limitations of each portfolio in terms of its ability to meet the seven objectives defined in the IWRP. A generic set of outcomes was then derived which forms the basis of implementation strategies for the short-term (up to 2010) medium-term (up to 2020) and long-term (up to 2040).

Phase 2 Activity 5: Implementation Planning

The analysis in this phase identified short-term actions to secure the current baseline or foundation supplies and to invest in the "no regrets" portfolio, and to defer decision on longer-term investments until there is more certainty in the future scenario predictions. Actions to secure the baseline and 'no regrets' portfolio are given below:

- Protecting imported water supplies by solving contract and policy issues, by supporting Bay-Delta system improvements and by resolving the San Luis Reservoir low-point problem
- Protect and sustain baseline local supplies
- Uphold the ability to provide clean, safe drinking water and to meet and exceed water quality standards through aggressive water protection and ongoing improvements to treatment facilities
- Shore up existing infrastructure based on the recommendations from the Water Infrastructure Reliability Plan and Asset Management Program
- Protect streams, fisheries, and natural habitat by taking a science-based watershed approach to new environmental issues as they emerge and through the development of a Habitat Conservation Plan/Natural Communities Conservation Plan
- Agricultural, municipal and industrial conservation for total additional annual savings of nearly 28,000 acre-feet
- Groundwater recharge capacity, including 4,500 acre-feet of onstream recharge and 14,900 acre-feet of pond recharge (approximately 20,000 acre-feet annually)
- An additional 60,000 acre-feet in water banking capacity

In addition to the specific actions and investments to secure the baseline and implement the "no regrets" portfolio, eleven additional recommendations are made which prepare the way to making the longer term decisions needed to meet water demand beyond 2010. These recommendations range from resolving water quality and market issues related to recycled water to looking for technology that improves project feasibility and decreases costs. Some recommendations include:

- Safeguard and maintain existing supplies, infrastructure, and programs to ensure their long-term viability
- Invest in the No Regrets portfolio to help ensure water supply reliability through 2010
- Evaluate opportunities to improve reliability through transfer and re-operations alternatives
- Resolve water quality and market issues related to recycled water to evaluate the potential for expanded use in the future
- Monitor risks that can change the water supply outlook and influence key external decisions to the extent possible
- Strengthen statewide and regional partnerships to support improvements to water supply reliability and water quality and to garner support for new investments
- Look for technology changes that improve project feasibility and decrease costs
- Improve planning to guide future District water conservation efforts
- Study supply and demand in South County to evaluate potential water resource impacts from development

- Explore water management tools such as water pricing structures that create incentives to influence water use
- Develop demand reduction contingency planning with County retailers to improve response during droughts or unforeseen events

Phase 3

As for most case studies, Phase 3 of the IUWM for the SCVWD is currently happening or is in the future. The stakeholder group needs to be reassessed, additional information on the existing system is required and new analysis tools need to be identified before the final decision on the portfolio for implementation. The SCVWD have identified these areas through recommendations in their IWRP (SCVWD, 2003). The following section utilizes this information and provides comment and review on how the SCVWD might move forward to develop a full IUWM plan, although it is unlikely they would develop such a plan for their entire region. IUWM is urban specific and the SCVWD would most likely do this in conjunction with water retailers and city councils.

Phase 3 Activity 1: Convene Key Stakeholder Group

The SCVWD have involved a wide range of stakeholders in the development of their IWRP (SCVWD, 2003). However, the SCWVD does not have jurisdiction or responsibility in wastewater management and recycling and the KSG would need to be extended to include these partners should a city wish to develop a full IUWM plan. Formal partnership or new governance structures may be necessary for joint ventures in water supply and recycled water development.

Phase 3 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

Objectives and measures have been developed from the District's mission statement and Ends Policies. As some aspects of the water cycle are outside SCVWD responsibilities, there are no objectives, measures and criteria for these areas. Wastewater quality, volumes, treatment costs and energy recovery are examples of measures which could be included in this area. The SCVWD has noted that waste water quality assessment has not been incorporated into portfolio analysis and this is important in developing a full IUWM plan.

Phase 3 Activity 3: Understand Current System

The SCVWD has a sound understanding of its current water system but lack data and information on evaporation, ground water quality and contaminant flows, needed to develop a complete water AND contaminant balance analysis.

Recent amendments to The Urban Water Management Planning Act require water providers to provide information on how they will service new and planned development. The integration of the urban land use planning with the urban water cycle is a key component of IUWM, and the UWMP Act requirements should initiate consideration of the impacts and effects of urban land use decisions on the urban water cycle. Examples of these impacts and interrelationships include:

- Increased water demand from urban growth
- Changing permeability, runoff and evaporation rates for different urban land use

- The urban heat island effect and impacts on water use
- New or expanded infrastructure needed to meet growth in demand
- Water and energy use for cooling and heating
- Energy or resources recovery from waste streams
- Encroachment to agriculture and open space

Phase 3 Activity 4: Assess System Performance

There was a lack of analysis of wastewater and contaminant flows in the urban water cycle, a deficiency which was recognized in the IWRP (SCVWD, 2003) and will be improved through the process recommendation to "Improve modeling capabilities to simulate more complex water system operations and to include water quality goals." The development of these modeling capabilities should be based on an understanding of the availability of existing data which will be required for model verification and calibration.

Regulatory restrictions on exportation of water from the Delta continue to become more stringent. As of this writing, imported water allocations from the state and federal water projects are expected to be reduced by 30% or more from quantities assumed in the 2003 IWRP and 2005 UWMP. The District is in the process of re-evaluating its previous water supply assumptions, analyzing impacts and developing potential mitigation actions.

Another area of re-assessment needed is potential impacts from climate change. The 2003 IWRP identified climate change as one of the long-term risk factors to water supplies but lacked the data and information to support analysis. As understanding and knowledge on climate change increases, the District will undoubtedly re-assess its water supply portfolio to both mitigate its carbon footprint and to adapt to changing conditions.

Phase 3 Activity 5: Implementation Planning

The SCVWD has proposed a staged approach to implementation of their IWRP outcomes, and this approach is recommended in IUWM.

Discussion

Through a number of plans and programs, the SCVWD has undertaken many activities of the IUWM planning process. It should be noted that the SCVWD initiated the first IWRP in 1996, with review and update in 2003. The IUWM planning process spans both of these programs and is an indicator of the time and resources required for development of an IUWM plan. The magnitude of the District's responsibilities and the required interactions with other water-related organizations may necessitate the initial development of IUWM at a smaller scale, i.e., city scale, rather than for the entire District.

The integration of the water and contaminants with the urban form are key components of IUWM. These aspects have not been considered by the SCVWD in their IWRP because of its lack of jurisdiction in land use decisions. The SCVWD has realized that it needs to include contaminant modeling in their assessments and this will help move towards an IUWM plan. In addition, the requirement for assessment of supplies to new urban development in the UWMP Act should provide some focus on the interrelationships between urban form and the urban water cycle.

EL PASO

El Paso Water Utilities (EPWU) manages the water supply, wastewater, reclaimed water and stormwater services for most of El Paso County. Water sources are primarily surface water and groundwater, and reclaimed water used for irrigation and industry. El Paso city is the largest urban area in the county and in the Far West Texas region, the most arid region of the State of Texas. The city is one of the fastest growing in Texas and is home to 80% of the Far West Texas Region's population. El Paso is on the Mexican boarder and the fast growing city of Ciudad Juarez Mexico is located across the Rio Grande from El Paso and shares some water sources.

In the past, most of the supply for El Paso was pumped from groundwater, but recently there have been concerns about the long-term sustainability of high rates of extraction. An additional problem is the migration of brackish water into the groundwater supply, increasing the salinity of this source. This issue has been addressed by the installation of a large modern desalination plant that treats groundwater to drinking quality. The groundwater supply is augmented by water from the Rio Grande, which is fed by snowmelt and water stored in upstream dams. EPWU is a customer of the local irrigation district, and can only withdraw water from the Rio Grande during the irrigation season. Return flows to the river must be of high quality, and must be maintained throughout the year. Lack of certainty on the future availability of supplies for a growing population has led to an aggressive conservation program.

Presently EPWU supplies golf courses, parks, schools and industry with reclaimed water, which is also used to recharge the Hueco Bolson aquifer. Reclaimed water treatment is to high secondary or tertiary level, with outputs to Type 1 or near drinking quality. A new wastewater reclamation facility was recently completed in the North West of the region. Reclaimed water has been used in the region since 1963 and today EPWU supplies end users with over 4.6 million gallons per day. Reclaimed water is also used for aquifer recharge and in-plant uses.

EPWU recently took responsibility for stormwater management throughout El Paso. Although the climate is very dry, with an average annual rainfall of only eight inches (200 mm), heavy storms recently caused extensive damage and a comprehensive stormwater plan was recently completed. The plan will extend the use of wetlands and ponds for stormwater retention and infiltration.

The manager of the El Paso Water Utilities is responsible for all aspects of the water cycle, and reports to and implements strategic policies set by the five-member El Paso Water Utilities Public Service Board (EPWUPSB). The Public Service Board was established in 1952 by City Ordinance, to completely manage and operate the water and wastewater system for the City of El Paso. The board of trustees consists of the Mayor of the City of El Paso and four residents of El Paso County, Texas, who are appointed by the City Council for staggered four year terms.

Within EPWU, different aspects of the water cycle are the responsibility of different departments, such as land management, operations services, technical services and water resources. However, the presence of one common manager ensures there is excellent understanding of the total integrated picture.

EPWUPSB produces a Ten Year Strategic Plan, (El Paso Water Utilities Public Service Board, 2006b) which is reviewed annually to provide a comprehensive set of initiatives and ongoing activities to enhance the present and future delivery of water and wastewater services. The plan addresses internal and external issues in the technical, finance, operations and maintenance, communications and government affairs, legal, human resources and policy and administrative areas. Section managers in these areas play an active role in the process and the plan is monitored on an ongoing basis to ensure that compliance and implementation goals are achieved. The Plan encompasses goals and objectives in specific Critical Success Factors in the areas of quality, government affairs, communications and marketing, resource management, organisation and management, finance and security.

In addition to the Ten Year Strategic Plan EPWU must also comply with the Regional Water Plan for Far West Texas first completed in 2001. The Regional Plan is not a static plan and is intended to be revised as conditions change and the current plan (Texas Water Development Board, 2006) is recognised as an evolutionary modification of the predecessor plan. The purpose of this plan is to provide a reference document for water planners for long and short term water management recommendations and to provide an educational tool for all citizens. To meet the requirements of this regional plan, EPWU formulated a report on Integrated Water Management Strategies for the City and County of El Paso in 2006 (El Paso Water Utilities Public Service Board, 2006b). The report presents the analysis of six integrated water development strategies, evaluating the interrelationship of individual components to provide a regional context to the plan.

The City of El Paso also has a Water Conservation Program which was initiated in 1990. The first report became the basis for El Paso's Water Conservation Ordinance which contains mandatory, year round restrictions on certain water use activities. Initiatives under the program include cash for your commode, free showerhead distribution, refrigeration unit rebate, horizontal (front loading) washing machine rebates, desert blooms CDROM, hot water on demand systems and waterless urinals. A recent addition to The Water Conservation Program is a new education centre. Rebates were discontinued in 2008 but may be restarted if needed.

EPWUPSB is also involved in master plans for new developments in the El Paso region, such as Fort Bliss. As such it is ideally placed to develop IUWM plans which integrate urban form and the water cycle.

There are many drivers for implementation of IUWM in El Paso. The Far West Texas region is the most arid in the State of Texas and population predictions suggest a doubling in size by 2060, 80 percent of which will occur in El Paso County. Complexities in the water resources in the area and sharing of sources with other rapidly growing urban areas also suggest an IUWM planning process would be advantageous. There are some water quality issues in El Paso, with concerns over salinity of sources. In addition, the recent flooding issues and the new stormwater responsibilities for EPWU increase the benefits of taking an integrated approach.

The following sections describe the alignment between the EPWUPSB Ten Year Strategic Plan (2006) and EPWU Integrated Water Management Strategies (2006) document and the phases and activities of the IUWM planning process. Comment is also provided on how El Paso could improve water system assessment by introducing additional aspects of IUWM into their approach.

Phase 1 Activity 1: Convene Key Stakeholder Group

There is no formal KSG for El Paso. However, EPWU is the only water service provider and works closely with staff and members of the City Council, who are the only other organisation that might be represented if a formal KSG was formed. The President (and manager) of EPWU has played a key role in the move towards IUWM, and continues as a powerful champion. He has the support of staff in all departments, and has secured funding from many sources. These include grants from the U.S. Bureau of Reclamation, grants and loans from the Texas Water Development Board, grants and loans from the North American Development Bank, City of El Paso Water and

Sewer revenue bonds from EPWU for the Northwest Reclaimed Water Project and other projects. The desalination plant was co-funded by EPWU and Fort Bliss to meet a common need.

Interaction with the community is strong, with active community awareness programs, a water education centre, and citizens' involvement in many decision processes through committees such as the 27-member Public Working Committee. Ultimately decisions are made by the five-member Public Service Board, together with the Mayor.

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The problems relating to the vulnerability of El Paso's water supply were so apparent that no objective statement, beyond those of the EPWU mission statement was formulated.

The mission of the El Paso Water Utilities/Public Service Board was to furnish, at fair and reasonable costs to its customers, high quality potable water in sufficient quantities and at adequate pressures to satisfy domestic, industrial and fire protection requirements in accordance with the Board's Water Conservation Plan, and acceptable and adequate services for collection of liquid waste from individual customers for treatment and disposal without hazard to health of the community in a manner that will protect the environment

The Integrated Water Management Strategies document (El Paso Water Utilities Public Service Board, 2006a) does not identify the objectives, measures and criteria used for the selection of the six strategies that were further analyzed. The six strategies were selected "because they represent combinations of individual strategies due to the unique nature of water management in El Paso."

