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International Water Association

Specialist Group Efficient Operation and Management

Canal de Isabel II

The International Demand Management Framework

Stage 1

Final Report

Prepared by

Institute for Sustainable Futures

For

Canal de Isabel II

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The International Demand Management Framework

Stage 1

Final Report

For Canal de Isabel II

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Read the comments of the secondary Reviewer(s) ❑ **Yes** ❑ **No**

I agree that this report reaches the standard set by the Institute for Sustainable Futures, University of Technology, Sydney.

Signed

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Institute for Sustainable Futures

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EXECUTIVE SUMMARY

This report presents the outcomes of Stage 1 of the International Demand Management Framework (IDMF), an initiative set up under the auspices of the International Water Association's (IWA) Specialist Group "Efficient Operation and Management" - Task Force No. 7.

The objectives of the overall IDMF study are to develop a step-by-step framework and associated manual on best practice approaches to urban water supply-demand planning with a focus on demand management/water efficiency.

The objectives of Stage 1 have been to gather and represent the core international literature in this field, to develop an outline and criteria that describe a best practice approach, and utilise these to benchmark the activities of a case study utility, Canal de Isabel II, the Madrid water utility. The work has been primarily conducted by the Institute for Sustainable Futures, with review and input from an international working group of experts in this field.

A large range of published and unpublished literature has been selected and reviewed, extracting elements that inform current best practice. This information has then subsequently been ordered into a systematised annotated bibliography which presents the literature under key topics for easy reference and use. A preliminary literature review has been prepared and is included in this report which synthesises the literature on water demand management and relevant parts of the field of integrated resources planning, the foundation of the emerging best practice approach advocated by this study.

The literature review demonstrates that recent ideas about water planning and management involve thinking of demand and supply in parallel, and bringing them together to assess the difference between supply and demand (the supply-demand balance) and designing and comparing potential options to find the most appropriate way to maintain a balance between supply and demand. The literature review also demonstrates a growing wealth of knowledge in end use measurement and analysis, as data collection methods are refined and utilities become familiar with detailed demand forecasting. While debate continues regarding the best approach of comparison of supply and demand options, there is widespread consensus that unit cost (average incremental cost) provides a robust comparison over time and between options of varying scales. Also, that qualitative assessment and participatory approaches are required to enable other sustainability criteria to be considered as a part of the decision-making process. Finally, evaluation is gaining increased importance as practitioners come to realise that demand management programs must be closely monitored to determine actual outcomes and learn about what works in the local context.

The best practice process outline and criteria have been developed based on the foundation provided by the international literature and the experience of key staff of the Institute for Sustainable Futures through a series of internal workshops. These criteria themselves are broadly applicable and concise. They have been elaborated at two levels of depth depending on their applicability to strategic, high-level planning, or detailed planning. The best practice process outline and criteria have been assessed by the working group members of the IWA Task Force No.7, broad spectrum of experts and practitioners in the fields of demand management and urban water planning from both developed and developing countries. The comments of the working group members have been incorporated into the final version of the process outline and criteria.

The best practice criteria have been used to benchmark a case study utility, Canal de Isabel II (CYII) of Madrid, on their demand management and planning activities. The criteria have proved useful for this purpose in two ways. Firstly, they have allowed a broad overview of CYII's work to be gained through mapping of their actions against the different steps in the IDMF process. From this, the areas in which significant effort had been invested were made evident, as were the areas not currently attempted and yet requiring attention. Secondly, at a detailed level, the criteria could be used to guide improvement of CYII's activities, such as how to increase the reliability in end use data collection.

Stage 1 of the IDMF project has therefore taken important steps forward in defining an internationally recognised and respected approach in the complex area of demand management and integrated resources planning. The next steps will be to conduct a more detailed literature review, and to use and refine the framework in diverse locations including developing and emerging economies.

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ABBREVIATIONS

CUWCC	California Urban Water Conservation Council
CYII	Canal de Isabel II (Madrid Utility)
IDMF	International Demand Management Framework
IWA	International Water Association

1 INTRODUCTION

1.1 Background

This document summarises Stage 1 of a broader study, the International Demand Management Framework (IDMF). The IDMF has been undertaken under the auspices of the International Water Association's (IWA) Specialist Group "Efficient Operation and Management" - Task Force No.7.

This Task Force was set-up in 2004 by the IWA and representatives of a number of leading demand management organisations and practitioners such as the California Urban Water Conservation Council (CUWCC), Canal de Isabel II (the Madrid water utility) and the Institute for Sustainable Futures, University of Technology, Sydney. The Task Force was initiated due to an identified need for the development of a common framework for demand management in the context of urban water planning and the supply-demand balance. As part of the Task Force a working group of leading experts and practitioners in demand management and urban water planning have been brought together to assist in the development and review of the study.

The overall IDMF study comprises of six stages and aims to develop a step-by-step framework and associated manual on best practice approaches to urban water supply-demand planning with a focus on demand management/water efficiency. The framework and manual will be designed for a broad audience (urban water supply and resource management agencies) in developing countries, emerging economies and the developed world. The manual will be written in such a way as to deal with how to use the framework in a diverse range of situations. Parts of the framework are already used in a range of emerging and developed countries. The IDMF study will aim to refine the framework and test it in a broader range of contexts through the use and documentation of case studies. Ultimately the manual and associated tools and resources will be disseminated to potential users through a range of methods to maximise knowledge transfer. Refer to Appendix A for the Terms of Reference of the overall IDMF study.

The IDMF will enable agencies to focus on service needs rather than supply-side options in isolation, improve asset management and planning, reduce capital and operating costs of providing water and sanitation services and make more informed decisions based on the economic, social and environmental benefits of water service provision options from a whole of society perspective.

Specifically, the framework will cover:

- detailed water demand forecasting in which demand is disaggregated into sectors and end-uses;
- options analysis guided by integrated resources planning in which supply and demand options are analysed together on a consistent basis in order to meet a projected supply-demand 'gap'; and
- evaluation of demand management programs including analysis of water savings, costs and other aspects such as participation rates.

The framework will be based on best practice applications and a comprehensive benchmarking of methodologies and practice. Given the high costs of achieving the Millennium Development Goals, these issues will become increasingly important in the developing country context. The framework will be refined and tested through case studies in a selection of countries to ensure wide applicability. The output will be a guidebook in the form of a CD and website with appropriate links to existing information and tools.

This initial project, Stage 1 of IDMF, has been funded by Canal de Isabel II (CYII), the Madrid water utility, and represents the first important step toward realisation of the larger study. Its focus has been on the gathering of core international literature and the development of a set of criteria that define 'best practice' in urban water planning with a focus on demand management/water efficiency. These best practice criteria have been tested on CYII, serving both to benchmark their performance in this area, and to refine the IDMF process and criteria developed.

1.2 Objectives of IDMF Stage 1

The objectives of IDMF stage 1 are:

- to gather the core international literature in key topic areas related to demand management in the context of supply-demand planning;
- to develop a preliminary literature review/annotated bibliography;
- to develop a "best practice" IDMF process outline;
- to develop associated criteria that can be used to assess to what extent an organisation is applying best practice with respect to demand management in the context of supply-demand planning; and
- to test the criteria developed using a case study organization through a benchmarking approach.

1.3 Outline of this report

This report contains three main sections.

Firstly an outline of the research methodology used.

Secondly, a preliminary literature review focused on international best practice in urban demand management and integrated resources planning is presented. This literature review leads to the development of the IDMF process outline. This is an iterative planning process that guides water authorities through a process of: defining the supply-demand balance through detailed demand forecasting; balancing supply and demand by considering supply and demand-side options alongside each other; and utilising evaluation, monitoring and review to assess outcomes and ensure an adaptive management.

The third section reports on the set of criteria that describe best practice methods of carrying out each step of the planning process.

The annotated bibliography which accompanies this report contains summaries and reference to core literature including research papers and other key resource materials such as project reports and specific studies. This literature is presented systematically to form a working document with details of current best practice approaches and offers guidance to a reader on which literature to consult for different topics of interest.

The appendices include:

Appendix A – The Terms of Reference for the overall IDMF study

Appendix B – The detailed best practice criteria

Appendix C – The Annotated Bibliography

2 STAGE 1 METHODOLOGY

This section describes the research methods followed in IDMF Stage 1. In terms of the overarching research methodology, the intent was to conduct Stage 1 in a collaborative manner, engaging the IWA Task Force No. 7 working group in the development of the different outcomes. In addition, internally within the Institute for Sustainable Futures (the Institute), several brainstorms and workshops were held in order to synthesise the views of several researchers who have been working in this area for some time. Due to logistics, communication with the working group was done primarily through email contact. For the case study, face-to-face interviews between staff at the Institute and CYII were conducted with regard to gathering information to assist in the benchmarking exercise.

2.1 Gathering core literature and preliminary literature review

Several steps were taken to form the initial annotated bibliography and subsequent preliminary literature review. These included:

- establishing a meaningful structure for the annotated bibliography;
- collecting a wide range of literature;
- filtering this literature to only include items that informed "best practice";
- including extracts or comments about each reference within the structure of the annotated bibliography; and
- writing a preliminary literature review based on the literature in the annotated bibliography.

The structure of the annotated bibliography was chosen to follow the areas of demand management listed in the Terms of Reference for the IDMF study (refer to Appendix A). In addition, a section was added focusing on developing country applications. A particular format for this document was chosen that allows a reader to collapse the document down to just headings and references to both facilitate input from the working group and allow easy access to the different parts of the document for reference.

Literature pertaining to the different areas of integrated resources planning and demand management was gathered from three primary sources:

- the Institute's existing library;
- a literature search of journal databases; and
- submissions from the working group.

The literature that has ultimately been included in the annotated bibliography was chosen based on its relevance to current best practice. Older references were only included if they had not been superseded by more recent advances.

Extracts from the chosen literature, or comments about these various resources were used to "annotate" the bibliography and generate a useful working document that can be easily consulted.

The annotated bibliography is provided in Appendix C.

2.2 Developing the IDMF outline and criteria

2.2.1 The IDMF process outline

As a starting point an existing demand management framework developed by the Institute was used (refer to IDMF Terms of Reference in Appendix A). During a sequence of internal workshops at the Institute, the structure was discussed and critiqued by individuals with direct experience in applying demand management and integrated resource planning in the Australian and international context. The various planning processes given in the integrated planning literature (Swisher 1997; Tellus Institute 2000; UK Environment Agency 2003) and key demand management literature (Dziegielewski 1993; Vickers 2001; Gleick 2003; United States Environmental Protection Agency (US EPA) 2004) were also used to inform the structure as these references provided a range of possible approaches and processes. In this way, a combination of theory and practice informed the chosen draft structure, ensuring that it represents a "best practice" approach to demand management. The draft structure was then provided to the working group for their comment/input and was subsequently refined.

2.2.2 Best practice criteria

The best practice criteria were also developed from a combination of theory and practice. The annotated bibliography provided in depth information about the breadth of approaches that are used internationally, and internal knowledge at the Institute based on a large range of both Australian and international demand management and urban water planning projects were used to shape the criteria. This was done through a sequence of internal workshops.

It was decided that the "best practice" criteria needed to be applicable at different levels of detail, since both the resources to carry out the IDMF process and the differing contexts (e.g. developing country or developed country, metered or unmetered, data-rich or data-poor) would inevitably constrain the possibilities. For that reason, the best practice criteria themselves describe particular principles and processes that are deemed essential to best practice and do not stipulate exactly how such criteria should be achieved. For each criteria the objectives are articulated to enable easier interpretation of the criteria, and better understanding of why that criteria has been included.

Each criteria is accompanied by examples at two different levels of application. Firstly, a first-pass or strategic level, for which it is imagined that existing data would be consulted where possible and an initial set of demand management options developed to trial and evaluate. Secondly, a detailed level for those already partially involved in demand management activities, where, providing the necessary resources were available, each step of the process would be done with significantly greater depth (i.e. demand forecasting using an end-use approach).

The draft criteria were circulated to the working group to elicit other points of view and input to the development of the criteria. The working group input was designed to enable an international best practice perspective to be developed, which could then be used by an international audience to apply the principles identified.

The IDMF outline and summary of best practice criteria are provided in Section 4. Further details are provided in Appendix B.

2.3 Benchmarking Canal de Isabel II

To test the IDMF process developed and set of criteria that delineate best practice, CYII was used in a benchmarking exercise.

To benchmark CYII, three information sources were utilised:

- in-depth interviews with CYII staff;
- internal publications; and
- external publications such as published papers explaining innovative aspects of CYII's operations.

Using these as a basis, CYII's past and current activities were assessed using the IDMF criteria.

Firstly, a mapping exercise was performed to provide an overall picture of CYII's coverage of different aspects of the 5-step IDMF process. The content of the interviews and written resources was matched against elements of best practice to determine which areas CYII have already covered in their work to date, and which areas CYII are yet to attempt.

Secondly a detailed assessment was made of performance against the individual IDMF best practice criteria. This has resulted in a detailed critique of *how* CYII have carried out particular aspects of their urban water planning, and a set of key recommendations on what CYII needs to do to incorporate more features of a best practice approach to urban water planning.

The results of this assessment have been provided to CYII in a separate report "*The International Demand Management Framework – Stage 1 – Benchmarking CYII*".

3 PRELIMINARY LITERATURE REVIEW

A summary of the preliminary literature review is provided below. The full annotated bibliography can be found in Appendix C.

3.1 Overall planning process

Different processes are articulated in the integrated resources planning literature compared to that of the demand management literature. A key feature in integrated resources planning is the consideration of supply-side and demand-side options alongside one another in a joint planning process (Swisher 1997; Tellus Institute 2000; UK Environment Agency 2003). Such a view also appears in UK demand-supply literature (Herrington 2005). In general, the demand management literature considers demand management in isolation (Dziegielewski 1993; Vickers 2001; Gleick 2003; United States Environmental Protection Agency (US EPA) 2004). Based on this, although the IDMF has a focus on demand management, it aims to allow comparison between supply and demand options to determine how best to fulfil the supply-demand balance, and thus considers demand management within the broader context of how water services are provided.

Much of the literature emphasises the use of monitoring and evaluation and iteration of the entire planning process (Dziegielewski 1993; Tellus Institute 2000; Vickers 2001) and this is considered to be an essential step in a best practice process. Other literature emphasises the involvement of various stakeholders (Harberg 1997; Tellus Institute 2000), another important attribute of a best practice approach.

3.2 Situation analysis and setting planning goals

The initiation of the planning process requires an iterative process of relevant data collection as part of a situation analysis and subsequent stakeholder deliberation on the issues at hand, informed by the synthesis of the data collected. Scenarios are commonly used at this stage of the process, as these enable assessment of the potential risks that face a particular region (Alcamo 2001; Cubillo 2003; Westcott 2003). The Tellus Institute (Tellus Institute 2000) lists a set of possible types of broad planning objectives and includes ideas such a increasing efficiency, minimising environmental impacts, using local resources, providing social benefits, diversifying supply, and retaining flexibility. In practice to date the objectives are usually more narrowly defined in terms of establishing demand management targets or meeting a demand-supply balance at least cost (Fane and White, 2003, AWWA 2006, White et al. 2006; Turner and White 2006). The depth of information collected and type of suitable planning objectives will vary depending on the local situation.

3.3 Demand forecasting and data collection

Three broad sorts of demand forecasting approaches exist: trend, econometric and sector and end-use (Tellus Institute 2000). The traditional approach of trend analysis based on existing demand is said to overestimate demand (Gleick 2003). It is almost universally accepted in the recent demand management literature that an end-use approach, with as high a degree of disaggregation as possible, is the preferred approach ((Billings 1996; White 1998; UK Environment Agency 2003; United States Environmental Protection Agency (US EPA) 2004). Other authors emphasise the need for explicit price and other assumptions to be considered and to incorporate sensitivity and risk analysis ((OECD 1989; UK Environment Agency 2003).

3.4 Options development, analysis and comparison

Best practice requires that a broad set of options are identified and considered that span across the full range of "total water management" actions (UK Environment Agency, 2003) such that customer, distribution, production and resource management (or demand and supply) interventions are considered. Many sources of options exist which have been used in various contexts. These will be worth consulting if a water authority does not have prior experience in developing demand management options. Some examples are (Zhang 2001; OECD 2002; UK Environment Agency 2003; United Nations 2003; Turner et al 2003, Almeida 2004; Almeida 2005; Herrington 2005). Some authors provide detailed information particularly focused on non-residential options development, for example (California Public Utilities Commission (CPUC) 2001; Vickers 2001; GDS Associates 2002).

Various approaches have been created to develop and to screen options. In developing options, it is widely agreed that the water savings potential should be analysed and considered (Turner and White 2003; Mitchell et al., 2004; Turner and White 2006; AWWA 2006 and Almeida et al., 2004). Criteria, which are also useful to screen options include (i) local availability of required technology (ii) appropriateness to local context (iii) customer acceptance and equity and (iv) the cost effectiveness of the option (United Nations 2003). Almeida et al. (2004) also promote the analysis of "viability" including economic, technological, functional, environmental, social and public health criteria.

The current approach to options analysis involves an economic analysis, and ideally, broader analyses to enable comparison, which might include for example sustainability assessment, environmental appraisal, and social appraisal. The methods of economic analysis include cost benefit analysis, cost effectiveness analysis and comparison based on unit cost. Cost benefit analysis and cost effectiveness analysis has been used in the past (Rocky Mountain Institute 1991; California Urban Water Conservation Council 1996) and even more recently (United Nations 2003) however it is widely accepted that unit cost is the best method to enable fair comparison between supply and demand options. Examples of unit cost are the AIC (average incremental cost) utilised by the UK Environment Agency (UK Environment Agency 2003) and levelised cost which is a measure of the present value unit cost of water saved or supplied (Fane and White 2003). A key feature of a robust economic analysis to compare options is the inclusion of multiple cost perspectives (whole of society and utility perspective as a minimum) (Herrington, 2005) and also the consideration and inclusion of avoided costs (benefits) (Feldman 2003).

Consideration of externalities, social and environmental impacts is usually achieved through qualitative means or using a full sustainability assessment. Many possible aspects might be considered using qualitative criteria, such as "reductions in wastewater costs, lower average peak water system loads, lower average peak energy demands, reduction in environmental damage due to water withdrawal and discharge" (Gleick 2003) or "non-quantifiable effects on the environment, social/political/legal institutions and customer equity and acceptability" (Dziegielewski et al. 1993). Sustainability assessment has recently been adopted for integrating qualitative assessments of social and environmental (and sometimes risk) criteria with cost analysis (Maheepala, Evans et al. 2004; Fane 2005). A scenario analysis may be constructed to allow assessment and discussion of the trade-offs and inherent choices concerning exclusion of options on qualitative grounds (Fane et al., 2005). Participatory processes are considered extremely important at this juncture, as subjective decisions must be made. The combination of a deliberative process with a multi-criteria assessment is considered a robust decision-making approach and was utilised for Sydney's Metropolitan Water Plan in Australia (White et al. 2006).

3.5 Planning implementation and program implementation

The implementation process must begin with a thorough, documented plan, as demand management is a complex process involving people and organisations as well as technical elements. Two key elements in the implementation plan are the budget and the communication and education campaign associated with the program and these are discussed below. Other aspects include consideration of regulatory implications, and staffing (including training).

The development of a budget plan is essential (Maddaus 1987; United Nations 2003; AWWA 2006). The budget must relate to the institutional arrangements, partnerships and cost sharing arrangements which will likely need to be put in place (Dickinson 2003; UK Environment Agency 2003; United Nations 2003; AWWA 2006). A communication and education campaign is critical in facilitating greater public awareness and promoting behaviour change. Multiple communication tools exist which may be employed such as advertising campaigns, media releases, training (formal and informal), direct marketing, etc. (White 1998) and which will need to be carefully designed and targeted.

Pilot programs are essential to conduct before full-scale implementation. Pilot programs permit a check on the estimated expected water savings and costs, and may also be used to refine program implementation processes and logistics (Turner and White 2006). Full-scale implementation involves stakeholders participating according to their agreed responsibilities, and project management of the process (Maddaus, 1987) including attention to the necessary monitoring and evaluation (Dziegielewski 1993).

3.6 Monitoring and evaluation

There exist many different approaches to monitoring and evaluation with regard both to the focus and the methods used. Of primary concern is to establish an understanding of the actual water savings and costs ((Dziegielewski 1993; Dickinson 2001; Gregg 2005; Turner 2005; AWWA 2006). Where resources are available, robust methods such as testing for statistically significant differences between a large sample and a paired control group (to correct for variation in demand due to external factors such as weather and water restrictions) (Billings 1996; Turner 2005). Where this is not possible, less accurate methods such as using a large representative sample of controls (say 50,000 households) rather than paired data. An even less resource intensive method is the use of regression analysis to develop a demand equation and the comparison between actual and modelled demand.

Other aspects of programs are also important to monitor and evaluate. These include participation rates, total and unit costs, and the implementation processes. Reflecting upon the 'process of implementation allows the lessons learnt to be captured and taken into account in future programs (Dziegielewski 1993; Tellus Institute 2000; Buckle 2003; Buckle 2005, Turner and White 2006)

3.7 Data collection

The latest practice in demand forecasting requires significant data collection to make the analyses possible. Methods for data collection for residential and non-residential end-uses are described in the literature and include both technically based approaches and social research methods. Issues of importance in data collection for each of these are described below.

Some studies of residential water end-use data collection include (AWWA Research Foundation 1999; Cordell 2003; Loh 2003; Turner 2003; Roberts 2004; Charalambous 2005; Roberts 2005). Studies vary in the resources available and therefore the sample sizes used, considerations in the choice of sample size, statistical significance sought (e.g. 95% confidence) and the types of information collection tools utilised, also vary. More resource intensive methods, for example face to face interviews including inspection, rather than for example telephone survey methods will promote a higher level of accuracy (Cordell et al. 2003).

Data collection in the non-residential sector is so far less extensive. Brown and Gregg (2004) provide best management water efficiency information for commercial and institutional sites which includes data collection on outdoor use and Vickers (2001) describes an audit process for such buildings which captures many aspects of water use.

Other types of data collection required include bulk water/metered demand, and information to enable climate correction and assessment of non-revenue water. Non-revenue water data collection and best practice leakage management methodologies are contained in (Liemberger 2004; Farley 2005; Liemberger 2005). More recently, techniques such as acoustic monitoring have been tested for their cost-effectiveness by Sánchez et al., (2005). (Maheepala 2003) describes a methodology developed for a quantitative assessment of climate change impacts on urban water supply systems. Turner et al., (2003) have also developed a climate correction model which identifies the impact of climate related variables (e.g. rainfall, evaporation and temperature) and other factors such as demand management initiatives on bulk water supply.

3.8 End-use and options models

A variety of demand forecasting (end-use) models and options models have been developed internationally. These include the model of (Haarhoff 2004), the IWR-MAIN model of the U.S. Army Corps of Engineers and promoted through the US EPA (US Army Corps of Engineers 2005), the decision support system (DSS) model (Levin, Carlin et al. 2005; Land and Water 2002) and a set of end-use/options models developed by the Institute for Sustainable Futures for clients in Australia (for example White et al., 2004; Turner 2003; Mitchell 2004; Snelling 2005). Such models are capable of utilising complex end-use information to produce more detailed demand forecasts. They usually contain spatial disaggregation, seasonal disaggregation, sector disaggregation, multiple determinants of water demand, user-added categories, and sensitivity analysis.

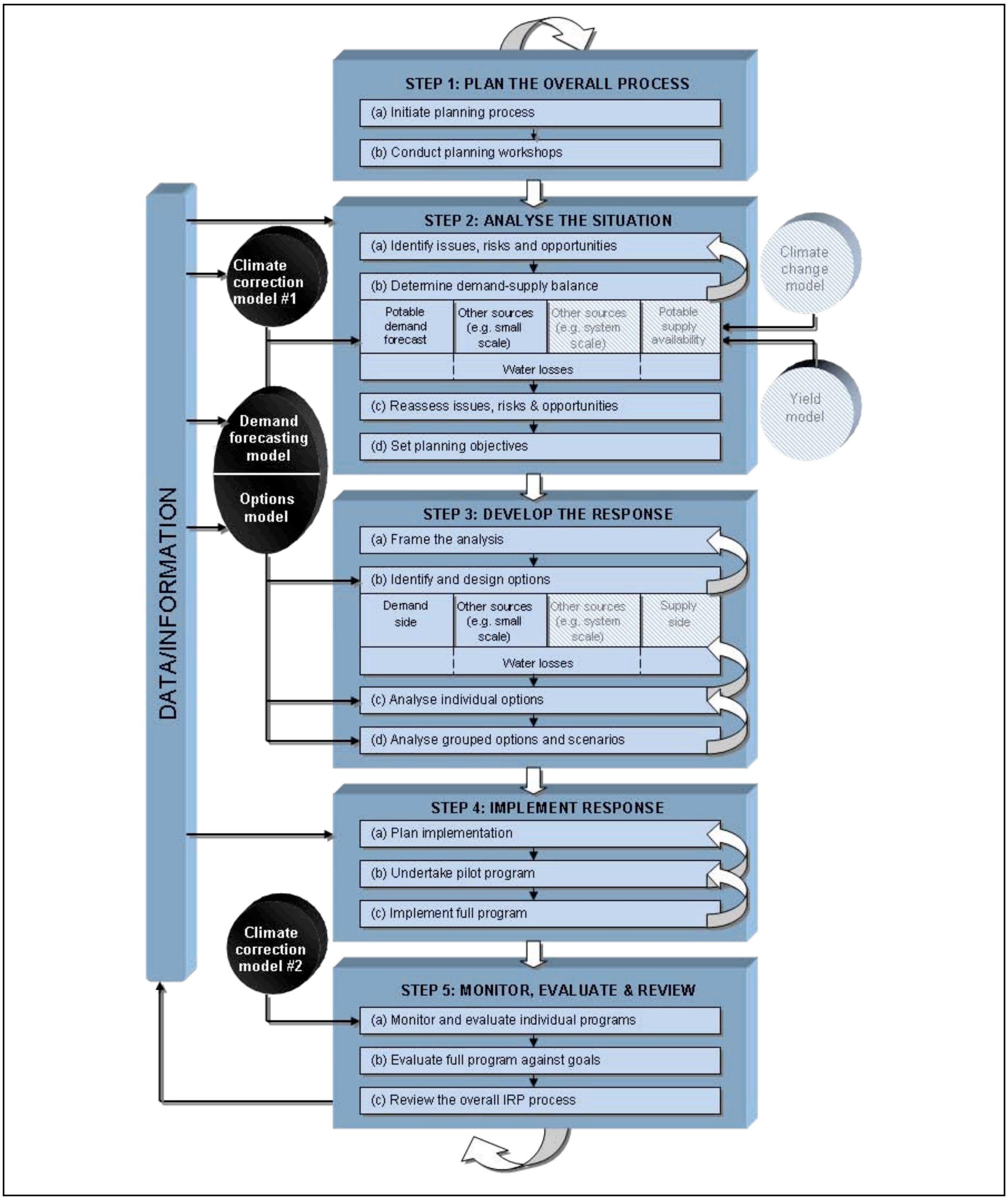
An important feature of these models is their ability to be used to plan demand management options. The effects of potential options may be modelled using estimates of participation rates, costs and water savings (Turner 2003; Jacobs 2004; Levin, Carlin et al. 2005). This provides key strategic information towards the design of effective options for a particular region to enable good decision-making at this stage in the planning process.

4 DRAFT IDMF OUTLINE AND BEST PRACTICE CRITERIA

4.1 *Outline of the IDMF process*

Figure 1 shows the overall planning process, which has five main steps, and the models and data/information that support this process. The following sections outline the best practice criteria developed. Appendix B contains more details of the criteria and examples of what this might mean at different levels of application.

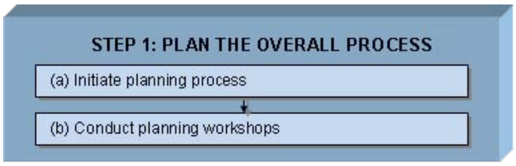
Figure 1: The IDMF Process Outline



4.2 Criteria for the overall process defined by the framework

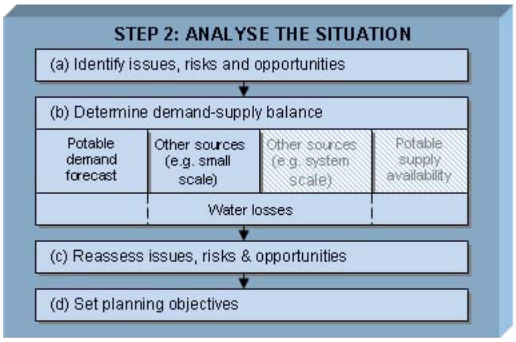
Criteria	Relevant Objective(s) (Why this criteria?)
Includes all steps in a logical sequence	To ensure integrity of the approach
Uses a depth of analysis that is fit for purpose	To avoid unwise investment in particular steps
Treats demand, potable water source substitution and supply options equally	To promote equal consideration of all the possibilities/options that might improve the supply-demand balance To ensure consistent comparison of all options
Is used iteratively and reflectively	To adjust to inevitable change To ensure the process and outcomes are refined through increased knowledge
Maximizes inclusiveness	To ensure representation of different perspectives To improve acceptance of the planning process and ownership of its outcomes To assist in enabling a common vision
Encourages deliberative decision-making	To maximize meaningful engagement by stakeholders
Maximises transparency	To allow various stakeholders to engage with the process and its outcomes To give legitimacy to the outcomes
Identifies level of uncertainty at each step	To assess the implications of the quality of data used To acknowledge the limits of the analysis undertaken To make level of uncertainty explicit to stakeholders and decision-makers so it may be managed To guide further data collection

4.3 Criteria for "Step 1: Plan the overall process"



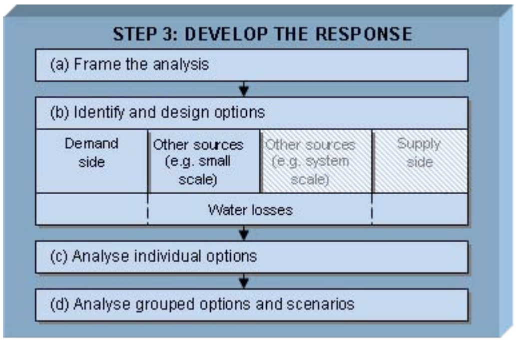
Criteria	Relevant Objective(s) (Why this criteria?)
Clearly defines all steps in process to be followed	To facilitate action on an agreed vision To define appropriate level of detail for each step
Clearly defines stakeholder roles in process	To delegate responsibilities appropriately To ensure clarity on roles and responsibilities
Matches defined process with available resources and skills	To ensure process can proceed as planned.
Determines general goals and scope of planning process	To define focus as being on the whole supply-demand balance or limited to demand management To define "system boundaries" to be used
Maximises inclusiveness	To ensure representation of different perspectives To improve acceptance of the planning process and ownership of its outcomes To assist in enabling a common vision
Encourages deliberative decision-making	To maximize meaningful engagement by stakeholders
Assesses skill requirements and staff training needs	To ensure that staff are capable of the tasks that this process will require of them To ensure attention is given to the many new skills which the IRP process entails (specifically, many social based skills versus technical skills are required)

4.4 Criteria for "Step 2: Analyse the situation"



Criteria	Relevant Objective(s) (Why this criteria?)
(a) Identify issues, risks and opportunities	
Defines clear system boundaries	To clarify geographic region of interest To clarify systems of interest (water supply, wastewater, stormwater, energy etc)
Investigates current water supply system characteristics	To determine system constraints To determine system costs
Identifies major sector water usage	To identify over-riding issues of concern in one or more sectors
Investigates current and future demographics	To determine likely effects of population on water demand
Analyses scenarios that describe the likely risks to the supply-demand balance	To directly consider the possible effects of scenarios such as climate change, economic growth, diseases (eg AIDS) etc. To promote a risk management approach
Engages informed stakeholders to decide on initial planning objectives	To guide the subsequent supply-demand balance analysis To ensure a common understanding between stakeholders supported by the joint consideration of information gathered. To avoid jumping to conclusions about "perceived" rather than "real" issues
(b) Determine supply-demand balance	
Analyses historical and current water demand	To understand how water is used in more depth as well as external factors that affect water usage
Forecasts water demand based on disaggregated demand trends	To establish a demand forecast 'reference case' or 'business as usual' case
Exposes stakeholders to the data, assumptions and method of demand analysis	To enable stakeholders to see, critique and modify the analysis
Defines appropriate level of contingency (headroom) in the supply-demand balance	To enable management of potential risks and changes that will affect either demand or supply.
(c) Re-assess issues, risks and opportunities	
Prioritises issues, risks and opportunities	To utilise supply-demand balance to inform the next stages of the planning process
(d) Set goals	
Clearly defines goals to be met	To engage stakeholders in deciding on a common set of goals To enable reflection later on as to the extent to which these goals have been met

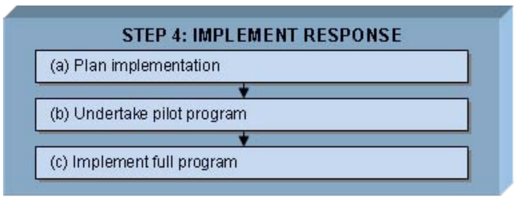
4.5 *Criteria for "Step 3: Develop the response"*



Criteria	Relevant objective(s)
(a) Frame the analysis	
Clarifies an appropriate depth of analysis	To match the depth and complexity of the analysis with the need and the available resources
Determines the cost perspectives, cost elements and cost metric	To map out the proposed method by considering advantages and disadvantages of different approaches
(b) Identify and design options	
Considers the widest possible range of options and their respective water savings.	To avoid missing good opportunities of a broad range of options
Defines maximum conservation potential.	To ensure that the full conservation potential available is made explicit.
Screens options by maximizing conservation potential.	To focus attention primarily on those options where water efficiency can be maximised
Defines best applicable instruments associated with each measure to form "options".	To increase the probability of achieving the desired outcome for a given measure(s)
Gives particular consideration to "best management practice" and local applicability.	To build on existing experience in demand management options yet still consider the local context.
Identifies the total costs and savings of each designed option.	To ensure all costs are identified for each option, the associated savings and the potential for decay.
Defines a suite of well considered individual options for further analysis	To ensure the suite of options are clearly defined for analysis in the next step.
Conducts sensitivity analysis on each option	To acknowledge and assess the inherent uncertainty present in each option
(c) Analyse individual options	
Conducts an economic analysis of each option (total resource cost or societal cost)	To make clear how various options differ with respect to cost when all costs (e.g. utility, government and customer) are considered To make sure that options are compared with the same costs, benefit and boundaries in mind.
Analyses explicitly the different cost perspectives in the economic analysis	To identify the options with least overall cost to society To analyse the cash flow for the utility To facilitate allocation of costs fairly between stakeholders.
Includes avoided costs in the economic analysis	To enable equivalent treatment of demand and supply side opportunities.
Conducts a robust technical assessment of each option	To allow inclusion of non-quantifiable technical concerns in the decision-making process
Uses an appropriate method for identifying social and political barriers and impacts for each option	To allow inclusion of non-quantifiable social effects in the decision-making process
Conducts an environmental impact assessment of each option	To allow inclusion of non-quantifiable environmental effects in the decision-making process
Conducts a sensitivity analysis on the various analyses	To explicitly deal with risk and uncertainty
Makes assumptions and intermediate	To ensure transparency of each of the analyses

Criteria	Relevant objective(s)
results explicit in the various analyses	
Uses a participatory process to consider the results of the economic, technical, social and environmental analyses	To deliberate on which options should be included in the subsequent step of grouping options.
(d) Analyse grouped options and scenarios	
Allocates options into groups that meet the goals set in step 2d over time.	To create sets of 'grouped options' for further analysis and comparison To take into account the time dimension of the supply-demand balance.
Initially considers "least-cost" groups using the present value of each group of options	To provide a base case against which the cost of risk-reduction can then be considered explicitly
Examines effects of most-likely risks/scenarios on groups of options	To gradually move from the "least-cost" group of options, to a group that is more flexible, diverse and reduces overall risk.
Performs a risk balancing exercise to determine optimal group of options	To balance risk within the group by choosing options that complement one another in terms of delivering savings under different scenarios.
Optimize synergies, links and dependencies between options	To reduce costs of individual options, maximize water savings and optimise implementation processes.
Uses a participatory process to deliberate on the required risk balancing and risk-cost trade-offs	To determine the preferred group of options for implementation

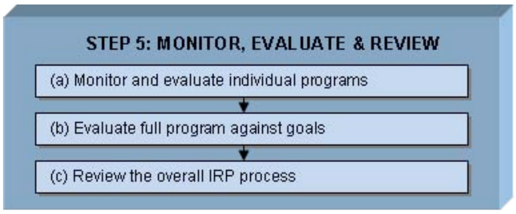
4.6 Criteria for "Step 4: Implement response"



Criteria	Relevant objective(s)
(a) Plan implementation	
Clearly identifies demand management implementation team/staff	To ensure roles and responsibilities are clarified and agreed upon
Thoroughly plans and documents the details of the implementation process	To ensure effective implementation of pilots and full-scale implementation
Develops a detailed budget plan	To clarify budget requirements over the implementation period
Determines cost sharing arrangements for each option and the overall preferred response	To ensure that supportive institutional arrangements and responsibilities are set up to implement options
Plans an education and communication campaign	To improve participation during implementation To ensure communication with stakeholders and community about the implementation process
Includes actions to facilitate the necessary culture change and public acceptability	To make sure strategies that facilitate changing habits and adjusting to new ways are included as a part of the implementation process
Plans the monitoring and evaluation procedure	To ensure evaluation is clearly identified as part of the implementation planning process and is planned and budgeted to inform decisions
(b) Undertake pilot program	
Conducts pilots of options	To ascertain the costs and logistics of implementation of options whilst also filling important knowledge gaps To avoid wasting resources through an uninformed implementation process To ensure an effective implementation process
(c) Implement full program	
Stakeholders participate according to agreed responsibilities	To ensure various aspects of the whole program are delivered as planned, lost opportunities in terms of savings are minimized and activities are undertaken by those with appropriate skills and authority.

