Towards the Adoption of Integrated Urban Water Management for Planning

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Towards the Adoption of Integrated Urban Water Management for Planning

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Abstract: Integrated Urban Water Management 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. The obvious starting point for adopting the IUWM approach is the strategic planning phase. However, little has been written on processes that enable application of the IUWM approach to planning. Identifying this knowledge gap, the Water Research Foundation and the CSIRO, Australia jointly developed a framework to adopt IUWM approach to strategic planning of urban water systems (referred to as *IUWM Planning Framework*). This paper discusses principles, drivers and benefits of IUWM approach and provides an overview of the *IUWM Planning Framework*. The Framework has three phases, each with distinct outcomes. Each phase has five activities. The activities undertaken in each phase are similar, and learnings from each phase feed into subsequent phases. The IUWM Planning Framework is a useful planning aid for 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.

***Keywords**:* Integrated urban water management, IUWM, IUWM planning framework.

1. INTRODUCTION

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. It is an emerging and alternative approach for urban water utilities to plan and manage urban water systems.

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. 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. However, little has been written on processes that enable application of the IUWM approach to planning. Identifying this knowledge gap, the Water Research Foundation and the CSIRO, Australia jointly developed a framework to adopt IUWM approach to strategic planning of urban water systems (referred to as *IUWM Planning Framework*). It is described in detail in Maheepala et al. [2010]. This paper discusses the principles, drivers and benefits of IUWM approach and provides an overview the IUWM Planning Framework.

1. INTEGRATED URBAN WATER MANAGEMENT

IUWM is an approach for urban water utilities to plan and manage urban water systems (i.e., water supply, wastewater and stormwater) to minimise their impact on the natural environment, to maximise their contribution to social and economic vitality and to engender overall community improvement [Maheepala and Blackmore, 2008]. This 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].

The principles of IUWM include considering of [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 practices which can provide water fit for purpose both in quality and quantity, and reduce the demand for potable water; the impact of water cycle management on the overall planning and management of towns and cities; the sustainability of water service provision; the local context and stakeholder views; engineering and functional aspects of the water system; and the means by which transition from current practice can be achieved

A number of terms with similar definitions to IUWM can be found in the literature, applied to urban water management. These terms include Integrated Water Cycle [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.

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 [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]. The key difference between IUWM and IWRM is the spatial scale and the sector of application. As per Maheepala and Blackmore [2008], the IWRM approach deals with the water allocation problem at river basin level, which might include a number of urban areas as well as rural, hydro-electricity and agricultural 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. Close interaction and communication between IWRM and IUWM planning processes is critical if each is to be successfully implemented.

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.

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 and potential 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 (i.e. to increase supply) and efficient demand management (i.e. to use less). 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.

2. NEED FOR A FRAMEWORK TO ADOPT IUWM FOR PLANNING

The obvious starting point for adopting the IUWM approach is at the strategic planning phase, where the existing long-term goals are reviewed or new 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. However, 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. Identifying this knowledge gap, a new process has been developed for adopting IUWM principles to strategic planning. This process is referred to as "IUWM Planning Framework" and it is described in detail in [Maheepala et al., 2010]. An overview of this process is given below.

Jeffcoat et al. (2009) reported a process for adopting IUWM principles into planning of urban water systems. The Framework described below 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 paper is much more comprehensive than the process described in Jeffcoat et al. (2009).

1. THE IUWM PLANNING FRAMEWORK: OVERVIEW

The structure of the IUWM planning Framework is represented as a spiral (see Figure 1). 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.