Phase 1 Activity 3: Understand Current System

The Rio Grande became completely regulated prior to the 1920's to provide water for irrigation, and there is no notion of "natural flows" that would return the river to its pre-development state. There is, however, an increasing understanding of the impact of extractions on groundwater basins, especially in relation to salinity. The geology of the region is well understood, and detailed monitoring is undertaken.

Demand is understood only at the whole-of-city level. By far the greatest demand is residential, and per capita consumption has dropped from 220 gallons per person per day in the late 1970s to 134 gallons per person per day in 2007, as a result of demand management. The stormwater system had become very run down after years of drought, but a severe storm in 2006 caused flooding and the situation is now being rectified. There is a leak detection program for the water and wastewater reticulation networks.

The Far West Texas Water Plan details population projections for El Paso and related water demand projections for residential and specific industrial uses. The report also acknowledges environmental and recreational water needs, although quantification of minimum flow requirements through the year is described as "impossible." The recommendations in the plan do recognize function of ecologically unique river and stream segments and identify five criteria to be used when assessing stream segments which will require additional information about the system. The five criteria for assessing ecological health of stream segments are:

- ***Biological function***—segments which display significant overall habitat value including both quantity and quality considering the degree of biodiversity, age and uniqueness observed including terrestrial, wetland, aquatic or estuarine habitats
- ***Hydrologic function***—segments which are fringed by habitats that perform valuable hydrologic function relating to water quality, flood attenuation, flow stabilization or groundwater recharge and discharge
- ***Riparian conservation areas***—segments which are fringed by significant areas of public ownership including state and federal refuges, wildlife management areas, preserves, parks, mitigation areas or other areas held by government organizations for conservation purposes under a governmentally approved conservation plan
- ***High water quality/exceptional aquatic life/high aesthetic value***—segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent in or associated with high water quality
- ***Threatened or endangered species/unique communities***—sites along segments where water development projects would have significant detrimental effects on state or federally threatened and endangered species and sites along segments that are significant due to the presence of unique, exemplary or unusually extensive natural communities

Phase 1 Activity 4: Assess System Performance

Analysis of new end-use strategies in times of drought is assisted by input from stakeholders, particularly the wider stakeholder group, to gain an understanding of how well accepted each strategy might be. The impacts of strategies, such as low-flush toilets and garden watering restrictions, are then predicted for household usage patterns. Results are reported as a general trend in overall consumption. Detailed understanding of impacts is not known, and impacts of conservation measures on waste water flows were not considered.

Phase 1 Activity 5: Implementation Planning

Although detailed integrated analysis has not been undertaken, many components of IUWM have been implemented. Grants and support to introduce new technologies, from desalination to low water use toilets, are secured and approvals gained through the Public Service Board to include innovative projects in the budget. Projects already implemented through the EPWU Water Conservation Program include:

- *Cash for your commode*—a rebate program for replacing high water use toilets with ultra-low flow toilets. Over 30,000 toilets have been replaced
- *Free showerhead distribution*—low flow showerheads have been delivered to 160,000 customers
- *Refrigeration unit rebate*—a cash rebate for installing central refrigeration units
- *Horizontal washing machine rebates*—a cash rebate for purchase and installation on a front loading washing machine for residential and commercial customers
- *Evaporative bleed-off line clamps*—free clamp for evaporative cooling systems (cooling water is 15% of residential end use)

- *Desert bloom CD ROM*—CD containing advice in English and Spanish on plants adapted or native to the area
- *Turf rebate program*—incentive to convert existing turfed areas to water efficient landscape design
- *Hot water on demand*—rebate for retail customers to install system that reduces amount of time tap needs to be run to get hot water
- *Waterless urinals*—promotion of the installation of waterless urinals in school districts and city offices

Phase 2 Activity 1: Convene Key Stakeholder Group

As stated in Phase 1 there is no formal KSG for El Paso, but as there is good representation from internal and external stakeholders this hasn't been a barrier to implementation of IUWM approaches.

The roles of Phase 2 KSG are to develop a more detailed understanding of the current system and undertake more detailed assessment of system performance. The EPWUPSB has recognized the need for coordination and cooperation with other regional stakeholders and has goals to increase stakeholder involvement by incorporating representatives from the following organizations:

- City Planning Department
- Corps of Engineers
- Texas Department of Transportation
- El Paso Association of Builders
- Chamber of Commerce
- Economic Development Council
- Paso del Norte Health Foundation
- Key legislators
- Political and community leaders
- Juarez water utility (through a memorandum of understanding)
- Paso del Norte Water Task Force
- State and federal lobbyists

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The strategies identified in the Integrated Water Management Strategy (El Paso Water Utilities Public Service Board, 2006a) were assessed in terms of their technical feasibility, cost, environmental impacts, impacts on agriculture, socio economic impacts and water quality. Some of the objectives and measures used are given:

- Increased water conservation strategy
  - Total per capita water use (total city water use/total population)
  - Appliance cost per acre-feet water conserved
  - Qualitative assessment of environmental and socioeconomic impacts
- Increased use of reclaimed water strategy
  - Qualitative assessment of water quality and reliability

  - Cost per acre-feet of reclaimed water and capital cost
  - Qualitative assessment of environmental and socioeconomic impacts
- Increased local groundwater pumping strategy
  - Available water estimates
  - Cost per acre-feet of water produced
  - Qualitative assessment of environmental and socioeconomic impacts

More detailed socioeconomic analysis for the Far West Texas Water Planning Area was carried out as part of the Far West Texas Water Plan (Texas Water Development Board, 2006) where regional "input-output" models were used to estimate how reductions in business activity might affect a given economy for different strategies.

While stormwater plans, in particular, aim to provide improved habitat for ecological species, no specific environmental measures have been identified. Major projects do, however, require an EIS, but this is seen as a separate process for gaining approval.

Phase 2 Activity 3: Understand Current System

As most system assessment in El Paso is at a broad brush level, more detail on the current system will not necessarily improve assessment in its current form. For example, water usage is measured in terms of total gallons per person per day, which includes water used in manufacturing and is not a residential water use value. At present this value is adequate and as long as the trend in total water use per person is downwards, this will indicate the cumulative result of the many water conservation and recycling programs. However, if this value remains static or increases, more information will be required in order to target strategies at the water users responsible for the increase. In Australian IUWM studies, residential water use is often broken down to toilet, bathroom, kitchen, laundry and outdoor uses and strategies developed to target specific areas of use.

Phase 2 Activity 4: Assess System Performance

EPWU undertakes detailed modeling of groundwater, and models are validated using data from a rigorous monitoring program. The results of this assessment appear in (Hutchison, 2006).

Economic assessment of the six strategies identified in the Integrated Water Management Strategy was undertaken, in terms of capital and operating costs for individual strategies and as integrated strategies. Examples of the costs assessed for two of the strategies are given:

- Reuse strategy
  - Treatment including process control improvements, facility upgrades and engineering and contingencies
  - Water distribution including new purple pipeline, pump stations, closed storages, engineering and contingencies for pipelines and pumps, mitigation and permitting
  - Operating costs for pipelines, pump stations, storage tanks, treatment and electricity
- Increased surface water and local groundwater strategy
  - Well field facilities including new wells, pumps and collection systems, engineering and contingencies, mitigation and permitting

– Treatment including surface water treatment, desalination of groundwater, engineering and contingencies, mitigation and permitting
– Disposal including deep well disposal, engineering and contingencies, mitigation and permitting
– Operating costs for pipelines, wells, surface water purchase and treatment, reverse osmosis treatment and reject water disposal

Other system impacts were also assessed in order to select the final strategy. These impacts were estimated from expert knowledge and understanding of the interactions and interrelationships between the different strategies.

Phase 2 Activity 5: Implementation Planning

The favoured integrated water management strategy includes an implementation strategy but this is not yet fully documented.

Phase 3

As with other case studies, Phase 3 of the IUWM planning process has not been implemented. Whilst some initiatives are already in place, the application and assessment of these has not been in an integrated manner. Given below are some suggestions and recommendations for EPWU to carry out more integrated urban water management at this level.

Phase 3 Activity 1: Convene Key Stakeholder Group

During this phase, the focus of the KSG should be on detailed analysis of the shortlist of portfolios, undertaken by technical groups overseen by the KSG. An area which may be further explored by El Paso is the flow of contaminants associated with water flows in the city. This will require some members of the stakeholder group to possess expertise and understanding of the contaminant sources, their chemistry, soil characteristics and local geology.

Phase 3 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

In Phase 3 of the IUWM planning process the objectives, measures and criteria should be selected to provide a more detailed assessment of integrated portfolios. Phase 2 analyses would include some qualitative assessment of environmental impacts and contaminant flows, and it would be prudent to include a more detailed assessment in Phase 3. One example where this could be applied is in the assessment of the impact of water conservation measures on wastewater quality. As some treated wastewater enters the Rio Grande and is then used for irrigation, there are potential environmental impacts of changes in wastewater quality due to water conservation.

Phase 3 Activity 3: Understand Current System

As El Paso moves towards an IUWM approach, it is likely that more detailed information on land use patterns, building structure, water end uses (municipal, residential, private business) and potential climate change impacts would be required. This would allow improved assessment and prediction of the interactions, interrelationships and impacts of more specific strategies.

Phase 3 Activity 4: Assess System Performance

The detailed modeling of groundwater in El Paso is likely to provide the required information for Phase 3 analysis. This would need to be coupled with detailed analysis of wastewater, stormwater and surface water flows as well as end use modeling for potable supplies to provide a full IUWM assessment. Most of the skills needed for system performance assessment exist within EPWU. EISs would require some of this information.

Phase 3 Activity 5: Implementation Planning

As El Paso moves towards an IUWM planning process to develop strategies for future water services, implementation plans would need to be coordinated with a wider group of stakeholders. Future plans might require the involvement of city planners and builders for successful implementation of integrated strategies, such as water sensitive urban design (WSUD) and decentralized wastewater.

Stakeholder Engagement

Motivated by the need to reduce water demand from 200 gallons per capita per day to 160 gallons per capita per day, in 1989 the Public Service Board named a 40 member Citizens Advisory Committee to look at all areas of water use and make recommendations for a water conservation program. This committee made a number of recommendations that was the basis for the Water Conservation Ordinance which was presented to the City Council. Based on the Water Conservation Ordinance, a number of water restrictions and policy changes were introduced, and by 2000, the water demand reduction target had been achieved.

Subsequently, in 1999, a 27-member Public Working Committee including academic, business, industry and environmental organizations, was assembled to make recommendations to staff on water resource management and other key issues. This was done by reviewing proposed programs and by identifying issues and concerns likely to be raised by affected community interests.

The reasoning for such committees is to provide community values and input into key policy issues. This consultative style of engagement functions to collect relevant grass roots information which can be used to improve efficiency of programs and to make implementations smoother. The consultative style of engagement is in line with the medium to high level of community acceptance required, but a low to medium level of complexity of the issues.

Discussion

El Paso Water Utilities is ideally placed to implement an IUWM approach. The organization has responsibility for water, stormwater and wastewater streams in both the urban and rural environment. The county has the largest urban population in the region and EPWU has strong links with urban planning stakeholders.

In order to achieve a more integrated urban water management approach the inclusion of contaminant flows into any assessment is recommended. Integration of modeling and assessment tools is also required in order to assess the interrelationships and interactions between different urban water flows. EPWU has thus far used a high level assessment of the impact of their initiatives and programs, using a total residential water usage figure as a measure of success. More detail of the breakdown of different end uses will be required in order to develop targeted programs for specific end uses.

CANBERRA

Canberra is Australia's national capital city and was designed by the Chicago-based architect, Walter Burley Griffin, who won a worldwide competition to design the city in 1912. It was named Canberra a year later, from the Aboriginal name for the area, "Kamberra" or meeting place. Construction of the Cotter Dam began in 1912 and was completed in 1915. A pumping station to provide the water to the city was begun in 1914 and was eventually powered by electricity in 1918. Wastewater was treated by privies and septic tanks until a sewerage plant at Weston was built and associated sewerage lines were finally completed in time for the opening of the Parliament House in 1927.

As the population grew, so did the demand for water. Surveyor Charles Scrivener's masterful plan of building the territory on water catchments meant that water was available but needed to be harnessed. A number of dams and water treatment works were completed throughout the 1960s and the 1970s and an upgrade of wastewater treatment facilities to incorporate physical, chemical and biological treatment occurred during this time. This upgraded wastewater treatment facility, the Lower Molonglo Water Quality Control Centre, is sited on the Murrumbidgee River in the lowest point in the Australian Capital Territory (ACT).

Canberra's current urban water system is a pipe-in, pipe-out system. Water is sourced from four surface water reservoirs on two major tributaries of the Murrumbidgee River (Cotter and Queanbeyan rivers), treated and reticulated to urban areas. Supply catchments are prone to bushfires and some lie outside the physical boundary of Canberra. Wastewater is collected, treated and discharged to the Murrumbidgee River. Stormwater is collected via a network of pipes and open channels and discharged to the Murrumbidgee River. Canberra is an inland city with potable water sourced from the Murrumbidgee River and stormwater and wastewater generated from urban areas is discharged to the same river, which is a source of water for a number of rural towns and irrigation activities downstream. Stormwater is not treated but flows through a series of artificial and natural wetlands and lakes which provide some biological treatment.

The 1980s saw the beginnings of self-government in the ACT and in 1988 it was decided to incorporate all services under the one body, ACT Electricity and Water (ACTEW). ACTEW Corporation Limited is a government-owned holding company with responsibility for providing energy, water, stormwater and wastewater services in Canberra. ACTEW implements policies and actions generated by the ACT Government through the ACT Chief Minister's office. The ACT Department of Territory and Municipal Services (TAMS) is a body responsible for the maintenance of grassed floodways, urban lakes, water bodies and other "natural" physical components of the stormwater network and both ACTEW and TAMS are government owned organizations.