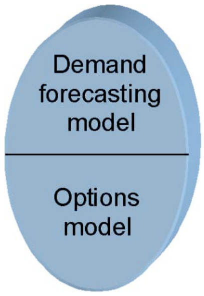
Criteria	Relevant objective(s)
Coordinates implementation activities with one another	To ensure effective implementation and minimization of wastage of resources in terms of expenditure and staff time.
Provides necessary staff training	To ensure that the identified activities are carried out to an agreed satisfactory standard. To ensure staff are comfortable with the new responsibilities and skills which accompany demand management programs
Utilises water efficiency and other equipment of satisfactory quality	To ensure participants in individual programs obtain the same level of service from the replacement equipment to minimize dissatisfaction.
Engages public and target groups in program	To ensure the program is effectively being implemented to achieve the required goals
Conducts monitoring and evaluation in parallel with implementation process	To ensure that the appropriate data is collected according to the monitoring and evaluation plans

4.7 Criteria for "Step 5: Monitor, evaluate and review"



Criteria	Relevant objective(s)
(a) Monitor and evaluate individual programs	
Assesses individual program processes	To ensure activities take place according to plans To help determine the effectiveness of the implementation process used. To enable learning about aspects that worked well and those that didn't To enable reflection and adaptive management.
Assesses individual program outcomes	To track outcomes of individual programs for residential sectors (participation rates, water savings, total costs and unit costs, level of customer satisfaction) and non-residential sector (water savings, costs, level of participation)
Assesses customer views on the individual implemented programs	To give insight to the rates of adoption, satisfaction levels and behaviour changes associated with options implemented and reasons behind these.
(b) Evaluate full program against goals	
Examine the results of the full suite of programs (implemented response) against the agreed goals	To determine on-going progress of the response against the goals (i.e. water savings, costs and participation rates) and enable adaptive management. To compare different individual programs in terms of their advantages and disadvantages To provide learning for future iterations of the planning process and refinement of programs.
Compares cost-effectiveness of individual options with one another	To determine the most cost-effective options for future programs
(c) Review the overall IRP process	
Assesses the 5 Step IRP planning process	To identify those processes which have worked well and those that have not To provide input into future iterations of the planning process.

4.8 Criteria for "Demand forecasting model/Options model"



Criteria	Relevant objective(s)
Designed to have a robust structure and model architecture	To enable other users to modify various parameters in the model as required without the model 'collapsing' or becoming inoperable.
Maintains transparency of data/ assumptions/ calculation processes in analysis	To enable other users of the model to understand the basis for its outputs.
Enables or restricts access according to need	To enable other users (other than modeler) to modify the model and associated parameters at an appropriate level to assist in model revision control
Has a user-friendly interface to the model	To enable modelers, planners (etc) to readily use the model as appropriate to make modifications where necessary as new data becomes available, generate new options and obtain outputs to assist in decision making.
Allows model to be calibrated	To increase accuracy of model on an ongoing basis and check the forecasts are reflecting metered readings.
Allows model to be linked to other planning tools	To enable easy transition of data and information making the models more useful in terms of planning tools which minimise the need for data manipulation.

4.9 Criteria for "Data/Information"

Criteria	Relevant objective(s)
Maximises data quality according to need and within resource constraints	To ensure the level of data quality and accuracy is matched with the level of detail required (e.g. strategic versus detailed design level analysis). To balance reliability and level of detail with costs of collection.
Coordinates data collection to fulfill multiple purposes	To ensure data collection is planned and useful as input to model, informs analysis, assist in decisions and answers priority information gaps. Maximises the benefit of collecting data using a specific method.
Maximises use of existing reliable data sources	To ensure relevant available and applicable primary and secondary data is used in preference to more expensive additional primary data collection.
Matches data collection method with required data quality	To ensure resources and time to collect data are invested appropriately, To ensure method of collection matches need To ensure low cost methods are considered first to supplement existing knowledge.
Utilizes actual data rather than theoretical data (where available and practical)	To maximise accuracy of outputs of modeling demand and/or water savings.
Uses time series data appropriately	To take into account that water use behaviour may fluctuate with seasons and other external factors (e.g. weather, restrictions).
Utilises representative data sets	To ensure data used is a representative sample and reflects the larger sample being modeled.
Includes a communication strategy	To ensure effective participation, cooperation and accurate information. To conduct the data collection process in an ethical manner.
Stores data and information in a centralised form	To ensure that existing data/information is readily available to those who need it To ensure consistency of data source To facilitate interaction between data and models

5 BENCHMARKING CASE STUDY

Canal de Isabel II was used as a case study to test the framework and criteria developed and determine how a benchmarking exercise might be undertaken. The full details of this benchmarking are confidential and are therefore provided in a separate report for CYII.

Whilst the benchmarking results for this particular case study are not available the way in which the benchmarking exercise was conducted and the sort of insights that stand to be gained through such a benchmarking exercise are available.

Overall, the criteria proved to be a very useful tool to analyse the activities of CYII and therefore will be useful for other utilities to analyse their own activities and processes and guiding them in attaining best practice in this area.

Mapping of CYII's activities against the overall IDMF process steps allowed CYII and the study team to take an overview of their activities as a whole. Through this, it was possible to see where and how CYII has invested significant effort and resources to date, and where certain areas need more effort and resources to provide a consistent and appropriate level of water management and planning based on the IDMF process. Since the planning process only makes sense if completed in its entirety, this exercise is useful in guiding where and how a utility should direct its efforts in the future to move towards a best practice approach.

Detailed analysis of interview material and CYII's internal and external publications against the criteria demonstrated areas of strength, and gave insight to how and where actions could be refined to move towards a best practice approach. Using the criteria and examples of best practice it was possible to go into detail in each step and provide specific recommendations that would help CYII improve their current practices.

Hence the benchmarking exercise has provided CYII with both an overview of where they need to concentrate in the future to ensure they conduct all five steps of the process but also at a more detailed level how they can improve for example specific processes and analysis methods. The summarised recommendations will enable CYII to move towards best practice and gain economic, social and environmental benefits by using the IDMF process for their water planning and management in the future.

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APPENDICES

APPENDIX A – IDMF TERMS OF REFERENCE

International Water Association
Specialist Group – Efficient Operation and Management
Task Force No. 7 – International Demand Management Framework

Terms of Reference (Draft – Rev 4)

Introduction

This document sets out the terms of reference for the IWA project '***The International Demand Management Framework***' (IDMF) being co-ordinated by the IWA Specialist Group - Efficient Operation and Management.

The Project

The project is to develop an international water demand management framework for water demand forecasting (using end use analysis[1]), options analysis[2] (using Integrated Resource Planning[3]) and evaluation[4] of demand management programs. The IDMF (or clear set of step by step guidelines) will be designed for a broad audience (urban water supply and resource management agencies) in the developed world, emerging economies and developing countries. It will be based on best practice applications and a comprehensive benchmarking of methodologies and practice. The IDMF will enable agencies to focus on service needs rather than the supply side options, improve asset management and planning, reduce capital and operating costs of providing water and sanitation services and make more informed decisions based on the economic, social and environmental benefits of water service provision options from a whole of society[5] perspective. Given the high costs of achieving the Millennium Development Goals, these issues will become increasingly important in the developing country context. The output of the IDMF project will be a widely accessible manual in the form of a CD and/or webpage with appropriate links to existing information and tools.

The Need

At the *End Uses and Demand Forecasting* Workshop held at Efficient 2003[6], a need was identified for the development of a consistent framework (or guidelines) for urban water demand forecasting,

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[1] End use analysis involves the disaggregation of water demand into customer sectors (e.g. single and multi residential dwellings, commercial/industrial properties, institutional properties and unaccounted for water/leakage) and further into individual end uses (e.g. toilets, showers, baths, taps and washing machines, garden irrigation and pools). Breaking water demand down into such detail assists in providing a clearer picture of historical, current and future water demand.

[2] Options analysis refers to the design and assessment (economic and sustainability) of options that satisfy water related needs, through demand management, leakage reduction, reuse and new sources.

[3] Integrated resource planning (IRP) is a process whereby, for example, a water service provider determines a range of options that provide water related services at the lowest economic, environmental and social costs. It enables supply options and demand management options to be assessed on an equivalent basis. This process recognises that customers do not necessarily want more water, rather they want the services that water provides (such as aesthetically pleasing landscapes, sanitation and clean clothes). The process aims to investigate the whole of society costs and benefits to highlight the most economically, environmentally and socially appropriate solution.

[4] Evaluation refers to measurement of water savings and costs from demand management programs implemented.

[5] Whole of society perspective provides consistent boundaries for options analysis for example taking into consideration the capital and operating costs from both the utility and customer perspective to ensure the full costs to society are considered.

[6] Efficient 2003 (held in Tenerife, Spain in April 2003) was the second International Conference on Efficient Use and Management of Water in Urban Areas organised by the IWA Specialist Group on Efficient Operation and Maintenance.

options analysis and evaluation of demand management programs. This need was identified as only a limited number of countries and organisations are currently aware of and applying such approaches. Development of a set of guidelines would allow a consistent international methodology and terminology, effective knowledge transfer of the latest research and skills, capacity building in developing countries and increase IWA support to its members.

Task Force No.7

The IWA and representatives of a number of other leading demand management organisations such as the California Urban Water Conservation Council (CUWCC) and the UK Environment Agency National Water Demand Management Centre (NWDMC) have supported the need for the development of the IDMF. Hence at the 4th IWA World Water Congress and Exhibition held in Marrakech in September 2004, the IWA Specialist Group – Efficient Operation and Management, established: **Task Force No. 7 – International Demand Management Framework** to take responsibility for development of the IDMF.

Roles and Responsibilities

To ensure the project reflects an international perspective and a set of guidelines that can be applied by a diverse range of stakeholders in addition to delivering a quality product on time and within budget, clear lines of responsibility have been defined for those involved in the Task Force as indicated in Appendix A. Unlike many other task forces developed by the IWA, this project is using core funding provided by a number of individual organisations interested in the project and the advancement of demand management internationally. This core funding is to ensure the bulk of the project is completed by a dedicated identified team rather than relying on ad hoc voluntary participation by IWA members which has proven to be problematic in terms of achieving deadlines in past projects. The dedicated team will consist of international researchers and practitioners who have extensive experience in all aspects of the key content areas that make up the IDMF. Members of the dedicated team, who will provide significant input at various stages of the project, will be individuals from the Working Group. Researchers from the Institute for Sustainable Futures, Sydney, Australia, who have been involved in the project development since the need was first identified in April 2003, will co-ordinate and play a primary role in the research.

Project Objectives

The key objectives of the project are:

- to develop a widely applicable consistent framework (or set of guidelines) for urban water demand forecasting (using end use analysis), options analysis (using IRP), implementation and evaluation of programs;
- to share existing knowledge on the key content areas of the IDMF:
- advance international research in an efficient manner; and
- to further engage IWA members and other stakeholders not currently actively involved in demand management, specifically individuals and organisations outside the USA, Australia and Northern & Western Europe.

Project Output

The key outputs of the project will include:

- A set of well designed guidelines (utilising best practice methodologies) to enable utilities and practitioners to collect and analyse end use data, accurately forecast demand (using an end use approach), analyse options (using a consistent IRP framework), implement and evaluate programs ultimately providing reliable methods to analyse choices for delivering reliable and secure water service provision within an identified planning horizon.

- A widely accessible detailed manual with case studies providing examples of application of the various key components of the IDMF, which will be in the form of a CD and/or webpage with appropriate links to associated information and tools.

- An active network of IWA members interested in advancing and sharing information on demand management who will be able to communicate more effectively due to a shared common understanding and use of consistent terminology.

A number of organisations listed in Appendix A will provide a contribution to core funding and case studies. These specific organisations will receive outputs specific to their needs but which test aspects of the IDMF process and ultimately contribute to the overall objectives of the IDMF project. For example:

- Canal de Isabel II, Madrid, Spain, will provide case study material for the project. Canal de Isabel II has been applying various aspects of the IDMF process, to ensure best practice water service provision in their region, for a number of years. The funding contribution provided by Canal de Isabel II will be used to gather core best practice literature on the various key components of the IDMF, develop criteria upon which to test whether a particular organisation is applying best practice international methodologies, benchmark Canal de Isabel II against those criteria and provide advice on where Canal de Isabel II can potentially make improvements. Hence Canal de Isabel II will receive a direct benefit from its funding contribution but this will also directly benefit the broader IDMF project (i.e. preliminary literature review and criteria establishment to determine/identify best practice methodologies/approaches).

- Subject to availability of multilateral agency support, the National Water Supply and Drainage Board (NWSDB), Colombo, Sri Lanka, have also expressed interest in becoming a case study for the project and this will test the overall application of the IDMF process from the perspective of a developing country. As such NWSDB will receive direct assistance in applying the IDMF process to its region (i.e. a detailed water demand forecast and suite of options that can be utilised to determine how to best provide water services over an agreed planning horizon). The case study will be incorporated into the Manual to show a practical application of the IDMF principles.

The specific outputs for each contributor will be negotiated on a case-by-case basis to ensure both the contributor and the overall IDMF project benefit from the collaboration.

Project Scope

The IDMF will include the following content areas:

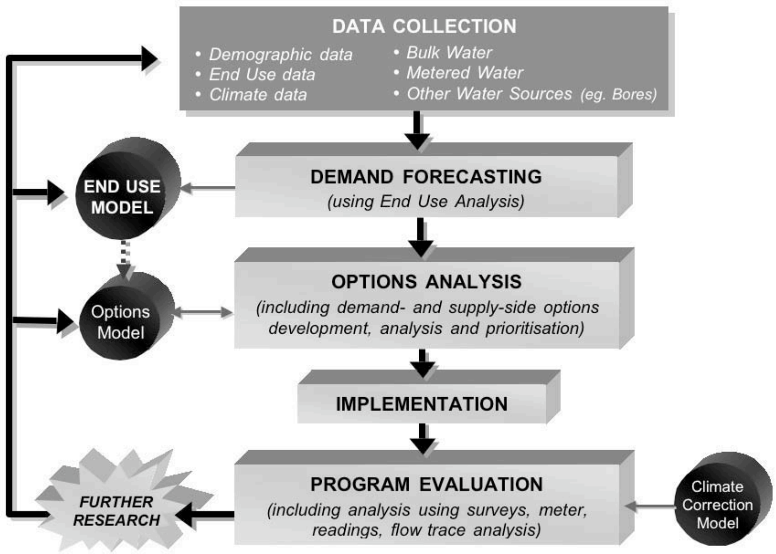
- Water end use data collection;
- Demand forecasting using end use analysis and modelling;
- Options analysis (using IRP);
- Evaluation of externalities and the use of participatory decision making methods for values assessment, objective setting and implementation;
- Implementation issues;
- Evaluation of implemented demand management programs; and
- Research/data gap assessment

Figure 1 shows how each of the key content areas fit within the framework.

Project Methodology and Expected Results

This project will take a participatory approach. Representatives from the IWA (the Efficient Operation and Management Specialist Group Chairman, Francisco Cubillo) and the Institute for Sustainable Futures (Institute Director, Professor Stuart White) will represent the 'Management Team' who will effectively drive the project, co-ordinate input from various individuals, moderate expenditure and ensure project timing, deliverables and quality. The Institute, as part of the Management Team, will provide core research input. However, due to the International nature of the project and goal of achieving a Framework that achieves best practice, significant input will be required from various individuals/organisations within the Task Force 'Working Group'. These individuals/organisations will provide paid or in-kind support depending on their funding requirements. Members of both the overall 'Working Group' and 'Reference Group' will be required to provide input throughout the project in the form of primary literature, case study materials, expert advice and review assistance. The project will take the form of an 'action research project', that is, findings from one stage may influence the methodology and output of the later stages to better meet the objectives of the project.

Figure 1 International Demand Management Framework (The process)



The major stages will be:

Stage 1: Preliminary literature review and criteria setting

This stage will involve gathering the core international literature including not only research papers but other key resource materials such as project reports related to the key topic areas of the IDMF process, shown in Figure 1. These international references will be gathered and reviewed with the assistance of individuals within the Working Group who have extensive knowledge and experience in various aspects of the IDMF process. Having gathered and reviewed the core literature, criteria will be developed to determine what can be considered best practice in each of the key IDMF topic areas. The Institute has worked in all the key IDMF topic areas and thus already has extensive knowledge on which methodologies represent best practice for example in terms of economic analysis and program evaluation. As such, the setting of criteria and the work associated with the development of the IDMF will be starting from a solid knowledge foundation and draft IDMF outline. The input from the Working Group at this stage (obtained through the use of structured interviews) will be to assess whether the current first draft IDMF outline is considered best practice internationally, is internationally applicable and covers all necessary topic areas.

Canal de Isabel II is providing the core funding for this stage of the project and as such will receive a specific output, as highlighted in the 'Project Output' section. Canal de Isabel II will provide case study material on how it is currently implementing the various aspects of the IDMF process (e.g. collection and analysis of end use data, forecasting demand, assessing demand management options against supply options). This material, gathered through structured interviews and collection of reports/information, will be reviewed against the criteria set for each of the key IDMF topic areas. This will enable testing of the criteria developed against a ‘real’ water service provider and enable Canal de Isabel II to benchmark itself against what is considered best practice in each of the key IDMF topic areas. This will assist the organisation to determine how it might improve its current approach to the core components of the IDMF process.

A report providing the results of the preliminary literature review, best practice criteria, the draft IDMF process outline and the benchmarking process of Canal de Isabel II against those criteria as a case study will be the output of Stage 1. The results of such benchmarking and the release of data/information concerning similar individual case studies will be released following approval by the case study participant.

Stage 2: International literature review and scoping study.

This stage will involve a more detailed literature review, desktop study and comprehensive reporting of existing and current international research, publications and water industry experience in the key topic areas of the IDMF process. There is a significant amount of literature internationally on the subject of demand management and related topics, however this literature is not exhaustive, consistent, widely applicable or accessible. Much of it has not been peer reviewed for clarity, methodology, analysis and conclusions. The outputs of this stage would be a literature review report, initial findings from a needs/gap analysis and a more detailed plan and further recommendations for undertaking Stages 3 and 4 of the project. A second draft of the Framework and proposed outline of the Manual will also be developed at this stage.

The timing of Stage 2 will be dependent on funding. To ensure all relevant literature is collected and that the leading demand management experts and organizations are involved in the project at an early stage to provide appropriate input, the Task Force members (i.e. the Management Team and Working Group) will assist in collating relevant material and providing advice on which additional experts in the field should be approached. This will be undertaken through structured interviews/surveys to ensure a systematic and transparent process. Additional experts and potential case study representatives will be requested to join either the Working Group or Reference Group depending on the potential for their level of involvement.

In addition to the more detailed literature review, this Stage will include a needs/gap analysis defining areas in need of more transparent methodologies, further research and case studies to test approaches (for example in different socio-economic regions). The review and analysis will allow the key topic areas of the IDMF process to be further expanded and enable a more detailed scope of Stages 3 and 4 to be developed. A draft report (s) on the literature review, needs/gap analysis, second draft IDMF outline, associated Manual outline and proposed scope of work for Stages 3 and 4 will be provided to the Working Group for review and further input. The comments from the Working Group will then be incorporated into a second draft report. Particular areas of the report are likely to require specialist input from Working Group members during the development of the second draft report, which will then be released to the broader Working Group and Reference Group for final comments. Following further incorporation of the comments the Final Report (s) will be released as the output of Stage 2.

Stage 3: Case Studies.

This will include trialling the application and use of the draft framework in different regional contexts. As detailed in ‘Project Output’ it is proposed that the National Water Supply and Drainage Board, Colombo, Sri Lanka, will be one such case study, along with an emerging economy and a developed country city. The outcomes of the case studies will assist in informing and further refining the draft Framework (e.g. with the level of data available in a specific region what level of end use model can realistically be developed to forecast water demand and what forms of low cost data collection can be used to refine inputs to such a model). The number, depth and timing of case studies will be dependent on opportunities and funding of each individual case study. The deliverables for the individual case study funders will be dependent on specific needs but will generally provide a direct benefit to the case study region. For example, for Colombo a forecast of water demand and development of a suite of demand management options that can assist in achieving low cost water service provision over an agreed planning horizon. As such each case study will have a direct benefit to the funder, region and the overall IDMF project (i.e. inform the IDMF project and the report prepared on the case study will be included in the IDMF Manual deliverables). Funding for case studies will be sought on a case-by-case basis. The case studies will need to be run, as far as possible, before or in parallel with Stage 4 (Develop Framework & Manual) to ensure the case studies inform Stage 4.

Stage 4: Develop Framework & Manual.

The second draft of the Framework and associated Manual outline developed and reviewed as part of Stage 2 will form the basis of the work to be undertaken in Stage 4 and will be further informed by the case studies carried out as part of Stage 3. The agreed Framework will effectively form a series of chapters in the Manual covering the following (and potentially additional) core topic areas:

- ***Water end use data collection***. Details on what kind of data is important and needs to be collected to enable accurate water demand forecasting and detailed options development (i.e. demographics, land use, types of end use, appliance stock information, bulk water production meter readings, customer water meter readings, additional sources of water, climate variables). Details on sources of such information and data collection methods.

- ***Water end use analysis and demand forecasting***. Details on how demand forecasting can be undertaken and the approach of end use analysis which considers demand by sector, individual end uses and how those end use volumes are made up of a combination of appliance stock, proportions of efficient and non-efficient stock, how these change over time, flow rates of each type of stock, usage patterns (i.e. human behaviour) and the effects of demographics over time etc.

- ***End use model/option models***. An outline of the structure and function of an end use model in which the data collected is used to develop a detailed water demand forecast for a specific region and an options model in which the water conservation potential of a specific region can be ascertained and a series of options developed for demand management, source substitution, reuse and supply options. The options model therefore enabling the options developed to be compared on an equal basis (using a consistent boundary and assumptions) for the particular driver affecting that region (e.g. need to defer supply augmentation, specified demand management target). The combined end use model/options model ultimately providing a decision making tool for service water providers. The use of case studies will test the level of modelling detail necessary and data collection appropriate and provide 'real' examples to fully engage the reader of the Manual.

- ***Options development and analysis***. Details on the types of demand management, source substitution and reuse options that can be developed. Details on the yield/cost/timing of options, economic and financial analysis methods used and how the total cost perspective (water service provider, government, customer) needs to be used rather than a more narrow utility perspective. Discussion on consideration of who pays (out of the water service provider, government, customer) for each option considered, the use of unit cost to compare options using the same boundary and assumptions and calculation of other quantifiable costs/benefits (e.g. reductions in energy, green house gas, wastewater, stormwater runoff).

- **Participatory methods.** Guidelines and reference material for innovative deliberative and representative processes for the purpose of objective setting by utilities, and for determining citizen preferences with regard to strategic direction, dealing with constraints on the water supply and sanitation system and understanding willingness to accept and willingness to pay. These processes are also useful in the assessment of values, where there are limits to the ability of scientific assessment, or where there are contested views and interpretations.

- ***Sustainability assessment***. Identification and guidance on the various sustainability tools available and how participatory decision making methods can be incorporated to gain a better understanding of non quantifiable externalities, value assessment, objective setting and risk assessment.

- ***Demand management program implementation planning***. Details of the typical program teams and skills needed to, for example, implement a demand management program, develop and maintain an end use model/options model and undertake ongoing evaluation of programs to allow adaptive management. The Manual will include examples of typical Implementation and Budget Plans developed by water service providers.

- ***Implementation***. Description of how programs are implemented, typical agency arrangements, contractual arrangements, barriers to implementation and opportunities for streamlining programs. Suggestions on how to increase program uptake and examples of typical communication strategies that link directly to other program instruments (e.g. regulatory requirements and economic incentives).

- ***Program evaluation***. Details of methods of how to evaluate programs implemented using for example participant/control analysis and testing for statistical significance in savings. The details will include discussion on the importance of evaluating savings, costs and community satisfaction to enable adaptive management (i.e. build on success and learn from mistakes of the implementation of specific programs).

- ***Other models.*** Description of other models and the importance of linking these other models to the process (e.g. yield, climate change and climate correction models) and examples of where these models have been used.

- ***Research needs***. Discussion and examples will be presented on where research/gap analysis has been undertaken and which areas might be deemed to be of priority importance. Discussion on how this section effectively feeds back into the water end use data collection and other sections of the IDMF process thus enabling ongoing refinement of demand forecasting, options development and an understanding of water service provision in a specific region.

The Manual will be written for a broad audience and include examples of the application of the core topic areas from various countries and specifically the case studies. The Manual will aim to be a step-by-step guide on how to undertake the IDMF process for various geographical and socio-economic regions. As such the Manual will assist those familiar and unfamiliar with the concepts identified.

In order to write the Manual various individuals/organizations from the Working Group will be requested to contribute to individual chapters of the first draft of the Manual, related to their specialist area. This completed first draft will then be circulated to the broader Working Group for review and comment. Comments will be obtained using structured interviews/surveys to enable a transparent and co-ordinated review process. Comments will be incorporated into the second draft Manual, which will include further description of case studies. This second draft will be circulated to both the Working Group and the Reference Group for further review and input as required, again using structured interview/surveys where possible. Final comments will be incorporated and the Manual finalised ready for the production phase.

Stage 5: Outputs and Production. During the development of the Manual consideration of the most appropriate outputs and tools will be considered to enable smooth transfer to the Stage 5 Production. The scope of Stage 5 will be developed during Stage 4 as the IDMF process and Manual are developed and finalised. Typical outputs are likely to be the Manual and associated tools such as an end use model[7] and database providing useful reference materials and website links collated during the development of the IDMF. The Manual and potential end use model will be available in hard copy format and via a website, which will also enable access to the associated database. The Manual, end use model and database will be developed in such a way as to enable ongoing improvements and updated versions to be released. It is envisaged that the IWA will take responsibility for the production of the Manual, set-up of the database, release of the Manual and end use model and subsequent release of updated materials. It is also envisaged that the Working Group and Reference Group would be maintained for a number of years to assist in any training required, updating the Manual (i.e. new case study materials) and maintaining an active 'Users Group' for ongoing co-ordination of knowledge transfer. Details of this stage will be scoped during Stage 4.

[7] A number of end use models are currently available. It is envisaged that a suitable end use model will become a tool for the Manual.

APPENDIX B – DETAILED BEST PRACTICE CRITERIA

The following table lists the best practice criteria identified for different steps in the IDMF process, and expands these with examples of how such criteria might be satisfied by processes carried out either at:

- a strategic or first-pass level (where few resources are invested in the process) OR
- a detailed level (where significant resources are invested, detailed analysis is possible and a larger group of stakeholders are involved in the process).

The reason behind indicating these two differing levels of application of the criteria is to account for dealing with different contexts and purposes internationally. In many cases it will make sense to initially conduct a first pass through the process without developing detailed models etc. Or indeed the resources to do anything more than this might not be available. Hence the value of the "first-pass level". In other cases, with dedicated resources, or some previous work conducted in this area, the detailed level processes will likely need to be carried out.

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
Overall process				
	Includes all steps in a logical sequence	To ensure integrity of the approach	As a minimum, carries out all the steps in a simple form.	Conducts each step to the greatest depth possible.
	Uses a depth of analysis that is fit for purpose	To avoid unwise investment in particular steps	Use of resources invested in different steps is decided explicitly rather than by default	Gives consideration to the value of investing more in particular steps by having undertaken research/gap analysis that clearly identifies the benefit of the outcome of the additional resource investment.
	Treats demand, source substitution and supply options equally	To promote equal consideration of all the possibilities/options that might improve the supply-demand balance. To ensure consistent comparison of all options.	As a minimum, considers both supply and demand management options alongside one another. Uses the same boundaries and assumptions and assesses options against a common set of objectives or goals.	Also considers source substitution options at various scales (e.g. large scale, community scale and household scale) alongside supply and demand management options.
	Is used iteratively and reflectively	To adjust to inevitable change To ensure the process and outcomes are refined through increased knowledge.	As a minimum, conducts a first pass through all steps and reflects on each of these.	Feeds detailed monitoring and evaluation information back appropriately into various steps of the planning process.
	Maximizes inclusiveness	To ensure representation of different perspectives To improve acceptance of the planning process and ownership of its outcomes To assist in enabling a common vision	Includes various departments within for example a water service provider undertaking the process (e.g. water supply strategic/operational depts, demand management, sewerage, stormwater) using as a minimum consultation of some sort	Includes, in addition: Regulatory agency, environmental agency, land use planning agency, community representatives etc. Identifies a core steering group with consistent members to maximize ease of process application.

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Encourages deliberative decision-making	To maximize meaningful engagement by stakeholders	Provides information to stakeholders prior to meeting and encourages open discussion about different perspectives.	Uses well-designed and prepared deliberative group processes such as backcasting (defining a desirable future state and from this identifying a plan to move towards it), visioning and consensus building.
	Maximises transparency	To allow various stakeholders to engage with the process and its outcomes To give legitimacy to the outcomes	Makes the process followed and underlying assumptions made explicit at all steps. Stakeholders can then critique the process, identify where improvements can be made or omissions addressed.	In addition, provides formal mechanisms for communication of progress through the process to appropriate stakeholders and incorporation of their feedback.
	Identifies level of uncertainty at each step	To assess the implications of the quality of data used To acknowledge the limits of the analysis undertaken To make level of uncertainty explicit to stakeholders and decision-makers so it may be managed To guide further data collection	Makes explicit the level of uncertainty qualitatively at each step.	Uses quantitative measures (error bars, levels of significance etc) as far as possible to define levels of uncertainty. Carries these uncertainties from step to step through the process and analysis.
1 - Plan the overall process				
	Clearly defines all steps in process to be followed	To facilitate action on an agreed vision To define appropriate level of detail for each step	As a minimum, plans at a high level, the full process and defines an associated timeline.	In addition, defines the circle of control, influence and concern and uses this to define the useful level of detail of particular steps. Also plans the scope of each step, resources to be invested, breadth of analysis to be conducted, data collection to be undertaken.
	Clearly defines stakeholder roles in process	To delegate responsibilities appropriately To ensure clarity on roles and responsibilities	Defines roles of a core group of participants in the process.	Defines roles of the larger group of participants in the process in collaboration with these parties.
	Matches defined process with available resources and skills	To ensure process can proceed as planned.	Identifies the available resources (monetary, people and data) to carry out the planning process and assesses what this means for definition of the planning process Specifically takes into account the necessary skills to accomplish this process (which includes skills in the social dimension as well as the technical) and existing skills and the extent to which these match.	Considers resource constraints, searches for ways to overcome these where they are likely to hinder the process. Examines ways to improve and diversify the skill-base such that all aspects of the process may be completed well.
	Determines general goals and scope	To define focus as being on the whole supply-demand balance or limited to demand management To define "system boundaries" to be used		

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Maximises inclusiveness	To ensure representation of different perspectives To improve acceptance of the planning process and ownership of its outcomes To assist in enabling a common vision	Includes as a minimum, all departments associated with different parts of the water cycle and regulatory agencies.	Includes as wide a range of stakeholders as possible that influence or are influenced by water service provision such as planning departments, community and environmental agencies and organizations.
	Encourages deliberative decision-making	To maximize meaningful engagement by stakeholders	Provides information to stakeholders prior to meeting to enable engagement and open discussion about different perspectives.	Uses well-designed and prepared deliberative group processes such as backcasting, visioning and consensus building.
	Assesses skill requirements and staff training needs	To ensure that staff are capable of the tasks that this process will require of them. To ensure attention is given to the many new skills which the IRP process entails (specifically, many social based skills versus technical skills are required)	Provides a minimum level of training to key staff members involved in planning and implementation of demand management options.	Train and retain specifically skilled demand management staff. Provide on-going professional development and training opportunities to this team to ensure their retention in their position and a high level of performance.
2 - Analyse the situation				
2(a) - Identify issues, risks and opportunities				
	Defines clear system boundaries	To clarify geographic region of interest To clarify systems of interest (water supply, wastewater, stormwater, energy etc)	Follows a pragmatic process to decide whether anything more than the water supply and distribution system for a particular population needs to be included.	Determines the system boundaries according to the context, the specific risks faced and the available resources to conduct the planning process.
	Investigates current water supply system characteristics	To determine system constraints To determine system costs	Documents details of current system characteristics (e.g. capital and operating costs, pipeline distribution system, treatment plants, pump stations, losses, pressure, current system constraints).	Also documents other systems where necessary, for example any constraints in the wastewater system.
	Identifies major sector water usage	To identify over-riding issues of concern in one or more sectors	Identifies system water usage (e.g. bulk water demand, customer metered demand by sector – residential, non residential, unaccounted for water/non revenue water) both historical and current. Uses this information to determine major sector usage, peak water usage, sewerage etc.	Considers in more detail the history and possible influences on demand and supply at different times to gain greater depth of understanding. Includes consideration of how particular end use appliances may affect demand in the future (e.g. areas where pour flush toilets are prevalent moving towards large single flush volume toilets and new properties installing inefficient water cooling systems).
	Investigates current and future demographics	To determine likely effects of population on water demand	Documents demographics (e.g. population, household types, occupancy ratios) and effects of tourism. Documents existing planning initiatives (e.g. urban consolidation, new	Considers in more detail various possible future population scenarios.