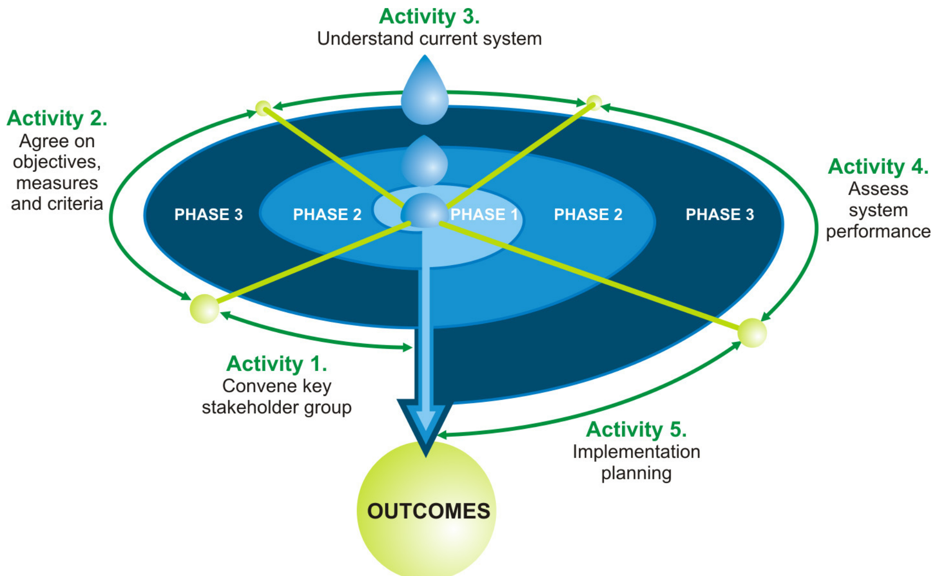

Figure 1. The IUWM Planning Framework (source: Maheepala et al. 2010)

The five main activities in the IUWM planning process are as follows:

1. **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, and ensuring that it is effectively run and that its constitution remains relevant is essential to the success of the process.
2. **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.
3. **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.
4. **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.
5. **Implementation planning**: Many major decisions must be made before the practice of IUWM becomes a reality. Long before the engineers start construction, strategies, 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. The three phases are as follows (see Figure 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.

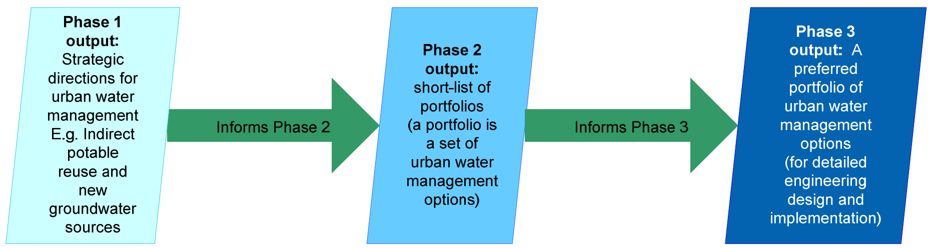

Figure 2. Outputs of each phase in the IUWM planning process

Table 1. An overview of activities undertaken in Phase 1 (source: Maheepala et al. 2010)

Activity	Brief description
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 as follows: • 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 (usually 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	• Clearly state the outcome, i.e., a strategic IUWM direction for urban water management, and the process and assumptions used to develop the outcome

Activity	Brief description
planning	• Ensure stakeholders are well-informed and understand and accept outcomes of Phase 1 • Document outcomes and prepare an implementation plan for Phase 2

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. An overview of tasks undertaken as part of each activity in each phase is described in Table 1, Table 2 and Table 3. See Maheepala et al., [2010] for details.

Table 2. An overview of activities undertaken in Phase 2 (source: Maheepala et al. 2010)

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

Table 3. An overview of activities undertaken in Phase 1 (source: Maheepala et al. 2010)

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

Activity	Summary
	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

4. CONCLUSIONS

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. 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 water utilities (e.g. El Paso, San Francisco and Santa Clara in North America and South East Queensland in Australia) are well advanced in their thinking, while others have a way to go. The Framework described in this paper provides an overview of 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. For those who are seeking details of the IUWM Planning Framework can be found in Maheepala et al. [2010]

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