ACTEW's Board comprises seven Directors: one executive Director and six non-executive Directors who are appointed by the Voting Shareholders, the Chief Minister and Deputy Chief Minister of the ACT. The Voting Shareholders determine the terms of appointment and remuneration paid to Directors and ACTEW agrees on business goals with the Voting Shareholders.

There are a number of previous programs and processes which have similarities to the IUWM planning process. The first is ACTEW's Environmental Management Plan (EMP) (ActewAGL, 2005), which was based on the principles of the Ecologically Sustainable Development (ESD) Strategy and Inter-Governmental Agreement on the Environment, which came into effect in 1992. The core objectives of the ESD strategy are to; enhance community and individual well-being and welfare, provide equity within and between generations and protect biological diversity and maintain essential ecological processes. The EMP (ActewAGL, 2005) generally covers the entire ACTEW service area so does not have an urban focus specifically and it includes strategies for both water and energy. From this EMP an Environmental Action Plan was developed and environmental risk assessments, benchmarks and audits provided input to the Action Plan.

At the same time as the EMP, a future water supply strategy was developed in 1994, providing a blueprint for water services for all of ACT to 2040. This strategy led to the formulation of an Environmental Impact Assessment (EIA) for the main Canberra wastewater treatment plant at Lower Molonglo in 1994. A Sewerage Strategy, Emergency Planning Strategy and Drinking Water Quality Strategy were also developed from the Future Water Supply Strategy.

The strategy was reviewed in 1999 and again in 2004. During the second review the ACT Government took responsibility for developing the plan (rather than ACTEW) and it was renamed *Think Water, Act Water* (ACT Government, 2004) and became the vehicle for implementing directions from the ACT Legislative Assembly and the objectives from Water ACT policy (2003). The directions from the assembly and Water ACT policy were to:

- Avoid the building of further water supply dams
- Maintain the quality of water leaving the ACT at the same level as water flowing in
- Maintain adequate flows in the ACT's waterways to maintain their environmental values
- Develop a water conservation and reuse strategy to ensure that the water needs of any increase in population can be met

The strategy was developed with extensive community consultation, input from a range of experts, and collaboration with relevant government agencies. It was released in April 2004. The strategy takes a catchment perspective and clearly specifies integration of stormwater, water supply and wastewater elements, to address supply reliability and receiving water quantity and quality targets.

Water scarcity is the main driving force for initiating a change to IUWM in Canberra as the city has experienced nearly a decade of drought, as have all other major cities in Australia. In 2006−07, system storage levels dropped from 51% to 41%. Climate change, bush fires in supply catchments and their impact on water quality and population growth are considered contributing factors for water scarcity. ACTEW has been aware of the need to balance environmental needs with development directions in order to provide long term security in their services since publication of their first EMP (covering the years from 1995 to 2000). This proactive rather than reactive approach, to move performance to a level beyond that required by regulatory guidance and to achieve best management practices, has also been a driver for Canberra to adopt an IUWM planning process. Acting as a flagship city in terms of water systems for all of Australia is an aim of the ACT Government.

A number of projects were initiated as per actions of the strategy released in 2004. One such project was the "Canberra Integrated Waterways Feasibility Study." The project was initiated in 2006 and its objective was to develop an optimal portfolio of stormwater harvesting options to meet a specified potable water saving target in sustainability terms. The project was initiated by TAMS and was carried out in collaboration with CSIRO, Australia, and a number of other institutions involved in planning and operations aspects of the stormwater system. These involved the ACT Planning and Land Authority who is responsible for the master planning and development of the new stormwater network at the sub division level and ACT Environment, a division within TAMS responsible for management of environmental flows, natural and overland stormwater paths and water quality aspects of urban stormwater discharges.

The following sections describe how the ACT Government *Think Water, Act Water* strategy (ACT Government, 2004) and TAMS project on stormwater options relate to the IUWM planning process described in this manual. While the focus of these sections are the TWAW strategy document and the TAMS stormwater project it should be noted that ACTEWs first EMP and Future Water Supply Strategy included many activities identified as Phase 1 IUWM activities. The EMP covered both water and energy services and whilst energy services are not the focus of IUWM, there are important interactions between energy and water services.

Phase 1 Activity 1: Convene Key Stakeholder Group

The ACT Government were the champions for the *Think Water, Act Water* strategy development process. Responsibility for action on water supply and wastewater options was with ACTEW and for stormwater this responsibility was with TAMS. The key stakeholders included representatives from the organizations with responsibilities for strategic and land planning in ACT (ACT Planning and Land Authority), protection of the environment (ACT Environmental Protection Authority), strategic water supply and wastewater planning (ACTEW Corporation), stormwater management (ACT Department of Territory and Municipal Services), the ACT Government and the community.

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The goal of the *Think Water, Act Water* strategy was to provide direction to long-term management of ACT water resources, and to implement best practice water resource management strategies. A number of challenges (which are related to drivers and objectives) were identified, to improve water supply requirements and urban and recreational amenity, water quality and ecological values in waterways. These challenges were based on the motion passed by the Legislative Assembly to avoid the building of further water supply dams, maintain the water quality leaving ACT at the same level as water flowing in and to maintain adequate flows in the ACT's waterways to maintain their environmental values. The challenges include:

- Ensure the ACT and region has a secure and reliable supply of water for current and future needs
- Continue to protect the ecological and social values of our waterways for our needs and the needs of future generations
- Take account of climate change, including scientific predictions for higher temperatures and lower and variable rainfall, in assessing the future sustainability of our resources

- Improve urban, housing and landscape design to fit with emerging water resource constraints
- Integrate an holistic approach to water cycle management with economic, spatial and infrastructure planning
- Ensure water supply and management practices are consistent with protecting public health.

Some of the wide range of initiatives included in the ACTEW EMP are also relevant to IUWM and provide an extensive list of areas which need to be considered. Examples of initiatives in the ACTEW EMP are:

- Community consultation and awareness
- Quality management
- Environmental impact assessment
- Heritage protection
- Environmental law
- Service standards
- Procurement of material and services
- Aesthetic qualities including noise and odor
- Trees and vegetation
- Future strategies
- Sewer acceptance of non-domestic wastes
- Sewer infiltration and inflow control
- Reuse of sewage treatment by-products
- National and territory initiatives
- Water conservation and demand management
- Waste minimization and recycling
- Effluent discharges
- Catchment management
- Greenhouse effect
- Alternate and renewable energy sources
- Environmental education and awareness for employees
- Drinking water safety
- Dam safety

Phase 1 Activity 3: Understand Current System

A number of past plans and strategies from ACTEW provided background understanding of the current system. These plans and strategies were:

- Future Electricity Strategy
- Future Sewerage Strategy
- Emergency Planning Strategy
- Drinking Water Quality Strategy
- Monitor regulatory compliance
- Benchmark Standards of Service against other relevant utilities

- Identify suitable processes for odor removal
- Customer surveys and participation
- Explore possibilities of wider-scale effluent reuse in new suburbs
- Continued investigation of sewer infiltration causes
- Continued research into the conservation biology of the legless lizard
- Consult community support for effluent reuse

In addition, details of population growth predictions, the impacts of bushfire, long term climate change predictions and the urban water cycle and water sensitive urban design were collated in the *Think Water, Act Water* strategy. Furthermore, a number of feasibility studies were carried out to understand surface water availability, locations for new dams, environmental flow needs of rivers and waterways and sustainable yield of surface water and groundwater. Details are given in Volumes 2 and 3 of *Think Water, Act Water* (ACT Government, 2004). Additional information on many other aspects of the urban water system were collated, processed and examined in order to understand the current system. Examples of information collated to understand the current system in Phase 1 are given:

- Polices and agreements:
  - International
  - National policies on water management
  - Intergovernmental arrangements for water sharing between states of Australia
  - Water acts and policies
  - Federal legislation and Territory legislation
- Water planning variables—population growth; long-term climate change and its potential impact on changes in temperature, rainfall and evaporation and temporal shift
- Water supply options—possible new dams, diversions, increasing capacity of existing reservoirs and availability of alternative sources
- Water consumption—per capita water use as well as residential and non-residential current and future water uses; temporal variation of end uses
- Water efficiency measures in their effectiveness in residential, non-residential and government sectors
- Water flow and quality in ACT rivers, lakes and aquifers including environmental flow requirements and riparian zone management
- Water sensitive urban design—concept and its implications, how it can be incorporated into urban land planning
- Community attitudes and processes for capacity building and engagement processes
- Condition assessment of built and natural assets

Data on international policies and agreements included Agenda 21 of United Nations Commission on Sustainable Development and international treaties such as the Ramsar Convention on wetlands of international importance. National policies examined included the principles of the Council of Australian Governments, the National Action Plan for Salinity and Water Quality and national strategy for ecologically sustainable development. Intergovernmental arrangements included the Murray-Darling Basin initiative, which is a collaborative arrangement between the Commonwealth Government and the New South Wales, Victorian and South Australian

Table 3.7
Canberra integrated water balance

Component	Annual volume in billion litres
Rainfall	494
Potable consumption	65
Stormwater	13
Wastewater	35
Recycled water	1.3
Environmental flows	269

Source: ACT Government (2004).

Governments for regulating and sharing water within the Murray-Darling Basin. This is relevant to Canberra as the Murrumbidgee River is a part of the Murray-Darling basin.

Phase 1 Activity 4: Assess System Performance

Total water cycle water balance analysis was carried out to understand the temporal and spatial variability of different water streams, inputs and outputs of the urban water system for the base case and alternatives. The average annual water balance completed for *Think Water, Act Water* is shown in Table 3.7. In addition, focus groups and surveys were used to assess social aspects of alternatives.

Phase 1 Activity 5: Implementation Planning

After the initial system assessment a number of water supply options were identified. This preliminary investigation revealed nearly thirty possible options which were narrowed down to eleven for more detailed analysis. These eleven options were different configurations of four specific water sources; building a new dam, enlarging an existing dam, water transfer from New South Wales and a range of small scale options. In addition to these four new sources of supply, stormwater was also identified as a feasible source. As well as identifying new supply sources to provide a long term, reliable source of water to ACT, there were five other implementation actions identified. All six actions are given:

1. Provide a long-term, reliable source of water for the ACT and region
2. Increase efficiency of water usage
3. Promote the development and implementation of an integrated regional approach to ACT/New South Wales cross-border water supply and management
4. Protect the water quality in ACT rivers, lakes and aquifers, to maintain and enhance environmental, amenity, recreational and designated use values and to protect the health of people in the ACT and downriver
5. Facilitate incorporation of Water Sensitive Urban Design principles into urban, commercial and industrial development
6. Promote and provide for community involvement and partnership in managing the ACT Water Resources Strategy

Table 3.8
Examples from ACTEW implementation plan

Implementation action	Responsible authority
Water Planning Variables	
Bushfire Impacts Continue research and analysis to gain a more accurate understanding of the likely impact of bushfires on water supply	ACTEW
Complete the installation of treatment facilities at the Mount Stromlo Water Treatment Plant	ACTEW
Stabilize and rehabilitate the fire-affected sections of the Cotter catchments where appropriate	Department of Urban Services
Climate change planning for the ACT's water resources will continue to take account of future climate change predictions for the ACT	ACTEW
Objective 1: Provide a long-term, reliable source of water for the ACT and region	
Water cap, by December 2005, aim to complete a memorandum of understanding with the New South Wales and Commonwealth governments that will include provision for a water cap	Chief Minister's Department (CMD)
Water supply, by December 2004, a range of planning scenarios will be developed on the basis of information augmentation on climate change, bushfire impacts and population growth which will help identify when a new water supply source would be needed and the demand to be supplied	CMD/ACTEW
By December 2004, provide recommendations on the more efficient use of the existing infrastructure, including the option to use Lower Cotter when the new water treatment facility is commissioned	CMD/ACTEW
By March 2005, provide recommendations on the options for a new water source for the ACT, including smaller scale options	CMD/ACTEW

Source: ACT Government (2004).

The above actions are assessed in more detail in Phase 2. An implementation plan was produced as part of the strategy, which identified actions required for implementing identified strategies (part of the implementation plan is given in Table 3.8 as an example). These actions were considered as independent checks on the effectiveness of the strategy implementation. Implementation of the ACT water strategy was identified as a continuing process involving policy review, refinement in the light of new or better knowledge, and assessment of management effectiveness.

During the implementation stage, the KSG was expanded to include community representation through a number of approaches, which included:

- Formation of a Community Reference Group
- Focus groups
- Presentations at community, business and industry group meetings
- A community summit on water
- Displays about water issues at public events
- Web site access to information about the strategy
- Email access to help the community submit views about what should be addressed in the strategy
- A quarterly community survey to seek community views on water issues

The community reference group was formed from community contacts from ACT Council of Social Services, Communities at Work, ACT Multicultural Council, Minister's Youth Council, Conservation Council of South East Region and Canberra, Rural Lessees Association, and the Property Council of Australia.

The draft Strategy was circulated for public comment for three months in late 2003. During this period, two community meetings were held to provide opportunities for public discussion. The final strategic direction document, i.e., *Think Water, Act Water* was released in April 2004 (ACT Government, 2004)

Phase 2

As mentioned earlier, the ACT Government initiated a number projects as per actions identified in the *Think Water, Act Water* strategy document. One such project was the "Canberra Integrated Waterways Feasibility Study." The project was initiated in 2006 and its objective was to develop an optimal portfolio of stormwater harvesting options to meet a specified potable water saving target in sustainability terms. The project was initiated by the ACT Government and administered by TAMS on behalf of the ACT Government.