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
			subdivisions, non residential growth)	
	Analyses scenarios that describe the likely risks to the demand-supply balance	To directly consider the possible effects of scenarios such as climate change, economic growth etc. To promote a risk management approach	As a minimum, considers scenarios of: • Different levels of risk and reliability • Upper and lower scenarios about a chosen dry year • Climate change	Considers the impact on the supply-demand balance of variations in for example: risk and which stakeholders bear the risk; reliability; drought; security; climate change; economic growth; demographic change; equity; level of service; political environment; and changes in international policy. Such scenarios need to be well-defined to be useful, and their probability and consequence considered
	Engages informed stakeholders to decide on initial planning objectives	To guide the subsequent supply-demand balance analysis To ensure a common understanding between stakeholders supported by the joint consideration of information gathered. To avoid jumping to conclusions about "perceived" rather than "real" issues	Stakeholders are provided with documented information gathered. An initial short term goal is identified. For example, this might be to keep the existing supply arrangement and set a target to reduce average water demand by 20% in 5 years. Equally, in a developing country where there is rapidly increasing per capita income that will lead to increased water use in the future, a goal would be set to reduce the rate of increase in per capita water use.	Defines initial short and long term goals for a range of issues (e.g. average water, demand, peak water demand, sewerage flows, environmental flow release, nutrient reduction in rivers, energy usage, greenhouse gas emissions, increased employment)
2(b) - Determine supply-demand balance				
	Analyses historical and current water demand	To understand how water is used in more depth and external factors that affect water usage.	Investigates any previous restrictions, regulations, pricing changes, water efficiency or source substitution initiatives that may have occurred that affect historical water demand. Uses a sector based approach. If meters are available, then as a minimum undertakes detailed sector based analysis that: • divides historical water demand into residential, non residential and NRW sectors • determines water demand (per household and per person) based how household numbers have changed and how occupancy in each household type has also changed • determines non-residential per property demand based on non residential property numbers (in sub sectors such as commercial, industrial, institutional if possible) and changes over time	In addition, includes in the analysis a more detailed end use based approach: • Disaggregation into individual end uses at least within residential sector and if possible commercial, industrial and institutional sectors (e.g. water using equipment, appliance stock and sales, usage practices). • More detailed understanding of factors affecting demand (e.g. land use change, lot/plot size change for the outdoor water component, economic factors that may have affected commercial properties, tourism, effects of housing age, behaviour of social groups and age).

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
			determines real losses per connection (using IWA standard methodology) and real losses in the network (ILI (Infrastructure Leakage Index)) • and how this has changed over time. • considers how other factors (e.g. lot size, existing efficiency initiatives, restrictions, source substitution, pressure, climate have affected historical demand). Where meters are not available: • Uses a sampling approach (e.g. as done in UK) to investigate characteristics of different sector's water demand using a representative sample size.	
	Forecasts water demand based on disaggregated demand trends	To establish a demand forecast 'reference case' or 'business as usual' case.	As a minimum makes demand forecasts using a sector based approach based on historical demand analysis and ensuring minimal factors affecting demand (e.g. population growth, shift in household type, occupancy ratio, numbers of non residential properties) are taken into consideration in forecasting individual sectors. Clarifies the 'reference case' demand which enables an appreciation of when supply augmentation may be required.	Uses an end use based approach where: • Changes in appliance stock X usage patterns X technology efficiency levels are used to determine change in water use over time (historical, current, future). • A regional end use model is built to facilitate detailed demand forecasting including the use of stock models to assist in clarifying how the stock and efficiency of various end uses (e.g. toilets, showers, washing machines) affects demand over time. • The model is calibrated where possible (e.g. bottom up approach of end use analysis is checked against sector metered consumption and bulk water demand). • Demand forecasts include quantified ('what if") sensitivity and risk analysis including confidence intervals
	Exposes stakeholders to the data, assumptions and method of demand analysis	To enable stakeholders to see, critique and modify the analysis	As a minimum, spreadsheets are set up to enable assumptions to be modified easily (e.g. population projections) and analysis is clearly set out to enable its communication and modification in the future.	In addition: • assumptions are clearly stated and referenced • analysis is set up to enable linkage with for example customer meter data base to facilitate ongoing analysis and updating of the end use demand forecasting model developed and recalibration.

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Defines appropriate level of contingency (headroom) in the supply-demand balance	To enable management of potential risks and changes that will affect either demand or supply.	As a minimum, considers the risk scenarios from Step 2a and determines their likely affect on supply and demand. Analyse this information in the context of required water supply reliability goals.	Conducts detailed sensitivity analysis of supply and demand to determine the uncertainty associated with each.
2(c) - Reassess issues, risks, and opportunities				
	Prioritises issues, risks and opportunities	To utilise supply-demand balance to inform the next stages of the planning process	Having obtained a more detailed picture of the local context and it's specific issues and opportunities the main issues requiring attention are prioritised, discussed and agreed between stakeholders.	Includes a larger group of stakeholders in the prioritization process and a clearly defined process for engagement with the information supplied about the supply-demand balance.
2(d) - Set goals				
	Clearly defines goals to be met	To engage stakeholders in deciding on a common set of goals To enable reflection later on as to the extent to which these goals have been met	Sets goals such as specific targets or other sorts of objectives. This assists in clarity of direction for the following steps of the process.	Includes a broader stakeholder group and specific participatory processes to ensure the community as a whole agree with and engage with the targets, objectives and process to be used in following steps.
3 - Develop the response				
3(a) – Frame the analysis				
	Clarifies an appropriate depth of analysis	To match the depth and complexity of the analysis with the need and the available resources.	Cost assessment only without incorporating full benefit or externality analysis of options	Full assessment of costs and benefits of options, consideration of externalities and possible use of participatory processes in the decision making process
	Determines the cost perspectives, cost elements and cost metric	To map out the proposed method by considering advantages and disadvantages of different approaches.	Includes as a minimum both economic (whole of society) and utility cost perspective. Cost elements are included according to a consistent time and spatial boundary. Cost metric might be annualised cost, a cost-benefit ratio or average incremental cost (considered best practice).	Cost elements included cover costs as well as avoided costs (benefits). Uses average incremental cost or levelised cost as the cost metric.
3(b) - Identify and design options				
	Considers the widest possible range of options and their respective water savings.	To avoid missing good opportunities of a broad range of options	Considers as a minimum: • all sectors such as residential (detached dwellings and flats), non residential (commercial, industrial, institutional) and UAW/NRW • major end uses such as toilets, showers, washing machines and cooling towers relevant to regional context Each option is defined as a measure (e.g. structural and/or behavioural aspects of water use).	Includes in addition, due to creation of end use based demand forecasting model, a more detailed assessment associated with specific additional sub sectors (hotels, hospitals laundries) and end uses such as taps and irrigation systems.

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Defines maximum conservation potential.	To ensure that the full conservation potential available is made explicit.	Considers as a minimum the full conservation potential and maximum potential participant uptake of major sectors and end uses.	Due to the use of an end use model approach consider the maximum conservation potential and maximum potential participant uptake of sectors, sub sectors and individual end uses over time (e.g. using stock models and considering behaviour change).
	Screens options by maximizing conservation potential.	To focus attention primarily on those options where the most water will likely be saved.	Identifies % contribution of each sector and major end use and the main measures to be considered in more detail.	Identifies with the aid of an end use model % contribution of each sector, sub sector and end use and the main measures to be considered in more detail.
	Defines best applicable instruments associated with each measure to form "options".	To increase the probability of achieving the desired outcome for a given measure(s)	As a minimum defines measure(s) and at least one associated instrument to form an individual option (economic incentives, communication and regulations).	Defines the most appropriate instruments associated with each measure(s) (i.e. minimum two instruments per measure assist in achieving water saving or water efficiency goals and increased participation rates) to form an option and relates the options to the local context (i.e. high population growth areas using regulatory measures to maximize conservation potential and participation rates and minimise cost).
	Gives particular consideration to "best management practice" and local applicability.	To build on existing experience in demand management options yet still consider the local context.	Gives priority to those options that have been proven to work well (i.e. save water and gain high participation rates) both locally and in other locations.	Collects information about other individual options and studies (through literature or interviews), especially those conducted in similar contexts and gives priority to those that have proved to work well but also allows innovative approaches to be developed relevant to a particular regional context (e.g. savings associated with evaporative air conditioners that may not be used in other locations).
	Identifies the total costs and savings of each designed option.	To ensure all costs are identified for each option, the associated savings and the potential for decay.	As a minimum determines: • the likely participant uptake, • calculates total costs (i.e. from the utility, government and customer perspective) of each option over the time period including capital, operating and project management costs. • consider the savings and any potential decay.	In addition uses an iterative process to refine options and determine how to increase potential uptake, reduce costs and increase savings including examining alternative/additional measures and instruments.
	Defines a suite of well considered individual options for further analysis	To ensure the suite of options are clearly defined for analysis in the next step (3b).	Options are defined in terms of measures, instruments, total costs, anticipated savings, potential decay, potential overlap in terms of savings with other options)	Consider the realm of control (e.g. for utility – leakage) and consider the potential barriers and opportunities for each option (e.g. regulatory framework, health issues, public perceptions).

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Conducts sensitivity analysis on each option	To acknowledge and assess the inherent uncertainty present in each option		Consider the potential range of participation rates, savings and costs for each option to assist in identifying potential risks and uncertainty of individual options.
3(c) - Analyse individual options				
	Conducts an economic analysis of each option based on total resource cost or societal cost	To make clear how various options differ with respect to cost when all costs (e.g. utility, government and customer) are considered To make sure that options are compared with the same costs, benefit and boundaries in mind.	Uses cost-effectiveness analysis as the method of economic analysis and utilises an appropriate metric to compare costs of options. Uses an appropriate discount rate to account for the changing value of money and water supplied over time.	Uses a metric to determine the costs and benefits of individual options in more depth and enable a more detailed comparison of options. For example levelised cost is an example of a best practice metric and is the present value of the stream of costs over a set period divided by the present value of the stream of water demand saved or supplied over the same period. By discounting both the costs and the water saved/supplied the metric reflects the value of both the money expended and the service provided (the water) and when it might be required in time.
	Analyses explicitly the different cost perspectives in the economic analysis	To identify the options with least overall cost to society To analyse the cash flow for the utility To facilitate allocation of costs fairly between stakeholders.	As a minimum, include the perspectives of utility, customer and total resource cost (utility plus customer).	Use 'cost tests', particularly the "whole of society" perspective which includes externalities not covered in the total resource cost. Also use the financial cost test for a utility and customers
	Includes avoided costs in the economic analysis	To enable equivalent treatment of demand and supply side opportunities.	For each cost perspective, defines the associated avoided costs.	Include avoided costs – these comprise those costs of supply that are not incurred when water is conserved (direct costs such as utility operating costs, costs of future augmentation and indirect costs such as customer energy cost savings from reduced hot water usage).
	Conducts a robust technical assessment of each option	To allow inclusion of non-quantifiable technical concerns in the decision-making process	As a minimum, considers the local availability of any required technology for an option and factors affecting its technical feasibility	Conducts a detailed analysis of similar interventions in the local situation (and from similar locations) and their level of uptake and success.
	Uses appropriate method for identifying social and political barriers and impacts for each option	To allow inclusion of non-quantifiable social effects in the decision-making process	As a minimum includes a participatory process including participants (beyond the group of option designers) to identify a range of social and political barriers, risks and potential impacts.	Considers equity effects of each option explicitly. Includes a larger range of stakeholders in the identification of barriers and impacts and considers the likelihood and consequence of each of these.
	Conducts an environmental impact	To allow inclusion of non-quantifiable environmental effects in the decision-	As a minimum, includes a participatory process that identifies likely environmental implications of each option.	Conducts both a detailed assessment of environmental impacts and risks and involves stakeholders in

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	assessment of each option	making process		deciding the likelihood and consequence of these different risks.
	Conducts a sensitivity analysis on the various analyses	To explicitly deal with risk and uncertainty	As a minimum, considers high and low costs and water savings volumes and high and low extremes in other variables.	Deals with the probability distribution for different costs and water savings volumes and other variables.
	Makes assumptions and intermediate results explicit in the various analyses	To ensure transparency of each of the analyses	As a minimum, all decision-making processes and their outcomes are documented.	In addition, notes clearly the uncertainties and inadequacies of the analysis.
	Uses a participatory process to consider the results of the economic, technical, social and environmental analyses	To deliberate on which options should be included in the subsequent step of grouping options.	Include other stakeholders (not just demand management option designers) to assess options to be considered in next steps.	Possible methods include: • Listing the attributes of each option using a large matrix format which is then discussed • Multi-criteria analysis (with some form of well designed participatory process to assist in determining weighting of criteria)
3(d) - Analyse grouped options and scenarios				
	Allocates options into groups that meet the goals set in step 2d over time.	To create sets of 'grouped options' for further analysis and comparison To take into account the time dimension of the supply-demand balance.		
	Initially considers "least-cost" groups using the present value of each group of options	To provide a base case against which the cost of risk-reduction can then be considered explicitly		
	Examines effects of most-likely risks/scenarios on groups of options	To gradually move from the "least-cost" group of options, to a group that is more flexible, diverse and reduces overall risk.		Includes risks and considerations such as drought, climate change, equity, hydrological risk etc.
	Performs a risk balancing exercise to determine optimal group of options	To balance risk within the group by choosing options that complement one another in terms of delivering savings under different scenarios.		Uses correlations between options to aid the risk-balancing exercise. For example two options that are both negatively affected by low rainfall will not help in the case of a drought, therefore the group of options must also contain options that will deliver savings under drought conditions.
	Optimises synergies, links and dependencies	To reduce costs of individual options, maximize water savings and optimise		

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	between options	implementation processes.		
	Uses a participatory process to deliberate on the required risk balancing and risk-cost trade-offs	To determine the preferred group of options for implementation	As a minimum includes a participatory process including participants (beyond the group of option designers) to determine the preferred response based on the analysis and previous decision making carried out during the process. Documents the participatory process and informs the public of the decisions made using a transparent consultation process.	Uses the broader stakeholder group in a well designed participatory decision making process (including public representatives) to determine the preferred response. Ensures that the decision-making process decisions are transparent, documented and accessible to the general public.
4 - Implement response				
4(a) - Plan implementation				
	Clearly identifies demand management team/staff	To ensure roles and responsibilities are clarified and agreed upon.		
	Thoroughly plans and documents the details of the implementation process	To ensure effective implementation	As a minimum plan and document: budget, staff requirements; sub-contractor arrangements and contracts; timing schedule; milestones; and contingency. Ensure that the staff are fully engaged with the process and outcomes required.	In addition: • Set up tools and database to assist in ongoing implementation of preferred response and evaluation of program • Conduct activities such as ongoing staff training and engagement.
	Develops a detailed budget plan	To clarify budget requirements over the implementation period.		
	Determines cost sharing arrangements for each option and the overall preferred response	To ensure that supportive institutional arrangements and responsibilities are set up to implement options	Ensures roles and responsibilities across institutions are clearly defined. These may differ significantly from supply-side institutional arrangements (e.g. regulations on water using equipment, council responsibilities for certification of new properties).	In addition, as many relevant stakeholders are part of the steering group and already informed and engaged in the option development, they will be sufficiently informed to commence detailed planning for their specific role.
	Plans an education and communication campaign	To improve participation during implementation To ensure communication with stakeholders and community about the implementation process	As a minimum includes aspects such as: community education campaign	In addition includes aspects such as: customer surveys, media, public presentations and seminars, informative water bills, school education, show case gardens, customer advisory services (web, call centre).
	Includes actions to facilitate the necessary culture change and public acceptability	To make sure strategies that facilitate changing habits and adjusting to new ways are included as a part of the implementation process		

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	Plans the monitoring and evaluation procedure	To ensure evaluation is clearly identified as part of the implementation planning process and is planned and budgeted to inform decisions	As a minimum budget is allocated each year to enable overall evaluation of the program to determine customer satisfaction and savings obtained.	In addition, budgets and schedules monitoring and evaluation process to enable ongoing tracking of participation, savings, costs etc. and ensures that data collection methods are tailored to assist the evaluation process.
4(b) – Undertake pilot program				
	Conducts pilots of options	To ascertain the costs and logistics of implementation of options whilst also filling important knowledge gaps To avoid wasting resources through an uninformed implementation process To ensure an effective implementation process		
4(c) - Implement full program				
	Stakeholders participate according to agreed responsibilities	To ensure various aspects of the whole program are delivered as planned, lost opportunities in terms of savings are minimized and activities are undertaken by those with appropriate skills and authority.	As a minimum key stakeholders meet on a regular basis throughout the implementation process to check status of participation against agreed activities.	
	Co-ordinates implementation activities with one another	To ensure effective implementation and minimization of wasting of resources in terms of expenditure and staff time.	As a minimum team are fully aware on an on-going basis of the tasks to be undertaken, costs, timing etc. to enable co-ordinated implementation of activities.	In addition, individual team members see linkages between activities and actively participate in improving co-ordination process and activities being undertaken.
	Provides necessary staff training	To ensure that the identified activities are carried out to an agreed satisfactory standard.	As a minimum implementation staff and contractors are sufficiently experienced and/or trained in various skills required to carry out activities and to ensure satisfactory planned outcomes.	In addition staff are multi skilled and motivated to enable strong and experienced implementation team to be developed that communicate well as a team and with various stakeholders including the public.
	Utilises water efficiency and other equipment being fitted of satisfactory quality	To ensure participants in individual programs obtain the same level of service from the replacement equipment to minimize dissatisfaction.	As a minimum equipment being used is known by team to be satisfactory (e.g. tested personally, checked in literature, checked with other experts/implementers with sufficient implementation knowledge),	In addition where appropriate tested through pilot studies and satisfaction levels obtained from participants to inform future decisions on equipment used. Quality of equipment and contractor services installing equipment, are audited to check satisfactory quality.
	Engages public and	To ensure the program is effectively being	As a minimum communication strategy is sufficient to	In addition, communication and education strategy are

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	target groups in the program	implemented to achieve the required goals	obtain required uptake.	carefully planned to: • match funding available and minimise waiting lists for program participants leading to disappointment • public are fully informed of implementation plan to enable them to appreciate when and how they might be able to participate in the program and if the community as a whole is achieving the agreed goals
	Conducts monitoring and evaluation in parallel with implementation process.	To ensure that appropriate data is collected in a timely manner according to the monitoring and evaluation plans.		
5 - Monitor evaluate & review				
5(a) Monitor and evaluate individual programs				
	Monitors the individual program processes	To help determine the effectiveness of the implementation process used. To enable reflection and adaptive management.	As a minimum monitor achievement of implementation plan timelines, budgets and outputs.	In addition consider setting up for example auditing of individual contractors for quality purposes and automated tracking of customers and associated payment to simplify data management procedures and check for illegitimate participants.
	Monitors individual program outcomes	To track outcomes of individual programs for residential sectors (participation rates, water savings, total and unit costs, level of customer satisfaction) and non-residential sector 9water savings, costs, level of participation) To give insight to the rates of adoption, satisfaction levels and behaviour changes associated with options implemented and reasons behind these.	Conduct well designed surveys of customers after implementation of individual programs and use to inform current and future programs.	
5(b) Evaluate full program against goals				
	Evaluates the implemented response against the agreed goals	To determine on-going progress against the goals (i.e. water savings, costs and participation rates) and enable adaptive management.	Use regression analysis to determine the demand equation based on climate and other factors and compare modelled demand with actual demand to determine savings obtained by the overall implemented response.	Use appropriate statistical analysis methods to identify the 'relative savings' of participants of each individual program (where possible) versus controls. For example:

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
		To provide learning for future iterations of the planning process and refinement of programs.	Monitor the total costs of the implemented response and assess against budget availability. Document valid participants of individual programs implemented.	use paired participants and controls to determine the 'relative savings' of the program being investigated or compare participants and controls using a large sample of controls that represent for example the average demand of single residential households. Monitor the costs of individual programs (where possible) to assess the actual unit costs of individual programs implemented. Monitor valid participants of individual programs and track on database system for ongoing assessment (e.g. decay of savings).
5(c)- Review the overall process				
	Assesses the 5 step IRP planning process	To identify the processes which have worked well and those that have not To provide input into future iterations of the planning process	As a minimum identify barriers and opportunities in the planning process and determine how they might be overcome.	In addition engage the broader group of stakeholders to identify the barriers, opportunities and a way forward to improve future iterations of the planning process using a well designed participatory process.
Demand forecasting model/options model				
	Designed to have a robust structure and model architecture	To enable other users to modify various parameters in the model as required without the model 'collapsing' or becoming inoperable.		
	Maintains transparency of data/ assumptions/ calculation processes in analysis	To enable other users of the model to understand the basis for its outputs.		
	Restricts access according to need	To enable other users (other than modeler) to modify the model and associated parameters at an appropriate level to assist in model revision control	Users of the model are aware of who has access to control of the model and revision control.	Model is pass word protected for various levels of use and protocol is documented.
	Has a user-friendly interface to the model	To enable modellers, planners (etc) to readily use the model as appropriate to make modifications where necessary as new data becomes available, generate new options and obtain outputs to assist in decision making.	Set up spreadsheets to enable user to know where and how to change assumptions (e.g. population projections, proportion of efficient stock of appliances, participation rates and operating costs for a specific option).	
	Allows model to be	To increase accuracy of model on an	As a minimum model is calibrated against bulk and sector	In addition the bulk and customer meter reading

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
	calibrated	ongoing basis and check the forecasts are reflecting metered readings.	customer meter readings at regular intervals (e.g. every 3 to 5 years).	databases are modified to enable minimal data manipulation before being used to calibrate demand forecasting model
	Allows model to be linked to other planning tools	To enable easy transition of data and information making the models more useful in terms of planning tools which minimise the need for data manipulation.		Planning models and databases (e.g. yield, climate correction, bulk water and customer metered demand databases) are linked and automated to minimise the need for separate data manipulation.
Data/information collection and storage				
	Maximises data quality according to need and within resource constraints	To ensure the level of data quality and accuracy is matched with the level of detail required (e.g. strategic versus detailed design level analysis). To balance reliability and level of detail with costs of collection.	Data obtained from various relevant reliable sources with limitations to method of data collection known and made explicit. Analysis uses triangulation of data from various sources (primary and secondary) to assist in determining appropriateness of data.	
	Is focused on what is needed but also takes advantage of collecting data for several purposes	To ensure data collection is planned and useful as input to model, informs analysis, assist in decisions and answers priority information gaps. Maximises the benefit of collecting data using a specific method.	Data collected, for example through combination of survey and site visits, provides information for various end uses in demand forecasting model and assists in options modeling.	
	Maximises use of existing reliable data sources	To ensure relevant available and applicable primary and secondary data is used in preference to more expensive additional primary data collection.	Appropriate data used such as: bulk water, customer meter readings, Government statistical information, market data, local/international research etc.	
	Method of collection chosen according to need	To ensure resources and time are invested where appropriate, method of collection matches need and low cost methods are considered first to supplement existing knowledge.	Existing knowledge based on mixture of primary and secondary data supplemented only by further primary data (i.e. surveys, data logging) when needed.	
	Actual rather than theoretical data used where practical	To maximise accuracy of outputs of modeling demand and/or water savings.	For example representative sample of actual measured flow rate of showerheads used instead of theoretical to maximize accuracy of demand forecasting and estimation of savings.	
	Uses time series data	To take into account that water use behaviour may fluctuate with seasons and other external factors (e.g. weather,	Collect data in time series (or at relevant points in time) where influenced by external factors.	

Step	Criteria (What does best practice look like?)	Relevant objective (Why this criteria?)	Example of best practice processes (first pass level)	Examples of best practice processes (detailed level)
		restrictions).		
	Data set is representative	To ensure data used is a representative sample and reflects the larger sample being modeled.	Data is stratified using various variables (e.g. water usage, household size, household type, owner occupier, socio-economic variable).	
	Includes communication strategy for customers participating in data collection study	To ensure effective participation, co-operation and accurate information. To conduct the data collection process in an ethical manner.	As a minimum participants contacted prior to data collection period requesting permission to obtain the data and explaining the purpose and how the information will be used.	In addition participants provided with greater level of information and contact and provided with feedback after participation (e.g. informed of own personal water use, how relates to average usage and how they could change).

APPENDIX C – ANNOTATED BIBLIOGRAPHY

The International Demand Management Framework

Stage 1

Annotated Bibliography

Prepared by

Institute for Sustainable Futures

For

Canal de Isabel II

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The International Demand Management Framework

Stage 1

Annotated Bibliography

For Canal de Isabel II

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Institute for Sustainable Futures

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1 THIS DOCUMENT

1.1 The study

The International Demand Management Framework (IDMF) is a study, which was set-up by the International Water Association (IWA) in 2004 and managed as Task Force No.7 under the IWA Specialist Group – Efficient Operation and Management. CYII and the Institute for Sustainable Futures lead the Task Force. Advice is provided by a working group of international experts and water planning practitioners involved in demand management activities in a large number of countries.

The overall study comprises of six stages and aims to develop a step-by-step framework and associated manual on best practice approaches to urban water supply-demand planning with a focus on demand management/water efficiency.

The objectives of IDMF stage 1, funded by CYII, are to:

- gather the core international literature in key topic areas related to demand management in the context of urban water supply-demand planning;
- develop an associated preliminary literature review/annotated bibliography;
- develop a "best practice" IDMF process outline;
- develop associated criteria that can be used to assess to what extent an organisation is applying best practice with respect to demand management in the context of urban water supply-demand planning; and
- test the criteria developed with a case study organisation through a benchmarking approach.

1.2 The purpose of this document

The purpose of this document, *The International Demand Management Framework – Annotated Bibliography* is to draw together a large range of international literature that contributes to how current best practice in demand management and integrated resources planning might be defined.

Information has been included from each reference (either as a direct quote or comment about the reference) that adds to the picture of best practice in this field.

The references collated in this Annotated Bibliography have informed the development of *Best Practice Criteria* in demand management and integrated resource planning, which is an additional deliverable of Stage 1 of the Study.

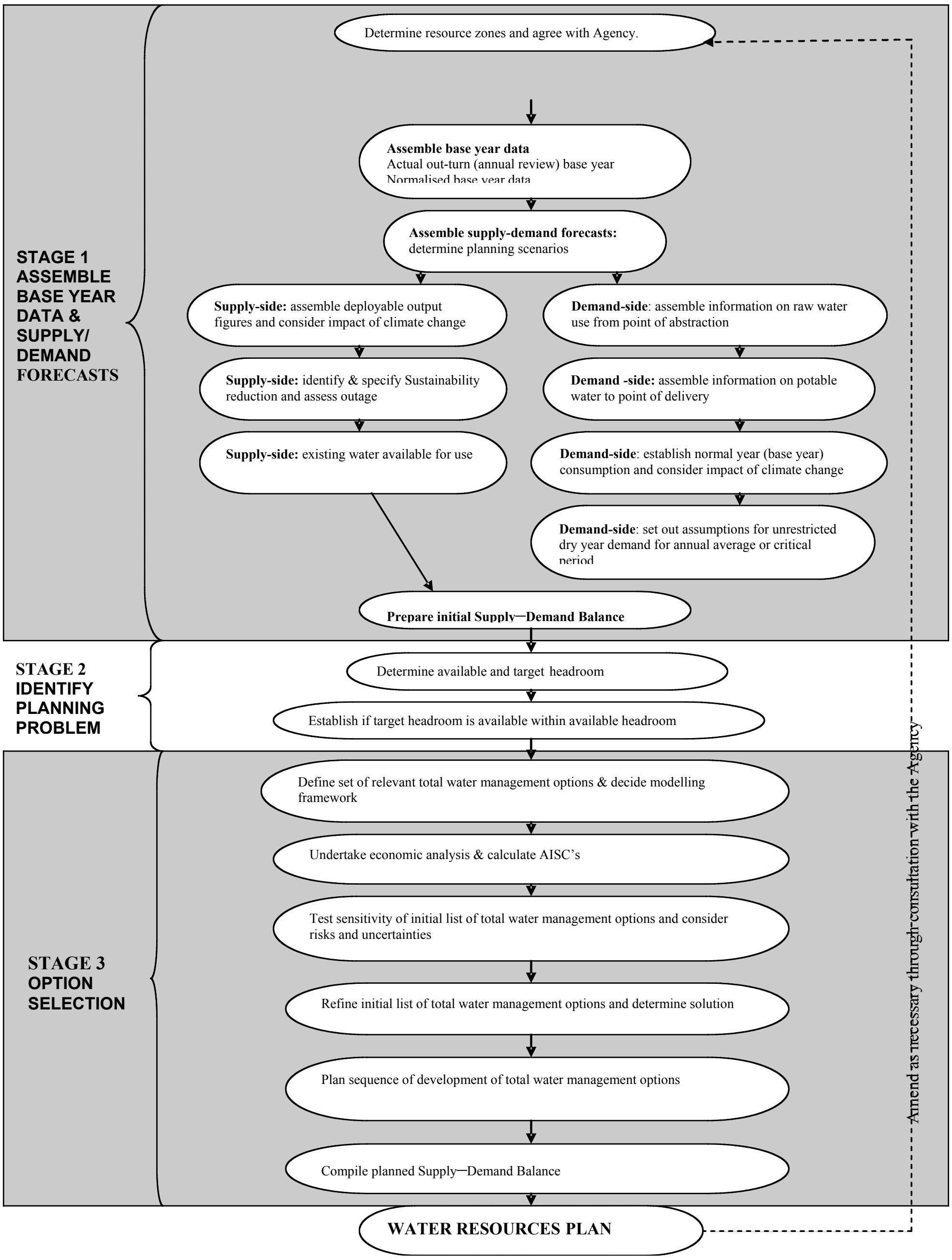
The document is intended to be used as a *working document.* It is intended to be used as a reference point from which information can be drawn for Stage 1 and other stages of the International Demand Management Framework study and, more specifically the foundation of the more detailed literature review, which will be undertaken in Stage 2 of the Study.

2 OVERALL PROCESS AND APPROACH

The literature below demonstrates the broad range of literature describing planning approaches adopted internationally in managing water demand and supply which demonstrates the similarities and differences in approaches.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

The purpose of this document is to provide a framework for the development and presentation of water company plans and help the water industry show how it intends to maintain the balance between water supply and demand to OFWAT and the Environment Agency. The process they ask companies to follow is shown in this diagram:



This report also contains tables with further details of what is involved in each of these steps and cross referencing to another two Environment Agency reports called "Economics of Balancing Supply and Demand Guideline and Main Report".

Mitchell, C., Turner, A., Cordell, D., Fane, S. and White, S. 2004 'Water conservation is dead: long live water conservation' 2nd IWA Leading Edge Conference on Sustainability in Water Limited Environments, Sydney 8–10 November 2004.

A planning process focused just on demand management. The steps include data collection, demand forecasting, options analysis, implementation and program evaluation (see Figure below).

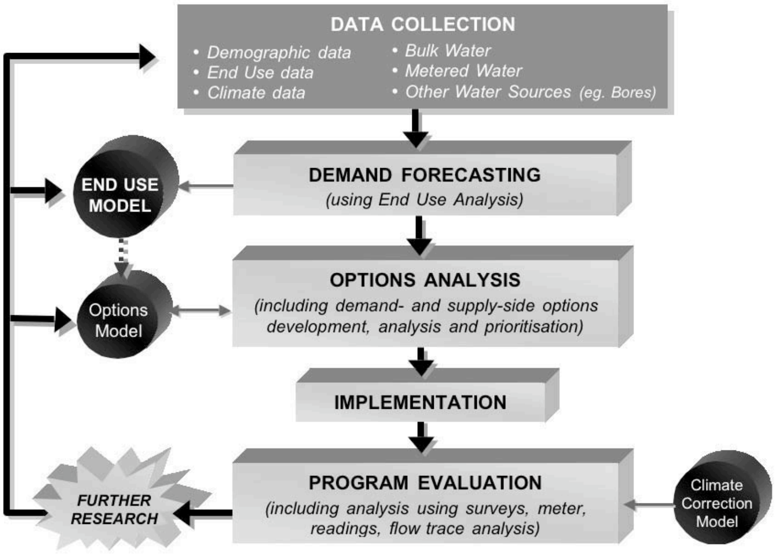
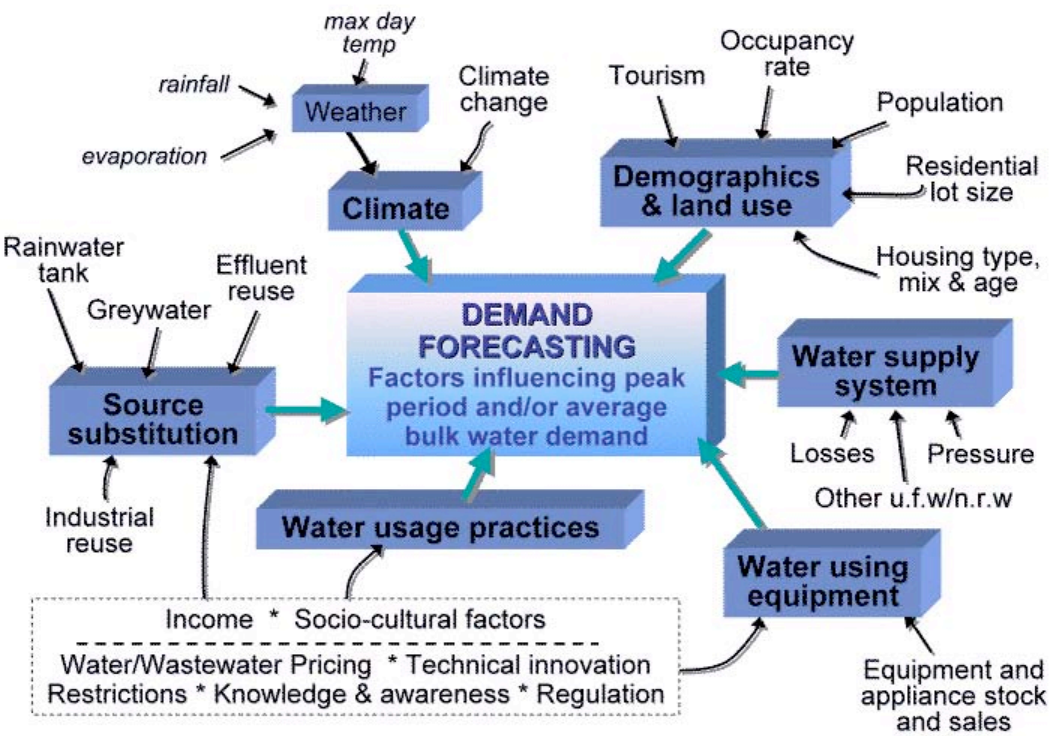


Diagram below describes the many influences on demand forecasting which need to be taken into account.



Gleick et al (2003) *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Steps outlined here are (p32):

1. Identify the potential for improving water-use efficiency

2. Identify the institutional, economic, and technological barriers that impede these improvements
3. Implementing appropriate economic, educational, and regulatory policies needed to remove the barriers and capture the available savings.

Page 33 describes in more detail the different approaches (for example economic, technical etc.)