Though the project was of stormwater focus, its objectives are in line with Phase 2 of the IUWM planning process, i.e., development of shortlist of portfolios. Therefore, we believe that the project provides useful demonstration of the detail required in many activities of Phase 2. Details of the Canberra Integrated Waterways Feasibility Study are given in Maheepala et al. (2009).

Phase 2 Activity 1: Convene Key Stakeholder Group

The project champion was a representative from TAMS who led the project on behalf of the ACT Government. A KSG was formed by the project champion at the commencement of project. It consisted of representatives from ACT Planning and Land Authority, ACT Environment and ACTEW, the Chief Ministers Department, ACT Parks and Sportsgrounds Associations, and three independent technical experts on fresh water ecology, hydro-geology and wastewater.

A technical team was set up to undertake technical assessment required for the project. The technical team was a multi-disciplinary team with expertise in civil and environmental engineering, fresh water ecology, economics, multi-objective decision making, social analysis and risk assessment.

A sub-set of KSG was appointed as a Technical Advisory Committee by the project champion to provide advice to the technical team and to ensure that the outcomes of the project are valid and technically acceptable. The technical advisory committee consisted of the project champion, technical experts from TAMS, ACT Planning and Land Authority and ACTEW and the three independent technical experts mentioned above.

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

As mentioned above, the objective for Phase 2 was to identify an optimal portfolio of stormwater harvesting options to meet a specified potable water saving target in sustainability terms. The target for potable water saving was defined as 3 GL/year by 2015 (i.e., 5% potable water saving compared with 2003 total potable water consumption). In addition, it was defined that stormwater was to be utilized only for irrigation purposes in urban areas and mixing stormwater with reclaimed water from sewer mining was to be considered along with the use of existing ponds/lakes, aquifers and new ponds for storage. These objectives, constraints and targets were in line with the strategic directions identified in Phase 1, that is:

- A 12% reduction in mains water usage per capita by 2013, and a 25% reduction by 2023 (compared with 2003), achieved through water efficiency, sustainable water recycling and use of stormwater and rainwater
- By 2013, increase the use of recycled water from 5% to 20%
- The level of nutrients and sediments entering ACT waterways is no greater than from a well-managed rural landscape.
- Reduce the peak flow and volume of urban stormwater flows so the run-off event that occurs, on average once every 3 months, is no larger than it was prior to development

Measures identified in Phase 2 were in line with sustainability principles. They also addressed more detailed requirements for the stormwater system alone (see Table 3.9). The Technical Team, Technical Advisory Committee and the KSG jointly defined the method of assessment as a two-stage process. Stage 1 analysis involved development of portfolios whereas Stage 2 analysis involved an assessment of portfolios developed in Stage 1 against the measures shown in Table 3.9. Deliberative multi-criteria assessment was chosen for outranking of portfolios and selecting a preferred portfolio.

The portfolio development involved defining objectives for each portfolio and identifying stormwater harvesting options that were relevant to each portfolio objective. Due to funding constraints, the KSG decided to develop two portfolios in line with the following two portfolio objectives:

- Portfolio 1 to include stormwater harvesting options that have least infrastructure life cycle costs and volumetric supply reliability of at least 95%. Potable water saving potential of the portfolio must be at least 3 GL/year (note 1 GL = 10^6 m^3)
- Portfolio 2 to include stormwater harvesting options that have least infrastructure life cycle costs and volumetric supply reliability of at least 85%. Potable water saving potential of the portfolio must be at least 3 GL/year

The role of the Technical Team was to identify suitable stormwater harvesting options for each portfolio in line with the objectives mentioned above. The Technical Team used the following methods for the development of portfolios and selection of preferred portfolios:

- Hydrological modeling and storage behavior modeling to quantify supply reliability from stormwater sources
- Whole-of-urban water system integrated water quantity and quality simulation modeling to system-wide quantify flow and water quality implications of each portfolio, in particular implications of stormwater harvesting on total system yield; flow and water quality in urban waterways; and flow and water quality of stormwater discharges to receiving waters
- Life cycle cost analysis to quantify financial costs in $/KL

Table 3.9
Measures used for developing stormwater harvesting portfolio

Dimension	Measures	Units
Economic	Levelized cost	($/kL)
Economic	Volumetric reliability	(in %)
Social	Impact on the community	1 means: very negative, very undesirable
Social	Impact on households	
Social	Appropriateness of pond location	
Social	Equity of access to water	5 means: very positive, very desirable
Social	Equity of access to pond	
Social	Potential recreational value	
Social	Potential for community education	
Social	Health impact	
Social	Safety impact	
Social	Impact on future housing development	
Social	Impact on future land prices	
Social	Compliance with regulation/legislation	
Social	Ecological habitat	
Social	Political support	
Ecological	Potential for emergent vegetation diversity (with harvesting)	Scale from 1 to 5
Ecological	Change in potential for emergent vegetation diversity (difference between base and harvesting)	Scale from 1 to 5
Ecological	Drawdown—harvesting	% of time (between November and April) with drawdown ≥ 0.5m
Ecological	Difference in drawdown between harvesting and base	% of time (between November and April) with drawdown ≥ 0.5m
Ecological	Nutrient load reduction indicator	% of time (between November and April) with drawdown ≥ 0.5m

Source: Maheepala et al. (2009).

- Ecological analysis based on outcomes of the hydrological analysis and relevant hydraulic analysis to quantify ecological measures shown in Table 3.9
- Social analysis to quantify social/cultural measures shown in Table 3.9. Data for the social assessment collated using focus groups and web-based community surveys
- Deliberative multi-criteria assessment for outranking of portfolios
- Risk assessment to identify and quantify the risks of whole portfolio failing to achieve potable water saving target

Phase 2 Activity 3: Understand Current System

In Phase 2, detailed information specific to the stormwater system was defined by the Technical Team based on the data required to undertake the method of assessment defined in Phase 2 Activity 2. Information collated in Phase 2 included:

Table 3.10
Life cycle cost information of the two portfolios developed in Phase 2

	Volumetric supply reliability	
Item	85%	95%
Capital cost in $	120	141
Operation and maintenance cost in $	27	33
Replacement cost in $	3	3
Supply m^3/year	3.5	3.3
Levelized cost with capital cost of headworks in $/m^3$	2.94	3.67
Levelized cost without capital cost of headworks in $/m^3$	1.61	1.70

Source: Maheepala et al. (2009)

- Polices and agreements—agreed harvestable amounts of runoff at sub-catchment level. These were available from ACT Environment. This is to ensure a minimum impact of stormwater harvesting on environmental flows requirement of urban waterways
- Planning variables—as per Phase 1
- Water supply options—possible locations of new stormwater ponds, allowed draw down from exiting lakes and ponds, possible locations for MAR (managed aquifer recharge) and sewer mining
- Water consumption—potential end uses of non-potable water sourced from stormwater harvesting and sewer mining
- Water flow and quality in ACT rivers, lakes and aquifers including environmental flow requirements and riparian zone management
- Cost—unit costs of various infrastructure components such as pipes, excavation and pumps and other non-structural unit costs such as procurement and contingency costs
- Community perception for using non-potable water instead of potable water for irrigation

Phase 2 Activity 4: Assess System Performance

As per methods of analysis agreed on in Phase 2 Activity 2, the analysis was undertaken in two stages: Stage 1 involved development of two portfolios as per portfolio objectives agreed on in Phase 2 Activity 2 and Stage 2 involved performance assessment of portfolios.

A comprehensive analysis was carried out to develop two portfolios as per portfolio objectives agreed on in Phase 2 Activity 2. It involved identification of all potential users of stormwater and harvesting locations and options (e.g., new ponds, existing lakes and ponds, aquifers for injection of stormwater and mixing stormwater with sewer mining); development of guiding principles to identify least-cost stormwater harvesting options using detailed hydrologic and lifecycle cost analysis; and screening of all stormwater supply-demand options using these guiding principles to identify least-cost options that have the ability to meet required volumetric reliability as per portfolio objectives. Life cycle costs of the two portfolios developed are shown in Table 3.10. Each portfolio included about 25 stormwater harvesting schemes with a mix of new ponds, existing lakes and ponds and aquifers as storage options.

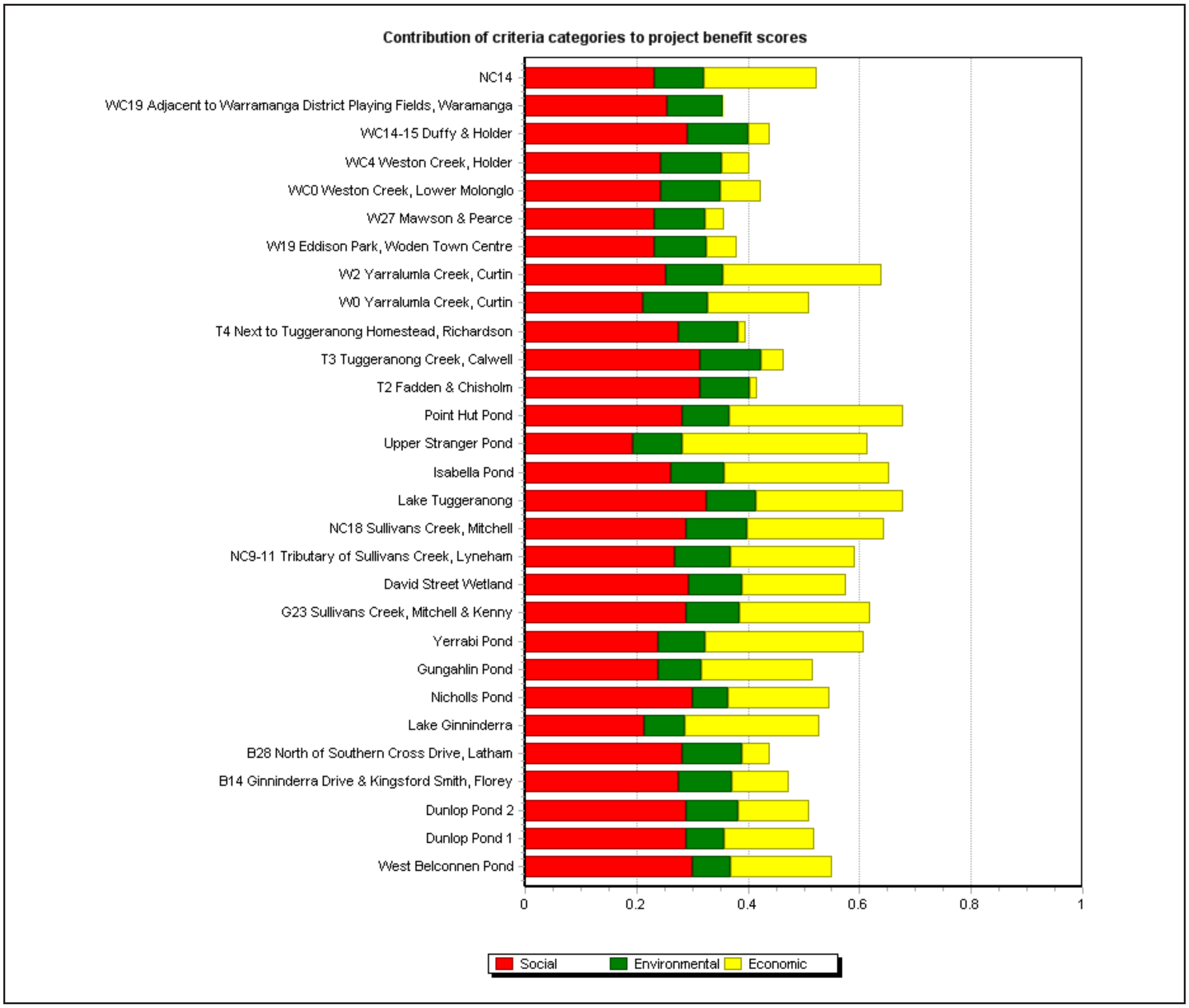

Figure 3.1 Multi-criteria assessment of the selected portfolio (source: Maheepala et al., 2009)

Upon completing the development of portfolios, they were presented to the KSG. At this point, the KSG decided to select a preferred portfolio based on two measures rather than all the measures given in Table 3.9 due time constraints for completing the project. The two measures were: volumetric reliability and financial costs based on infrastructure life cycle costs. The selected portfolio for implementation was Portfolio 1 or the one with 95% volumetric reliability, Performance of the selected portfolio was the assessed against all the measures in Table 3.9.

Performance analysis involved undertaking a detailed social analysis and ecological analysis for the portfolio with 95% volumetric reliability. The social analysis included collation of community views on stormwater harvesting in Canberra using focus groups, web-based surveys and workshops. The ecological analysis involved quantification of stormwater harvesting on flow regimes in urban waterways and rivers, changes to nutrient discharges and health of ponds and lakes due to wetting and drying of riparian zones. Quantified measures were fed into MCAT, multi-criteria assessment software to compare economic, social and environmental aspects of each stormwater harvesting scheme in the selected portfolio (Figure 3.1).

A preliminary risk assessment was also undertaken as part of the performance assessment. It informed risks associated with stormwater harvesting, in general, rather than specific risks associated with the selected portfolio.

Phase 2 Activity 5: Implementation Planning

At the time of writing there is no implementation plan for the TAMS stormwater portfolio. The implementation plan will likely define actions required to implement preferred components of the portfolio, which would include recommendations to undertake a detailed assessment of infrastructure costs, ecological aspects, and other environmental considerations such as energy usage and greenhouse gas emissions and macro-economics such as implications on the regional economy.

Phase 3

At present, Canberra is in implementation stage of the Strategy and this is progressing with a focus on individual aspects of the water cycle, but with some integrated considerations.

Discussion

As with other case studies there are some aspects of IUWM in Canberra that are well advanced and others that require further development. The planning process for the *Think Water, Act Water* strategy seems to align well with the IUWM planning process although there are some aspects of the IUWM planning process that were not addressed. Fully integrated water quality assessment was not undertaken and more detailed analysis of wastewater, mains water and evaporative flows is required. The importance of integrating national and regional legislation and policies is highlighted in this case study.

The TAMS stormwater project primarily aligned with Phase 2 of the IUWM planning process, but only addressed one aspect of the water cycle (stormwater harvesting) and, although the need was recognized, it did not consider a full range of sustainability measures to compare performance portfolios. Hydrology and construction costs were the main performance measures considered for developing the shortlist, which consisted of only one portfolio due to consideration of only two possible portfolios.

Phase 2 demonstrated a method that could be used for the development of portfolios. Though the method followed was comprehensive, it provided portfolios that were fully in line with portfolio objectives.

Although a multi-objective decision analysis method was used for the performance assessment, it was used for assessing the performance of individual options in the chosen portfolio, rather than analyzing the whole portfolio. This is due to making a decision to shortlist portfolio based on a limited number of measures due to time constraints. If there were no time constraints, more than two portfolios could have been developed and the performance of all portfolios could have been assessed using a full range of sustainability measures. This would lead to a shortlist of portfolios as the outcome of Phase 2.

SOUTH EAST QUEENSLAND

South East Queensland (SEQ) is Australia's fastest growing region. Up to 18 per cent more growth is projected in SEQ for the next quarter century (1.5 million people) than in the last (1.3 million). As a result, by 2031 South East Queensland will have a population of 4.2 million, which will be larger than Queensland's population in 2006 (4.1 million) (Queensland Government, 2008). The region covers 22, 890 square kilometres, stretching 240 kilometres from Noosa in the north to the Queensland–New South Wales border in the south, and 160 kilometres west to Toowoomba. SEQ's regional landscape is a rich mix of bushland and beaches, ranges and paddocks, rivers and lakes.

The SEQ region includes land covered by eleven city and regional councils. Brisbane is the largest city. Traditionally, city councils have been the provider of reticulated water, wastewater and stormwater services and there were about twenty-five entities involved in bulk water supplies and wastewater and water transport and treatment.

Realizing that such a fragmented institutional arrangement cannot effectively ensure water supply security to the region, the Queensland State Government formed a new entity called the Queensland Water Commission (QWC) in mid-2006 to coordinate and drive efforts to ensure secure water supply for SEQ. The principal role of the QWC is to advise the Queensland Government on matters relating to supply and demand management for water and the delivery of desired levels of service objectives for water supplied to the SEQ region and designated regions, In addition, the QWC is responsible for facilitating and implementing regional water security programs and ensuring that the community compliance with the regional water security programs (Office of the Queensland Parliamentary Counsel, 2009).

SEQ relies almost solely on surface water supplies, with only about 5% of potable water coming from groundwater. Water supplies are treated and reticulated to urban areas. Wastewater is collected, treated and discharged either to inland waterways or to Moreton Bay, which is a sensitive marine environment and a wetland listed in the Ramsar Convention. Stormwater is discharged to inland waterways and Moreton Bay largely without treatment. In addition, water supplies in the region are currently highly dependent on climatic conditions as the majority of sources are surface water. Environmental concerns are also an issue, with increased nutrient content and increased sediment in waterways due to urbanisation. The energy requirement for water supplies is also a concern due to intensive energy requirements for water treatment, in particular for wastewater treatment, desalination and for pumping desalinated water around the region.

The issues facing SEQ are not new and there are a large number of residential, industrial and urban initiatives currently in place to address these issues. Many of the initiatives are in line with IUWM principles. For example, the initiatives include community education and behavioural change programs, incentives, regulations and information programs to encourage installation of water efficient appliances, pricing and tariff changes, water sensitive urban design promotion, industrial recycling, commercial water management and rural water use efficiency. There are many urban case study sites where large-scale water recycling or smaller-scale greywater use, rainwater collection and on-site treatment systems are installed and assessed.

The QWC developed the draft SEQ water strategy, titled *Water for Today, Water for Tomorrow*. The draft strategy was developed with a total water cycle (i.e., IUWM) planning approach, designed to produce the best possible environmental and public health outcomes. It was released for public consultation in March 2008 (Queensland Water Commission, 2008). The draft strategy was recently revised (Queensland Water Commission, 2009) and released again for public consultation in November 2009. It is due for final revision about April 2010. At the time of writing, it is the most recently released water strategy in Australia. The strategy addresses planning for water supply requirements for the next 50 years within an IUWM framework. The Strategy aims to supply sufficient water to support a comfortable, prosperous and sustainable lifestyle while meeting the needs of urban, industrial and rural growth and the environment.

Drivers for the development of a new strategy incorporating total water cycle concepts are to ensure that:

- A proactive rather than reactive approach for securing water supply, is in place
- The region is well prepared to respond to extreme drought conditions, which may be due to natural climate variability or a consequence of climate change
- The region is well prepared for needs of the population growth, which is expected to generate demand for 735,500 new dwellings, as well as supporting infrastructure and services by 2031 (Queensland Government, 2009)
- There is a high economic growth in the region and the cost of any new infrastructure required for economic growth is equitably shared across current and future generations

The draft SEQ Water Strategy includes a number of features of the IUWM planning process described in Chapter 2 and follows the activities in phases 1 and 2. The following section outlines the similarities in the two processes and uses examples from the draft SEQ Water Strategy to demonstrate specific activities.

Phase 1

Phase 1 activities are not well documented as they probably occurred in initiatives and programs prior to the development of the draft SEQ Water Strategy. Information is presented where available otherwise activity content is deduced by implication.

Phase 1 Activity 1: Convene Key Stakeholder Group

The QWC was formed by the Queensland Government to champion water supply planning and management in SEQ. This represented a fundamental shift in the management of water supply in SEQ from traditional pipe-in-pipe-out approach to an integrated and total water cycle management approach, i.e., IUWM. Underlying this shift was recognition within the Queensland Government that water is a regional resource and should be planned for and managed as such (Spiller, 2008). The KSG involved representatives from the following organizations and/or informal community groups:

- Queensland Water Commission
- Queensland Government
- The Council of Mayors in SEQ (i.e., representatives of all of the City Councils in SEQ)
- Regions bulk water authorities (such as SEQ Water and SunWater)
- Industrial water groups
- Rural water groups

- Specialist working groups
- Healthy Waterways Partnership

Phase 1 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

The principles underpinning the planning process were derived from the Water ACT 2000 (Office of the Queensland Parliamentary Counsel, 2009) The main guiding principle of the planning process was that water in the region is to be managed on a sustainable and integrated basis to provide secure and reliable supplies of water of acceptable quality for all uses. The specific principles included:

- Water is a scarce resource that is to be shared across the region
- Water quality should be managed from its source to its end-users in a way that ensures the health of catchments, aquifers and their ecosystems, and delivers water of a quality desired by the end-users at the lowest overall cost
- Water supply operations should maximise efficient and cost-effective service delivery and the efficient use of water such as appropriate connectivity between supply sources, and in accordance with desired levels of service objectives
- Costs of water sources should be shared among users who benefit from them
- Pricing should be consistent with commitments of the State under intergovernmental agreements
- Regional water supply should consider environmental, social and economic factors and include the application of 'least cost planning' to ensure proper economic comparison of all supply-side and demand-side options
- Water restrictions should help the achievement of the region's objectives for long-term demand management for water and enable the appropriate management of any significant threat to the region having a sustainable and secure water supply
- Flood mitigation and dam safety should be considered in the preparation of assessments of regional water supply.

The other state and national legislative and policy frameworks considered were:

- *The SEQ Regional Water Security Program:* The SEQ Regional Water Security Program is made by the Queensland Government. It specifies, at a high level, how regional water security is to be achieved.
- *The SEQ Regional Plan (Queensland Government, 2009):* Provides a framework for sustainable growth to 2031 describing water and transport management strategies, regional land use patterns and policies. The SEQ Regional Plan requires water in the region is managed on a sustainable and total water cycle basis to provide sufficient quantity and quality of water for human uses and to protect ecosystem health.
- *Water Resource Plans and Resource Operations Plans:* A requirement of the Water Act 2000 (Office of the Queensland Parliamentary Counsel, 2009) detailing government aims for a catchment's social, economic and environmental needs, both now and in the future regarding water allocation.

- *SEQ Healthy Waterways Strategy (SEQ Healthy Waterways Partnership, 2007):* A program focussing on providing leadership, commitment and voluntary cooperation to improve catchment management and waterway health in the SEQ.
- *The Australian Drinking Water Guidelines (Australian Government National Health and Medical Research Council, 2004):* Provides a framework for the good management of drinking water supplies to ensure safety at point of use of water.
- *Groundwater Regulation:* The Water Act 2000 (Office of the Queensland Parliamentary Counsel, 2009) provides guidance for the management of groundwater extraction and the *Integrated Planning Act* outlines development permit requirements for bores
- *Recycled Water Regulation:* the Australian Guidelines for Water Recycling comprise a risk management framework and specific guidance on managing health and environmental risks associated with the use of recycled water. The Queensland government is also developing a recycled water regulatory framework
- *National Water Initiative:* An inter-governmental agreement between the Commonwealth of Australia and all states and territories to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimizes economic, social and environmental outcomes

The overall planning objective was to ensure that there will be sufficient water to support a comfortable, sustainable and prosperous life style while meeting needs of urban, industrial and rural growth and the environment. This was called "Water Supply Guarantee," which was to be achieved by the following set of objectives:

- Balancing community expectations of water security, quality and cost
- Embedding water efficiency throughout the water supply and demand chain
- Managing water security through diversified and integrated water supplies and drought preparedness
- Improving environmental outcomes, including healthier waterways, through integrated strategic planning and catchment management

Phase 1 Activity 3: Understand Current System

Prior to the development of the SEQ Water Strategy there was already a sound understanding of the current system through documents developed by:

- Local councils, such as *An Integrated Water Management Strategy for Brisbane* (Brisbane City Council, 2008) and *Gold Coast Water Future Strategy* (Gold Coast City Council, 2007)
- Key organizations involved in urban water management in SEQ such as annual environment reports (SEQ Water, 2001); annual sustainability reports (SEQ Water, 2004) and SEQ Healthy Waterways Strategy (Healthy Waterways Partnership, 2007)
- The Queensland Department of Environment and Resource Management such as *water resource plans*. The water resource plan provides a framework to share water between human consumptive needs and environmental values. They are developed through detailed technical and scientific assessment as well as extensive community

consultation to determine the right balance between the many interests that rely on the state's water resources. Generally, a water resource plan will apply to a plan area's rivers, lakes, dams and springs and, if necessary, underground water and overland flow. In developing a plan, the size and nature of the resource is assessed to ensure that water is allocated within sustainable boundaries. Each plan has a 10 year life and the first plan for SEQ was released in 2006.

- The Queensland Government and Council of Mayors such as *South East Queensland Regional Water Supply Strategy* (The State of Queensland, 2005).

Information in these reports and strategies included the following information:

- Population projections
- Climate projections
- Supply/demand balances
- Water demand projections
- Health of waterways
- Segregated residential water use data
- Current water policies and law
- Educational campaigns
- Social obligations
- Potential for new sources of supply (which included cloud seeding; damming the Broadwater; dams and yields; desalination; evaporation control; greywater; groundwater; indirect potable reuse; ponding upstream of existing dam; rainwater tanks; recycled water; river barrages; stormwater harvesting; use of recycled water for environmental flows; water conservation; and water pressure and leakage management)
- Environmental flow needs

Phase 1 Activity 4: Assess System Performance

The performance assessment method reported in the Draft SEQ Water Strategy Queensland Water Commission (2009) includes constructing demand projections for two population projection scenarios known as medium series population projection and high series population projection, defining a base case portfolio and conducting whole-of-urban water system water balance analysis for the base case portfolio. The base case included the medium series population projection, demand management options currently in place and existing supply sources. The outcomes of the whole-of-urban water system water balance analysis were used to identify when and where the supply gaps would occur.

Feasible future water supply sources were then identified to reduce the supply gap. The process followed to identify feasible future water supply sources included identification of all the possible options and screening feasible options using a preliminary hydrologic performance and indicative costs as assessment criteria for screening. Potential yields of the feasible sources were then quantified and integrated water balance assessment was carried out with the potential water supply sources to assess how they could contribute to reduce the supply gap. The potential water sources identified through this process were rainwater, local stormwater and recycled water where feasible via a third pipe system, centralised recycled water via indirect potable recycling, ground water, desalinated water and surface water.

The screening process removed alternatives with low hydrologic performance and high economic, social and environmental costs as well as alternatives that required scientifically proven technologies. Accordingly, high preference was given to desalinated water, additional surface water sources and the use of rainwater in new houses for appropriate internal uses as well as outdoor watering.

Phase 1 Activity 5: Implementation Planning

Working from the existing data and information from other sources the QWC developed a number of possible options which met their primary objectives. These options were then carried through for more detailed analysis in Phase 2.

Phase 2 Activity 1: Convene Key Stakeholder Group

The composition of the KSG did not change from Phase 1 to Phase 2. Technical advisory groups were formed, to address speciality areas. For example, an expert advisory panel on the regulatory framework for water recycling included members with microbiology, ecotoxicology, environmental science and advanced water treatment expertise.