Harberg, R. J. (1997) *Planning and Managing Reliable Urban Water Systems*, American Water Works Association, USA

Defines the planning process as a "reliability planning process". This process involves least cost planning, multiple objective approaches and integrated resource planning (p18). Lists the following steps:

1. Identify important questions and issues regarding system reliability and review them with stakeholders
2. Inventory, forecast and analyse conditions that affect reliability focusing on critical issues, variable, scenarios, consequences, alternatives. Establish initial reliability levels or criteria
3. Review the above with stakeholders to confirm importance of reliability issues originally identified
4. Formulate reliability management alternatives to address critical issues, scenarios and consequences
5. Review of the above with stakeholders, comparing their effectiveness and ramifications
6. Select the appropriate reliability level of water system reliability and reliability management alternatives and establish appropriate reliability criteria.

OECD (1989) Recommendation of the Council on Water Resource Management Policies: Integration, Demand Management, and Groundwater Protection, *Environment* 31 March 1989. C (89)12/Final

These recommendations maintain that:"5. Technical, economic, environmental and financial appraisal of alternative supply-expansion, supply-reallocation and demand management policies should be carried out to determine optimal water resource strategies."

This document contains potentially useful information on institutional arrangements (PART I: Guidelines for improved institutional arrangements for integrated management of water resources and other policies) and water demand management generally (PART II: Guidelines for improved water demand management)

UKWIR/Environment Agency (1996) *Economics of Demand Management – Practical Guidelines* (we have hard copy,

Their "best practice framework" for making decisions between demand management, investment in (or deferral of) water resources development schemes or operational options consists of the following steps:

- Problem definition
- Qualitative assessment of impacts and identification of potential options (eliminate those potential options which can be ruled out based on some qualitative criteria)
- Quantification and valuation of impacts (valuation techniques suggested include effect on production, replacement cost, preventative capture, travel cost, hedonic prices and contingent valuation in Annex 2, p115–7)
- Arrival at initial solution
- Making solution consistent by taking into account all inter-linkages
- Improving the solution by making further allowance for risk and equity (risk elements involves adjusting the programs to reduce high risks for all parties, and adjust program by eliminating options with exceptionally high uncertainty, and adjust program to reduce unacceptable risks to some groups in society)

Their analysis is based on "social cost-benefit analysis" which takes into account environmental costs and benefits and welfare gains and losses

Dziegielewski et al (1993) *Evaluating Urban Water Conservation Programs: A Procedures Manual* (hard copy)

Process for systematic analysis of water conservation alternatives has eight steps (p7). These are Planning Steps: 1. Analyse Water use and service area data, 2. Prepare baseline water use forecasts, 3. Screen conservation techniques and practices, 4. Analyse benefits and costs of conservation, 5. Develop a long-term water management plan. Evaluation steps: 6. Evaluate program implementation process 7. Water conservation savings 8. Develop a long-term monitoring plan

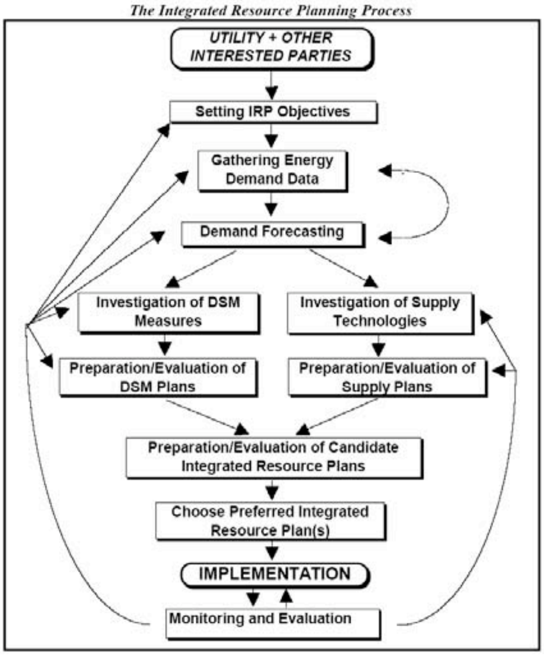
Tellus Institute (2000) *Best Practices Guide: Integrated Resource Planning for Electricity* Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

This resource states that: "Integrated resource planning is built on principles of comprehensive and holistic analysis. Traditional methods of electric resource planning focussed on supply-side projects only, i.e. construction of generation, transmission, and distribution facilities. Demand-side options, which can increase the productivity with which electricity is used by consumers, were not considered. Too often, even the assessment of supply-side options was limited to a few major technologies, and cost-benefit analysis of the alternatives was rudimentary. By contrast, IRP considers a full range of feasible supply-side and demand-side options and assesses them against a common set of planning objectives and criteria." (p13)

The steps in the IRP process generally are to:

1. establish objectives
2. survey energy use patterns and develop demand forecasts
3. investigate electricity supply options
4. investigate demand-side management measures
5. prepare and evaluate supply plans
6. prepare and evaluate demand-side management plans
7. integrate supply- and demand-side plans into candidate integrated resource plans
8. select the preferred plan and
9. during implementation of the plan, monitor, evaluate, and iterate (plan revision and modification).

The Integrated Resource Planning Process



Chestnutt et al (2005) Water Efficiency Programs for Integrated Water Management, Efficient2005 Santiago Chile

Defines the challenges of water conservation/efficiency initiatives as:

Conceptual. How do we define the benefits and costs of conservation programs? How do those benefits and costs differ when viewed from different perspectives? Why are those different perspectives important?

Informational. From where is a water utility to obtain valid and reliable information to estimate the benefit and cost components? Often, the information needed to assess costs and benefits is either not readily accessible or not directly applicable to the particular circumstances and planning constraints of a water utility.

Analytical. How should the benefit and cost information be properly compared to make the correct decisions? What analytical tools can facilitate these comparisons?

Cubillo, F. (2003) Drought, Risk Management and Reliability, Efficient2003, Tenerife, Spain

Paper points out that there are no clear criteria based on risk management to prevent and manage water scarcity scenarios due to drought. Puts forward that few regulatory frameworks deal with robustness and reliability however that this is needed in order to prepare for possible future climate scenarios. Therefore need to lean on the methodologies of risk analysis, management and evaluation in order to adequately deal with possible future droughts

This author suggests that we should examine all possible ways and means of securing future urban water supply, including supply options as well as water conservation options and therefore the definition given for “efficiency” includes supply system management, risk management, resources operation and demand

US EPA (2004) Water Conservation Plan Guidelines. Available on http://www.epa.gov/owm/water-efficiency/wave0319/index.htm accessed 8/7/05

“The next three parts contain the water conservation plan Guidelines: Basic, Intermediate, and Advanced. The Basic Guidelines are designed for use by water systems serving populations of 10,000 or fewer. Some water systems, especially those serving fewer than 3,300 people, may be included in a capacity-development approach, described above, instead of having a plan requirement. Systems should check with their state primacy agency for information and guidance about capacity development. The Intermediate Guidelines are designed for water systems serving between 10,000 and 100,000 people. The Advanced Guidelines are designed for water systems serving more than 100,000 people.

The Basic Guidelines contain five simplified planning steps. The Intermediate and Advanced Guidelines follow nine planning steps (with some variations in the scope of analysis and level of detail requested): Specify Conservation Planning Goals, Develop Water System Profile, Prepare Demand Forecast, Describe Planned Facilities, Identify Conservation Measures, Analyze Benefits and Costs, Select Measures, Integrate Resources and Modify Forecasts, and Present Implementation and Evaluation Strategy.”

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Provides “Ten Key Planning Steps to a Successful Water Conservation Program” (p.2), including:

1. Identify Conservation Goals
2. Develop a Water-Use Profile and Forecast
3. Evaluate Planned Facilities
4. Identify and Evaluate Conservation Measures
5. Identify and Assess Conservation Incentives
6. Analyse benefits and Costs
7. Select Conservation Measures and Incentives
8. Prepare and Implement the Conservation Plan

9. Integrate Conservation and Supply Plans, Modify Forecasts
10. Monitor, Evaluate, and Revise Program as Needed

White, S. (Ed) (1998), *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

A manual for water authorities to design and implement cost-effective demand management plan. Does not prescribe a particular process to follow but contains detailed information on all the following topics.

> Metering/leak detection

> Pricing/regulation

> Education/customer advisory services

> Incentives

> New markets in water/reclamation/re-use

Rocky Mountain Institute (1991), Water Efficiency: A Resource for Utility Managers, Community Planners, and other Decision-makers, by the Water program, Rocky Mountain Institute, Colorado.

Most successful water efficiency programs (in the US) have the following in common (p.78):

> a least-cost planning program which enables the implementation of efficiency measures to compete on level ground with new water supply options

> coordination between entities, particularly between utility and planning departments, water and wastewater entities, and water and energy interests and

> a mix of ordinances, financial incentives, information programs, and efficiency measures that have as their primary goal the realisation of target levels of water and/or wastewater savings.

Maddaus, W. (1987), *Water Conservation*, American Water Works Association, CO.

Developing and Implementing Water Conservation, including the following processes:

1. Defining program needs and establishing goals:
   - identifying supply-and-demand problems,
   - evaluating current conservation programs,
   - public participation,
   - establishing program goals

2. Program planning:
   - preparing a work plan and schedule\
   - Identifying opportunities to reduce water demand,
   - assessing legal and institutional factors,
   - identifying long-term conservation practices,
   - developing alternative conservation programs,
   - calculating water savings,
   - evaluating costs and benefits,
   - evaluating other impacts,
   - selecting a plan,
   - draft and final plan preparation,

3. Program Implementation
   - developing an implementation framework,
   - staff training and supplies,
   - program start up,
   - assessing and updating the program

Beecher (1995) Integrated Resource Planning Fundamentals, *Journal AWWA*, Vol. 87, No. 6, (1995), American Water Works Association, Denver, Colorado, USA.

Cornerstone paper, outlines basics of IRP with flowchart of process and comparison between traditional and IRP approach.

Swisher JN, Jannuzzi GM and Redlinger R (1997) Tools and Methods for Integrated Resources Planning: improving energy efficiency and protecting the environment, UNEP Collaborating Centre on Energy and Environment, Riso National Laboratory, Working Paper No. 7 ISBN: 8755023320, ISSN 10252258. Roskilde, Denmark.

A 270 page document with details on econometric and end-use based models of demand, various cost tests in analysing cost effectiveness from different cost perspectives.

There is a chapter in integrating demand and supply-side options with appropriate methods for each of the steps involved.

Herrington, P (2005) The Economics of Water Demand-Management: Chapter 10 in *Water Demand Management*, International Water Association, Editors David Butler and Favyaz Memon, August 2005, 384 Pages, ISBN: 1843390787

This resource covers least cost planning (LCP), integrated resources planning (IRP), economics of balancing supply and demand (EBSD); economics of demand management (EDM) are normally pursued within the following framework:

1. Construct supply and demand forecasts (with present demand policies unchanged)
2. Identify and quantify future supply-demand balance problems (averages, peaks, zones)
3. Screen supply and demand based options to identify feasible list
4. Evaluate cost-effectiveness of feasible options
5. Undertake option selection routine (CEA or other)
6. Allow for tariff and demand feedbacks, risk, environment and equity, as required
7. Identify preferred plan (p19)

Economics of balancing supply and demand (EBSD): "balancing future water supplies and demands with an optimal mix of initiatives and schemes for water resource production and management, water distribution and customer-side management" (quote from Baker et al 1996, as cited by Herrington)

Atkinson, J. and Buckland, M. 2002, The Economics of Balancing Supply and Demand (EBSD) Guidelines, Report Number 02/WR/27/4, UKWIR/Environment Agency.

Atkinson, J. and Buckland, M. 2002, The Economics of Balancing Supply and Demand (EBSD) Main Report, Report Number 02/WR/27/3, UKWIR/Environment Agency.

Considers supply demand balance and an overall planning process in detail: (each step is elaborated as a section in the report).

1. Assemble supply and Demand Forecast
2. Identify planning problem
3. Identify and unconstrained option set
4. Screen the unconstrained options set to identify feasible options
5. Quantify All impacts, costs and benefits of options
6. Decide on the modelling framework
7. Decide on the selection routine
8. Calculate *average incremental costs* for options
9. Establish the targets and collect willingness to pay data

10. Apply the modelling framework and selection routine
11. Improve the solution by taking account of indivisibilities
12. Consider tariff and demand feedbacks
13. Improve the solution by making further allowance for risk, environment and quality
14. Review and consolidate stage reports

Karamouz, M., Szidarovsky, F. and Zahraie, B. (2003) Water Resources Systems Analysis. CRC Press LLC, Boca Raton.

Includes chapters on decision-making under uncertainty and optimisation and conflict resolution (as well as chapters on time series analysis and demand management). The figure below shows their proposed process for water resources planning.

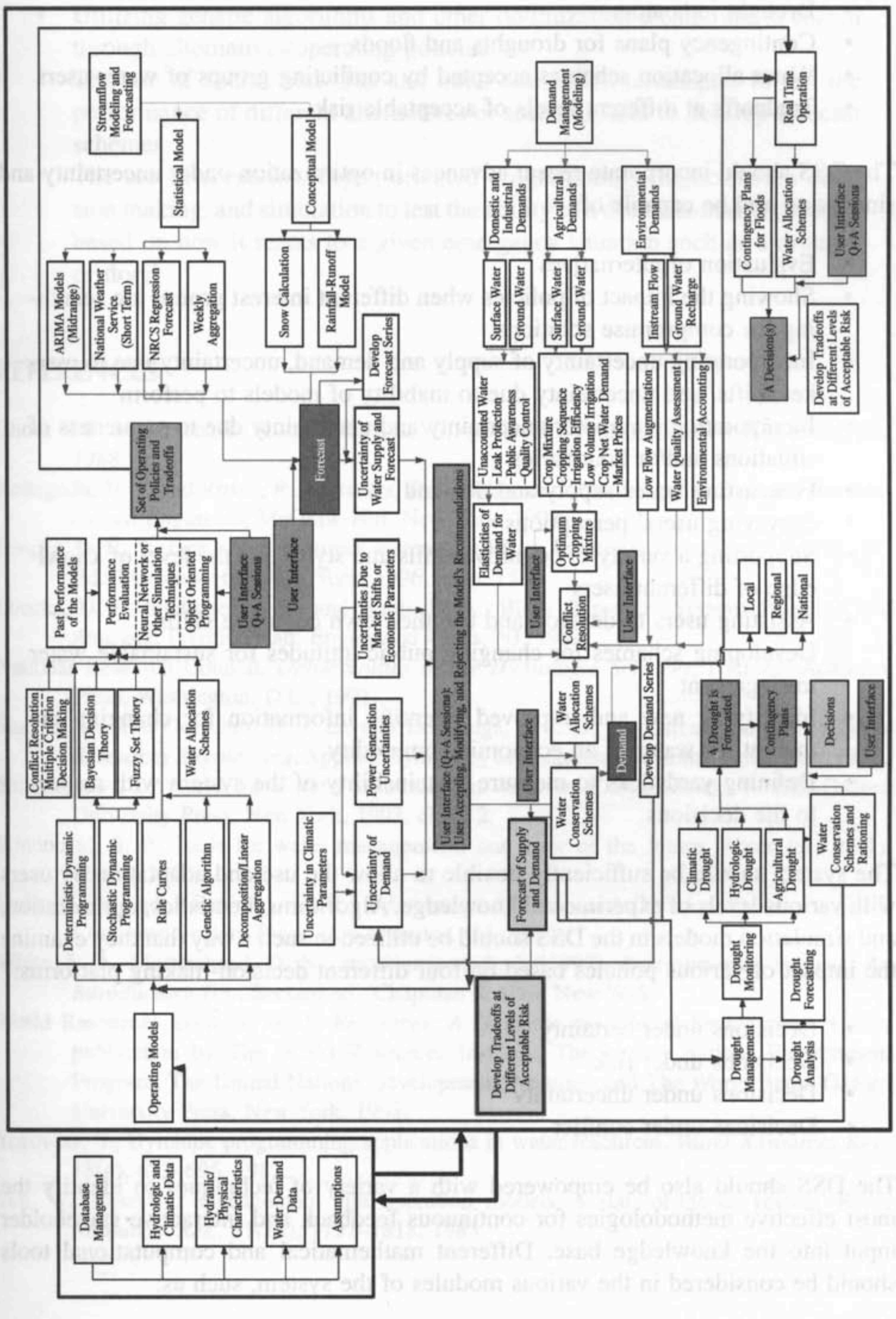


FIGURE 1.7 Framework of a decision support system (DSS) for sustainable water resources planning and management.

3 INITIATING PLANNING PROCESS AND SITUATIONAL ANALYSIS

3.1 Setting planning objectives

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity. Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

Possible objectives for Integrated Resource Planning suggested by these authors are shown in the table below:

Objective	**Nature of the objective**
Reliable electric service	Serving customers with minimal disruptions in electric service
Electrification	Providing electric service to those without convenient access to electricity is a common objective in developing countries
Minimise environmental impacts	Reducing the impacts of electricity generation (and energy use in general) is a goal that has received increasing attention in recent years. Environmental impacts on the global, regional and local scales can be considered.
Energy security	Reducing the vulnerability of electricity generation (and the energy sector in general) to disruptions in supply caused by events outside the country
Use of local resources	Using more local resources to provide electricity services – including both domestic fuels and domestically manufactured technologies – is of interest in many countries. This objective may overlap with energy security objectives
Diversify supply	Diversification may entail using several types of generation facilities, different types of fuels and resources or using fuels from different suppliers
Increase efficiency	Increasing the efficiency of electricity generation, transmission, distribution and use may be an objective in and of itself
Minimise costs	Cost minimisation is key impetus for pursuing IRP and a key objective in planning. The costs to be minimised can be costs to the utility, costs to society as a whole (which may include environmental costs), costs to customers, capital costs, foreign exchange costs or other costs
Provide social benefits	Providing the social benefits of electrification to more people (for example, refrigeration and light for rural health clinics and schools, or light, radio and television for domestic use). Conversely, social harms, as from relocation of households impacted by power project development are to be prevented or minimised
Provide local employment	Resource choices have different effects upon local employment. IRP objectives can include increasing local employment related to the electricity sector and increasing employment in the economy at large
Acquire technology and expertise	A utility (or country) may wish to use certain types of supply project development in order to acquire expertise in building and using the technologies involved
Retain flexibility	Developing plans that are flexible enough to be modified when costs, political situations, economic outlook or other conditions change

"Integrated Resource Planning, or IRP, can be thought of as a process of planning to meet users needs for electricity services in a way that satisfies multiple objectives for resource use. Broad objectives can include:

> Conform to national, regional, and local development objectives.
> Ensure that all households and businesses have access to electricity services.
> Maintain reliability of supply.
> Minimize the short term or long term economic cost of delivering electricity services or their equivalent.
> Minimize the environmental impacts of electricity supply and use.
> Enhance energy security by minimizing the use of external resources.
> Provide local economic benefits.
> Minimize foreign exchange costs.

Each country, or other planning region, establishes its own objectives to guide planning for electricity services. Objectives such as those listed above are often among those selected to guide IRP. Such objectives as the above conflict with one another to varying degrees. Therefore, preparing, deciding upon, and implementing a preferred resource plan requires both a series of objective analyses and the use of processes by which the values and judgements of stakeholders are applied in developing plans." (p11)

3.2 *Use of scenarios*

Cubillo F (2003) Drought, Risk Management and Reliability, Efficient2003, Tenerife, Spain

It is essential to ensure that risk scenarios concerning water scarcity are included in the planning process. These scenarios must be well-defined and include the probability and consequence of their occurrence.

Cubillo F (2003) Water Supply, Risk Management and Efficiency. IWA Yearbook 2003

This paper considers drought risk and asserts that each location needs to conduct a systematic risk assessment based on the available supply, and to make decisions between taking more or less frequent actions of different scales to mitigate risk.

Alcamo J and Ribeiro T (2001) Scenarios as tools for international environmental assessments Experts' corner report Prospects and Scenarios No 5, European Environment Agency

Good resource on scenario development. Promotes use of scenarios to go beyond the business as usual projection and as a tool to enable better decision-making by synthesising and communicating extensive, complex information. The report proposes a thorough approach based on qualitative and quantitative information. It describes the different types (exploratory, anticipatory etc.) and methods for creating scenarios, characteristics of good scenarios.

Westcott (2003) A Scenario Approach to Demand Forecasting, Efficient2003 2nd International Conference in Efficient Use and Management of Water for Urban Supply, Tenerife, Spain, April 2003

Promotes use of scenarios to test own water resource plans with benefit of improved confidence and clarity of the risks. Four scenarios are used: Provincial enterprise, world markets, global sustainability and local stewardship and their effect on drivers of demand (eg regulations on particular household appliances) are elucidated. The scenarios are aimed to stimulate debate between businesses, regulators and government departments, and indicate alternative patterns of social development.

Lundie S., Peters G., and Beavis, P (2004) Life Cycle Assessment for Sustainable Metropolitan Water Systems Planning, Environ. Sci. Technol. 38:13,3465–3473

Uses several scenarios to examine Sydney's water situation; does not disaggregate demand. The scenarios include desalination plant, demand management with 6% reduction in water use, four alternative population scenarios, energy efficiency, energy regeneration, energy from biosolids, upgrade coastal sewage treatment plants, and implementation of integrated local water cycle management concepts in greenfield sites.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

Scenarios that need to be considered are: (from table on p22):

1. Normal year annual average unrestricted daily demand (baseline)
2. Dry year annual average unrestricted daily demand (baseline and final planning)
3. Dry year critical period unrestricted daily demand (baseline and final planning)

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

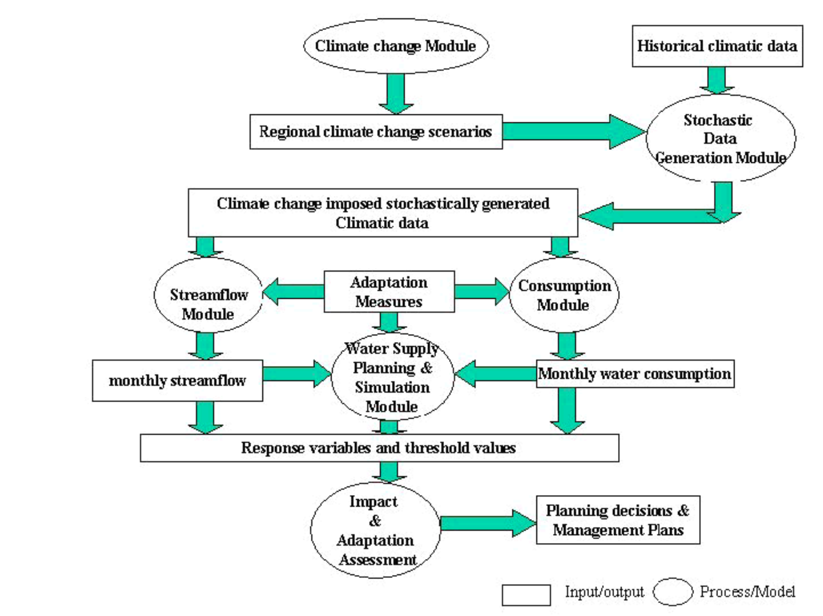
In assessing the impact of climate change on demand, companies should refer to: *Climate Change and the Demand for Water* (DoE 1997 and Defra 2003) and supplementary guidance on climate change to be released by the Agency as part of the preparation of water resources plans. *Water Resources and Supply: Agenda for Action* also asked water companies to conduct further studies of the implications of climate change on the demand for water.

Maheepala S (2003) Assessing Climate Change Implications for Urban Water Supply Planning, AWA Regional Conference, 16–18 October, Lorne, Victoria.

At present, historical values of rainfall, evaporation, water consumption and streamflow are being used for planning of urban water supplies. Use of historical values of climatic variables for water supply planning studies, without considering the effect of climate change would result in exposing of water supply facilities to climatic conditions for which they have never been designed. This could result in supply systems that are more vulnerable and less flexible to future climatic conditions during their design period.

Paper "describes a methodology developed for a quantitative assessment of climate change impacts on urban water supply systems. This impact assessment methodology is based on the concept of probability to take into account the uncertainties associated with the future climate change projections. This assessment methodology has been applied to Benalla water supply system in North East Victoria (Australia) to examine implications of climate change scenarios projected for 2030 on streamflow volumes in supply catchments, water use and system yield."

Figure 2 shows climate change impact assessment framework of Maheepala and Perera [2002a and 2002b]. The main components of this framework are: climate change module, climate variability module, streamflow module, water consumption module, water supply planning simulation module and impact and adaptation assessment module



4 DATA COLLECTION

This section deals with details on what kind of data is important and methods for its collection to enable accurate water demand forecasting and detailed options development (i.e. demographics, land use, types of end use, appliance stock information, bulk water production meter readings, customer water meter readings, additional sources of water, climate variables).

Gleick et al (2003) Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Amongst the recommendations and conclusions: Coordinate data collection by state and local water agencies with other industry associations and national agencies. Also, to reconcile data reported from different agencies where the reported data is inconsistent or in conflict. p16

Jacobs HE and Haarhoff, J (2004) Structure and data requirements of an end-use model for residential water demand and return flow, Water SA, Vol. 30 No. 3 July 2004

The various data and parameters required to populate their end-use model are discussed, guideline values are presented and possible methods for calibration of the model to measured results are proposed (p298). The model is highly detailed: 79 parameters are needed per month, and 189 for a year (by making a set of assumptions shown on p297)

Kowlaski and Marshallsay (2005) Using Measured Microcomponent data to model the impact of water conservation strategies on the diurnal consumption profile, Efficient2005 Santiago Chile

These authors state that: "Microcomponent data from the data pool of 500 properties were combined with socioeconomic data and lifestyle indicators from the UK 2001 Census, CACI (ACORN socio2 economic classification), and water company archives. A comparison with the national stock of households in England using Census and ACORN data was conducted to assess the validity and representativeness of the data sample to be analysed. The dataset was found to contain a good spread of occupancy and house types, but favoured properties in the south-east of England for historical reasons. In addition, flats and single-occupancy households were under-represented, largely owing to the greater practical difficulties in monitoring flats. None of the households in the sample were metered consumers. However, metered consumers currently only account for about 12% of the total distribution input (25% of households) compared with 56% of distribution input consumed by unmeasured households (OFWAT, 2004). These data were tested against the consumption profiles of the microcomponent dataset to look at which factors influence domestic consumption in the UK. This exercise identified a number of factors which drive the components of water use in the UK and allowed the assessment of variability and statistical uncertainty in volumes consumed, ownership and frequency of use for various microcomponents.

Regression analysis was used to determine the key factors influencing off-peak consumption. These included day of the week (working weekday or weekend/holiday), occupancy, house type (flats, terraced, detached, semi-detached houses) and ACORN socio-economic group. Owing to its more volatile nature and a limited dataset, seasonal peak consumption cannot be assessed using regression analysis. Instead, comparative analysis of the largest consumers with the norm identified a number of factors which identified features about those consumers likely to use considerable volumes of water on warm, dry days. Perhaps unsurprisingly, our study indicates that these consumers are likely to be in the wealthiest socio-economic group, own a detached property and possess a garden sprinkler."

Diurnal study component stated that: "The study also looked at the microcomponent dataset to derive the diurnal variation in water use at the microcomponent level. Consumption on working weekdays and weekends/holidays were compared at various times of the year when normal and peak demand for water would be expected. This allowed a model to be developed which, together with information on house types, numbers of properties, socio-economic class and occupancy rates, allows the simulation of demand for water supply zones and other metered areas of the water network.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

In terms of data collection, it is expected that: "Companies should set out clearly in their plans and any supporting documentation, key supporting data and sources, and details of assumptions being made. Key data sources might include: Office of National Statistics, local authorities, National Survey of English Housing, company billing systems and customer databases, specific customer surveys and consumption monitors. The Agency expects that all companies should use the latest census information in developing their final water resources plans.

Companies should clearly indicate which data sources have been used, how their current best estimates have been reconciled and the basis on which their forecasts are made. This is an important early step in the WRP process and should be identified for early discussion and agreement with the Agency."

Also mentions another report: UKWIR/NRA reports on Demand Forecasting Methodology and Forecasting Water Demand Components (see Annex 5) defining industry good practice.

Also, this document contains many tables for companies to use as templates and fill out/collect information- something similar might be useful in the IDMF

Billings, R. and Jones, C. (1996), Forecasting Urban Water Demand, American Water Works Association

Tips and guidelines for collecting water demand data are given, including:

> using national water use data
> utility billing records
> time series
> how much to disaggregate
> other variables (eg, weather, population, income etc).

Alegre, H. and Coelho, S. T. (1993). "A methodology for the characterisation of water consumption." Integrated computer applications in water supply, Research Studies Press Ld., Reino Unido, 369–384.

These authors describe a methodology for the statistic assessment of daily and weekly demand profiles along the year, as well as the identification of the main social-demographic and habitat factors affecting them. It is based on temporary surveying campaigns held on representative study areas.

4.1 Water using equipment and practices data and collection methods

Loh M and Coghlan P (2003) Domestic Water Use Study in Perth, Western Australia 1998–2001

Details of the methodology for data collection: "In Phase 1, household data was collected from 720 volunteer households across the Perth metropolitan area which comprised of:

> A Pilot Group of 120 households at which special metering equipment was installed to continuously monitor water use from November 1998 to June 2000 and
> A Main Group of another 600 households at which total monthly water usage was recorded from November 1998 to February 2000.

All 720 households completed three questionnaire surveys covering demographics, appliance ownership and attitudes to water use. The Pilot Group consisted of 3 sub-samples of 40 households drawn from low, medium and high income locations. The Main Group was a stratified sample and is statistically representative of the Perth metropolitan area. Data gathered from the Main Group were used to help validate the Pilot Group data on key variables.

In Phase 2, household data were collected from 297 volunteer multi-residential households (4) across the Perth metropolitan area which comprised of:

> A Pilot Group of 124 households (5) at which special metering equipment was installed to continuously monitor water use from September 2000 and November 2001 and
> A Main Group of another 173 households that provided questionnaire data only. Data from additional households in the Main Group were used to help validate the Pilot Group data on key variables."

Further information also given about the questionnaires themselves and the detailed results from this research are contained in the report.

AWWA Research Foundation (1999) *Residential End Uses of Water*, AWWARF, Denver.

This study at the time was the most extensive water end use data collection study in the US on residential water end uses. The study provides: actual data (eg. on average water use for each residential end use), highlights important parameters for feeding into an end use model, and best-practice methodologies for data collection, including data logging and analysis with Trace Wizard software and calibration with historical water billing data.

AWWA Research Foundation (2000) *Commercial and Institutional End Uses of Water* AWWARF, Denver

This study collected detailed water end use data from the non-residential (CI) sector in 12 states in the US. Further, it aimed to provide end-use models for various CI categories and to develop a set of benchmarks for the various CI categories (including Restaurants, Hotels and motels, Supermarkets, Office buildings, Schools). However, unlike the residential sector, it found the CI sector is difficult to disaggregate and model through detailed end-use analysis (i.e. water use in schools through to restaurant is hard to normalise per capita, per m^2 or other unit).

The study also notes that when using data logging, the results/analysis will only be as accurate as the meter the data loggers are connected to. “In general, the smaller the meter, the better resolution can be obtained from flow trace analysis” (p.146)

Institute for Sustainable Futures and CSIRO Urban Water (2001), *Melbourne End Use and Water Consumption Influences Study*, the Retail Water Companies for the Water Resource Strategy Committee for the Melbourne Area, Melbourne

This study collates the latest and most reliable Australian (and some international data) as at 2001, on residential water end use parameters that could feed directly into an End Use Model. The study both provides best-available actual data, and, identifies parameters considered important for building an End Use Model. Ideally including flow rates – both actual and capacity (L/min) of technology of varying efficiencies, frequency of use where relevant (use/person/day), duration of use (min/day), ownership levels of various technologies (%). Mainly covers secondary end use data on water efficient technologies from previous studies. While it was collected for a Melbourne End Use Study, much of the data could feasibly be used for other regions depending on their similarity to Australian technologies and practices. This would need to be determined on a case by case basis. E.g. are residents in Region X likely to shower the same frequency as Australians?

Cordell, D.J., Robinson, J.E. and Loh, M.T.Y. 2003 'Collecting Residential End Use Data from Primary Sources: Dos and Don’ts', Efficient 2003: Efficient Use and Management of Water for Urban Supply Conference, Tenerife, 2–4 April 2003.

This paper provides best-practice tips on identifying appropriate residential end use data for the level of modelling required. These include:

> “Being explicit about the objectives of the data collection study,
> determining the types of data best suited to the purpose of the study,
> looking for ways to value add to the study,
> considering appropriate data collection techniques, including the advantages and limitations of each,
> communication strategies with water customers participating in the study,
> ensuring samples are representative and stratified,
> collecting data in an appropriate season, and
> considering issues around gender and ethics”(p.2).

Best-practice techniques for collecting residential water end use data from primary sources are described, with the aim of maximising quality and minimising costs/resources of data collection process. Methods covered include: technical measurements via metering, data logging; or surveys (face-to-face, telephone, mail, market surveys), or asking householders to keep diaries of water use. It is often preferable to use a combination of complimentary techniques, as one will typically not be sufficient to capture all types of data required.

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: C. Lallana, W. Krinner and T. Estrela, CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen

If using secondary data (i.e. existing end use data rather than collecting new data), this report provides some European figures on household water use, including:

> percentage water use by residential end use, Litres per appliance use (eg. toilets 9.5L/flush in England/Wales) (p.18)

> "Most of the water used in households is for toilet flushing (33 %) and bathing and showering (20–32 %). The lowest percentage of domestic use is for drinking and cooking (3 %)". (p.20)

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Basic steps for conducting a residential water audit provided and pros and cons of residential sub-metering (p21).

Turner, A., Campbell, S. and White, S. 2003 ' End Use Modelling and Water Efficiency Program for Arid Zones: The Alice Springs Experience' Efficient 2003: Efficient Use and Management of Water for Urban Supply Conference, Tenerife, 2–4 April 2003.

Authors state that: "In the investigations undertaken to build the end use model and demand management program for Alice Springs, a wide variety of low cost data and information sources have been used. These have included:

> bulk production and customer metered demand

> review of previous local studies on water issues

> assessment of database information (e.g. swimming pool registration)

> design and implementation of a resident indoor/outdoor water usage survey (subsequently linked to customer metered demand)

> interviews with supplier/maintenance specialists (e.g. pools, air conditioners and garden irrigation) and

> the use of air conditioning experiments."

Roberts Peter (2005) 2004 Residential End Use Measurement Study, Yarra Valley Water Report, June 2005, Victoria.

The Residential End Use Measurement Study (REUMS) is the second stage of a comprehensive two part research project into how and where water is used in the residential sector.

The first stage was the Appliance Stock and Usage Patterns Survey (ASUPS) which involved household visits to 840 Yarra Valley Water residential customers. This survey identified in detail all water using appliances, measured flow rates and flush volumes and ascertained usage behaviours for all water use. ASUPS was the subject of a separate report published in November 2004.

The REUMS used high resolution meters and data loggers to collect water usage data at five second intervals for two weeks in February 2004 (summer) and two weeks in August 2004 (winter). The usage data was subsequently disaggregated into specific end uses using an end use water analysis tool, Trace Wizard©.

One hundred separate homes were selected from the 840 ASUP homes and fitted with the special measurement equipment. The end use measurement phase was deliberately restricted to "separate" homes to maximise the collection of garden irrigation data since this is known to be a significant component of residential water use in Melbourne. Consequently the findings of the REUMS cannot always be interpreted as being representative of the complete residential customer base because flats, apartments and any other non separate dwellings have inherent differences to detached houses.