Phase 2 Activity 2: Agree on Objectives, Measures, Criteria, and Methods

To establish a secure water supply, an approach called level of service (LOS) was used. Details of this approach can be found in Erlanger and Neal (2005). It required development of a number of objectives (known as LOS objectives). The objectives defined the desirable maximum frequency, duration and severity of water restrictions, and the average amount of water per capita that should be supplied in normal times. They reflected community expectations on water restrictions and their willingness to pay for improved security of supply. The objectives were used to determine the volume of water that could be supplied from the whole urban system on average every year. This volume was called LOS system yield and it was defined as the maximum amount of water that could be supplied on average every year without breeching LOS objectives. The LOS objectives used by the draft SEQ Water Strategy (page 65, Queensland Water Commission, 2009) are given:

- During normal operations sufficient grid water will be available to meet an average total urban demand of 375 litres per person per day (including residential, non-residential and system losses) of which 230 litres per person per day is attributed to residential demand
- Sufficient investment will occur in the water supply system with the objective of ensuring that:
    - Medium-level restrictions will not occur more than once every 25 years, on average;
    - Medium-level restrictions need only achieve a targeted reduction in consumption of 15% below the total consumption volume in normal operations;
    - The frequency of triggering drought response infrastructure will be no more than once every 100 years, on average;

Table 3.11
Objectives and measures used in SEQ

Objectives	Measures
Balance community expectations of water security, quality and cost	• Medium-level water restrictions will not occur more than once in every 25 years on average, and will need to achieve a reduction in consumption of 15% below the normal consumption • Comply with drinking water quality standards • Affordable and equitable water supply, sanitation and flood mitigation service • Returns on investment • Regional growth • Healthy waterways; access to sports fields, parks and gardens; home gardening and acceptable urban landscape for increased recreation and lifestyle
Increase water efficiency	• Efficient water use behavior measured in terms of ability to achieve an average water demand of 375 litres per person per day with 230 litres per person per day attributed to residential water demand • Best practice water efficient plans for businesses • Equitable water sharing among competitive uses
Manage water security through diversified and integrated water supplies and drought preparedness	• Since 2007, new detached houses must target savings of 70,000 litres per year while new terrace houses and town houses must aim to achieve savings of 42,000 litres per year, trough the use of rainwater tanks for appropriate internal uses as well as outdoor watering • Ensure the level of service objectives under drought conditions are met, e.g., – The frequency that combined regional storage reservoirs reach levels of 10% capacity will not be more than once every 1000 years, on average; – Regional water storages must not be permitted to reach 5% of combined storage capacity; and – Wivenhoe, Hinze and Baroon Pocket dams must not be permitted to reach minimum operating levels
Improve environmental outcomes including healthier waterways	• Balance environmental flows • Reduce pollutant levels in urban waterways • Reduce energy usage and greenhouse gas emissions • Reduce odor • Balance biodiversity and catchment health

Source: Queensland Water Commission (2009).

– The frequency that combined regional storage reservoirs reach levels of 10% capacity will not be more than once every 1000 years, on average;
– Regional water storages must not be permitted to reach 5% of combined storage capacity; and
– Wivenhoe, Hinze and Baroon Pocket dams must not be permitted to reach minimum operating levels

These objectives were coupled with a number of economic, social and environmental measures, to assess the objectives for achieving the water supply guarantee (see Table 3.11). Environmental measures include environmental flows and quality in waterways, greenhouse gas emissions, odour, biodiversity and catchment health. Economic measures include returns on investment and regional growth. Social measures include continuity of supply in waterways, efficient water use behavior, equitable water sharing, recreation and public health and safety (see Table 3.11).

Phase 2 Activity 3: Understand Current System

A comprehensive assessment had been carried out to understand the current system and identify potential strategies. A number of technical studies were undertaken to understand the urban water system in SEQ in detail. These included analyzing urban demands and developing demand forecasts, assessing available water supplies and potential future supplies, assessing water balance, assessing rural water needs and economic aspects of provisioning water to the SEQ region. Documentation related to all technical studies can be found at <http://www.qwc.qld.gov.au/SEQWS+supporting+documents>.

Data collated for this exercise was extensive and included many aspects of the regional water system. Some of the data collated were:

- Polices and agreements in regional planning, water resource planning, healthy waterways, drinking water quality, regulation on groundwater use, regulation on recycled water use and any national water initiatives
- Current institutional arrangement and its limitation
- Water planning variables—population growth; long-term climate change and its potential impact on changes in temperature, rainfall and evaporation; and temporal shift
- Existing and future water supply options including centralized recycling (i.e., using recycle water to top up surface water reservoirs) and desalination
- Current and future water consumption
- Water efficiency measures and their effectiveness in residential, non-residential and government sectors
- Water flow and quality in waterways
- Water sensitive urban design and total water cycle planning—concept and its implications, how it can be incorporated into urban land and water planning
- Community needs

Phase 2 Activity 4: Assess System Performance

Three main supply portfolios were considered for Phase 2 analysis. One of them represented the base case, which was identified as Phase 1 analysis. The other two represented alternatives to the base case. The first alternative utilised desalination options to reduce the supply gap in the base case. The second alternative utilised both desalination options and additional surface water options that were not part of the base case.

For each portfolio, variations were introduced by considering (1) cases with and without climate change effect (i.e., a decrease of 10% in surface water supply due to climate change) and (2) cases with an increase and a decrease of per capita demand by 30 litres per person per day. This resulted in 12 portfolios (i.e., 3 main portfolios X 4 variations). Further, two population projections were considered for each portfolio: one represented a high growth and the other represented a medium growth, which resulted in altogether 24 portfolios.

All portfolios were analyzed in detail against the Level of Service objectives and within a Multi-Criteria Assessment (MCA) framework which took account of longer–term supply security factors as well as a wide range of social and environmental assessment criteria. Quantitative analysis of portfolios was carried out for water volumes, energy analysis and greenhouse gas emissions only. Outcomes of the quantitative analysis can be found in the draft SEQ Water Strategy (Queensland Water Commission, 2009). The other criteria were qualitatively assessed using expert inputs. These criteria included:

- Economic: return on investment and regional growth
- Environmental: environmental flows in waterways; pollutants in waterways; greenhouse gases; odour; biodiversity and catchment health
- Social: continuity of supply in waterways; balancing extractions for residential, non-residential and rural production; efficient water use behavior; equitable water sharing; healthy waterways; amenity and landscapes; access to sports field, parks and gardens; home gardening; drinking water quality; sanitation, dam safety and flood mitigation

Phase 2 Activity 5: Implementation Planning

The outcome of the Phase 2 was an implementation plan comprising 87 activities or initiatives for implementation over the next ten years. They were grouped into thirteen categories. These categories and collective aim of the initiatives listed under each category are given (more details of these categories can be found in Chapter 7 of Queensland Water Commission, 2009):

1. South East Queensland water strategy
    - Review and update the strategy including the long-term water balance at least once every five years, aligned with the Regional Plan
2. Regional water security program
    - Every six months, report to the Queensland Government on the status of the implementation of the Regional water security program
3. System operating plan
    - Review and update the system operating plan regularly to include operation of the SEQ Water Grid
    - Report operation of the SEQ Water Grid to the Queensland Government
    - Implement a skills development scheme across all the entities involved in urban water planning
4. Drought response plan
    - Prepare a drought response plan for future droughts and update it regularly
5. Demand management
    - Implement permanent water conservation measures
    - Monitor, analyse and report consumption trends
    - Work with the Australian Government to promote the water efficiency labelling scheme and ban the sale of appliances that do not meet these requirements as an ongoing activity
    - Implement standard infrastructure and billing requirements across SEQ
    - Investigate water pricing policies

   - Develop best practice water efficiency framework for business use
   - Promote water efficiency through education programs
6. Total water cycle planning
   - Prepare total water cycle plans for sub-regions and large scale developments that are not included in sub-regions
   - Prepare a guidance document to assist commissioning total water cycle studies
7. Rainwater and stormwater
   - Undertake a technical evaluation of connecting roof water into the distribution system
   - Audit compliance with the Water Savings Target related to rainwater tanks and undertake research to refine the target
   - Investigate opportunities to use stormwater as source of supply
8. Dams and weirs
   - Investigate possibilities to increase the yield of existing surface water sources (e.g., raising existing dam structures, building pipe connectors to move water and undertake further detailed hydrologic analysis to better address the potential impact of climate change on inflows to major dams)
9. Desalination
   - Undertake detailed investigations of potential desalination projects
   - Develop an improved understanding of ecological implications of desalination projects
10. Recycled water
    - Investigate opportunities to supply purified recycled water to residential and non-residential uses
    - Develop an improved understanding for augmenting existing surface water sources with purified recycled water
11. Rural towns and villages
    - Prepare drought response plans for stand-alone communities
    - Develop a policy position regarding the provision of reticulated water supplies to communities that currently rely on rainwater tanks and groundwater bores for drinking water as a medium-term priority
12. Research and development
    - Research community attitudes to alternative water supplies
    - Research opportunities to further improve performance in relevant areas
    - Develop an integrated urban water modelling framework for SEQ
    - Research the impact of climate change on yield of dams in SEQ
13. Water quality
    - Prepare a recycled water management plan for Western Corridor Recycled Water project, as a short-term priority
    - Prepare and implement plans and controls for drinking water quality management

In addition, a need for a range of more detailed plans and the organisation responsible preparing them were identified. These included the following plans (further detail can be found in Chapter 7 of Queensland Water Commission, 2009):

Regional Scale

- Regional water strategy, regional water security program, system operating plan and drought response plan by the QWC
- SEQ water grid water quality management plan by the SEQ Water Grid Manager

Sub-Regional Scale

- Water resource planning by Department of Environment and Resource Management
- Sub-regional total water cycle plan and detailed investigations of potential sources by the QWC in partnership with key stakeholders
- Regional healthy waterways strategy by SEQ Healthy Waterways Partnership

Local Scale

- Development scale structure and master plans by local councils
- Development scale distribution network plans by an entity responsible for distribution networks
- Development scale minor treatment plant plans by an entity responsible for distribution networks

On-site Scale

- On-site scale development assessment by the Local Councils
- On-site scale water efficiency management plans by individual businesses

Furthermore, it was identified that there was a need for an institutional reform to successfully implement the SEQ Water Strategy. The first phase of reform implementation was completed on 1 July 2008 with the establishment of the four new entities that own and operate the urban water system in SEQ. These were Queensland bulk water supply authority (trading as Seqwater), Queensland manufactured water authority (trading as WaterSecure), Queensland bulk water transport authority (trading as LinkWater) and SEQ Water Grid Manager. These new institutions and some existing institutions will jointly manage the urban water system in SEQ as follows:

- The Queensland bulk water supply authority (trading as Seqwater; www.seqwater.com.au), to own all dams, groundwater infrastructure and water treatment plants in SEQ. Seqwater is an existing institution.
- The Queensland manufactured water authority (trading as WaterSecure, www.westerncorridor.com.au and www.desalinfo.com.au), to own all desalination plants, recycled water and stormwater harvesting projects. This is a newly formed institution.
- The Queensland bulk water transport authority (trading as LinkWater; www.linkwater.com.au), to own all major pipelines in SEQ and moves water from dams and other water sources through bulk pipeline networks. This is a newly formed institution.
- The SEQ Water Grid Manager (www.seqwgm.qld.gov.au), to oversee operation of the SEQ Water Grid and flow of water around the Grid, purchases bulk water and water transport services, and sell water to Retail Businesses. The SEQ Water Grid is a network of reversible pipelines connecting major water sources in SEQ to allow water from areas of water surplus to be moved to areas that face a shortfall. The SEQ Water Grid Manager is a newly formed institution.
- The individual city councils in SEQ (there are 11 city councils, <http://www.dip.qld.gov.au/resources/map/seq-regulatory-2009/seq-regulatory-map-index.pdf>) to own stormwater reticulation in individual council jurisdictions. These are existing

institutions. Councils are also responsible for managing the development of local total water cycle management plans in conjunction with other key water management stakeholders.

The second phase of water reform involves the establishment of three distribution/retail entities that will own water and sewerage distribution infrastructure and be responsible for selling water supply and sewerage disposal services to customers. The three businesses will cover the following regions:

- Brisbane, Scenic Rim, Ipswich, Somerset, Lockyer Valley
- Gold Coast, Logan, Redlands, and
- Sunshine Coast, Moreton Bay

This phase of reform will be implemented from the 1 July 2010 with a transition period until 2013.

Phase 3

At the time of writing, the SEQ Water Strategy has been circulated for community comment and review. Phase 3 of the process has not yet been initiated. Once feedback has been received more detailed feasibility assessments will be required to prove project viability and sustainability. These are the processes that will occur in Phase 3.

Summary and Conclusions

The draft SEQ Water Strategy (Queensland Water Commission, 2009) is the most recent initiative presented in this Manual and as with all other strategies and case studies is a "work in progress." The draft SEQ Water Strategy uses the IUWM approach and it closely follows the processes outlined in Chapter 2 for Phase 1 and Phase 2. Phase 3 is yet to be undertaken, which will include a detailed total water cycle assessment and a fully integrated assessment of shortlisted portfolios to choose a final portfolio. At this stage, it is not clear whether the processes outlined in Phase 3 would be undertaken. As with other case studies, the strategy defines a framework for a region rather than a specific town, city or urban area.

The process followed in the draft SEQ Water Strategy shows how the IUWM approach can be adopted for strategic planning. It emphasizes the importance of a suitable institutional structure that reflects service functions rather than local council (or city) boundaries, for implementing an urban water planning strategy based on IUWM principles. Planning at a regional scale has allowed water to cross institutional boarders to meet the greatest need and highest value use, which is one of the important aspects of the IUWM approach.

CITY OF CALGARY

The City of Calgary has been included as a case study and information and understanding of their process was obtained via e-mail communication. As this information exchange was more limited than that for other cities, the case study presented here is less detail than the other case studies.

The City of Calgary has a traditional water in, wastewater out system. Until recently, urban water in Calgary was managed by two separate divisions. The Waterworks Division looked after all aspects of water supply, while the Sewer Division looked after wastewater and urban drainage. In 2006, the Waterworks and Wastewater Divisions were merged into an integrated water and wastewater utility with additional responsibilities for urban drainage. The two businesses provided many similar functional services and the merger was built on the opportunity to share many resources including lab services, strategic planning and policy, construction crews, infrastructure planning and delivery of infrastructure projects. With the closure of the South Saskatchewan River basin to new water licenses in 2006, the merger also provided the opportunity to integrate all water planning in one area. This facilitated a new way at looking at water resources and the opportunities that could be realized through water reuse and conservation. Planning for water is now the responsibility of the Water Resources Division. The Water Resources Division has, or is appointing, all the expertise required to undertake systems performance assessment.

In 2003, the Province of Alberta undertook an initiative, 'Water for Life' which provided a vision for water management in Alberta. The strategy was directed at ensuring a healthy and sustainable water supply for the environment, communities and economic well-being.

In 2008, the strategy was reviewed to determine whether it was still relevant in the face of an increasing population, economic growth and changing water needs. The renewed strategy is based on three outcomes: safe, secure drinking water supply; healthy aquatic ecosystems; and reliable, quality water supplies for a sustainable economy. Each of those outcomes has to be achieved through knowledge and research, partnerships and water conservation.

The renewed strategy includes many features of the IUWM. For example, Calgary has a *Water Efficiency Plan, 30-in-30, by 2033* directed at reducing consumption by 30 percent in 30 years (2005–2034) to offset an anticipated growth in population from approximately one million to 1.5 million over this period of time. A number of indicators are being used to measure and report progress to the City Council. They include consumption in "lpcd" (litres per capita per day) and peak day consumption and total river water withdrawals. The objective is to reduce water consumption through water conservation, in order to maintain the same level of river water withdrawals despite the future population growth. A fully funded conservation program covering such aspects as policy change, incentives to conserve, community outreach, public education as well as lead by example internally is currently in place to enable achieving 30% in 30 years consumption target. In addition, a metering program is currently in place to enable tracking the usage and assesses the feasibility of achieving the water conservation target. The metering program aims to achieve fully metered residential services by the end of 2014. At present, about 82 percent of Calgary's residential services are metered.

As part of the renewed strategy, stormwater management is aimed at reducing runoff volume and sediment loadings into waterways to ensure regulatory compliance as well as protecting the health of the river. The amount of TSS (total suspended solids) has to remain unchanged over the period 2015–2005. This is embedded in the operating approval issued by the Provincial regulator. This target forces the City of Calgary to refit the city in terms of end of pipe treatment where there is direct discharge. In addition, for new communities and redevelopment of older communities, there is a need for looking at ways to 'spread out, slow down and soak in' urban runoff. There are a number of programs in place for achieving the best practices for low impact development. These include green roofs, bio-retention, bio-swales, rain gardens, porous pavement and rainwater harvesting. Progress on implementation of the stormwater management aspect of the renewed strategy (i.e., stormwater strategy) is also reported to City Council on an annual basis.

The City of Calgary committed funding to implement the renewed strategy. As mentioned above, this strategy has many features of the IUWM, but it does not link goals of water conservation with those of the stormwater management. The focus now is to find ways in which the goals of conservation and stormwater management are looked at in tandem. Models to support planning in this regard at lot, community and watershed levels are being explored to bring together conservation, water reuse and low impact development.

Convene Key Stakeholder Group

The Water Resources Division is an organisational unit within the City of Calgary, and brings a "water" perspective to other, ongoing sustainability initiatives within the city. The Water Resources Division addresses planning for the entire water cycle, and reports to the Utilities and Environmental Protection Department, which in turn reports to the City Manager and the Mayor and City Council, who are the ultimate decision makers. While IUWM is initiated from within Water Resources Division, key members of the KSG (which does not currently exist) would include the manager of strategic services, the leader of strategic planning and policy, and representatives of watershed engineering and community and customer initiatives. It would be desirable to include representation from roads, parks and planning sustainability initiatives, to address the wider impacts of IUWM on city planning. The KSG would recommend policy to the City Council.

Agree on Objectives, Measures, Criteria, and Methods

Objectives of IUWM have not yet been clearly articulated, and Calgary is seeking guidance on formulating outcome-based objectives, expressed in such a way that multiple solutions can be developed to meet local needs and financial constraints. Measures of achievement of objectives would include water efficiency and total pollutant loadings.

Understand Current System

The infrastructure that Water Resources Division manages is fairly new and the Division has a good understanding of infrastructure performance. The Division has invested in time and resources for the measurement of key indicators such as actual water consumption in lpcd and total suspended solids.

At present, demand forecasting models are being developed to understand the future water consumption under different population growth and water conservation scenarios. There are good models in use for understanding potential impacts of land use at watershed scale on the production of annual discharge of total suspended solids into waterways, i.e., river loading.

There are fixed arrangements for water allocations and prioritisation of water rights, and total loading guidelines for return flows from wastewater treatment plants. Operating approvals are controlled by the provincial government. In the latest operating approval for wastewater and drainage issued by the provincial government, the City has made commitments to manage total loadings on the river in 5 key areas: total suspended solids, primarily as a result of the drainage system, dissolved oxygen, total phosphorous, nitrogen and ammonia.

In terms of plumbing codes, the City of Calgary is working with other municipalities across Canada on policy changes and incorporating them into local by-laws, for example, low flow fixture requirement is currently in place in City's local by-law in order to advance this requirement in the

Provincial Plumbing Code. At present, the City is currently working on a possible requirement for high efficiency toilets assuming that these will be required at some date in the future. In general, innovative issues are addressed collaboratively with other municipalities and partnerships, e.g., Canadian Water and Wastewater Association.

Assess System Performance

While Calgary has a good understanding of current water balances, there is, as yet, only limited understanding of the potential of water reuse. There are currently no processes in place for integrated water systems analysis, but great interest in achieving a fuller understanding. Water balance models have been used for incorporating low impact development principles in new developments. The City of Calgary also has a triple bottom line sustainability policy which guides the Water Resources Division in developing these principles, together with an integrated risk management approach.

Implementation Planning

Key policy initiatives such as water conservation, stormwater strategy, and linking water planning to land use planning are all considered by Calgary's City Council. The Water Resources Division enjoys good support from City Council and has received support and endorsement, as well as funding for these programs. While the Calgary City Council is the final decision maker, the Water Resources Division is well respected and is in a strong position to make recommendations, especially in linking water planning to land use planning.

Stakeholder Engagement

The City of Calgary has a commitment to actively involving their citizens in transparent and inclusive processes. Consequently, the City of Calgary has a formal engagement policy. It is described at <http://www.calgary.ca/docgallery/bu/cityclerks/council_policies/fcs002.pdf>, with the following principle:

> *The City of Calgary (Council and Administration) recognizes that decisions are improved by engaging citizens and other stakeholder groups where appropriate, and is committed to transparent and inclusive processes that are responsive and accountable, and within the Corporation's ability to finance and resource.*

Public engagement at a level of 'inform' or 'consult' would be anticipated for key policy changes in the area of integrated urban water management. This engagement would be expected prior to policy being brought forward for City Council's consideration.

CHAPTER 4
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

IUWM Planning Process

IUWM is an emerging approach for urban water utilities to plan and manage urban water systems to minimize their impact on the natural environment, to maximize their contribution to social and economic vitality and to engender overall community improvement. Drivers for undertaking IUWM can be site, utility, state or national specific reasons or simply a desire to provide a more sustainable water service than the current practice. Whatever the reason, IUWM provides a approach into which the right ingredients can be fitted to provide optimal solutions to current urban water challenges, which include diminishing surface and groundwater supplies due to a warming climate, frequent and high intensity flooding in urban areas, population growth, expansion of urban areas, aging water infrastructure and the need for protecting the surrounding environment.

There is an increased interest in adopting the IUWM approach by urban water utilities all over the world. This interest has led to adoption of elements of the approach in strategic planning of individual aspects of urban water systems (e.g., water supply) by some urban water utilities. However, at present, there is no standard approach for incorporating IUWM principles into strategic planning for urban water systems.

Incorporating IUWM principles into existing strategic planning processes is not a trivial task because it demands taking a holistic view of the urban water system and brings the concept of sustainability to urban water management which includes, amongst other considerations, the health of the surrounding environment and integrating water management into city planning. Hence the system boundaries for IUWM considerations spread far beyond town or city limits.

This manual presents a structured process to incorporate IUWM principles into strategic planning of urban water systems. The process has three phases, each with distinct outcomes. The aim of Phase 1 is to develop a strategic direction for IUWM that has potential to meet the needs of the town or city under consideration. The output of Phase 1 informs Phase 2, which aims to develop a shortlist of portfolios of complete schemes or options that are in line with the strategic direction selected in Phase 1. In Phase 3, the portfolios of options are compared and a preferred portfolio is selected for final implementation. Each phase consists of five activities and learning from each activity feeds into subsequent activities. Activities provide guidance to: (1) setting up a key stakeholder group (KSG); (2) agreeing on objectives, measures and criteria in line with IUWM principles; (3) understanding the current system to identify opportunities and constraints for improving the system in line with objectives; (4) designing alternatives and assessing the performance of alternatives using integrated systems analysis and multi-objective decision analysis methodologies; and (5) setting actions to implementation of outcomes of each phase by engaging a wider stakeholder group, including public participation.

There is no defined point in time to initiate the IUWM planning process. It can be commenced at any time using existing planning knowledge of the urban water system. Any institution in the water industry (e.g., water district, retail and bulk water companies, water utility in a city, local and state governments) or an individual person can initiate the IUWM planning process by focusing on a specific problem (e.g., water scarcity, water quality problems associated with wastewater and/or stormwater discharges and energy usage problems associated with transport and treatment of water and wastewater).

However, the initiating body must form a key stakeholder group (KSG) with members representing the management of various parts of the total water cycle and city planning, and the community, to capture both physical and non-physical influences of the whole urban water system. The KSG steers the IUWM planning process and decides what is, and what is not relevant within the system boundaries. The KSG is supported by a project champion who could be either a person from a key organization or a key organization itself.

Since achieving a state of sustainability is a moving target, and the prime purpose of adopting the IUWM approach is to achieve sustainability, regular updates to IUWM-based strategic planning are essential. The IUWM planning process should not be thought of as a once only process; rather it should be thought of as a continuous process that fits well within adaptive management of the urban water system. It can be initiated as the need arises, and reviewed at regular time intervals, e.g., every five years.

Successful adoption of the IUWM approach requires gaining commitment to change from all parties involved and carrying this through to practical implementation. Some towns in both North America and Australia are well advanced in their thinking, while others have a way to go. This Manual provides a process that will encourage those who are part-way there to continue, and assist those who have yet to begin to assimilate their needs and knowledge into their first steps. We believe that the results will manifest themselves in a more sustainable future for all.

Case Studies

Six case study sites, four in North America and two in Australia have been used to test alignment of the IUWM planning process with practice. The case study sites were San Francisco, Santa Clara, El Paso, and Calgary in North America, and Canberra and South East Queensland in Australia. Case studies demonstrated the following points:

- All case study sites have begun transitioning to IUWM. Hence, planning processes currently in place at case study sites demonstrate some elements of IUWM. However, no case study site has adopted the IUWM planning process described in this manual in its entirety for urban water systems planning.
- Drivers for undertaking IUWM related activities in case study sites are of global, regional and local nature. On a global scale, a need for contributing to global sustainability through the reduction of carbon and ecological footprints and global impact of climate change on regional and local water resource and flooding is seen as a common driver. On a regional scale, balancing needs for water among urban, industrial, agricultural and environmental sectors in a drying and warming climate is seen as a common challenge. Local drivers change from site to site, but common drivers include increasing population, aging existing urban water infrastructure, diminishing of surface and groundwater resources, high treatment and disposal costs of wastewater and stormwater discharges to comply with environmental regulations, increased flooding due to increased frequency of high intensity rainfall, and increased awareness among the local community for greener and more sustainable cities.

- All case studies follow the five activities included in the IUWM planning process described in this manual. However, there is no clear distinction of phases, although phases can be identified by taking a closer examination of the process, as was presented in Chapter 3. Lack of recognition of phases has led to an inefficient use of funds and resources, undertaking analysis that is not essential for making decisions. For example, there is no need to undertake a detailed hydrologic, hydraulic and water quality modeling of individual water management options to set a strategic direction. A high-level integrated hydrologic and water quality assessment using typical data and expert knowledge is sufficient to identify water availability and discharge opportunities.
- Despite the lack of clear distinction of phases, processes adopted in some case studies, in particular Santa Clara Valley Water District's integrated water resource planning process, El Paso's integrated urban water management process and the planning process adopted in South East Queensland in Australia closely follow Phase 1 and Phase 2 of the IUWM planning process.
- None of the case studies has followed a formal process for forming a KSG including formal allocation of roles and responsibilities of members. This is partly due to the governance structures currently in place, in which management of the urban water system is undertaken by many organizations or many divisions within one organization, and the focus of each organization/division is to achieve a set of goals specific to a component of the urban water system. The silo nature of current governance structures is seen as a barrier for adopting the IUWM approach, in particular for gaining the commitment required to change from all the relevant parties involved.
- Case studies demonstrated the importance of having a dedicated project champion who could be an influential and highly regarded individual within the urban water industry or an organization with authority to undertake all planning matters of the urban water system, e.g., Queensland Water Commission in the South East Queensland case study.
- A great deal of knowledge of the current system and its performance already exists for almost all urban water systems. IUWM activities currently taking place at case study sites demonstrate how the existing planning information (e.g., water supply strategic plans, sewerage strategic plans and recycling strategic plans) can be incorporated in an IUWM-based planning process.
- Case studies also demonstrate the importance of incorporating the following aspects into IUWM-based strategic planning, which are in fact in agreement with IUWM principles given in Chapter 1:
  - City planning
  - Environmental regulations such as EIS requirements
  - Legislative requirements
  - Engagement with key stakeholders including the local community throughout the whole planning phase
  - Risks, resilience and uncertainties of system components and how they impact on the whole system

RECOMMENDATIONS FOR FURTHER RESEARCH

A wider adoption of the IUWM planning process described in this manual requires methods, and/or tools to aid (1) participation of key stakeholders; (2) setting problem-specific objectives and assessment criteria in a wider sustainability context; (3) multi-objective decision making that accounts for uncertainty in underlying data and methods, and risks of not achieving objectives; and (4) quantification of physical and non-physical total water cycle influences to feed into multi-objective decision making methods. Methods and/or tools to aid the adoption of IUWM are emerging; some are new with only research experience to prove their validity, some are new with few applications, and some are existing approaches which have been modified. At present, there is no standard set of methods and tools to support (1) to (4) above. Hence, for the urban water industry as a whole, it will be beneficial to undertake a review of existing and emerging methods and tools. Such a review can provide guidance on methods and tools to be used for participation of key stakeholders and, assessing hydrological, water quality, social, economic and environmental implications of alternative urban water management options to feed into multi-objective decision making methods.