Per capita consumption estimates are derived from the reported number of people in the household at the time that the survey was undertaken. In most cases this was shortly before the first logging period. It is assumed that the number of people in the household remained at this level throughout both the summer and winter logging periods.

Some further details:

- Chose to sample 100 households not to be able to gain a certain confidence level (eg of 90% or 95% as this required too many households and was too expensive) and so emulated what AWWARF report in 1999 did and used 100.
- Decided to deliberately sample a higher proportion of high use customers and a lower proportion of low use customers since the impact of high users is greater. The sample target was to get around one quarter of the sample to be in the bottom third of users (based on annual consumption), one quarter in the middle third and one half in the top third.
- Also chose according to household size, income, willingness to participate (for a $50 gift voucher)
- Focused more on separate houses in order to learn more about outdoor use.
- Equipment used included Monatec Data Monita XT data loggers, Actaris CT5 standard residential water meters modified to 72 pulses per Litre to improve accuracy, Trace Wizard, which is able to differentiate between end-uses based on the characteristics of the pulse of water use.

Roberts P. (2004) 2003 Appliance Stock and Usage Patterns Survey, *Yarra Valley Water Report,* November 2004, Victoria.

Author states that there is a need to conduct such a survey every 3–4 years to understand the nature of appliance stock and reliably assess trends in adoption of efficient appliances. In this study, 840 households were visited.

The study found advantages of household visits and actual measurements over data collected via telephone or mail surveys since investigators were able to see misinterpretations that had been made from previous surveys.

Site visits allowed a more accurate identification of appliance type than is normally the case for an appliance stock survey. In addition the assessors were able to measure the actual flow rates of the showers and taps.

The 2003 ASUP survey also collected information on actual flush volumes for all toilets in the household. This was done utilising a device called the T5 Flushmeter.

Ibáñez, J.C., Cubillo, F. (2004) Setting the Framework for an Efficient Demand Management Policy in Madrid Urban Water Supply. IWA 2004 International Conference, Marrakech, September 2004

Madrid water [CYII] established a strategy to improve its knowledge and adapt its operational planning procedures. They utilised the following methods to collect information.

- analysis of 'main demand patterns' based on historical billing data – customers metered every 1–3 months
- survey on 5,000 domestic and commercial customers – # inhabitants/users, income, age of users, type and age of plumbing and appliances, saving taps, etc.
- Study of the needs and water consumption for outdoor uses – inventory of all areas with watered vegetation and swimming pools [using 1:50,000 maps, aerial photography, cadastral info, GIS]
- Continuous end uses monitoring in 300 domestic properties (selected from 5,000 surveyed users).

Charalambous, C.N. (2005) Water conservation research report

Collected data included the following:

- Population predictions
- Type of buildings in the urban areas of Cyprus
- Type of Building in the rural areas of Cyprus
- Geometrical characteristics of houses in the urban areas
- Number of persons per room in the urban areas
- Number of persons per household in the urban areas

> Percentage of occupied houses in the urban areas

> Various statistical data concerning the plumbing fixtures in each household

> Meteorological data of the 1982–1997 period

> Total supply of water by the Water Development Department in the area of Nicosia, Larnaca, and Limassol

> Total supply of potable water in various areas covered by the Water Board of Nicosia

> Water consumption per person in the Nicosia Area

> Number of water consumers in the Limassol area

> Total volume of produced potable water, the supplied and consumed potable in the Limassol area

> Type of pipes in the Limassol area

> Type of fixtures that can be used in Cyprus for reducing water consumption

> Methods for automatic metering of water consumption in houses

Authors state that: “During the course of the study various water meters were evaluated. The most appropriate water meter for use in this research project was selected. The selected water meter was installed in households of Nicosia and Limassol for the purpose of collecting water use data. Originally the data were collected by the use of special electronic data loggers supplied by the Water Board of Nicosia and Limassol. In a later stage the research team used new data loggers that allow the storage of data in a bigger volume and in a higher frequency (one reading per 10 seconds). The collected data were evaluated by the use of a personal computer and a specialized software. The specialized software that was used for the evaluation of the results is capable of recognizing the purpose of the water use by each consumer with high accuracy. This is possible by evaluating various factors such as the flow of water and the time period that the water was used by the consumer.”

4.2 Bulk/metered water data sources and collection methods

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

Comprehensive guide on water metering, including (p.51):

> Why meter

> Types of meters

> Accuracy of meters

> Maintenance of meters

> Location of meters

> non-domestic customers

> remote metering

> cost-benefit of metering

> metering in unmetered towns

5 DEMAND FORECASTING

This section describes literature covering demand forecasting methods and detailed information on the end use approach which considers demand by sector, individual end uses and how those end use volumes are made up of a combination of appliance stock, proportions of efficient and non-efficient stock, how these change over time, flow rates of each type of stock, usage patterns (i.e. human behaviour) and the effects of demographics over time etc. In an IRP process, the demand forecasting would take place in parallel with an assessment of supply projections for a region so that the two can then be compared and the supply-demand gap determined.

5.1 Overview of demand forecasting methods

Tellus Institute (2000) *Best Practices Guide: Integrated Resource Planning for Electricity*. Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

Defines three types of demand forecasting: trend (based on the past), econometric (relates resource use with economic and/or demographic variables eg price, household income, employment, commercial output etc) and end-use (detailed bottom-up analysis- data intensive but extremely useful for demand management)

Gleick et al (2003) *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Traditional approaches overestimate demand by using future projections based on existing demand. This report argues for the need to understand who will require water, for what purpose water is required, what kind of water meets the specific goals and how much water is needed to meet a given goal. p18–20

Availability of good data is a major constraint to comprehensive assessment to conservation potential, or uncertainties about existing data may also limit the reliability of analyses done.p29

Gaps in data that need to be urgently filled:

> Residential landscape is highly uncertain

> Residential and commercial landscape use is poorly understood

> Distribution of residential water-using appliances by type and use, is not well known

> Economic costs of conservation options are sensitive to many factors, therefore need to use cost estimates developed on a regional and utility basis etc

OECD (1989) Recommendation of the Council on Water Resource Management Policies: Integration, Demand Management and Groundwater Protection, *Environment* 31 March 1989 – C (89)12/Final

This resource states: "4. Demand management policies should be based on long-term forecasts for the major types of water services. For this purpose authorities should prepare coherent demand forecasts based on explicit price and other assumptions and incorporate sensitivity and risk analysis."

UK Environment Agency (2003) *Water Resources Planning Guideline*, Version 3.3 December 2003

This guide states: "Water companies should submit a base year demand broken-down into micro-components. UKWIR/EA reports on Demand Forecasting Methodology and Forecasting Water Demand Components recommend the use of micro-component analysis to construct forecasts and examine the impacts of forecast assumptions on drivers of household demand (see Annex 5 for references). All estimates should be expressed in units of litres/head/day and exclude underground pipe losses. Companies should also clearly set out in their plan, the method used, sources of data (for example, consumption monitors), assumptions and adjustments made. It should also explain how companies assess average occupancy for each category of household demand and its application in driving the values." (p37)

Also that, "Companies will be expected to produce demand forecasts from micro-component analyses of household demand and from econometric modelling of the industrial and commercial sectors of non-household demand taking account of differences between resource zones." (p80)

Billings, R. and Jones, C. (1996), *Forecasting Urban Water Demand*, American Water Works Association

"General forecasting process (p.145):

1. clarification of purpose of the forecast
2. choice of forecast approach
3. collection and analysis of data
4. identification of forecast models
5. estimation of the forecast models
6. diagnosis of the statistical adequacy of the models
7. production of the forecast, including confidence intervals
8. evaluation of the forecast
9. use of the forecast by decision-makers
10. *ex-post* analysis of forecast error."

US EPA (2004) *Water Conservation Plan Guidelines*, Part 5 Advanced Guidelines for Preparing Water Conservation Plans "Part 3. Prepare a Demand Forecast" http://www.epa.gov/owm/water-efficiency/wave0319/advance3.htm

Advanced water demand forecasting generally involves:

1. Disaggregated forecasts by customer class or other relevant groups, by average-day and maximum-day demand, and by off-peak and peak season.
2. Multivariate models that seek to explain variations in water demand in terms of variations in other factors, such as climate, income, and price.
3. Quantified sensitivity ("what if") analysis, which allows systems to address uncertainty by varying inputs and assumptions

5.2 End-use and sector based approaches

US EPA (2004) *Water Conservation Plan Guidelines*, Part 5 Advanced Guidelines for Preparing Water Conservation Plans "Part 3. Prepare a Demand Forecast" http://www.epa.gov/owm/water-efficiency/wave0319/advance3.htm

"Disaggregating forecasts by customer class is important because of the different load factors that groups of customers present. Disaggregating forecasts according to type of demand is relevant for advanced demand management techniques that take into account how different types of demand affect the utility's functional costs. As discussed in Section 4, different types of supply-side facilities are designed to meet average-day or maximum-day water demands, and various conservation measures target different types of demand.

Several computer models are available for advanced forecasting, many of which can be used in accordance with these guidelines. An example of an advanced forecasting tool is the widely-used IWR-MAIN model, which was developed by the U.S. Army Corps of Engineers (see below) is an illustration of the inputs and outputs of the model. The key features of IWR-MAIN are: spatial disaggregation, seasonal disaggregation, sector disaggregation, multiple determinants of water demand, user-added categories, and sensitivity analysis. The current version of the model also allows planners to incorporate the effects of demand-management into various planning scenarios. Use of empirical models, including but not limited to IWR-MAIN, clearly is consistent with the purpose of these guidelines."

Billings, R. and Jones, C. (1996), *Forecasting Urban Water Demand*, American Water Works Association

Comprehensive guidelines on best-practice methods and techniques for water demand forecasting and analysis (based on US experience and situation – i.e. that metered customer data exists). Including:

- prelim data analysis (eg. cleaning data),
- curve fitting (incl. regression analysis and other techniques),
- seasonal and peak demand forecasting,
- how to incorporate population, economic and technical forecasts, weather and climate,
- how to incorporate pricing effects eg through price-elasticity coefficients.

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

Brief description of end use analysis as a tool in planning for a demand management strategy (p.10).

Snelling, C., Mitchell C., and Campbell S. (2005) Manual: Melbourne End Use and Options Model, Institute for Sustainable Futures, July 2005

Manual that accompanies recently completed End-Use model for Melbourne Utilities.

5.2.1 Residential

Cubillo, F. (2005) Impact of End Uses Knowledge in Demand Strategic Planning for Madrid. IWA – Efficient2005, Santiago de Chile, March 2005

This paper reports on end-use analysis completed by Canal de Isabel in Madrid utilized for improving demand forecasting and insight to useful demand management options.

Ibáñez, J.C., Cubillo, F. (2004) Setting the Framework for an Efficient Demand Management Policy in Madrid Urban Water Supply. IWA 2004 International Conference, Marrakech, September 2004

This paper details end-use analysis conducted in Madrid including detailed information about the data collection methods and encoding of data to make it amenable for manipulation

Garcia, V. J., García-Bartual, R., Cabrera, E., Arregui, F. and García-Serra, J. (2004). Stochastic model to evaluate residential water demands. *Journal of Water Resources Planning and Management*, 130(5), 386–394.

Buchberger, S. and Wu, L. (1995). Model for instantaneous residential water demands. *Journal of Hydraulic Engineering*, 121(3), 232–246.

In order to understand better consumption patterns in urban networks, Garcia et al., (2004), Buchberger and Wells (1996) and Buchberger and Wu (1995) developed stochastic models for residential water demand.

Butler, D. and Graham, N. J. D. (1995). Modeling dry weather wastewater flow in sewer networks. *Journal of Environmental Engineering*, 121(2), 161–173.

A model to predict the spatial and temporal variation of domestic dry weather flow in sewer networks is presented. A probabilistic framework was used to interpret appliance usage and methods for modelling the spatial distribution of inflow.

Arregui, F. (1998). Propuesta de una metodologia para el analysis y gestion del parque de contadores água en un abastecimento. PhD thesis, Polytechnical University of Valencia, Valencia, Spain.

Arregui (1998) analysed domestic consumption data in order to quantify the unbilled authorized consumption due to metering inaccuracies, by monitoring individual household consumption.

5.2.2 Non-residential

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Contains information on how to conduct a water audit that is useful for forecasting demand in this sector.

AMWUA (2003). *Facility Manager's Guide to Water Management*, Arizona Municipal Water Users Association. http://www.amwua.org/conservation/facility_managers_guide.htm

Contains information about end-use in non-residential settings.

Cobacho, R., Arregui, F., Parra, J.C. and Cabrera Jr., E. (2005), 'Improving efficiency in water use and conservation in Spanish hotels', *New Developments in Water Efficiency, Efficient2005*, Santiago, Chile.

Data on daily water use in Spanish hotels broken down by hot/cold, toilet/shower/taps/leakages by measurements

5.2.3 Non-revenue water

Office of Water Services (OFWAT) (2004), Security of supply, leakage and the efficient use of water, Office of Water Services, Birmingham, UK.

This reference covers:

> Security of water supply (latest security supply data and security of supply index)

> Leakage (performance against targets, estimating leakage and other balance targets)

> Efficient use of water (compliance with duty to promote efficient water use).

IWA, (2000) The Blue Pages – Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures, Oct 2000, p5.

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non-Revenue Water (also UFW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorised Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Farley, M. (2005), Non-Revenue Water – International Best Practice for Assessment, Monitoring and Control, White paper (see http://www.idswater.com/water/us/WhitePaper_non_revenue_water/55/paper_information.html

"The components of NRW can be determined by conducting a water balance. This is based on the measurement or estimation of water produced, imported, exported, consumed or lost – the calculation should balance. The water balance calculation provides a guide to how much is lost as leakage from the network ('real' losses), and how much is due to 'apparent' or non-physical losses."

This paper describes the IWA approach to developing a NRW strategy, a water balance calculation, and an international measure of performance – the international leakage index (ILI).

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana, C., Krinner W., and Estrela, T. CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen

If using secondary data for leakage rates, this doc provides a table (p.22) of estimated losses (% of water supply) rates in 25 European countries.

Liemberger, R., Farley, M. (2004) Developing a Non-Revenue Water Reduction Strategy, Part 1: Investigating and Assessing Water Losses, Conference Proceedings, IWA World Water Congress, Marrakech (can be downloaded from www.liemberger.cc)

The work of the IWA Operation and Maintenance Specialist Group in general and its Water Loss Task Force in particular has led to a set of performance indicators ideally suited to assess the water loss situation and to quantify the components of NRW. This paper is the first part of the outline of a basic NRW reduction strategy and is intended to motivate utility managers to establish a standard water balance, calculate the level of NRW, quantify its components and identify main problem areas. A separate paper, part 2 of this strategy, deals with the planning of the strategy and its implementation.

Liemberger, R., McKenzie, R, (2005) Accuracy Limitations of the ILI – Is it an Appropriate Indicator for Developing Countries? Conference Proceedings, Leakage 2005 Conference, Halifax, September 2005 (will be available at www.lieberger.cc)

The paper describes the accuracy limitations of the ILI. The authors suggest that it is still the best indicator to benchmark water losses in developing countries and provide data of three water utilities in South and Southeast Asia.

Seago, C., McKenzie, R., Liemberger, R. (2005) International Benchmarking of Leakage from Water Reticulation Systems, Conference Proceedings, Leakage 2005 Conference, Halifax, September 2005 (will be available at www.lieberger.cc)

This paper evaluates the IWA methodology of water loss benchmarking in terms of how it is being used in practical situations and present the results from a number of Water Utilities throughout the world. Various issues of specific relevance to the South African situation are also discussed and some new software developments are presented.

Sánchez, E. H., Ibáñez, J.C., Cubillo, F. (2005) Testing Applicability and Cost Effectiveness of Permanent Acoustic Leakage Monitoring for Loss Management in Madrid Distribution Network. Halifax, IWA EOandM Water Leakage Task Force, September 2005

This paper presents information obtained and conclusions reached from a pilot experience using acoustic leakage monitoring developed at different locations of diverse characteristics and behaviour, all of which form part of the distribution network of the drinking water supply system of Madrid, Spain. The conclusions were that:

> "Permanent acoustic leakage detection is an effective technique under all the tested conditions",

> "From an economic perspective, this technology is more efficient than conventional leakage detection with ground microphones and correlators only in those networks with a certain degree of deterioration. This threshold has been established for the Madrid distribution system in 2.0 total bursts per kilometre and year. This level is only reached in a limited number of network sectors, which account for less than 15% of the

total length of the Madrid water distribution network. For those heavily deteriorated networks, having poorer indicators, pipeline renewal is an option to be considered".

> "When accurate indicators of real losses are not available, the number of bursts per km and year has proved to be an alternative value, closely related to the number of leaks and water losses, where the Madrid system and soil conditions are given" and

> "Additional information acquired from this study is the natural ratio of leaks occurrence, that is, for an average sector in the Madrid network of 1.06 new leaks / km year"

5.2.4 End use models

This section covers literature on the structure and function of an end use model for water demand forecasting for a specific region and an options model in which the water conservation potential of a specific region can be ascertained through testing of different management options. An options model enables options developed to be compared on an equal basis (using a consistent boundary and assumptions) for the particular driver affecting that region (e.g. need to defer supply augmentation, specified demand management target). The combined end use model/options model ultimately providing a decision making tool for service water providers.

Haarhoff, J. and Jacobs, H. E. (2004) Structure and data requirements of an end-use model for residential water demand and return flow, Water SA, Vol. 30 No. 3 July 2004

"The model predicts five components relating to water use and wastewater flow at a residence: indoor water demand, outdoor water demand, hot water demand, wastewater flow volume and concentration of total dissolved solids in the wastewater."

"REUM is a powerful and comprehensive tool for residential water demand and sewer flow end-use analysis, has a relatively simple mathematical structure and could be a useful base for further refinements in this regard."

The model was constructed due the following motivations:

> "With such a model a sensitivity analysis could be conducted on all parameters influencing water use and wastewater flow at a stand in order to determine the most significant parameters – these should be the parameters which water managers should focus on.

> The model could be used to evaluate the water saving and subsequent return on investment brought about by individual WDM measures implemented at a stand, such as dual flush toilets, low-flow showerheads, xeriscaping, et cetera.

> In view of the above water saving, the model could also be used to evaluate the impact of such water saving on the wastewater flow."

"The model calculates 12 monthly results, for each of the five components, to provide a typical seasonal pattern as well as an annual value."

In terms of model calibration: "The data acquisition and calibration of REUM is a topic for future study. Genetic algorithms (GAs) are considered to be a possible method for calibration in view of the large number of parameters and relatively few equations. GAs have recently been applied successfully to various problems in civil engineering, including the water field (Van Vuuren, 2002 Rouhiainen et al., 2003)."

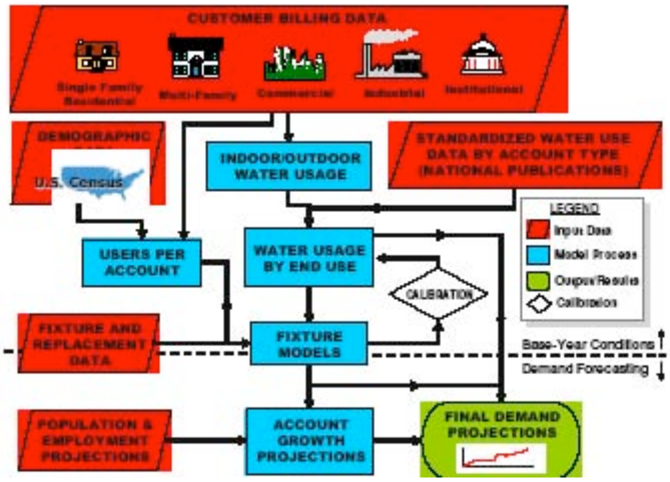
Jacobs, H. E. and Haarhoff, J. (2004) Application of a residential end-use model for estimating cold and hot water demand, wastewater flow and salinity, *Water SA* Vol 30 No3 July 2004

In this paper, their end-use model is verified by investigating the convergence between the predicted model results and independently observed values by others. The paper also illustrates how a few specific water demand management (WDM) measures could be evaluated in detail with the use of their end-use model.

The authors state: "REUM (their model) indicates that a large number of parameters influence water demand, hot water demand, waste water flow and waste water TDS concentration, but that it is possible to estimate values for each of these parameters and apply the end-use concept practically. Future calibration of the model would further increase the accuracy and subsequently lead to wider practical application. Discrepancies between model results and empirical data are ascribed to the fact that unpredictable and varying human habits are not easily converted to parameters, which are required as inputs to the model– this is particularly relevant when predicting garden water demand."

Levin, E., Carlin, M., Maddaus, W. O. (2005) Defining the conservation potential for San Francisco's 28 Wholesale Customers, Efficient2005, Santiago, Chile.

Figure 2. Schematic of DSS Model as Applied to an urban water agency or regional area



Authors state that: "An initial list of 75 conservation measures was screened using qualitative criteria related to the following:

1. Does the product (water-using fixture) work well and is it readily available?
2. Would the measure have widespread application in the Bay Area?
3. Will the retail customer participate in the measure or use the product and is it fair how the measure is applied to the different customer types?
4. Among similar measures that accomplish the same thing, is this the best one?

Thirty-two conservation measures passed the qualitative screening. For those measures, the DSS model was used to evaluate the cost-effectiveness of each conservation measure over a 30-year planning period for each wholesale customer."

Snelling, C., Mitchell C., and Campbell S. (2005) Manual: Melbourne End Use and Options Model, Institute for Sustainable Futures, July 2005

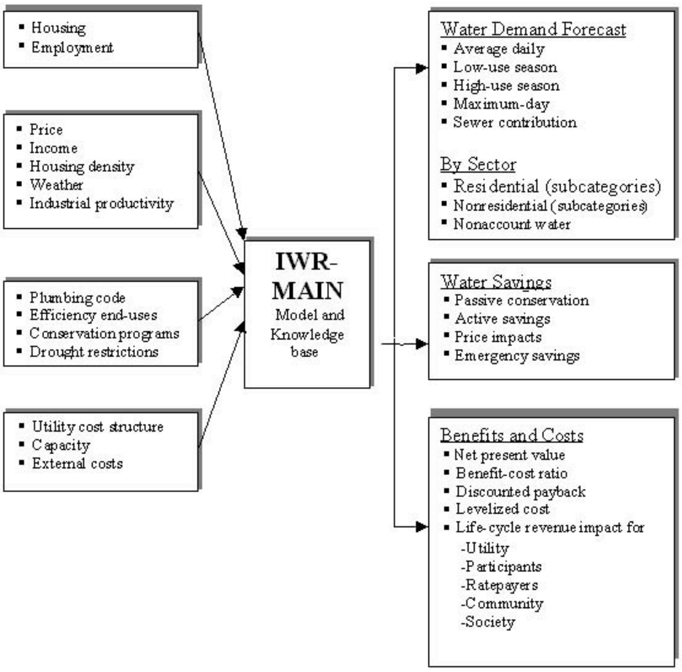
This manual is designed to enable users to fully utilise the Melbourne End Use model developed by ISF, and therefore contains much information about model structure, how to perform various tasks (eg how to run baseline report, a comparative forecast, how to modify/update data and assumptions, create scenarios etc). It will be useful for defining the characteristics of a best practice end-use model.

Sydney Water Corporation (2003) EUM User Guide Version 4.1

Explains the details of the current Sydney Water End-use model, including both demand forecasting and option analysis.

US EPA (2004) Water Conservation Plan Guidelines, Part 5 Advanced Guidelines for Preparing Water Conservation Plans "Part 3. Prepare a Demand Forecast" http://www.epa.gov/owm/water-efficiency/wave0319/advance3.htm

"Several computer models are available for advanced forecasting, many of which can be used in accordance with these guidelines. An example of an advanced forecasting tool is the widely-used IWR-MAIN model, which was developed by the U.S. Army Corps of Engineers (see below) is an illustration of the inputs and outputs of the model. The key features of IWR-MAIN are: spatial disaggregation, seasonal disaggregation, sector disaggregation, multiple determinants of water demand, user-added categories, and sensitivity analysis. The current version of the model also allows planners to incorporate the effects of demand-management into various planning scenarios. Use of empirical models, including but not limited to IWR-MAIN, clearly is consistent with the purpose of these guidelines."



US Army Corps of Engineers (2005) IWR-Main Software, http://www.iwr.usace.army.mil/iwr/software/software.htm

IWR-MAIN is designed to project output from programs impacting water management programs such as: drought planning, watershed planning, capital improvement planning, conservation planning and evaluation, etc.

Van Zyl, K. and Haarhoff, J. (2002) A Residential Water Use Model for Rand Water with Elasticity for Price, Stand Size, Income and Pressure. South Africa.

This study utilised IWR Main to project a scenario for the next 10 years. . To obtain an envelope of minimum and maximum values, combinations of elasticities were selected for the various parameters to either maximize or minimize the total demand. This resource states that: "IWR-Main allows the user to include various factors, including:

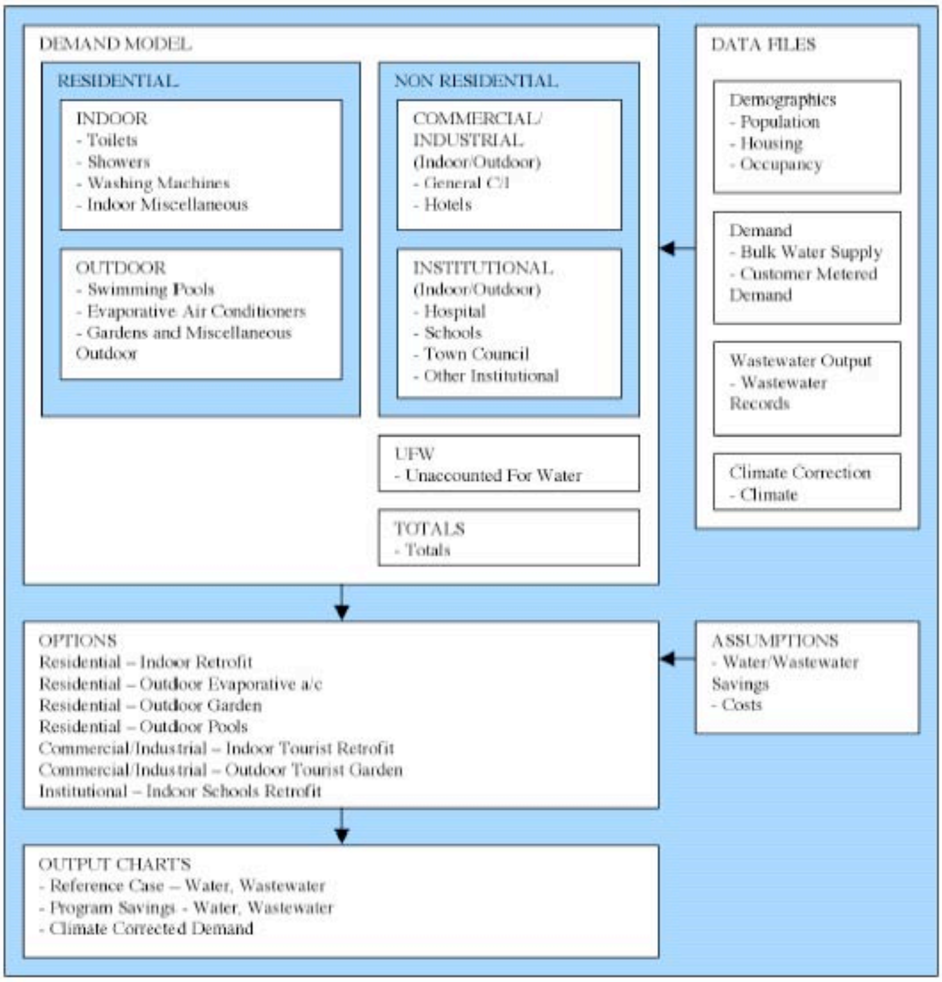
- The implementation over time of plumbing codes to install water saving fittings in houses.
- Including seasonal variations in demand to estimate minimum and maximum demands during each modelling year.
- Various active and passive conservation scenarios.
- Emergency conservation.
- Cost-Benefit analyses of various programmes." (p28) and that:

"The study showed that end-use modelling is a powerful tool for estimating future water demand that can be of great benefit to a bulk water supplier like Rand Water for planning and emergence preparedness purposes.

Quality of input information is of the highest importance for reliable modelling results. It is recommended that Rand Water plan and implement a systematic program to collect and maintain data on its supply area for end-use modelling purposes" (p29–30).

Turner, A., Campbell, S. and White, S. 2003 ' End Use Modelling and Water Efficiency Program for Arid Zones: The Alice Springs Experience' Efficient 2003: Efficient Use and Management of Water for Urban Supply Conference, Tenerife, 2–4 April 2003.

Schematic of the end-use model developed for Alice Springs.



Water Services Association of Australia (2005) EUM User Guide – V.1

"The EUM has been designed as a decision support tool with two primary purposes in mind. The first, forecasting and the second, options analysis and evaluation. These two purposes can be undertaken independently or used together in a single decision making process."

This user guide provides assistance in using the end use model developed by Sydney Water Corporation and adopted by the Water Services Association of Australia the peak body for Australian water utilities.

NSW Department of Land and Water Conservation (2002) Demand Side Management Least Cost Planning Decision Support System – Version 12 User Manual

"The structure of the decision support system is shown in Figure 1. The Baseline Water Use and Savings modules are used once in every DSS file. All other sheets (Measure Impact and Program Evaluation Sheets) can be copied and used any number of times."

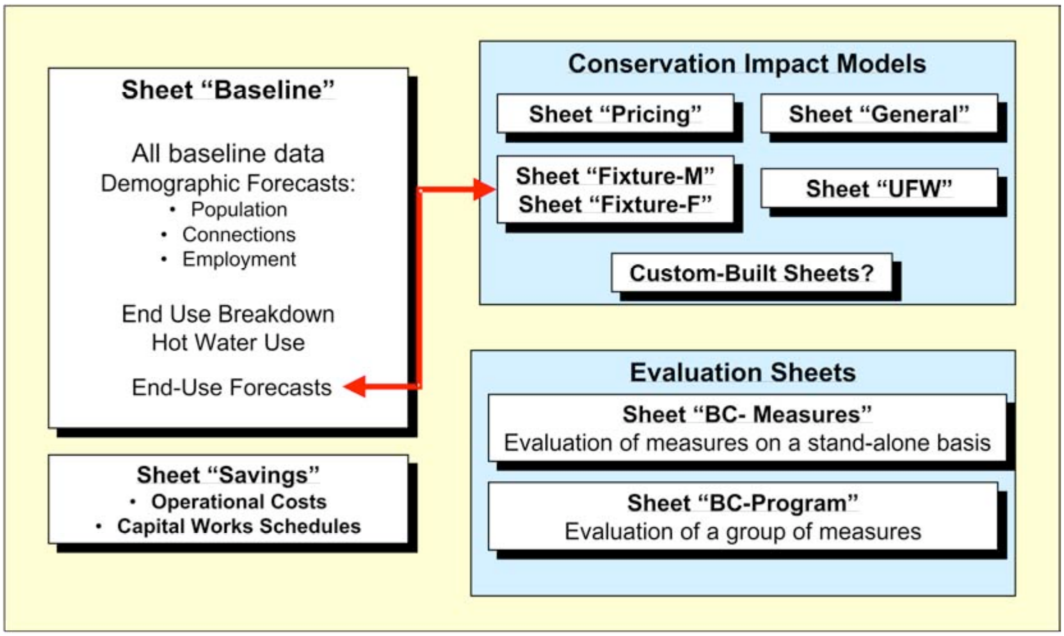


Figure 1: Decision Support System Structure

5.3 *Econometric methods*

Arbues, F., Garcia-Valinas, M. A., Martinez-Espineira R. (2003) Estimation of residential water demand: a state-of-the-art-review. The Journal of Socio-Economics. 32:81–102.

Abstract: "This paper surveys the main issues in the literature on residential water demand. Several tariff types and their objectives are analyzed. Then, the main contributions to the literature on residential water demand estimation are reviewed, with particular attention to variables, specification model, data set, and the most common econometric problems. The paper concludes with comments on future trends and a summary of the contents of the study."

Says that there is no general consensus on the best methodology to analyse water demand, includes a comprehensive table of price elasticities put forward by a large range of authors in the literature. Conclusions state that: "Water price, income, or household composition are crucial determinants of residential consumption."

5.4 *Other types of analysis and models*

5.4.1.1 Agent-based models

Athanasiadis, I., Mentes, A., Mitkas, P. and Mylopoulos, Y. (2005). A hybrid agent-based model for estimating residential water demand. *SIMULATION* 81(3), 175–187.

An agent community is assigned to behave as water consumers, while econometric models and social models are incorporated into them for estimating water consumption. Also provides a brief review of agent-based simulations for water management.

5.4.1.2 Climate correction modelling

Turner, A., Campbell, S. and White, S. (2003) ' End Use Modelling and Water Efficiency Program for Arid Zones: The Alice Springs Experience' Efficient 2003: Efficient Use and Management of Water for Urban Supply Conference, Tenerife, 2–4 April 2003.

As the seasonal variation in demand for water is so significant in Alice Springs, a climate correction model has also been developed which identifies the impact of climate related variables (e.g. rainfall, evaporation and temperature) on bulk water supply. Using these variables and by correcting for population increase over the 20 year period examined, a predicted bulk water supply demand curve has been developed for Alice Springs. This predicted demand curve, developed through multiple regression analysis, has been plotted against the observed bulk water supply records.

When "observed demand is less than predicted demand, this indicates that some other factor has influenced demand (e.g. a price increase, an alternative water source was brought on line or a leak in the system occurred).

The climate correction model is therefore a useful tool that has enabled assessment of whether previous Power and Water (the utility) demand management initiatives implemented in the past have had a noticeable impact on water demand. This model will be used in the future to assist in evaluating demand management initiatives implemented as a result of this Study and other initiatives.

5.5 Sensitivity analysis in demand forecasting

US EPA (2004) Water Conservation Plan Guidelines, Part 5 Advanced Guidelines for Preparing Water Conservation Plans "Part 3. Prepare a Demand Forecast" http://www.epa.gov/owm/water-efficiency/wave0319/advance3.htm

This resource states that: "Multivariate models recognize that demand is dynamic and can change with changes in other variables. Sensitivity analysis helps planners deal explicitly with uncertainty that goes along with these dynamics. Addressing uncertainty is a very important part of advanced forecasting. With larger and more diverse service territories, uncertainties are greater; uncertainty also grows with the time horizon of the forecast. Contingency planning can help utilities cope with uncertainty."

6 OPTIONS DEVELOPMENT AND ANALYSIS

This section covers literature on types of demand management options, source substitution and reuse options. It also covers how to compare options through economic analyses and other qualitative methods to account for non-quantifiable impacts and institutional arrangements necessary to achieve cost-sharing between water authorities and other agencies.

6.1 Processes to identify options

OFWAT (2001) Efficient Use of Water – current progress and future plans

Selects the best options to pursue based on past experience (rather than an end-use approach). OFWAT promotes use of cistern devices, self-audits and long-term education programs and water saving in schools and institutions (particularly hospitals) by promoting self-auditing.

This document reports on actual activities of various UK water companies and assesses them relative to OFWAT's expectations.

Gregg, T. T. and Manager, P. E. (2005) New Developments in Water Efficiency, Efficient2005, Santiago, Chile

Describes a range of approaches which have been employed in recent years to encourage water efficiency and qualitatively describes their value in terms of resulting in water savings.

Very useful resource to consult in describing the possible options that a utility might consider.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

This resource states that: "The plan must consider options available across the full range of "total water management" actions. These include:

- customer side management (policies affecting customer use and supply pipe losses)
- distribution management (policies targeted at activities between distribution and the point of consumption)
- production management (policies targeted at activities between abstraction and distribution input)
- resource management (polices affecting DO, such as new reservoirs or resource transfers). p 42)

The report says that the following options must be considered, amongst any additional ones (p45):

- Customer-side management
  - metering and tariffs (for different customer types)
  - the effect of the new water regulations/ market trends
  - retrofit programmes/appliance exchange (waterless urinals, showerheads, toilet displacement bags etc)
  - behavioural/ awareness
  - water audits (households and non-households) .
- Distribution management
  - leakage control (including different components)
  - trunk mains leakage
  - leakage/overflows at service reservoirs.
- Production management
  - reduction in process water losses.
  - recycling of water and / or improved treatment technology.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

The Agency expects the widest range of total water management options to be considered at the outset of preparing the plan.

Wilson (2004) Schools water efficiency and awareness project, *Water SA* Vol. 30 No. 5, pp 93–94

Lays out the methods used and success of, intervention in schools using heavy duty bags inserted into toilet cisterns and action plans to improve water efficiency. The savings were 400% more than the cost of the project – therefore it is a beneficial, low-cost project that could be implemented elsewhere.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Measure screening process (p35)– suggests screening options by rating 1–5 for the criteria below:

1. technology/market maturity: eg. is technology locally available?
2. service area matching eg. is it appropriate to the climate, local conditions?
3. customer acceptance/equity. Eg. will it be acceptable to customers (which may be based on convenience, economics, perceived fairness, cultural acceptance, aesthetics, environmental values). Also, equity needs to be considered so that not just one category of customers is made to pay
4. best available measure– if choosing between two or more measures of equal effectiveness then other criteria (eg ease of implementation, lower unit cost) may be used to screen.

Given that this is a qualitative process, need to decide who should be involved in this step in the decision-making. The objective is to reduce the list to 20–30 measures that pass the screening. An example table is given on p36 of measures and their ratings for Coffs Harbour.

Almeida, M. C., Baptista, J. M., Vieira, P., Ribeiro, R. and Silva, A. M. (2004), Efficient use of water in Portugal: a national program, IWA World Congress and Exhibition, Marrakech, September 2004

Considering a measure as an action leading to better water use (reduction of consumption or of wastage), a total of 87 measures were identified where 50, 23 and 14 directly applicable to the urban, agricultural and industrial sectors, respectively. For each measure the following assessment was carried out:

1. Characterisation: description of the measure, beneficiaries, main advantages and disadvantages.
2. Evaluation of the potential water savings: reduction in total volume based in calculations, or experience from similar situations, and corresponding efficiency.
3. Implementation strategy: appropriate mechanisms for implementation, responsible for the implementation and addressees.
4. Analysis of viability: using viability criteria (economic, technologic, functional, environmental, social and public health).

Following the assessment, priorities were assigned to each measure and conditions necessary for its effective implementation identified (which mechanisms, responsibility for implementation and target groups). Once the theoretical potential efficiency is identified for each measure, the actual efficiency in water use was estimated for the three sectors.

Almeida, M.C., Melo Baptista, J., Vieira, P., Moura, E., Silva, A. (2001). Saving urban water in Portugal: assessing the potential of measures and strategies for implementation. *Efficient use and management of water for urban supply*, 21–23 May, Madrid, Spain (Spanish version page 48–56, ISBN 84-932364-1-1. English version CD-ROM and *Water Intelligence Online, 2002, ID:* 200205018).

The analysis of viability of each measure is meant to provide the basis for the implementation proposal. The following set of criteria covers aspects considered more relevant:

> *Economic viability* – From the calculated potential water saving in a typical average situation, expected investment as well as reduction in water, wastewater and eventually energy bills estimated.

> *Technologic viability* – An indication is given on whether products or equipment necessary to implement the measure, are available in the market.

> *Functional viability* – The difficulty associated with the implementation of the measure in terms the operation or extra maintenance is addressed.

> *Environmental viability* – Benefits or drawbacks to the environment resulting from implementation of the measure are assessed.

> *Social viability* – Public acceptance of the measure is evaluated.

> *Public health viability* – Potential public health risks that a measure may introduce are assessed. Exception made to the economic viability, all other criteria are not quantifiable and only a qualitative evaluation is carried out. The same applies to the economic viability when quantification is not possible.

6.2 Detailed design of options (including measures and instruments)

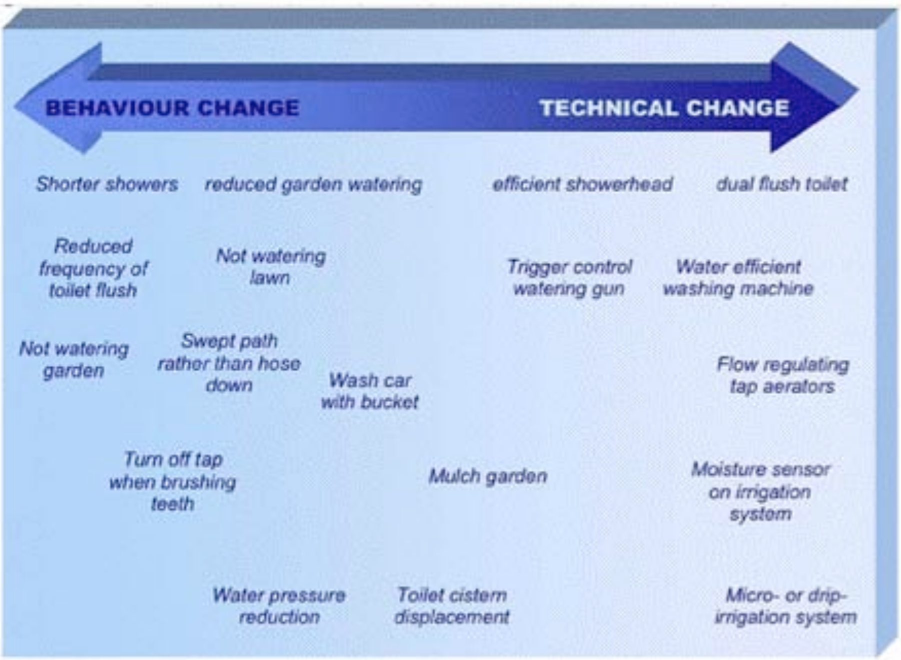
Turner, A. & White, S. 2006 'Does demand management work over the long term? What are the critical success factors?' Sustainable Water in the Urban Environment II Conference, Sippy Downs, Queensland.

This paper states: "This paper identifies some of the key issues in planning, developing, implementing and evaluating demand management (DM) programs to ensure water efficiency is maximised and savings are achieved and maintained in the long-term. The paper draws on the experience of the Institute for Sustainable Futures (the Institute) and key staff who have worked closely with many water planners and DM managers across Australia since the early 1990s."

This paper specifically covers concepts such as water conservation potential, behavioural and technical change and measures and instruments which are all critical when designing options.

"Figure 3 illustrates some of the typical options available in the residential sector and the combination of structural/technical and behavioural changes that can be used to tap into the conservation potential available.

Figure 3 – Structural/technical and behavioural changes (White et al, 2003) "



Turner, A. & White, S. 2003 *ACT Water Strategy: Preliminary demand management and least cost planning assessment,* report prepared by the Institute for Sustainable Futures for ACTEW Corporation, ACT, Australia

This public document demonstrates how options were developed for ACT, Australia

Turner, A., White, S. & Bickford, G. 2005 'The Canberra Least Cost Planning Case Study', *International Conference on the Efficient Use and Management of Urban Water*, Santiago, Chile, 15-17 March 2005.

This paper covers: "…the assessment a suite of options consisting of demand management, source substitution, reuse and supply were developed to determine how to satisfy water demand requirements for the projected population over the 50 year planning horizon whilst also achieving the identified demand reduction targets"

Turner, A., Campbell, S. & White, S. 2004, 'Methods Used to Develop an End Use Model & Demand Management Program for an Arid Zone' *Biennial World Water Congress,* Marrakech, Morocco 19-24 September 2004.

This paper is focused on how options were developed for an arid region of Australia. The abstract states: "Outdoor demand in arid climates generally represents a significant proportion of total demand and is often extremely seasonal in nature and difficult to characterise, leading to problems when building an end use model and determining which options will provide the highest water savings at the lowest cost. In the investigations undertaken for Alice Springs, a wide variety of low cost methods for gathering data were used to disaggregate water demand, build an end use model and assist in the development of the demand management (DM) program. These included: analysis of bulk water and customer metered demand; review of available data and documents on water issues; the use of a low cost residential water usage survey which was linked to customer metered demand; interviews with suppliers/maintenance specialists (e.g. pools, air conditioners and garden irrigation); and an experiment in relation to evaporative air conditioning systems. During these investigations it was found that the unit cost of the individual DM options ranged from as low as 0.20 AUD per kilolitre for some institutional efficiency options to 1.40 AUD per kilolitre for residential washing machine rebates. It was also found that due to the high energy costs associated with pumping water from the existing supply, considerable savings could be made by deferring borefield augmentation and operating costs. In fact for the proposed demand management program, combining 15 individual DM options, the savings in operating costs for water supply alone exceed the whole of society costs of the DM program. This paper will be useful to those dealing with water efficiency issues in arid zones by providing details on cost effective data/information sources and methods, the use of climate correction, the types of DM options available for arid zones and details of typical unit costs."

Turner, A., White, S., Smith, G., Al Ghafri, A., Aziz, A & Al-Suleimani, Z. 2005 'Water Efficiency - A Sustainable Way Forward for Oman' Stockholm Water Symposium, Workshop 5.

This paper states: "This paper provides details of a water efficiency and sustainable water management strategy, including allocation planning, undertaken for Salalah, the second largest city in the Sultanate of Oman. The balance between water supply and demand in Salalah means that the groundwater resources are increasingly suffering from saline intrusion, which will result in economic, environmental and social impacts."

This paper provides details of both the demand forecasting methods adopted using limited information and the suite of residential, non residential and non revenue water options developed and costed in the urban sector as well as heavy industry and agricultural options.

US EPA (2004) Water Conservation Plan Guidelines. Available on http://www.epa.gov/owm/water-efficiency/wave0319/index.htm accessed 8/7/05.

A three-level structure is presented for water conservation measures. Level 1 contains four categories of measures that are recommended for consideration, at a minimum, in the Basic Guidelines. Additional measures and categories are added for Levels 2 and 3, and recommended for consideration in the Intermediate and Advanced Guidelines, respectively. The three levels and the categories included in each are:

> Level 1 Measures: Universal metering, Water accounting and loss control, Costing and pricing , Information and education
>
> Level 2 Measures: Water-use audits, Retrofits, Pressure management, Landscape efficiency
>
> Level 3 Measures: Replacements and promotions, Reuse and recycling, Water-use regulation, Integrated resource management

Six appendixes to the Guidelines provide supporting information: detailed descriptions of conservation measures (Appendix A), conservation benchmarks (Appendix B), acronyms and a glossary (Appendix C), information resources (Appendix D), funding sources (Appendix E), and state contacts (Appendix F)."

Green (2003) Education towards improving irrigation efficiency and furthering water-wise landscaping practices, Efficient2003 2nd International Conference in Efficient Use and Management of Water for Urban Supply, Tenerife, Spain, April 2003

Explains the range of initiatives they employed including rain sensor give-aways/requirement/education, water-wise plant lists and stickers, water-wise demonstration gardens, educational videos.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Contains a comprehensive list of conservation measures (p58–66, Annex II).

OECD Policy Brief (2002) Towards Sustainable Household Consumption? Trends and Policies in OECD Countries

"Box 3. Policy tools for household sustainable consumption: some examples:

1. Where externalities exist or where the public good quality of environmental goods or services makes it impossible to use markets to allocate resources effectively, governments have an important role to play in increasing market effectiveness and providing the framework conditions in which society meets it environmental protection goals. They can do so using a combination of economic, regulatory and social instruments.
2. Economic Instruments: e.g. waste fees, taxes on energy and water use, deposit-refund schemes for beverage bottles and batteries, removal of water subsidies, subsidies for green energy, tradable permits for municipal waste, green tax reform
3. Regulatory Instruments: e.g. regulation on environmental labels and "green" claims, waste management directives, energy-efficiency standards, extended producer responsibility regulation, statutory pollution emissions targets, water quality standards, product bans
4. Social Instruments: e.g. public information and environmental awareness campaigns (on waste, energy, water, transport), education, public debate and participatory decision-making processes, support to voluntary citizen initiatives, partnerships with other actors (private sector, NGOS, etc.)
5. Other Tools: e.g. state of environment assessment and goal setting, development of sustainable consumption indicators, incentives for environmentally superior technological innovation and diffusion, infrastructure provision, zoning and land-use planning.

Zhang, H. H. W., and Bessie W. M. (2001) Water Demand and Water Efficiency Management, OECD document

Economic Techniques: These are the techniques based on the demand (vs. requirement concept) of the water use which is a general concept of economy to denote the willingness of consumers or users to purchase goods, services or inputs to production processes, since that willingness to pay varies with the price of the commodity. (Kindler and Russell, 1984, p8) These techniques rely upon a range of monetary measures both incentives such as rebates, tax credits and disincentives such as higher prices, penalties and fine.

1. A. Pricing

> Rate policies including: Uniform commodity rates, Increasing block rates, Peak load pricing, Seasonal pricing, Summer surcharges, Full-cost pricing, Lifeline base price with inclining pricing, Excessive use charges, System development fees (Section 2.1)

Structural and Operational Techniques:

1. Structural techniques: that alter existing structures to achieve better control over water demand
   > Metering
   > Retrofitting
     - Toilet: Leak detection and repair, Ultra-low-flush toilets, Early closure flapper valve
     - Shower: Low-flow showerheads, Shower-flow restrictors, Shut-off valves,
     - Bathroom and kitchen faucet: Low-flow faucets, Faucet aerators, Faucet washer,
     - Urinal, Ultra-flow flush urinal, Valve retrofit,
     - Water treatment devices, Water efficient reverse osmosis filters, Water efficient water softeners,
     - Other water efficient appliances such as washing machine, dishwashers, air conditioners.
   > Controlling Flow/ pressure reduction
   > Water reuse/recycling/recirculation
     - Greywater system,
     - Dual flush system,
     - Cooling water recirculation,
     - Reuse of cooling and process water,
     - Reuse of the treated wastewater
2. Operational techniques: that are actions by water users to modify existing water use procedures to, control the demand pattern more efficiently.
   > Leakage detection and repair
   > System rehabilitation
   > Xeriscape, Water efficient design, Water efficient plant material, Efficient irrigation system, Garden hose timer, Soil moisture sensor, Turf reduction, Scheduled irrigation,
   > Water use restriction during periods of water shortages,
   > On-site water audit (Section 2.2)

Socio-political Techniques: These in water demand management context refer to policy and related measures that can be taken by public agencies to encourage water conservation.

1. Public education (information) program,
   > Direct mail, Bill inserts, Newsletters, Pamphlets ,
   > Public media, Newspaper, Radio and television spots, Posters and flyers,
   > Special Events, Environment days, Demonstration gardens, Water facility tours, School programs, Educational videos,
   > Personal contact Dissemination of domestic water-saving devices and kits, Conversation/ assistance hot lines, Speaker program
2. Laws and regulations
   > Land-development codes,
   > Tap fees for development hook-ups,
   > Turf limitation by-laws,
   > Water-efficient landscaping by-laws,
   > Efficient Land-development pattern (smaller, more dense housing),
   > Subdivision agreement modifications,

- Water permits,
- Plumbing code,
- Lawn watering restrictions,
- Landscape water assessments,
- Once-through cooling system bans,
- Industrial, commercial and, institutional water use inspections,
- Limited-use, contracts

3. Direct Restriction on Use:

- Rationing including:
    - Fixed allocation,
    - Variable percentage plans,
    - Per capita use allotments,
    - Prior use allotments,
- Priorities on water use by customer class:
    - Time of day restrictions on lawn watering,
    - Bans on certain water uses,
- Moratorium on new service connections

4. Government economic policies: that are designed to obtain cooperation from the public in moving, toward improved water management practices. Thus one of the most important techniques in this field is effective public education (Section 2.3)

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana, C. Krinner W. and Estrela T., CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen, Copenhagen.

This resource states that: "Water savings are likely to increase when linked with metering. Therefore, there seems to be a better acceptance by users if they can see a reduction in their water bills. Metering is an essential element of water demand management. Immediate savings from introduction of metering are estimated to be about 10–25 % of supply. The introduction of metering is usually accompanied by a revised charging system and leakage reduction schemes. It is difficult to separate the impact of meters from the other measures, in particular from the water charges applied." (p.56)

Measures can be categorised (p11):

- *"by type of incentive:*
    - legal obligation (e.g. compulsory use of certain technologies, quota for water use)
    - economic incentives (e.g. tariff systems, progressive pricing, subsidies for water saving investments)
    - information, motivation (e.g. information campaigns, user education, programs to increase environmental awareness, concern for public image)
- *by kind of tools used:*
    - infrastructure improvement (network improvement, repair leaks, etc.)
    - non-structural measures (information, education, pricing), which may, however, finally lead to infrastructure improvements being implemented normally through end-users because of the measures adopted
- *by time horizon:*
    - emergency measures
    - medium- and long-term measures
- *by location of the water supply system, where measures are implemented:*

- abstraction facilities
- storage facilities
- conveyance and distribution network
- end-users' facilities

> *by entity bound to carry out measures:*

- agencies and public authorities (e.g. initiatives within water supply companies)
- end-users (households, industries, farmers)

> *by entity promoting demand management initiatives:*

- international treaties and conventions
- EU legislation and policies
- national legislation
- local and regional initiatives

> *by sector in which measures are applied:*

- urban use (households, small commerce, etc.)
- industry
- agriculture."

Billings, R. and Jones, C. (1996), Forecasting Urban Water Demand, American Water Works Association

Simple way to include/model water conservation programs into a demand forecast is to deduct the estimated savings of the conservation program from the BAU forecast. A more sophisticated approach would be to include conservation impacts as independent variables along with the price of water, personal income, weather, etc. in a multivariable forecast model. (p.142)

Rocky Mountain Institute (1991), Water Efficiency: A Resource for Utility Managers, Community Planners, and other Decision-makers, by the Water program, Rocky Mountain Institute, Colorado.

Implementation techniques for end-use technologies include (p.56):

> ordinances,

> financial incentives (such as hook-up fees for new construction, giveaways and rebates, retailer rebates, direct installations, surcharges, grants and loans, voluntary curtailment for reducing peak loads),

> education (information and promotion),

> integrated programs (examples provided p. 67).

> advanced methods (such as transferable savings, competitive bidding, limited-use contracts.

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Contains basic steps in a residential water audit (p. 20), basic steps in a landscape water audit (p. 152) and basic steps in an ICI water audit (p. 241). States that: "First step towards increased water-use efficiency at an ICI facility typically involves conducting a water audit and subsequently, preparing a site water conservation plan."

Specific water efficiency measures for ICI sector are provided in detail here (note costs are not discussed). p.244

Landscape water efficiency measures (p.155 for more detail). 8 step blueprint for designing and maintaining a water-efficient landscape:

1. Group plants according to their water needs.
2. Use native and low-water-use plants
3. Limit turf areas to those needed for practical uses
4. Use efficient irrigation systems
5. Schedule irrigation wisely

6. Make sure soil is healthy
7. Remember to mulch
8. Provide regular maintenance.

Californian Urban Water Conservation Council (2001), BMP9 Handbook: A guide to Implementing Commercial, Industrial and Institutional Water Conservation Programs as specified in Best Management Practice 9, prepared by Whitcomb, J., Hoffman, B., and Ploeser, J. for CUWCC, California.

Details of a CII Ultra Low Flow Toilet replacement programs are provided (p.15). Including total water savings potential, replacement strategy, council reporting requirements, CII Replacement implementation.

Also provided are measures to meet performance-based targets (eg. 10% reduction of CII water use). Measures include: ULFT replacements, landscape surveys and water budgets, water-use surveys, financial incentives, performance contracting, water and sewer rates, regulations/ordinances/laws.

GDS Associates, Brown, C., Gregg, T., Axiam–Blair Engineering (2004), Water Conservation Best Management Practices Guide, Texas Water Development Board. http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf

This is an updated list of BMP practices for municipal, industrial and agricultural conservation. Glossaries for municipal, industrial, and agricultural conservation.

Herrington, P. (2005) The Economics of Water Demand-Management: Chapter 10 in Water Demand Management, International Water Association, Editors David Butler and Favyaz Memon, August 2005, 384 Pages, ISBN: 1843390787

Detailed analysis of various options for various end-uses and their success and application: p25–33. Concludes that (p42) retrofitting water saving components (WC adjustments, new showerhead) is more likely to satisfy economic criteria that accelerated replacement of white goods with new economy models (WCs, dishwashers, washing machines). Significant rainwater harvesting or greywater recycling for potable water use is shown to be unlikely to be economic at present, although evidence to support non-potable use demands has been shown.

Metering – to meter or not to meter….p35– literature review of several studies in which there was an economic gain associated with implementing metering, and also benefits derived from more sophisticated tariffs such as increasing-block and seasonal tariffs for already metered households. Conclusions– often selective household metering generate higher economic gains than universal metered charging.

Options: Table 10.4 compares IRR and unit costs for a range of studies for a range of options- such information would be useful for decision-making and policy-makers in deciding which measures to take forward.

Econometric studies of demand management p36d

Foxon, TJ; Butler, D; Dawes, JK; Hutchinson, D; Leach, MA; Pearson, PJG; Rose, D J. (2000) An assessment of water demand management options from a systems approach. Chart. Inst. Water Environ. Manage. 14(3) 171–178.

A systems approach is used to model the urban water and wastewater system. Scenarios are developed for the implementation of a range of water demand management measures, including (a) leakage reduction, (b) the increasing use of water metering, (c) the replacement of standard WCs by low-flow WCs, and (d) the introduction of greywater recycling systems. These measures are assessed according to the water saving, cost per unit of water saved, and other indicators of the relative contribution to the sustainability of the system. Preliminary assessments of selected environmental costs and benefits are also included.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Measures: typical measures Section A (measures that can be taken by the utility like leak detection) and Section B (measures that can be taken by customers) in Part V

Pricing: p30–33: Types of pricing that encourages efficiency include:

> low rate for baseline usage and high rates above this
> inclining tier rates with volume amounts where higher unit rates apply at higher water use levels
> seasonal rates or excess-use charges
> marginal cost pricing

It is critical for planners to have an understanding of price elasticity concepts since they greatly influence the revenue generated and thus the financial situation of the utility. Two key refs on this are Tom Chestnutt (Implementing conservation rate structures) and AWWA (Water rates, fees and charges)

Roberts P. (2005) 2004 Residential End Use Measurement Study 2004, Yarra Valley Water. Report, June 2005. Victoria.

Large residential measurement program conducted in 2004– contains much useful information that might be useful for understanding water use and designing options based on this understanding.

Roberts P. (2004) 2003 Appliance Stock and Usage Patterns Survey, Yarra Valley Water Report, November 2004.Victoria.

Reports the trends in changes in appliance stock and usage between 1999 and 2003 and therefore has potentially useful information for designing options.

Almeida M. C., Baptista J. M., Vieira, P., Ribeiro, R. and A. M. Silva (2004), Efficient use of water in Portugal: a national program, IWA World Congress and Exhibition. Marrakech, September 2004

Four programmatic areas (PA) as follows: PA1 – Information and education, PA2 – Documentation, formation and technical support, PA3 – Technical regulation, labelling and standardization, PA4 – Economic, financial and fiscal incentives.

Almeida, M.C., Melo Baptista, J., Vieira, P., Moura, E. and Silva, A. (2001). Saving urban water in Portugal: assessing the potential of measures and strategies for implementation. *Efficient use and management of water for urban supply*, 21–23 May, Madrid, Spain (Spanish version page 48–56, ISBN 84-932364-1-1, English version CD-Rom and *Water Intelligence Online, 2002, ID:* 200205018).

Information and education: The promotion and divulging of information on the relevant issues is fundamental for the successful implementation of any measure. Different formats have to be used depending on the target audience, which can be the general public or specific groups of professionals, among others.

Regulation, standardisation and legislation: The development of documents that regulate the necessary aspects of the activities of water supply undertakers, the characteristics of efficient equipment, devices and appliances, wastewater discharge permits, environmental impacts assessment and others can result in important benefits for water use efficiency. The certification of activities, firms and products can also bring improvements in the general performance of their associated procedures leading to a more rational consumption and recovery of resources.

Economic and financial incentives: The establishment of economic and financial incentives often is the best way to foster the application of a certain measure for efficient use of water.

Water audit procedures: A water audit consists of procedures to assess the present state of water use aiming at the identification of potential reduction alternatives. Audits can be applied to any type of facilities (e.g. commercial, industrial, institutional) or even at households.

Research and development: Despite of the existing knowledge and experience there still open areas that need further research to improve the applicability, efficacy and viability of certain potential measures as well as the development of technological innovations.

Almeida, Maria do Céu, Vieira, Paula, Ribeiro and Andrade, Márcio (2005). Needs and Barriers in Technical Regulations and Standards for the Efficient Use of Water: Situation in Portugal and Brazil, Efficient 2005, Santiago, Chile

Authors state that: "Appropriate legislation, technical regulations and standards are essential to put into practice water-efficient technologies, procedures and products, both to promote the implementation and to avoid eventual barriers in the application of the adequate measures. In Portugal as in Brazil, efficient use of water and the reduction of water waste are important environmental goals. In the former, the National Program for the Efficient Use of Water for the urban, agricultural and industrial sectors is the base document for this purpose. In the later, the National Program to Prevent the Waste of Water, for the urban sector, is in action since 1997.

The purpose of the paper is to present a brief overview of the current situation in terms of regulations and standards, highlighting the needs and some barriers, having as reference the situation in Portugal and Brazil, and the measures intended to be applied in the respective programs."

6.2.1.1 Non-residential sector options

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Contains information on how to conduct a water audit that is useful for forecasting demand in this sector.

Basic steps in an ICI water audit (p. 241). "First step towards increased water-use efficiency at an ICI facility typically involves conducting a water audit and subsequently, preparing a site water conservation plan."

1. Obtain support from the ICI facility's owner, managers and employees.
2. Conduct an on-site inventory of water use.
3. Calculate all water-related costs.
4. Identify and evaluate water-efficiency measures.
5. Evaluate payback periods using life-cycle costing.
6. Prepare and implement an action plan.
7. Track and report progress.

Specific water efficiency measures for ICI sector are provided in detail here (note costs are not discussed). p.244

AMWUA (2003). *Facility Manager's Guide to Water Management*, Arizona Municipal Water Users Association. http://www.amwua.org/conservation/facility_managers_guide.htm

"Recognizing the wide variety of non-residential water users in the Valley and the differences among the non-residential water use sectors from city to city, these materials were designed to be applicable to nearly every type of non-residential user.

The materials are assembled in a handbook for non-residential facility managers, general managers, public information officers, and other personnel involved in water conservation and employee communication. The handbook contains information regarding the critical steps of developing and implementing a water conservation plan:

- Commitment of top management
- Understanding your water system
- Plan development
- Employee participation

Contains a series of "how to" sheets and checklists, as well as water conservation messages and artwork for use in employee newsletters and other employee communications are also included. The three-ring binder allows individual cities to customize the information and materials to meet specific needs."

US Department of Defence (1997), Military handbook water conservation http://www.pdhonline.org/courses/c131/c131.pdf

Water conservation, maximizing the efficient use of water resources, is rapidly becoming a critical part of many military operations as more and more demands are placed upon existing water supplies. This military handbook provides numerous methods to increase water efficiency and details the requirements of Executive Order 12902 as it relates to water conservation within the Department of Defense. In addition, this handbook also includes, in its appendices, procedures for submitting water conservation projects for central funding programs.

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana C., Krinner W. and Estrela T., CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen, Copenhagen.

This resource states that the “Essential elements of water demand management programmes in the urban context are measures dealing with economic incentives. Price structures are generally fixed at municipal level and can vary widely within a country. The differences, in general, take into account different types of users (e.g. domestic, industrial and agricultural), and tend to reflect differences in cost structures.”

Case studies of economic incentives (incl. in different tariff structures) provided from pg. 37.

Regarding price elasticity (p.38), this resource states: “In practice, there are many methodological problems associated with studying this relationship. One of the main problems is that water consumption patterns are influenced by a great number of factors (e.g. network repairs/pressure variations, information campaigns and climate variations), making it very difficult to isolate price as the main factor explaining the variation of water uses. From this, it has been concluded that water price is difficult to use as a demand management tool. However, increased tariffs are often considered a useful tool to make users more responsible for their water use, when applied in conjunction with other water conservation advice and techniques. ”

Keating, T. and Styles, M. (2003). Performance Assessment of Low Volume Flush Toilets St Leonards Middle School, Hasting http://www.greenbuildingstore.co.uk/es4report.pdf

Toilet flushing accounts for up to a third of the total domestic water consumption and has therefore been a focus for water efficiency campaigns and promotions by water companies.

Ongoing debate about robust ways of reducing flush volumes prompted Southern Water to trial 4.5 litre, single flush ES4 toilets in a practical school setting, to verify their water saving potential and performance.

Type of measure	PNUEA	PNCDA	Regulations	Standards
Pressure management of public water supply systems	✍	✍	Definition of operation ranges and maximum daily fluctuations in pressure at water distribution systems	Specifications for Pressure Reduction Valves defining minimum performance standards
Control of losses in public water supply systems	✍	✍	Setting of reference values by the national water sector regulator	Adoption of the International Water Association terminology and methodology for the water audits as a standard procedure
Use of tariff structures promoting water saving	✍		Definition of tariff structures promoting water saving by the national regulator	-
Use of non-potable water including wastewater reuse	✍	✍[1]	Regulations regarding applications and conditions	Procedures and criteria for wastewater reuse in non-potable urban uses and in aquifer recharge Procedures and criteria for the use of non-potable water (non treated water from surface or underground sources, grey water, rain water) in building water networks
Replacement or retrofitting of toilets, showers, taps, urinals	✍	✍	Compulsory use of efficient devices in new developments or rehabilitation works Compulsory use of automatic control systems in urinals in new developments or rehabilitation works of facilities for public use Compulsory use of appropriate labelling of all devices available on the market	Specifications for efficient devices Test procedures for efficient devices Specifications for labelling of devices available on the market
Replacement of clothes and dish washers	✍	✍	Limitation of the characteristics of equipment on the market for domestic use Compulsory use of appropriate labelling of all washers available on the market	Specifications for efficient equipments Test procedures for efficient equipments Specifications for labelling of equipments available on the market
Use of waterless toilets	✍		Compulsory use of appropriate labelling of all devices available on the market	Specifications for the devices, including design, installation, operation and maintenance procedures and performance criteria Definition of situations where the use of these devices is recommended Specifications for labelling of devices available on the market
Thermal insulation of hot water distribution pipes	✍		Compulsory use of insulation in new developments or rehabilitation works	-
Use of portable high pressure water cleaning devices for car washing	✍		-	Specifications for labeling of the devices with information on water consumption
Adequate management of irrigation, soil and vegetable species in gardens and other vegetated areas (e.g., sportive areas, golf courses and parks)	✍		Compulsory use of water efficient landscaping in public gardens and other vegetated areas, including an adequate soil preparation, the selection of native vegetable species, the use of more efficient irrigation techniques and the limitation of area planted with non-native vegetable species	Specifications for labeling of irrigation equipment with information on water consumption Specifications for labeling of vegetable species generally in terms of preferred location conditions particularly for drought resistance
Rainwater use in gardens and other vegetated areas (e.g., sportive areas, golf courses and parks) and in water features	✍	✍	Compulsory use of rainwater in new vegetated areas with big dimensions, comprising compulsory construction of water collection and storage infrastructures	-

[1] Not directly included in PNCDA but in many municipal programs.

6.2.1.2 Commercial, institutional and industrial sector options

Maddaus, W. (1987), Water Conservation, American Water Works Association, CO.

Briefly describes measures on how to reduce commercial and institutional water use

Brown, C., Gregg, T., Axiam-Blair Engineering (2004), Water Conservation Best Management Practices Guide, Texas Water Development Board.
http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf

This is an updated list of best management practices (BMP) practices for municipal, industrial and agricultural conservation. Glossaries for municipal, industrial, and agricultural conservation including indoor and outdoor uses. Important reference since it includes outdoor spaces overseen by councils etc

Vickers, A. (2001), *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Describes in detail characteristics of water use for irrigating landscaped areas, including lawns and presents water efficiency measures to conserve water in outdoor sector. Sources of landscape water are described (such as poor irrigation scheduling) p144.

Basic Steps in a landscape water audit (p.152):

> Explain purpose of audit
> Review outdoor water use
> Evaluate lawn, landscape and irrigation features
> Measure water use of irrigation equipment
> Provide landscape water-efficiency recommendations
> Leave information and install conservation devices.

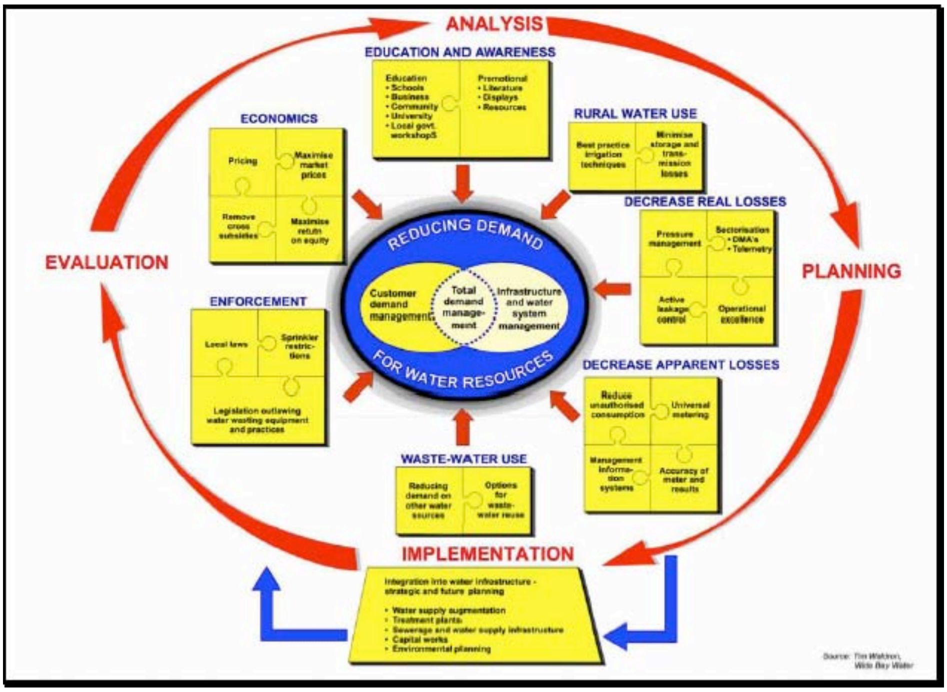
Vickers, A. (2001) *Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms*. WaterPlow Press, MA.

Covers methods for water audits in industrial sites.