IUWM-based strategic planning not only considers planning aspects but also management of operation and maintenance as well. The current governance models for planning, operation and maintenance do not fully support IUWM. For example, Water Districts in the U.S.A. do not have responsibility for management of wastewater and stormwater generated from urban areas, yet such water streams and their interactions with water supply must be considered under the IUWM approach. Hence it is recommended that a review be undertaken to assess the degree of adequacy of current governance structures to support successful implementation of IUWM. If current structures are found to be inadequate, it will be beneficial to develop new governance structures because without them, the community will not accept the IUWM approach at all.

IUWM is an emerging water management method. Individual water utilities may or may not be fully aware of IUWM principles and the benefits of adopting this approach, how it can be incorporated into existing planning processes and state-of-the-art knowledge on methods and tools to support its adoption. An industry-wide training program would help alleviate any misconceptions and raise awareness on the IUWM approach. Hence, it is recommended that a training program and an information support system (with web access) for IUWM be developed in collaboration with research organizations that are up-to-date with emerging research on the IUWM approach. It is essential that the training programs be developed with varying complexity because some water utilities are well advanced in their thinking with regard to IUWM, while others have a way to go.

APPENDIX A
IUWM WORKSHOP

WORKSHOP OBJECTIVES

As an integral part of the project, a workshop attended by representatives from 20 water-related utilities across North America, was held in Boulder, Colorado, on 18–19 June 2007. The aim of this workshop was to interact with stakeholders in the urban water, stormwater and wastewater industry in North America, to obtain input for improving the usefulness and applicability of the IUWM Manual and to identify possible case studies. The objectives of the workshop were to:

- Assist participants to become familiar with the IUWM approach
- Identify the potential benefits of IUWM, drivers for implementing IUWM in North America and how these can best be communicated
- Identify strengths and weaknesses of past experiences, and lessons learned in Australia and North America
- Identify potential limitations and barriers to implementation and possible ways and processes to overcome them
- Identify methods, processes and models used in evaluating urban water system performance in North America
- Identify locations and participant details for North American-based case studies to explore application of the proposed IUWM planning process
- Test application of the proposed IUWM planning process to different scenarios, and identify changes and improvements to the process

WORKSHOP STRUCTURE AND CONTENT

The workshop was held over two days. It was structured around short presentations followed by break-away sessions. The break-away groups included four to five participants with different interests and from different locations. Feedback from break-away sessions provided opportunity for plenary discussions, and the outputs of plenary discussions were used in development of the IUWM manual. Aspects of IUWM discussed at break-away sessions were as follows:

- An overview of IUWM covering its definition and benefits
- Australian IUWM experience: drivers, barriers, progress to date and future direction
- U.S.A. IUWM experience: drivers, barriers, progress to date and future direction
- Key difficulties in achieving/implementing IUWM
- Assessing performance of urban water systems in IUWM context: methods, models, data and processes
- The IUWM planning process described in this manual
- Experience in applying the IUWM planning process described in this manual in Australia

- Application of the IUWM planning process described in this manual to hypothetical cases and a discussion on its applicability and possible improvements

Presentations were given by Shiroma Maheepala, CSIRO; Jane Blackmore, CSIRO; Clare Diaper, CSIRO; Shaun Cox, Director, Gold Coast Water, Australia; and Jerry Brown, Director of Planning, Contra Costa Water District, Concord, California. Shaun Cox presented the Australian experience on IUWM whereas Jerry Brown presented the U.S.A. experience on IUWM.

WORKSHOP PARTCIPANTS

	Participant's Name	Company
1	Shiroma Maheepala (CSIRO Project Leader)	Principal Research Scientist, CSIRO, Australia
2	Jane Blackmore (CSIRO Deputy Project Leader and workshop Facilitator)	Principal Research Scientist, CSIRO, Australia
3	Clare Diaper (CSIRO Research Team Member)	Senior Research Scientist, CSIRO, Australia
4	Linda Reekie (WRF Project Manager)	Project Manager, Water Research Foundation
5	Jerry Brown (Project Advisory Committee Member)	Director of Planning, Contra Costa Water District, Concord, CA
6	Brian M. Murphy (Project Advisory Committee Member)	National Water Planning Services Manager Black and Veatch
7	Shaun Cox	Director, Gold Coast Water
8	Paul Fesko	Manager, Strategic Services City of Calgary—Water Resources
9	Susheel Arora	Manager of Operations Halifax Regional Water Commission
10	Michael Saling	Principle Engineer City of Portland Water Bureau
11	Michael Wallis	Director of Operations & Maintenance East Bay Municipal Utility District
12	Randall Lynn Campbell	Vice President Water Resources Operations Columbus Water Works
13	William F Haney	Water Division Director City of Mesa
14	Ellen Levin	Director of Water Resources San Francisco Public Utilities Commission
15	George J Adrian	Associate Civil Engineer—Water Policy, City of San Diego—Water Department
16	Amy Fowler	Special Programs Engineer, Santa Clara Valley Water District
17	John Balliew	Water Systems Division Manager El Paso Water Utilities
18	Peter Mulvaney	Projects Administrator, City of Chicago Dept. of Water Management

	Participant's Name	Company
19	John Woodling	Principal Geologist, California Department of Water Resources
20	Tom Gohring	Executive Director Sacramento Water Forum
21	Neil Dorigan	WWTP Operations, Metropolitan Water Reclamation District of Greater Chicago
22	Clifford (Drew) Goins	Assistant Director—Water Production Augusta Utilities Department
23	Cal Youngberg	Water Resources and Environmental Engineer City of Longmont Public Works & Water Utilities
24	Joan Kersnar	Drinking Water Planning Manager, Seattle Public Utilities
25	Richard Marsicek	Senior Water Resources Engineer, Aurora Water
26	Christine Marjoram	Stormwater Program Manager Philadelphia Water Department
27	Mike Muse	Source water Protection USEPA

WORKSHOP OUTCOMES

The outcome of the workshop was a rich and diverse pool of knowledge gleaned from the experience of participants, which enhanced and improved the applicability of the IUWM manual, especially in a North American context.

Learnings from the workshop are listed here:

Drivers:

- Drivers for IUWM in North America differ from those in Australia. In Australia, IUWM is being implemented because other more cost-effective alternatives have either been implemented or are not available and there is a political will to make this type of change. In North America, water shortage is being dealt with at a watershed level. Addressing water shortage at the urban setting has not yet been necessary even in the driest communities. In North America, Water Districts, as bulk water suppliers, are obliged to provide for the water needs described in Cities' planning documents. Furthermore, cities develop land use plans and water districts are then responsible for ensuring adequate supplies to meet the projected demands. The political will to address water shortage at the urban setting using IUWM would require the leadership of land use planning authorities. Water Districts in the North America do not have the legal authority that would be necessary to implement IUWM independent of the Cities.
- Water districts do see climate change as a possible future driver for IUWM.

- The Safe Drinking Water Act ensures public health aspects of the potable water supply. The Clean Water Act and the Endangered Species Act ensure stormwater and wastewater discharges and overflows are environmentally compliant.
- Utilities that operate in arid areas such as City of Mesa, Arizona, and El Paso, Texas, see recycled water use as a norm, but not necessarily as IUWM
- The ownership of recycled and stormwater was an issue for many utilities and the following questions were raised. Can cities use recycled and stormwater as water sources? If so, how does it impact on investments of water districts?

Stakeholders:

- There is a need to identify who the decision makers are and the links between the stakeholder group and the decision makers. There will probably be technical advisory groups that will be formed for specific activities.
- The roles and responsibilities of each stakeholder group and the individual stakeholders should be clearly defined.
- Corporate goals and constraints for individual stakeholders should be recognized at the start of the process, and suitable action taken to adjust these where necessary.
- Continuity of the stakeholder group throughout the project life is important. The manual should stress this point
- The original concept of a "Project Champion" who initiated activities was discussed and the possibility of an elected champion, maybe even a politician, was suggested.
- Peer review is provided by the stakeholder (or other specialist) group and need not be considered as a separate activity. Review should occur throughout the process.
- Early buy-in of key stakeholders is necessary for a smooth pathway to success—the constitution of the key stakeholder group should ensure this happens.

About the Draft IUWM Planning Process:

- A hierarchy of goals and objectives, with clear definitions, is needed. Linking measures and criteria to objectives and analysis is an important part of the process—these clear links add transparency to evaluation and decision processes.
- Criteria should have impacts at different scales—global, federal, state, watershed, district, local, user. Identification of the extent of the impact will help in the decision process.
- The process can be applied to single issue activities, to identify a more comprehensive picture of the impacts. There should therefore be a clear and easy pathway through the document for "simple" application.
- Guidance on generating options is needed, and should include considering which components will be common to all options and which will be varied. An option can include both structural and non-structural initiatives.
- Options should have a development profile linked to funding availability and existing system conditions. This should be considered in the option evaluation and selection, and in the implementation. For this reason consideration of implementation should be included in the manual.

- Economic considerations are a powerful force in the success of system selection and implementation. Consideration should be given to how this is addressed in the manual. Although it can be considered to be just one aspect of system performance, availability of funding can have a real impact on the selection of options, and on the overall system performance. The research team need to explore how this is incorporated into the manual.
- Understanding the current system does not necessarily provide a base case for comparison. A "base case" should be clearly defined, and will include a defined future scenario.
- The current system plays two roles—it is the basis of the base case, and also the start point for transitioning the system.
- Data and information should be represented at a level suitable for purpose. For example, technical analysis might need to be modified for representation to the public. However, "dumbing down" of technical analysis must be avoided. Data should only be collected where the reason for collection is valid.

Potential Case studies:

The following utilities expressed interest to take part in case studies:

- San Francisco Water Utility
- Santa Clara Valley Water District
- City of Calgary Waterworks
- El Paso Water Utilities

APPENDIX B
READING MATERIAL ON IUWM

GENERAL IUWM ISSUES

Blackmore, J., and C. Diaper. 2004. Integrated Urban Water Systems—A Method to Evaluate Relative Risk. In *Proceedings of the 2nd IWA Leading-Edge Conference on Sustainability: Sustainability in Water Limited Environments.* Sydney, Australia, 8–10 November.

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GLOSSARY

Criteria—Value (of a measure or metric) against which performance can be judged; a target value.

Day-lighting—Redirecting an enclosed stream into above-ground channels and returning it to a more natural condition.

Integrated Urban Water Management (IUWM)—An approach for urban water utilities to plan and manage urban water systems (i.e., water supply, wastewater and stormwater systems) to minimize their impact on the natural environment, to maximize their contribution to social and economic vitality and to engender overall community improvement.

IUWM activity—A group of related actions. Activities are repeated during different phases of IUWM.

IUWM option—A specific water management option (e.g., a [particular] dam, a defined water restriction regime, an $X rainwater tank rebate).

IUWM Phase—The part of the IUWM planning process that leads to an outcome:

Phase 1: Setting strategic direction
Phase 2: Portfolio shortlist development
Phase 3: Final portfolio development

IUWM planning process—The process described in this manual to transition to IUWM.

IUWM strategic direction—Output of phase 1 of the IUWM planning process given in this manual. It specifies general approaches to water management that are part of IUWM (e.g., aquifer recharge, wastewater recycling, end use control).

Level (analysis)—Level of analysis needed to produce the outcomes of a phase.

Low impact development (LID)—A design approach that aims to maintain and enhance the pre-development hydrologic regime of urban and developing catchments.

Managed aquifer recharge (MAR)—The practice of adding a water source such as recycled water to underground aquifers under controlled conditions.

Measure—System, standard or unit of measurement (also metric).

Portfolio—A complete and unique set of components that make up a system.

Sustainable Urban Drainage Systems (SUDS)—A sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.

Water sensitive urban design (WSUD)—The integration of water cycle management into urban planning and design.

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ABBREVIATIONS

ACT	Australian Capital Territory
ACTEW	ACT Electricity and Water
AwwaRF	Awwa Research Foundation (now Water Research Foundation)
CBA	cost benefit analysis
DM	decision maker
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPWU	El Paso Water Utilities
ESD	ecologically sustainable development
IUWM	Integrated Urban Water Management
IWRM	Integrated Water Resource Management
IWRP	Integrated Water Resource Planning
KSG	key stakeholder group
LID	low impact development
MAR	managed aquifer recharge
MCDA	multi-criteria decision aid
MGD	million gallons per day
QWC	Queensland Water Commission
SCVWD	Santa Clara Valley Water District
SEQ	South East Queensland
SFPUC	San Francisco Public Utility Commission
SUDS	Sustainable Urban Drainage Systems
UWMP	Urban Water Management Plan
WSG	wider stakeholder group
WSUD	water sensitive urban design

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