6.2.1.3 Non-revenue water options

McKenzie, R.S., Buckle, H., Wegelin, W.A., Meyer N. (2004), *Water Demand Management Cookbook*, Rand Water, United Nations Human Settlements Programme UN-HABITAT, Water Resource Planning and Conservation

Covers a simple and straightforward approach to managing leakage/losses and education within the context of WDM, specifically for use in developing countries. Flowchart for Developing WDM Strategy (p.5):



Farley, M., Liemberger, R. (2004) Developing a Non-Revenue Water Reduction Strategy, Part 2: Planning and Implementing the Strategy, Conference Proceedings, IWA World Water Congress, Marrakech (can be downloaded from www.liemberger.cc)

This paper deals with the tasks and tools required to address the constraints, and to develop a strategy to reduce NRW which is practicable and achievable, and which can be adapted for any distribution network anywhere in the world. The paper discusses each step of the strategy and its development, from upgrading the network by improved infrastructure management and zoning, to the available techniques and equipment for monitoring and detecting real and apparent losses.

6.3 Options analysis

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

In broad summary the following steps should be identifiable in the development of the plan:

1. Establish an overall basket of options
2. Determine the sub-set of options worthy of further consideration. This should still be a greater number of options than the final number required to achieve or maintain the supply-demand balance
3. Consider timing and scheduling
4. Apply economic appraisal
5. Identify an initial preferred economic solution
6. Consider linkages between options
7. Refine initial solution
8. Consider wider issues of risk, uncertainty, sustainability etc
9. Identify alternative combinations of options in respect to wider issues
10. Compare and contrast relative merits of alternative solutions
11. Conclude a “final planning” solution.

Herrington, P. (2005) The Economics of Water Demand-Management: Chapter 10 in *Water Demand Management*, International Water Association, Editors David Butler and Favyaz Memon, August 2005, 384 Pages, ISBN: 1843390787

Comparison between options: Need technical, economic, environmental and social dimensions to appraisal and it is worth keeping these criterion separate (p5).

Environmental– some believe should include with economic analysis, others say that should keep separate and either set environmental standards that reflect society's chosen sustainability requirements (and include costs that it takes to reach these standards can be included in an analysis) or conduct a completely separate environmental appraisal such as an Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Risk Assessment (RA), Life Cycle Analysis (LCA) or some sort of Multi-criteria analysis (MCA).

Social appraisal- social (public opinion), political (legislative position) and institutional (capacity) feasibility. These are more like hurdles which must be overcome than appraisals as such.

6.3.1 Economic analyses

Gleick et al (2003) Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Uncertainty prevails in all economic analyses, and in this case is due to variations in water prices and rate structures that vary over a wide range of values and designs, to human responses to price changes and to changing costs of water-efficiency options. To address these uncertainties, need to make assumptions and citations explicit- noting the uncertainties and inadequacies of the analysis. Soliciting extensive external review and feedback on methodology used helps improve reliability. p28

CPUC (2001) California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects, by the California Public Utilities Commission

Provides updated information on the various cost perspectives tests and what aspects are included and excluded for each one- covers participant, ratepayer impact, total resource cost and program administrator perspectives.

ADB (1999) Handbook for the Economic Analysis of Water Supply Projects, Guidelines, Handbooks, and Manuals, Economics and Development Resource Center, Asian Development Bank ISBN: 971-561-220-2, 361 pages.

Handbook is better than current industry practice in that it covers some details on external effects and distributional impacts.

The non-market costs that they include and describe are opportunity cost of water (eg costs lost if the water is not used for agriculture), depletion premium for the withdrawal of groundwater (as a finite resource which therefore can't be used in the future), household cost associated with a technological option (eg. Rainwater collection costs a householder whereas a tube-well might not).

There is a chapter on least cost analysis (describing different methodologies), another on financial analysis and another on economic analysis and they summarise how they view the differences between these on p 169.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

A key feature of the development of the plan is the economic analysis of options to manage the supply-demand balance. Approaches to the economic assessment of options have recently been reviewed by the UKWIR/Environment Agency project *The Economics of balancing supply and demand* (2002). The approaches proposed by this work build on the average incremental social cost (AISC) approach used by the Agency and companies in the development of water resources plans in 1999. It goes on to propose intermediate and advanced approaches that companies may use to assess the optimum solution in managing headroom; most companies are expected to follow the intermediate methods beyond simple AISC's. A number of new methodologies exploring alternative approaches to risk and headroom are also proposed. Supplementary guidelines to the water resources planning guideline will be issued once these reports have been published and the implications to the current approaches agreed.

Swisher, J. N., Jannuzzi, G. M. and Redlinger, R. (1997) Tools and Methods for Integrated Resources Planning, UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark

Lays out a proposed spreadsheet arrangement for analysing the potential savings and costs, see p137

Feldman M., Maddaus, W. and Loomis, J. (2003) Calculating Avoided Costs Attributable to Urban Water Use Efficiency Measures: A Literature Review Prepared for the California Urban Water Conservation Council, Sacramento CA May 2003

Avoided costs and covers the range of methodologies which can be used to calculate avoided cost.

The authors state: "Avoided Cost is the incremental cost savings associated with not having to produce additional supplies as a result of choosing an alternative planning option or course of action. For example, avoided water supply costs are the costs of water supply that are avoided by conservation, which reduces the need for new supply projects." (p11)

The findings of the literature review were: "Generally, the avoided cost concepts identified in previous CUWCC publications are found to be as advanced as any found in this literature survey. However, the survey revealed approaches and specific methodologies that might prove fruitful in implementing the CUWCC guidelines. These approaches include topics such as valuing short-run operating costs, valuing avoided capital costs, present value discounting, risk and uncertainty considerations, and evaluation of environmental externalities." (p2 Executive summary)

Herrington, P. (2005) The Economics of Water Demand-Management: Chapter 10 in Water Demand Management, International Water Association, Editors David Butler and Favyaz Memon, August 2005, 384 Pages, ISBN: 1843390787

Economic analysis/appraisal: Separate to "cash flow", involves identifying, quantifying and evaluating (in monetary terms) the benefits and costs of a measure, program or policy change. Distinct from a "financial appraisal" in which financial effects on one or more stakeholder groups is analysed. Social cost-benefit appraisal includes all these gains and losses to different actors and comes out with a "net" benefit or cost to society.

Potential methods to examine a proposed demand management program include:

- cost-benefit analysis
- internal rate of return (useful only in some places, eg as the decision rule in a present value expression)
- cost-effectiveness analysis
- payback period (crude and potentially misleading, ignores the time value of money)
- total resource cost test (preferred best practice approach) whereby cash flow changes are seen as pure transfer payments that do not contribute to the net societal benefit.

The author states the "best way of…comparing different demand or supply-based options is to estimate and then compare the "average incremental social cost (AISC)" of each option, calculated as a present worth of the costs incurred over its lifetime divided by the present worth of the quantity it will save for or deliver to consumers."

Office of Water Services (OFWAT) 2001, The role of long run marginal costs in the provision and regulation of water services, Office of Water Services, Birmingham UK.

Covers overview of LRMC, current estimates and guidance for estimation.

6.3.1.1 Cost effectiveness analysis

Rocky Mountain Institute (1991), Water Efficiency: A Resource for Utility Managers, Community Planners, and other Decision-makers, by the Water program, Rocky Mountain Institute, Colorado.

Covers the economics of water efficiency including cost considerations, and ways to illustrate costs and water savings, including using supply curves to compare various water supply and efficiency programs (p.13). Benefits Finclude: allowing direct comparison of cost of saving water with the cost of increasing supply. 2. It shows the average cost of each efficiency measure and supply measure as averaged over the life expectancy of the investment. 3. It emphasises that water saved through an efficiency program is just as useful as water from supply-side projects.

California Urban Water Conservation Council (1996), *Guidelines for Preparing Cost-effectiveness Analyses of Urban Water Conservation Best Management Practices*. Authors: Pekelney, D., Chestnutt, T., Hanemann, W.

Steps for a Cost-effectiveness analysis, CEA (p2–2):

1. Identify costs and benefits (incl. life-cycle costs and benefits, intangibles, perspectives for identifying costs and benefits – see Table 2.1 p2–3; transfer payments)
2. Measure and value costs and benefits
3. Discount costs and benefits and
4. Analyse uncertainty

Costs and benefits are identified for each BMP category (see Dickinson (2003) under ‘8.2 Institutional Arrangements’) (p. 3–4). For each category of cost or benefit, type of cost, data needed and data sources are provided. Further, tips for measuring and valuing these specific costs and benefits are provided. Illustrative examples of CEA of specific programs (eg. ultra low flush toilets) from p.4–1)

Note: Authors states that there is controversy within the economics and water planning professions regarding CEA methodology. e.g. choice of social discount rate, and valuing the environment (p.5–1). These guidelines were intended as a ‘living document’ to be updated.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Chapter VI covers evaluating cost effectiveness of water efficiency measures based on a cost-benefit approach

6.3.1.2 Least cost planning

Fane, S. (2005) Planning for Sustainable Urban Water: Systems-approaches and distributed strategies, PhD Thesis, University of Technology, Sydney.

Least cost planning involves end-use modelling, backcasting and least cost analyses that include various integrated resources planning ‘cost tests’.

Cost analyses in LCP have three distinguishing features:

- Options are designed and analysed around a service defined end-use model
- Avoided costs are always included- they comprise those costs of supply that are not incurred when water is conserved (direct costs, costs of future augmentation and indirect costs)
- Use of ‘cost tests’, particularly the “whole of society” perspective. Also financial cost test for a utility and customers so can analyse cash flow and allocate costs fairly between stakeholders.

Turner, A., White, S. and Bickford, G. 2005 'The Canberra Least Cost Planning Case Study', International Conference on the Efficient Use and Management of Urban Water, Santiago, Chile, 15–17 March 2005.

LCP is a process whereby, for example, a water service provider determines a range of options that at lowest cost provide their customers with the water related services they require rather than the water itself. This process recognises that customers do not necessarily want more water; rather they want the services that water provides such as aesthetically pleasing landscapes, sanitation and clean clothes. The process aims to investigate the whole of society costs and benefits to highlight the most economically, environmentally and socially appropriate solution.

Unit cost

Fane, S. (2005) Planning for Sustainable Urban Water: Systems-approaches and distributed strategies, PhD Thesis, University of Technology, Sydney

For Fane, the levelised cost is “the unit cost of conserved water”- allows ranking of measures on relative unit cost (dollars per kilolitre). Levelised cost is used as a measure of the present value unit cost of water saved or supplied. It is defined as the present value of the stream of costs over a set period divided by the present value of the stream of water demand saved or supplied over the same period (Fane, Robinson and White2003).

Herrington, P (2005) The Economics of Water Demand-Management: Chapter 10 in *Water Demand Management*, International Water Association, Editors David Butler and Favyaz Memon, August 2005, 384 Pages, ISBN: 1843390787

This resource covers least cost planning (LCP), integrated resources planning (IRP), Economics of balancing supply and demand (EBSD), Economics of demand management (EDM) and promotes the use of average incremental cost (or levelised cost) as the basis for comparison of options.

Atkinson, J. and Buckland, M. 2002, The Economics of Balancing Supply and Demand (EBSD) Guidelines, Report Number 02/WR/27/4, UKWIR/Environment Agency.

Atkinson, J. and Buckland, M. 2002, The Economics of Balancing Supply and Demand (EBSD) Main Report, Report Number 02/WR/27/3, UKWIR/Environment Agency.

Considers supply demand balance and uses a calculation of *average incremental costs* for options.

Fane, S. and White, S. 2003 'Levelised cost, a general formula for calculations of unit cost in integrated resource planning' *Efficient 2003: Efficient Use and Management of Water for Urban Supply Conference*, Tenerife, 2-4 April 2003.

Covers details of a particular unit cost called levelised cost, in which water is discounted over time as well as cost, including debates that surround its use.

Fane, S.A., Robinson, D. & White, S.B. 2003, ‘The Use of Levelised Cost in Comparing Supply and Demand Side Options for Water Supply and Wastewater Treatment', *Water Supply Vol 3 No 3 pp185-192, IWA Publishing.*

This paper highlights the importance of using levelised cost rather than annualised cost when comparing options of different scales.

Turner, A. & White, S. 2003 *ACT Water Strategy: Preliminary demand management and least cost planning assessment,* report prepared by the Institute for Sustainable Futures for ACTEW Corporation, ACT, Australia

This paper demonstrates the use of levelised cost to prepare supply curves that enable comparison of supply-side and demand-side options and formation of a suite of options to satisfy the potable resource needs.

6.3.1.3 Cost-benefit analysis

Louw D. B., and Kassier, W. E. (2002) The Costs and Benefits of Water Demand Management (WDM), Final Report by Centre for International Agricultural Marketing and Development, South Africa

This report remarks: “The ultimate cost effectiveness of WDM is the deferral of waterworks. The cheapest water in the future may well be the water, which was wasted in the past.” It was funded by Swedish International Development Agency (SIDA), the International Development Research Centre (IDRC) and World Conservation Union (IUCN).

This study “focused on the costs and benefits of WDM. This included an overview of water demand in southern Africa, a theoretical perspective on the WDM measures available to policy makers and the costs and benefits associated with such measures. This was followed by a discussion of the relevance for decision-makers of costs and benefits. Also, a methodological framework is proposed to conduct cost-benefit analyses. Particular attention is paid to the position of the poor.”

Example of analysis of potential water savings: "Today there are 58 million residents in the SADC who are not served by developed supply systems – 12 million in urban centres and 46 million in rural areas. A 10% reduction in Southern Africa's 36,130 million m3/year irrigation demand, would save 3 613 million m3/year and would yield enough water for 100 million people at 100 litres per day."

ADB (1999) Handbook for the Economic Analysis of Water Supply Projects, Guidelines, Handbooks, and Manuals, Economics and Development Resource Center, Asian Development Bank ISBN: 971-561-220-2, 361 pages.

The Handbook states that a need for "distributional analysis" exists in the following circumstances:

1. "to assess whether the expected distribution of project effects corresponds with the objectives of the project (e.g., increased wellbeing)
2. to assess the likely impact of policy changes on the distribution of project benefits (e.g., pricing and exchange rate policy) and
3. to provide the basis for the poverty impact assessment (Section 9.5).

This assessment evaluates which portion of the net gains of the project will ultimately benefit the poor." (p208)

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Chapter VI covers evaluating cost effectiveness of water efficiency measures based on a cost-benefit approach.

Dickinson, M., Maddaus, L. A. and Maddaus, W. O. (2001) Benefits of the United States Nationwide Plumbing Efficiency Standards

From the abstract: "This paper highlights an example methodology into the overall assessment of water and cost savings from water conservation programs. This methodology, more fully presented in the original report document, provides is particularly useful for water agencies quantifying benefits when seeking to avoid acquiring new source water supply and/or defer building capital projects."

The report: "discussing the full details of the findings titled, Impact of the National Plumbing Efficiency Standards on Water Infrastructure Investments (California Urban Water Conservation Council (CUWCC, 2001)) serves as an example methodology for assessment of water and cost savings from water conservation programs including implementation of plumbing fixture retrofit programs. This methodology is particularly useful for utilities quantifying benefits when seeking to defer acquiring new source water supply and/or defer building capital projects."

Overview of the methodology used: "In order to develop information on the value of the national plumbing standards, a nationwide survey of water utilities was conducted. Data from the surveys was entered into a database and were analysed using a benefit cost model to estimate water savings and associated cost savings. The analysis identified the changes in water demand and required capital investments in water infrastructure with and without the national plumbing efficiency standards. This type of analysis has been used by many individual water utilities to evaluate and help select a program of water conservation measures that is best suited to local conditions. This approach is based on utility responses that provided data on water use, demographics, and planned investments in water supply and treatment infrastructure."

Method of Analysis was given as "analysis of impacts of water demand reduction on utilities. The following basic steps were used to estimate the benefits of retaining the national plumbing efficiency standards. The steps are illustrated in Figure 1, with the exception of estimating the costs (since the plumbing efficiency standards costs have been absorbed and so benefit-cost ratios are not meaningful here).

Baseline water use projections were developed without conservation. Employment (jobs) associated with each sample was estimated based on statistics from the United States Bureau of Labor (www.bls.gov). Water use then was separated into indoor and outdoor components based on a comparison of the lowest water use month with the average water demand in million gallons per day (MGD). A Decision Support System (DSS) model was used to estimate the water savings and benefits from water use reductions. The baseline water use projections with conservation were developed including the water savings from the plumbing efficiency standards, as determined in the AWWARF Study. Projections were developed through the year 2030. Benefits to the water utility are based on the sum of the present worth of capital deferrals and reduced operation and maintenance costs. The basic methodology used is described in more detailed in the Impact study report (Maddaus, et. al., 2001) and the reference Impacts of Demand Reduction on Utilities (Bishop, et. al., 1996). The operational cost savings (benefits) to the water utility were computed using the costs of electricity and chemical per million liters or million gallons (MG) of treated water produced, as provided in the survey. Benefits each year in the DSS forecast period (30 years) were determined as the sum of the present worth of the capital deferrals and the present worth of the operational cost savings. Benefits were computed at a discount rate of 3%."

The authors found that water efficient toilets and showerheads did conserve water, that utilities saved money through deferral of capital costs and reduced operation and maintenance costs.

Evaluation of water savings is facilitated by availability of monthly water consumption data by customer class but this is only available in a small portion of utilities. Lack of long-range planning also made it difficult to ascertain whether demand management approaches were cost-effective.

6.3.1.4 Dealing with lost revenue

Charalambous, C. N. (2001) "Water Management under Drought Conditions", European Conference on Desalination and the Environment: Water Shortage, Lemesos, Cyprus, Elsevier Science B.V, pp.3–6

If the correct institutional arrangements are not in place, disincentives to the water utility in the form of lost revenue occurs- this is an example from Cyprus in which this was the case in the necessary response they made to drought conditions:

The author finds that "The implementation of the water cuts has a direct financial cost to the Water Board. On the one hand the Water Board suffers loss of revenue due to the decrease in the sales of water. On the other hand there are additional expenses paid to staff in overtime for opening and closing the sluice valves to implement water rationing and for repairing damages caused to the pipe work due to the frequent emptying and filling of the pipes.

The Board estimates that the average loss of revenue per annum due to the reduction in water sales is of the order of US$300.000 and the additional expenses paid as overtime to staff and cost of pipe work repairs is of the order of US$100.000. The Board suffered loss of revenue in the last four years of approximately US$1,2 million."

Charalambous, C. N. (2002) "Water conservation: A Practical Approach", European Water Resources Association International Conference, Athens, Greece, Proceedings, pp.211–218.

The author describes how: "The Water Board of Lemesos promptly responded to the government's declared drought measures and in February 1997 restricted supply to consumers to four days a week. In 1998, with the announcement of the increased restriction measures the Water Board was forced to decrease further the availability of water reducing the time of the water being available to the consumers to 12 hours every 48 hours.

In addition the program enforced the following measures:

> Production and distribution of 100.000 plastic water bags for use in toilet cisterns.
> Hosepipe ban for washing cars, pavements, patios, etc.
> Public information and education programs to promote water conservation.
> Promotional leaflets on water conservation sent with water bills.

The above actions resulted in an overall reduction in the use of domestic water of approximately 15% per annum."

6.3.2 Risk-based approaches and treatment of risk, sensitivity analysis

Gleick et al (2003) Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Both technical risks and economic risks are smaller for small-scale water efficiency efforts than conventional large systems – supported by Lovins (1977) observation in the energy sector, that the industrial dynamics of the small-scale approach are very different. p28

Harberg, R. J. (1997) Planning and Managing Reliable Urban Water Systems, American Water Works Association, USA

In order to make decisions that lead to the greatest net benefit to the public and are equitable (i.e. benefits and costs distributed fairly among the affected stakeholders), need involvement of an expanded group (reduces partiality due to perception of risk). Possible approaches suggested are (p13):

> Top-down versus bottom up approaches
> Contingency versus probability approaches

The resource classifies risk approaches as quantitative risk analysis, comparative risk analysis, consequential risk analysis and also refers to sensitivity analysis and benefit-cost analysis

ADB (1999) Handbook for the Economic Analysis of Water Supply Projects, Guidelines, Handbooks, and Manuals, Economics and Development Resource Center, Asian Development Bank ISBN: 971-561-220-2, 361 pages.

Deals with project implementation risk and what it would take the bank to justify a project (p199)

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

The Guidelines specify that, "In developing the final plan, companies should consider a range of planning scenarios to test the sensitivity, robustness and flexibility of their preferred strategy in maintaining security of supply in view of the risks and uncertainties within, and outside the final planning scenario.

At its simplest, upper and lower scenarios about a chosen final or best estimate dry year planning scenario should be presented as part of the final plan. These upper and lower limits could be viewed as demonstrating a "risk envelope" against which companies should derive a balanced portfolio of (supply and demand management) options. The UKWIR / Environment Agency report Economics of balancing supply and demand provides a number of alternative, more detailed approaches for evaluating more complex supply–demand situations" (see more on p20)

Within the assessment criteria for plans (one of the appendices) the following are listed: "Have key data / components of the plan been tested for their:

> Effects on the preferred strategy?
> How have environmental and social costs been tested?
> Are the climate change scenarios consistent with supplementary guidance?"

Feldman, M., Maddaus, W. and Loomis, J. (2003) Calculating Avoided Costs Attributable to Urban Water Use Efficiency Measures: A Literature Review Prepared for the California Urban Water Conservation Council, Sacramento CA May 2003

These authors conclude that risk and uncertainty are often not well addressed in IRP literature though they are mentioned. They have located the following sources for further information (p34):

"AWWA (1994a) provides some methodological suggestions for dealing with risk and uncertainty including use of scenario evaluation, sensitivity analysis, ranking and decision analysis approaches. However, their Guidelines for an Effective IRP Process do not provide specific methods for quantitatively assessing these values. Pekelney (1996) suggests uncertainty be evaluated using sensitivity and scenario analyses, and provides some examples. EPA's Water Conservation Plan Guidelines omit mention of risk and uncertainty in their cost-benefit evaluation, even in their Advanced Guidelines section."

6.3.3 Qualitative criteria and analysis

Gleick et al (2003) Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Qualitative benefits that may be hard to quantify include:

> Reductions in wastewater costs

> Lower average peak water system loads
> Lower average peak energy demands
> Reduction in environmental damage due to water withdrawal and discharge
> Investments in water-use efficiency leave money in local communities and create local jobs. Investments in distant supply options usually take money from communities and create distant jobs. p29.

Dziegielewski, et al (1993) Evaluating Urban Water Conservation Programs: A Procedures Manual

Non-quantifiable effects on the environment, social/political/legal institutions and customer equity and acceptability need to be considered (p116–117). Procedure put forward here is simply to evaluate whether the impact is positive, negative, or neutral (Table 4–6 on p118 shows an example of this)– doesn't go any further into how the decision-making should take place, simply that the meanings of + and – should be made explicit.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

In this process key aspects to consider further are:

> the time for promotion and implementation
> whether there are any links and dependencies between options
> the equity of different combinations of options
> Uncertainties and risks, including climate change
> The contribution made toward sustainable development.

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

The attributes shown in the table below are examples of aspects of demand management options it is useful to consider in comparing them.

Attributes of options

Attribute	Information about the attribute
Applicability	To what sectors and end-uses can the DSM measure be applied? What is the size of the market for which the measure is applicable?
Fuel type	For fuel-switching measures, what fuel is used?
Reliability and lifetime	How has the measure performed in previous applications? What is its typical lifetime?
Efficiency	How much energy and power does the measure save, relative to standard equipment?
Capital and operating costs	What does it cost to own, operate and maintain the technology?
Environmental impacts	What are the impacts of the technology, relative to standard equipment?
Foreign exchange requirements and local input	What fraction of the materials and technology for the DSM measure can be provided locally?

6.3.4 Sustainability assessment

Fane et al (2005) 'Meeting Sydney's Water Demand–Supply Balance: An evaluation of demand and supply side options for the NSW Government Plan – Securing water for our people and rivers', Report

The framework used "integrates qualitative assessments of social, environmental and risk criteria with cost analysis. Diverse demand–supply scenarios for Sydney were analysed. The combination of a quantitative and qualitative evaluation allowed a range of social, environmental and risk considerations to inform the economic analysis. Scenarios were built based on the lowest levelised cost options – implemented first within the constraints imposed. The scenario analysis was constructed to allow assessment and discussion of the trade-offs and inherent choices concerning exclusion of options on qualitative grounds."

Maheepala, S., Evans, M., Sharma, A., Gray, S. and Howe, C. 2004, 'Assessing water service provision scenarios using the concept of sustainability', International Water Association: Leading Edge Conference on Sustainability, Sydney.

The proposed assessment method is a hybrid of life cycle, multi-criteria and indicator assessment methods and it is applicable at the planning and conceptual design stages of the water system of both greenfield and infill development schemes. Briefly, it requires a set of sustainability assessment criteria and at least one measurable indicator for each criterion be defined, values of indicators to be estimated for a set of scenarios for which sustainability assessment is to be performed and ranking of scenarios using a multi-criteria assessment method.

White, S., Fane, S., Giurco D. and Turner A. (2006) Putting the economics in its place: decision making in an uncertain environment. In proceedings of Ninth Biennial conference of the International Society of Ecological Economics on "Ecological Sustainability and Human Well-being" 15-18 December 2006, New Delhi

This paper states: "This paper describes a decision-making process for meeting the water supply-demand balance in urban centres. This is a complex sustainability issue, with strong elements of risk and uncertainty, resource and ecological limits, economic constraints, the potential for conflict and an over-arching need for the community to be engaged in the decision-making process. A worked example is used to illustrate the process, which employs several different component methods, each of which has been applied before, but not in combination. This decision-making process is likely to have relevance to a wide variety of other applications, in particular those relating to urban infrastructure."

The process to deal with non-quantifiable aspects of options described is: "The process of decision-making also needs to consider a range of issues which do not lend themselves to easy quantification, which in this process are categorised under the headings: environment; social; risk and feasibility.

To accomplish this, a process was developed that used modified multi-criteria decision-making within a deliberative space. The unique characteristics of the process were the fact that it did not attempt to mix the relatively easily quantified economic criteria with the other, less readily quantified criteria. The qualitative criteria were weighted, scored and ranked by stakeholders in a deliberative process, and these results used to filter or 'screen' options from the portfolio, thus deriving the cost impact of decisions to include and exclude options, based on the qualitative multi-criteria decision process.

The exercise was successfully used as an adjunct to the economic ranking of options within a portfolio, and it avoids the risk of moving beyond a reasonable 'monetisation frontier' associated with methods that attempt to quantify all environmental and social costs, and usual multi-criteria analysis where economic factors are often double counted and 'gaming' the process is a risk.

Case studies from a number of urban water planning studies undertaken by the authors have been used in the elaboration of an example process. Much of the data derives from Sydney, Australia but other data is used to illustrate the more general case. The aim of this paper is to provide researchers and practitioners with a practical example of a decision making process that incorporates a number of principles important for sustainability, and uses a selection of well-tested methodologies in combination. The outcome resulting from the application of this process should be more transparent, improved decision-making."

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

It is noted that "selecting a preferred integrated resource plan (or a few top options) from a wide range of choices is a complex process, and should be decided systematically if the result of the planning process is to be credible. There are several methods, with many variations, for deciding which plan or plans is or are most desirable. These range from simply listing each attribute of each plan in a large matrix (for example, on a board in a conference room) and methodically eliminating candidate plans (noting why each is eliminated), to quantitative approaches involving Multi Criteria Analysis or Multiple Attribute Analysis.

Whatever tool or technique is used to aid in deciding among plans, it is ultimately the people involved in the planning process who will decide which plan is to be adopted and implemented. The initial ground rules for the planning process as a whole will have identified the locus of ultimate responsibility for arriving at a decision on the preferred IRP. One of the critical process principles of IRP is to conduct the decision process in a transparent, clear, and complete manner, so that others may review the decisions made along the way." (p44)

Sample criteria for assessment of Integrated Resource Plans

- Financial criteria
  - Overall plan cost (including capital, fuel and other costs, usually expressed in "present value" terms)
  - Plan capital cost
  - Plan fuel costs
  - Plan foreign exchange cost
  - Interest coverage ratio
  - Return on equity
  - Utility net income
  - Internal generation of funds
- Performance criteria
  - Customers served
  - Loss of load probability
  - Reserve margin
  - Efficiency of energy use (on supply- and /or demand-side)
- "Energy security" criteria
  - Diversity of supply (fraction of each fuel used)
  - Use of domestic resources
  - Use of renewable resources
- Environmental criteria
  - Amount of carbon dioxide produced over the life of the plan
  - Amounts of other air pollutants (acid gases, particulate matter, hydrocarbons) produced over the life of the plan
  - Amount of land used for energy facilities
  - Liquid waste production
  - Solid waste production (accounting for differences between hazardous and non-hazardous wastes)
  - Plan impact on wildlife, biodiversity
- Other criteria
  - Aesthetic issues (impact of plan on recreation, tourism)
  - Employment impacts of plan
  - Impacts of plan on other economic sectors (both positive and negative impacts)
  - Political acceptability /feasibility of plan
  - Social implications of plan (including impacts of local and indigenous populations)
  - Cultural impacts of plans (impacts on culturally important resources)

Lundie S., Ashbolt N., Livingston D., Lai E., Karrman E., Blaickie J and Anderson J (2005) Sustainability Framework - Methodology for Evaluating the Overall Sustainability of Urban Water Systems, Centre for Water and Waste Technology, CWWT/2005-14, June 2005

This publication contains a process for developing and comparing options that meet certain objectives. These authors state that sustainability criteria "…should cover the five primary criteria (economic, human health, environment, technical and social) and it needs to encapsulate the various context-specific objectives identified…"

The suggest the following (Table 7, p28-29) as a starting point for development of sustainability criteria:

Table 7 List of example primary and secondary criteria for sustainability assessment and examples of mitigations to achieve sustainability (literature labelled with * is available on the enclosed CD-Rom)

Primary criteria	*Secondary criteria*	*Examples of mitigations to achieve sustainability*	*Refs to assessment tools*
Economic	Life cycle costs including capital and operational expenditure [$]	Ensure that the total life cycle costs are affordable.	
Human health	Risk of infection (DALY; e.g. [years of life loss/year])	Ensure that exposure probability to pathogens remains within acceptable limits to humans or the environment.	Ashbolt *et al.* (2005)*
	Exposure to harmful substances (eg toxic, carcinogenic or endocrine-disrupting compounds).	Ensure that environmental concentrations remain below those harmful to humans or other organisms.	Ledin *et al.* (2005)*
Environmental	Extraction of freshwater and groundwater resources [kL/year]	Ensure that environmental flow requirements (or for groundwater minimum water level requirements) are met.	Guinee *et al.* (2002)
	Land use and disturbance [ha/year]	Offset harm by purchase of substitute land, or rehabilitate degraded land off-site.	Lenzen and Murray (2001), Guineé *et al.* (2002)
	Resource input [t/year]	Purchase products with the highest resource-use efficiencies and with 'cradle-to-grave' recycling guarantees by their manufacturers.	Guineé *et al.* (2002)
	Biodiversity	Offset temporary losses by rehabilitiation ; offset permanent losses by purchasing natural habitats for long-term protection, rehabilitate degraded land elsewhere or create new habitats (eg wetlands).	Guineé *et al.* (2002)
	Greenhouse gas emissions [t CO_2-eq./year]	Low carbon intensity sources of power ; renewable energy and/or carbon sequestration to offset emissions	Guineé *et al.* (2002); IPCC (2005)
	Eutrophication [t Phosphorus/year]	Ensure that nitrogen and phosphorus loads remain within the assimilative capacity of the receiving environment.	Kärrman and Jönsson (2001), Guineé *et al.* (2002)
	Photochemical Oxidant Formation	Remove from or reduce concentrations in emissions to the atmosphere.	Guineé *et al.* (2002)
	Ecotoxicity including terrestrial, marine and freshwater aquatic[6]	Ensure that environmental and tissue toxin concentrations remain below those harmful to terrestrial, freshwater and marine organisms.	Lundie *et al.* (2005)*, Guineé *et al.* (2002)
Technical	Performance potable water and wastewater quality	Quality remains within the limits specified in Customer Charter or the discharge licence.	Time-series analysis, compliance comparisons
	Reliability	Design and manufacture of the product provides an acceptable frequency of failure.	Western Consortium for Public Health (1997), Vasquez *et al.* (2000)
	Resilience/vulnerability	Ensure that the system is robust, and that it can recover rapidly after upsets by: preventative maintenance; multiple barriers; purchasing resilient or "shock-resistant" equipment.	Teoh & Case (2004)
	Flexibility	Redundancy and/or flexibility should be "designed in" to ensure capacity to adapt to foreseeable contingencies.	Expert opinion
Social	Affordability	Basic water services (i.e. 'water for life') are affordable for the community.	
	Employment	Long-term employment opportunities are created.	
	Acceptability to community	Timely and open engagement of the community is essential to maximise acceptability of proposals, as is establishing an agreed framework for assessing sustainability.	STRAD
	Distribution of responsibility	A clear, fully accountable and fully funded governance model is essential for the good ongoing management of new assets.	
	Organisational capacity and adaptability	Recruit and retain the best staff; run the business at a profit; develop and maintain trust and credibility; invest in strategic and scenario planning; invest in emergency preparedness.	Guitouni and Martel (1998)
	Public understanding and awareness	Timely and open provision of information to the community is essential to maximise acceptability of proposals.	STRAD

[6] The environment-specific effect factor is equal to $E_{j,s} = \frac{\partial msPAF_j}{\partial C_{j,s}} \approx 0.7 \cdot \frac{1}{HC50_s}$ (Van de Meent and Huijbregts, 2005) where $E_{j,s}$ represents the effect factor of substance *s* for compartment *j* (year m^{-3}), ∂msPAF$_j$ is the marginal change in the Potentially Affected Fraction of species due to exposure to a mixture of chemicals in compartment j, and HC50$_s$ is the Hazardous Concentration of substance s where 50 percent of the species is exposed above an acute or chronic toxic value (kg m^{-3}). All HC50s are based on acute aquatic toxicity data.

7 PLANNING OF IMPLEMENTATION AND PROGRAM DESIGN

This section contains details of the typical program teams and skills needed to implement a demand management program, develop and maintain an end use model/options model and undertake ongoing evaluation of programs to allow adaptive management. It includes how to design the implementation process, timeline, monitoring, work out who is going pay (institutional arrangements and negotiations for price pass through etc).

Turner, A. & White, S. 2006 'Does demand management work over the long term? What are the critical success factors?' Sustainable Water in the Urban Environment II Conference, Sippy Downs, Queensland.

"This paper identifies some of the key issues in planning, developing, implementing and evaluating demand management (DM) programs to ensure water efficiency is maximised and savings are achieved and maintained in the long-term. The paper draws on the experience of the Institute for Sustainable Futures (the Institute) and key staff who have worked closely with many water planners and DM managers across Australia since the early 1990s."

Sydney Water Corporation (2005) "Water Conservation & recycling Implementation report 2004-2005"

"The Water Conservation and Recycling Implementation Report charts the progress of Sydney Water's Demand Management Strategy for the 2004/2005 financial year. Program capital and operating expenditure has totaled more than $107 million since 1999."

This report is an excellent example of a utility documenting the demand management and water planning goals they are required to achieve, what is being done to achieve the goals and how they are tracking with respect to participation rates, costs and savings.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Suggested contents of an implementation plan include projections of the budget and staffing over the life of the project, covers the monitoring and reporting required, provision of a statement of intention or official adoption of the plan (p7).

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

This reference contains detailed information on planning implementation process for demand management initiatives, including the necessary communication strategy required.

Vickers, A. (2001), Handbook of Water Use and Conservation: Homes, landscapes, businesses, industries, farms. WaterPlow Press, MA.

Contains detailed information about implementation of demand management activities in the non-residential and residential sectors.

Maddaus, W. (1987), Water Conservation, American Water Works Association, CO.

For effective implementation, the plan should cover (p.29):

- goals
- schedules
- staff responsibilities
- organisational structures, and
- budget.

Possible steps in program implementation and evaluation could include (expanded on p.29):

> Develop implementing framework
> Purchase supplies and conduct staff training
> Begin action programs
> Assess program effectiveness
> Update program elements.

7.1 Institutional arrangements

Description of how programs are implemented, typical agency arrangements, contractual arrangements, barriers to implementation and opportunities for streamlining programs. Suggestions on how to increase program uptake and examples of typical communication strategies that link directly to other program instruments (e.g. regulatory requirements and economic incentives).

Important aspects:

1. decision between an external dedicated body or an internal group within a utility implements the program and
2. Level of subcontracting- subcontract large chunks or just low level contracting with higher internal staffing

Dickinson (2003) Proof for the Stakeholders: Water Utilities to Earn Certifications of Efficiency, Efficient2003 2nd International Conference in Efficient Use and Management of Water for Urban Supply, Tenerife, Spain, April 2003

Describes the first large scale water conservation implementation certification program, based on using 14 best practice management principles

BMP 1: Residential Surveys, BMP 2: Retrofits , BMP 3: Audits , BMP 4: Metering , BMP 5: Landscape , BMP 6: Clothes Washers , BMP 7: Public Info , BMP 8: School Education , BMP 9: CII , BMP 10: Wholesaler Incentives , BMP 11: Rates , BMP 12: Consv Coordinator , BMP 13: Waste Prohibitions , BMP 14: ULFTs

This program is a test model for the regulatory permitting of sufficient water conservation implementation.

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana, C., Krinner, W. and Estrela T., CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen, Copenhagen.

The resources notes: “Through a number of case studies discussed in the report, the importance of developing sound partnerships between water authorities, water users and water suppliers is demonstrated.” (p.56)

7.2 Education and communication

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana, C., Krinner, W. and Estrela T., CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen, Copenhagen.

The resource makes clear that: “Information and educational campaigns in all sectors are always part of a wider plan for using water more efficiently in order to encourage more rational water use and change habits. Information campaigns are considered to be an important part of initiatives such as promoting water-saving devices, raising prices to pay for leakage and encouraging more rational water use. Cases studies 34 and 43 in the Appendix illustrate examples where information supply has played a particularly important part of a city’s water conservation plan.” (p.46)

“In the industrial sector, water savings are just part of a wider program which includes measures to reduce water pollution and implement environmental management systems.” (p.46)

“It is difficult to quantify the effect of a public educational campaign because it is always part of a wider water-saving program which includes other measures.” (p.46)

San Roman Navarro, N., and Gomez Perez, M.P. (2005), A Comprehensive Educational Project on the Environment by Canal de Isabel II, Proceedings of Efficient2005, Santiago, Chile

This paper describes: "an ambitious and comprehensive educational program centred on environmental awareness in its broadest sense, making use of all the educational tools developed by new technologies and educational sciences."

A large range of initiatives for children of all ages (pre-school, primary school, secondary school and higher education) were implemented. They have also used a web-portal with a magazine format

In terms of evaluating the effects of their program, the methods used were: "The results obtained can be measured using two scales: the satisfaction index of teachers and students, which is pending the results of a survey that will be performed at the end of the 2004-05 academic year, i.e., next June, and which is clearly the index that will assess the relevance of the initiatives developed by the program, and the program acceptance index, which is easy to measure based on participation.

A lesson learnt was that "mouth to mouth" communication is one of the most effective methods to transmit information. They also used the media.

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

Guidance on a communication strategy for demand management programs, covering: (p.111):

- community education campaign (customer surveys, media, public presentations and seminars, water bills,
- school education
- community extension
- customer advisory services
- special events

8 PROGRAM MONITORING AND EVALUATION

The sections contain details of different methods to evaluate demand management programs during and after they have been implemented. It includes evaluation of water savings, costs and community satisfaction. Evaluation is important to enable adaptive management. It should be noted that the term "evaluation" is sometimes used to refer to the process of deciding between options, which in this document has been referred to as "options analysis". The term evaluation here is more narrowly defined to examining the effects of a given program, and in some cases, the implementation process followed.

Dziegielewski et al (1993) Evaluating Urban Water Conservation Programs: A Procedures Manual

Evaluation steps (p7):

> Evaluate program implementation process
> Water conservation savings
> Develop a long-term monitoring plan

Justification for program evaluation is needed since this step is expensive, some ideas for this are given on p127-128.

Desirable characteristics of evaluation designs:

> Internal validity: need to make sure that other confounding factors (eg climate, price changes, economic factors) don't jeopardise the validity- must be clear that effects are attributable to the program, and so must control for external factors in the evaluation design.
> External validity: ensures that the findings of the evaluation can be generalised to similar conservation programs within the service area (inference). Replicability is important and yet hard to ensure due to differences in programs and evaluation procedures (p130).
> Factors effecting validity are history, maturation, testing (Hawthorne effect), instrumentation, regression-to-the-mean, self-selection bias and experimental mortality (p131)

Three types of evaluation design are described – experimental design, quasi-experimental design and non-experimental design including information about sample size

Platt, J. and Berry, S. (2005) Development of Performance Indicators for Water Efficiency: Measures used to Benchmark Progress in a Mid-sized Utility

Benchmarking has been defined as "the process of determining who is the very best, who sets the standard, and how do we quantify what that standard is". Within the public utilities sector, commonly used benchmarks include metered sales, revenues per customer, revenues per thousand gallons of water sold, expenses relative to average plant investment, total operating revenues, gallons of water sold, and number of customers. However, few benchmarks are used in the water conservation sector. The set of performance indicators from this reference are shown below:

Table 1. Key Performance Objectives

- Ensure a 1% annual reduction in per capita water use.
- Ensure all customer callbacks occur within a 24-hour period.
- Ensure cost benefit ratio greater than 1.0 for water efficiency programs.
- Ensure a peak day to average daily ratio for water consumption does not exceed 1.60 for FY 2004.

Table 2. Key Performance Measures

Performance Measure	Actual FY2003	Actual FY 2004	Projected FY 2005
% reduction in per capita water use	1%	1%	1%
% of non-residential customers with consumption in top tier of water usage	4%	17%	12%
% of non-residential customers exceeding top tier > once	n/a	58%	45%
% of residential customers with consumption in top tier of water usage	n/a	5%	3%
% of residential customers exceeding top tier > once	n/a	40%	30%
% Town single family residential customers with Block Leaders	18%	18%	20%
% reduction in irrigation water use by Block Leader coverage area	10%	10%	15%
Number of flapper rebates redeemed	100	100	200
Rain barrels sold at wholesale	n/a	94	100
Compliance rate with rain sensor ordinance	95%	97%	98%
Peak day to average daily ratio of water use	1.6	1.6	1.5

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

Need to build in re-evaluation of the plan that was chosen, usually in 2–5 years, though maybe earlier if conditions change. The description below is taken from p50:

Sample criteria for assessment of Integrated Resource Plans

- Financial criteria
  - Overall plan cost (including capital, fuel and other costs, usually expressed in "present value" terms)
  - Plan capital cost
  - Plan fuel costs
  - Plan foreign exchange cost
  - Interest coverage ratio
  - Return on equity
  - Utility net income
  - Internal generation of funds
- Performance criteria
  - Customers served
  - Loss of load probability
  - Reserve margin

  - Efficiency of energy use (on supply- and /or demand-side)
- “Energy security” criteria
  - Diversity of supply (fraction of each fuel used)
  - Use of domestic resources
  - Use of renewable resources
- Environmental criteria
  - Amount of carbon dioxide produced over the life of the plan
  - Amounts of other air pollutants (acid gases, particulate matter, hydrocarbons) produced over the life of the plan
  - Amount of land used for energy facilities
  - Liquid waste production
  - Solid waste production (accounting for differences between hazardous and non-hazardous wastes)
  - Plan impact on wildlife, biodiversity
- Other criteria
  - Aesthetic issues (impact of plan on recreation, tourism)
  - Employment impacts of plan
  - Impacts of plan on other economic sectors (both positive and negative impacts)
  - Political acceptability /feasibility of plan
  - Social implications of plan (including impacts of local and indigenous populations)
  - Cultural impacts of plans (impacts on culturally important resources)

8.1 Evaluation of water savings

Dziegielewski et al (1993) Evaluating Urban Water Conservation Programs: A Procedures Manual

This text provides detailed information about how to analyse water savings.

Sarac, K., Day, D. & White, S. 2002, 'What are we Saving Anyway: The Results of Three Water Demand Management Programs in NSW'. *Proceedings of the International Water Association Congress, Melbourne, April 2002*.

This paper covers the evaluation of three retrofit programs undertake in NSW. The abstract states “The use of demand management programs to achieve permanent and reliable decreases in water consumption through retrofits of water using equipment is relatively new in Australia, and has been carried out on the basis of models which predict savings, and on results of demand management programs undertaken overseas. The availability of information on actual savings achieved by demand management programs in Australia is extremely limited. This paper outlines the results of the evaluation of three retrofit programs undertaken in NSW, two of which involved a visit by a plumber to households to carry out a retrofit of indoor water using equipment at a subsidised price; the other taking a hands-off’ approach and relying on a discount incentive mechanism to increase the market share of water efficient showerheads.”

Snelling C, Simard S, White S, Turner A (2006) Gold Coast Water – Evaluations of the Water Demand management Program, report prepared by the Institute for Sustainable Futures for Gold Coast Water , Queensland, Australia

This report provides the results of statistical evaluations of water savings of a residential rebate program undertaken in the Gold Coast in Australia. Rebates included rainwater tanks, washing machines, shower roses, spa covers, dual flush toilets, garden products and pool covers.

In this resource, “Task 2 Statistical analysis of water savings is described thus:

The methodologies for determining water savings will be developed during the study and will be determined based on the data available. However, the methodologies used will primarily focus upon three main methods which ISF have used in the past and are considered best practice:

> Statistical analysis using paired participants and controls (the preferred method) to determine the 'relative savings' of the program being investigated. This will require the collection of the water meter readings for both the participants of the program and a selection of controls (usually three) that are houses usually on the same street that have not taken part in a rebate program. The use of controls selected in this way enables the water demand of the participants and controls to be tested in terms of checking that both groups are (in statistical terms) from the same population and thus reacting to other factors such as climate in the same way. By checking this, there can then be confidence that the relative savings identified after the measure is implemented (i.e. showerhead replacement, installation of a garden bore) will in fact be attributable to the measure implemented and not some other factor such as climate variables. Water meter readings from pre 2001 restrictions to the most current reading for each participant and control would be required for the analysis.

> Statistical analysis using a large sample of controls (say 50,000 households) that represent the average demand of single residential households in the Perth Metropolitan region. The participant households can then be compared to the controls using statistical analysis to determine the level of savings achieved. This method is often used where the sample size of participants is restricted.

> The use of regression analysis to develop a demand equation based on climate factors and other relevant factors, such as the presence of restrictions. The demand equation can then be used to model the demand over the time in question (e.g. post rainwater tank installation). Comparing the modelled demand to the actual demand can indicate the influence of other factors, such as the fitting of a rainwater tank, however it will not specifically indicate the impact of the rainwater tank, rather that some factor other than climate impacted on the demand.

Where possible two methods will be used to check the savings for each measure to determine how each method affects the level of relative savings identified and the confidence level."

White, S. (Ed.) 1998, *Wise water management: A demand management manual for water utilities*, Water Services Association of Australia, Sydney, NSW.

Appendix 10.5 in Chapter 10 summarises the details of the Kalgoorlie-Boulder Water Efficiency Program which was the first comprehensive water efficiency program undertaken in Australia. This section includes discussion on the evaluation of the savings of the program.

Bruvold, W.H., Mitchell, Patrick R. 1993, 'Evaluating the effect of residential water audits', *Journal AWWA*, p. 79.

This paper summarises the findings of evaluating the residential audit program conducted by the Contra Costa Water District of Concord, California. Three estimation procedures are used: the constructed comparison group, direct estimation and statistical modeling.

GDS Associates, Gregg, T., (2002), Quantifying the Effectiveness of Various Water Conservation Techniques in Texas, Texas Water Development Board
http://www.twdb.state.tx.us/RWPG/rpgm_rpts/2001483390.pdf

Provides information on the effectiveness and costs of water conservation strategies on a regional level.

Turner, A., White, S., Beatty, K. and Gregory, A. 2005 'Results of the Largest Residential Demand Management Program in Australia', International Conference on the Efficient Use and Management of Urban Water, Santiago, Chile, 15–17 March 2005.

Evaluation of a residential retrofit program, using statistical analysis of water meter readings of the sample of single residential households analysed.

"Savings of 20.9 ± 2.5 kilolitres per household per annum (kL/hh/a) were found"

Methodology was as follows:

"Of the 200,000 program participants, a large sample of over 24,000 randomly selected single residential household participants and an equal number of non participants (representing the control group) were used for the analysis. The purpose of using the control group was to correct for variations in demand that occur due to factors other than the retrofit itself such as the impact of weather variables and water restrictions. The controls were chosen such that each program participant household had a matched pair control group household that is geographically as close as possible to the program participant household (e.g. same street) and yet is not a participating household. The program participants analysed received retrofits during the period January 2000 to September 2002 with the first retrofits being conducted in quarter January to March 2000.

Turner et al (2005) A Review of Water Efficiency Programs in Western Australia: Towards a Strategy for Best Practice Final Report for Water Corporation of Western Australia

The preferred approach is as follows:

"The use of a control group is generally the recommended analytical approach. This involves identifying two samples, which are selected to be the same in all respects except for the fact that one sample has undergone the intervention (i.e. in statistical terms, the participants and controls are from the same population but one set has received a different treatment - participation in a program). The two samples are analysed before the change to determine whether they respond similarly to other variables such as whether their demand is similar under restrictions. An illustration is shown in Figure 5.1. Statistical analysis (a t-test) can also be used to confirm the relationship and this may be important where self-selection is involved in a program (i.e. households willing to install a rainwater tank or garden bore may have a different kind of garden to those who do not participate or be more water conscious in the first place).

The sample size and composition of the control group for this purpose is of primary importance if statistically significant results are sought. There are two basic choices: either two samples are used (a participant and control sample) and means are compared or a matched pair sample is developed."

Billings, R. and Jones, C. (1996), Forecasting Urban Water Demand, American Water Works Association

Generally accepted (US) approaches for studying effectiveness of water conservation program include:

1. Control group comparisons and
2. Multi-variate models estimated by regression analysis. (p.142)

Strub, D. (1999), Xeriscaping: Sowing the Seeds for Reducing Water Consumption. U.S. Bureau of Reclamation and City of Austin.

Multivariate analysis of residential outdoor water use factors seeking to isolate the effects of Xeriscaping.

8.2 Qualitative analysis of process and outcomes

Qualitative analysis is important for answering questions such as "How well is it working? How do the savings in make sense context of the timeframe", "what are people's acceptance and attitudes". They are useful for investigating the behavioural side of demand management.

Dziegielewski et al (1993) Evaluating Urban Water Conservation Programs: A Procedures Manual

Evaluation of the *process* of program implementation (a formative evaluation) which involves survey of baseline conditions, field tracking and program administration procedures including cost accounting, surveys of customers after completing of the program, and other evaluation elements and procedures (p10). Helps tell you about rates of adoption and retention of conservation measures- needed for evaluating cost effectiveness of the program versus other approaches. The evaluation needs to be planned early in the process, before program implementation. A list of potential measurements for process evaluation is given on p161.

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

The resources states: "Process evaluation aims to assess the implementation of programs. This includes management, marketing, field delivery of programs, quality control procedures, and the response of target groups, such as customers and dealers, to the program. Process evaluations provide critical feedback as to both tactical issues of program delivery and strategic issues of program design. They inform program sponsors, managers, and stakeholder parties both about mid-stream corrections that may be feasible and desirable, and about how to build on the lessons of the program in promoting replication.

Process evaluations employ several methods. These include in-depth surveys with program managers, site visits, survey techniques, focus groups, and documents review. Process evaluations must be thoroughly coordinated with impact evaluations. Though their methods are mostly distinct, there are some cases in which survey instruments are administered to participants and non-participants to serve both impact and process evaluation needs." p50

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

This text contains an Appendix on Kalgoorlie Boulder evaluation including a survey regarding the implementation process.

8.3 Long-term monitoring program

Dziegielewski et al (1993) Evaluating Urban Water Conservation Programs: A Procedures Manual

Such a monitoring program is needed to assess the progress toward reaching the goals of the implemented conservation program. Lists minimum essential elements are listed on p237.

9 PRICING

White, S. (Ed) 1998, *Wise Water Management: a Demand Management Manual for Water Authorities*, Sydney: Water Services Association of Australia. ISBN 1 875298 87 8.

In-depth guidance on pricing, including (p.29):

- objectives of a pricing policy
- two-part tariffs
- other tariff types (incl. flat rate charges, flat rate plus water allowance, declining block tariff, inclining block tariff)
- marginal cost of water
- seasonal and time-of-use pricing
- drought/scarcity pricing
- impact of tariff reform
- price elasticity
- residential units
- tenant-landlord issues
- hardship response
- sewerage pricing

OECD (2000) The Price of Water: Trends in OECD countries, Executive summary. OECD Environment Programme ISBN: 9234170790

Two page summary of key trends across OECD countries: the text focuses especially on the important water-using sectors of agriculture, industry, and households. It also addresses several "non-sectoral" pricing topics, such as water subsidies, institutional change, and affordability.

OECD (2002) Social Protection in Urban Water Sector in OECD Countries, Prepared by Henri Smets, Consumer Protection and Public Participation in the Reforms of the Urban Water Supply and Sanitation in the NIS Expert Workshop, 4–5 March. Paris, France

This paper reviews various methods used in OECD countries to enable poor users to pay for water supply and sanitation. It deals only with regions, which are already equipped with water supply networks.

OECD (2002) Affordability of Urban Water Services in the NIS, Prepared by Alexander P Martussevich, Consumer Protection and Public Participation in the Reforms of the Urban Water Supply and Sanitation in the NIS Expert Workshop, 4–5 March. Paris, France

This discussion paper "aims to provide an overview of "affordability constrains" related to water sector in the NIS, and to identify main issues to be addressed by the Guidelines, and to formulate preliminary recommendations for methodologies, policy and institutional measures required to ensure economic affordability at macro and micro level, in broader sector reform, including reform of tariffs."

OECD (2003) Social issues in the provision and pricing of water services

This book explores the links between social issues and the provision of water supply and sanitation services in OECD countries.

The main focus of the report is the affordability of water services, as well as the social measures currently in place aimed at resolving these affordability problems. The report also examines the potential role of the private sector in incorporating the social dimension into water pricing decisions, as well as issues related to making the transition towards higher levels of access to water services.

Main contribution is by Paul Herrington.

European Environment Agency (2001), *Sustainable water use in Europe. Part 2: Demand management*, Authors: Lallana, C., Krinner, W. and Estrela, T., CEDEX, S. Nixon, Water Research Centre, J. Leonard, J. M. Berland, IOW. ETC/IW Leader: T. J. Lack, EEA Project Manager: N. Thyssen, Copenhagen.

Socially acceptable tariffs: When addressing water tariffs, it is necessary to take into account vulnerable customers who may have difficulties in paying for the water used for essential purposes, since it is generally recognised that no one should have to compromise personal hygiene and health in order to be able to pay the water bill. For example, the proposed water framework directive requires an affordable price to guarantee a basic level of domestic water supply (Article 12a) (see Appendix, case study 30). (p.38).

Industry pricing: The industrial sector faces two different ranges of prices depending on the water source: direct abstraction or from the public water supply. Abstraction charges can take the form of a nominal licence fee linked to an abstraction permit regime, or they can vary depending on the quantity used. They can also have explicit environmental objectives, including, for example, consumption reduction incentives. (p.39).

ADB (1999) Handbook for the Economic Analysis of Water Supply Projects, Guidelines, Handbooks, and Manuals, Economics and Development Resource Center, Asian Development Bank ISBN: 971 561 220 2, 361 pages.

Deals with "financial sustainability" and user payments, tariff design methods, with some reference to affordability and when subsidies are appropriate.

Arbues, F., Garcia-Salinas M.A., and Martinez- Espineira, R. (2003) Estimation of residential water demand: a state-of-the-art-review. The Journal of Socio-Economics. 32:81-102.

The abstract notes: "This paper surveys the main issues in the literature on residential water demand. Several tariff types and their objectives are analyzed. Then, the main contributions to the literature on residential water demand estimation are reviewed, with particular attention to variables, specification model, data set, and the most common econometric problems. The paper concludes with comments on future trends and a summary of the contents of the study."

Focus of the paper is on price, tariffs and their effect on water demand. Says that there is no general consensus on the best methodology to analyse water demand, includes a comprehensive table of price elasticities put forward by a large range of authors in the literature. Conclusions state that: "Water price, income, or household composition are crucial determinants of residential consumption."

Van Zyl, K. and Haarhoff, J. (2002) A Residential Water Use Model for Rand Water with Elasticity for Price, Stand Size, Income and Pressure. South Africa.

Several page discussion price elasticity and reports information from other literature on this issue.

Sensitivity analysis on price elasticity considered short term and long term elasticity (p20).

Charalambous, C.N. (2002) "Water conservation: A Practical Approach", European Water Resources Association International Conference, Athens, Greece, Proceedings, pp.211-218.

Here, a strategy to deal with the lost revenue due to water shortages is put forward: "reduced water sales because of conservation often develop slowly in small increments that can be accommodated in periodic rate adjustments."

The author states: "Over the long-term, conservation can decrease a utility's need for new capital facilities for supply acquisition, treatment, storage, pumping, and distribution. It may also reduce the costs of operating those facilities. Deferring investment in such facilities or reducing their size can provide significant cost savings. In areas experiencing population growth, conservation can provide additional capacity to accommodate growth, resulting in a larger customer base over which to spread future capital costs. Water rates may by lower with conservation than without.

The first goal of any rate structure is to generate sufficient revenues to maintain efficient and reliable utility operation, and the second is fairness in the allocation of utility service costs. Generally, it is possible to satisfy both of these goals in a rate structure that encourages water conservation or penalises excessive water use.

Conservation-oriented water rate structures by themselves do not constitute an effective water conservation program. Rate structure work best as a conservation tool when coupled with a sustained customer education program. Customer education is important to establish and maintain the link between customer behaviours and their water bill. Utility customers require practical information about water-conserving practices and technologies. Participation in other water conservation programs, such as plumbing-fixture retrofit and replacement programs, can also be enhanced by rate incentives and customer education. Finally, public acceptance of rate structure changes is often enhanced if customers understand the need for and benefits of water conservation."

Stratus Consulting (1999), Water Price Elasticities for Single-Family Homes in Texas. City of Austin for Texas Water Development Board http://www.twdb.state.tx.us/RWPG/rpgm_rpts/96483189.pdf

Price sensitivity analysis among residential water customers in Austin, San Antonio and Corpus Christi. The study looks at the impact on increasing block rate pricing in these three cities.

10 PARTICIPATORY METHODS

Guidelines and reference material for innovative deliberative and representative processes for the purpose of objective setting by utilities, and for determining citizen preferences with regard to strategic direction, dealing with constraints on the water supply and sanitation system and understanding willingness to accept and willingness to pay. These processes are also useful in the assessment of values, where there are limits to the ability of scientific assessment, or where there are contested views and interpretations.

Tellus Institute (2000) Best Practices Guide: Integrated Resource Planning for Electricity Prepared for: Energy and Environment Training Program Office of Energy, Environment and Technology Global Bureau, Center for the Environment United State Agency for International Development

In this resource, "IRP, as we intend the approach, is also a transparent and participatory planning process. It contrasts with traditional planning that is typically top-down, with public consultation occurring only as a last step, when plans are virtually complete. IRP can make planning more open to relevant governmental agencies, consumer groups, and others, thus considering the needs and ideas of all parties with a stake in the future of the electric system. In summary, IRP provides an opportunity for electric system planners to address complex issues in a structured, inclusive, and transparent manner. At the same time, it provides a chance for interested parties both inside and outside the planning region to review, understand, and provide input to planning decisions." (p13)

Gleick et al (2003) Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment and Security, Oakland California

Participatory methods are particularly important because: "One of the reasons that adopting efficiency approaches are difficult for traditional water agencies to adopt is that they shift the burden from engineering logistics to social ones…highly trained engineering experts…unfamiliar with methods for designing and implementing conservation programs" p28.

Carson L. and Gelber K (2001) Ideas for Community Consultation: A discussion on principles and procedures for making consultation work A report prepared for the NSW Department of Urban Affairs and Planning February 2001

Excerpt from the executive summary: "Part 1 (Principles) of this report identifies a range of challenges facing plan makers as they try to integrate public input into the plan making process, and help communities identify with and participate in complex procedures of government. This Part offers three key ideas for achieving better community consultation. These are:

- engaging principles for effective community consultation
- collaboration and
- basing consultation methods on a four-step model.

This Part also deals with the question of selecting participants in a consultative process. Where representativeness is important, the application of random selection is recommended. Arguments supporting random selection, and means of achieving it, are outlined. In this context, the specific challenges to plan making faced at the State, regional and local levels are discussed, so that practitioners can determine clearly how the proposed skills offered in this Part will help them undertake better community consultation.

Part 2 (Procedures) describes a range of consultative methods. Some relative advantages and disadvantages of each method are outlined, to assist plan makers and government agencies determine which method would be appropriate for a particular consultative challenge at any given moment. The methods discussed in Part 2 complement the principles outlined in Part 1, and together these proposals offer dynamic and flexible options for enhancing community consultation in the planning process. The focus of this draft report is on proposing innovative and dynamic solutions, to energise and activate community consultation by government agencies in NSW."

Planning NSW (2003) Community Engagement in the NSW Planning System, Department of Planning, see www.iplan.nsw.gov.au/engagement/

This resource has a comprehensive coverage of many engagement techniques. The range of methods that span the range from "inform, consult, involve, collaborate, to empower" are all described.

UNDP, Willing To Pay But Unwilling To Charge: do 'willingness-to-pay' studies make a difference?

This report from UNDP–World Bank Water and Sanitation Program (1999) argues: "many urban and rural communities are willing to pay more than the prevailing rates for water and sanitation, to ensure a better or more reliable service. However, governments seem unwilling to match this with a willingness to charge consumers for these services and the result is a continuing cycle of low revenues, high costs, unsatisfactory services and financial crisis".

It concludes that "There is plenty of evidence, both direct and indirect, to show that rural and urban India is prepared to pay more for reliable, safe and adequate water supply and sanitation services. There is also evidence that if suppliers can set tariffs at reasonable levels based on real costs, consumers will respond positively to tariff increases to secure the required levels of service."

"This Field Note explores the approaches to assessing willingness to pay, examines the evidence of previous willingness-to-pay surveys carried out in India and takes a critical look at the experience of such surveys in influencing policy change."

ADB (1999) Handbook for the Economic Analysis of Water Supply Projects, Guidelines, Handbooks, and Manuals, Economics and Development Resource Center, Asian Development Bank ISBN: 971-561-220-2, 361 pages.

Includes appendices that outline Willingness to Pay and Contingent Valuation survey approaches.

UK Environment Agency (2003) Water Resources Planning Guideline, Version 3.3 December 2003

In terms of public consultation/communication, OFWAT, UK Env Agency expects the following: "The Agency expects water companies to publish, in an appropriate format, their plans or appropriate summaries to demonstrate to the community at large how they intend to take account of their interests. This should include the potential impact of proposed measures to manage their supply–demand balance on the environment. It is expected that increased transparency and openness in the planning process will result in an improved understanding of the issues by the public and non governmental organisations, together with better informed and quicker decisions by the Agency and others." (p22)

Skeel, T. (2001), *Water Conservation Potential Assessment: A Tool for Strategic Resource Management*, presented at Efficient Use and Management of Water for Urban Supply. 21-23 May 2001, Madrid. Tim Skeel, Principal Economist, Seattle Public Utilities, Seattle, WA, USA (Endnote entry 83)

Proposes that a 'Conservation Potential Assessment' (CPA) process should incorporate review from conservation and industry experts outside the water utility.

Conservation Potential Assessment Advisory Committee

A Conservation Potential Assessment Advisory Committee (CPAAC) should be convened to represent diverse business, community, customer, and environmental perspectives on conservation and the impact of potential measures. During program design, the CPAAC should meet monthly to review the CPA model and research findings. Throughout the CPA process the project team should depend on the CPAAC to raise and help resolve significant issues pertaining to the conservation program equity, measurement of cost effectiveness, and external costs and benefits of program options. Overall, CPAAC participation will assured that project results would reflect the reality of the utility's customers.

Technical Advisory Groups

The CPA should convene Technical Advisory Group (TAG) Workshops, inviting technical experts from local businesses and consulting practices to discuss their industries (commercial landscape, residential landscape, commercial/ industrial/ institutional water user, and domestic use). Each facilitated workshop will generate a list of the most promising conservation opportunities in that water use category. Of great value is the anecdotal information gathered from these professionals regarding water use behaviors and opportunities for conservation and enhanced efficiency. The CPA should incorporate the findings from each of these sessions into the development of water conservation measures.

Customer focus groups and survey

Public opinion regarding water conservation and specific conservation measures under consideration in the CPA should be evaluated in a *Water Conservation Attitudes and Perception Study*. The study can provide focus group and survey data regarding customer water use, conservation perceptions, attitudes, and receptivity to implementing certain conservation measures in the future.

Interdepartmental Working Team

To ensure that the CPA project is appropriately coordinated within the utility, and with outside interested agencies, the CPA should convene an Inter-Departmental Working Team (IDT). The IDT includes staff from the utility and other interested agencies. This internal team can provide detailed review of intermediate CPA products and modeling assumptions to assure that the CPA is fully integrated with past and current conservation efforts and is responsive to the needs of agency planning efforts.

Conservation Expert Review Panel

A panel recognized water conservation experts should be asked to review and comment on the CPA model and findings. The goal of this review is to provide an objective review of the results by industry professionals familiar with conservation efforts throughout the world.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

P24-26 provides ideas on participation in water resources planning.

Eleven steps for effective public participation as defined by and AWWARF publication. Important ones worth noting are:

> identify constraints- which issues can be negotiated with the public and which not
> identify when input is needed, at what stages in a planning process
> identify potentially affect stakeholders who need to be involved
> determine vulnerability and "must resolve" issues and focus on these issues and groups that are likely to generate the greatest conflict
> manage change- plan must be flexible enough to adapt to changes in schedule, political climate, staff or critical issues.

Consensus building techniques include:

> public meetings that provide informal and participatory forums
> citizen advisory committees which allow a broad range of stakeholder input throughout a project
> workshops that provide a participatory process for exchange of ideas and information
> task forces charged with the task of devising or recommending a solution to a specific problem
> professional or scientific panels
> mediation using an experienced facilitator to aid with conflict resolution
> arbitration as a last resort if a mediated consensus fails.

Tools that help the above processes include:

> participant surveys (random telephone surveys, one on one interviews with key stakeholders)

- issue or discussion papers- that help to define the issues and provide a common basis of knowledge about an issue- these can be used as catalysts for starting discussion
- policy statements that commit participants to a specific position.

Guidelines for conducting a successful process:

- setting realistic goals
- optimize participation- only involve those stakeholders that need to be involved- groups of less than 25 are more efficient at making decisions and reaching consensus.
- Discourage hidden or disruptive agendas
- Create access and openness (eg make staff available between meetings etc.

City of Phoenix Water Conservation Plan 1998 ftp://www.ci.phoenix.az.us/pub/payf/waterpln.pdf

Reasoning behind why participation is so important in water demand management ventures: “Water conservation is not something that can be imposed on the public; it must be voluntarily and willingly accepted and become a shared responsibility between the Water Services Department and the citizens of the City of Phoenix. Only if citizens are willing to embrace and practice a conservation ethic, and adopt water conservation as a fundamental part of their southwestern lifestyle, can the city succeed in meeting its long-term water conservation and supply goals and its commitment to keeping Phoenix a desirable place to live. The 1998 Water Conservation Plan is a partnership between the citizens of Phoenix and the city to provide the assistance and support necessary to exercise proper stewardship over our water resources. Through comprehensive planning, the responsible application of best available water conservation technologies, public education, and reuse of wastewater, our water resources can be managed to sustain projected growth well into the future.”

11 ISSUES SPECIFIC TO DEVELOPING COUNTRIES

Mulwafu et al (2002) Water Demand Management in Malawi: Problems and Prospects for its Promotion

Reports the state of water resources in Malawi and the institutions responsible for water demand management. Also covers urban and rural situations

In terms of urban domestic demand management, there are two groups- those that pay and those whose bills are paid by public institutions (employees, students, hospitals etc)

Constraints to water demand management are expanded upon- this is useful information for designing programs in such countries (p6)

Gumbo, B. and Van der Zaag, P. (2001) Water losses and the political constraints to demand management: the case of the City of Mutare, Zimbabwe 60, 2nd WARFSA/WaterNet Symposium: Integrated Water Resources Management: Theory, Practice, Cases, Cape Town, 30-31 Oct. 2001

Reports the key constraint to be consideration of alternatives to supply side put forward by engineers, financiers and politicians.

The author notes: "As a strategy it is suggested that: (a) stakeholders should be better informed about alternative solutions to water problems: (b) a new generation of engineers trained in integrated water resources management is needed with the skills to carefully study the problem definition before rushing to solutions, and (c) financiers should be made aware of the relevance and economic rationale of demand management solutions.

United Nations (2003) Guide to Preparing Urban Water Efficiency Plans, Water Resources Series No 83. Authors Bill Maddaus and Lisa Maddaus, Economic and Social Commission for Asia and the Pacific (ESCAP)

Minimum data needs are: demographic data and projections, Monthly water production data, the number of water accounts by customer class, monthly water sales (usage) data by customer class.

Can fill data gaps with estimates from similar water utilities or research projects- eg. average customer use for each end-use is known for US and can gradually collect this information for Asia and elsewhere.

12 OTHER TOPICS

12.1 Network flow modelling

Coelho, S. T. (1988). "A System for Demand Analysis and Forecasting in Water Supply Systems." Master Thesis, University of Newcastle Upon Tyne, UK.

Coelho (1988) developed a time series-based model for demand forecasting and a method for producing 'standardised daily demand patterns'.

Alegre, H. and Coelho, S. T. (1993). "A methodology for the characterisation of water consumption." Integrated computer applications in water supply, Research Studies Press Ld., Reino Unido, 369-384.

These authors describe a methodology for the statistic assessment of daily and weekly demand profiles along the year, as well as the identification of the main social-demographic and habitat factors affecting them. It is based on temporary surveying campaigns held on representative study areas.

Jankovic-Nisic, B., Maksimovic, C., Butler, D., and Graham, N. J. D. (2005). "Use of flow meters for managing water supply networks." Journal of Water Resources Planning and Management, 130(2), 171-179.

Jankovic-Nisic et al. (2004) combined domestic and network telemetry data to establish a methodology for meter location and selection of the monitoring step to control DMA, in order to improve on-line monitoring and burst detection in water distribution networks.

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