This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can adapt to climate change. This resource has been developed through support from the Federal Government’s Department of Climate Change’s Climate Change Adaptation Professional Skills program.


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Chief Investigator and Project Manager: Mr Karlson ‘Charlie’ Hargroves, Research Fellow, Griffith University.

Principle Researcher and Author: Dr Michael Smith, Research Fellow, Fenner School of Environment and Society, ANU.

Peer Review
Peer review has been received for this lecture from Professor Stuart White – Director, Institute for Sustainable Futures, University of Technology, Sydney. Dr Matthew Inman - Urban Systems Program, CSIRO Sustainable Ecosystems, CSIRO. Ann tonette Joseph, Director – Urban Water Efficiency Initiatives, Commonwealth Department of Environment, Water, Heritage and the Arts; Harriet Adams - Urban Water Efficiency Initiatives, Commonwealth Department of Environment, Water, Heritage and the Arts. Dr Matthew Inman, CSIRO.

Additional peer review for this module has been received from Professor Stephen Dovers, Director, Fenner School of Environment and Society, Australia National University; Chris Davis, Institute of Sustainable Futures, University of Technology; Alex Fearnside, Sustainability Team Leader, Melbourne City Council; Associate Professor Margaret Greenway, Griffith University; Fiona Henderson, CSIRO Land and Water, Bevan Smith, Senior Project Officer (WaterWise) Recycled Water and Demand Management, Queensland Government, Department of Natural Resources and Water. Dr Gurodeo Anand Tularam, Lecturer, Griffith University. Associate Professor Adrian Werner, Associate Professor of Hydrogeology, Flinders University, Professor Stuart White, Institute of Sustainable Futures, UTS.

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Enquires should be directed to:
Dr Michael Smith, Research Fellow, Australian National University, Fenner School of Environment and Society, Co-Founder, The Natural Edge Project, Contact Details at http://fennerschool.anu.edu.au/people/academics/smithmh.php
**Integrated Water Resource Planning in a Changing Climate**

**Lecture 5.2: Integrated Water Resource Planning In a Changing Climate – Water Supply and Demand Management.**

**Educational Aim**

Lecture 5.1 showed that climate change is going to affect water supply and demand significantly over the coming century. Here in Lecture 5.2 we show that there is a range of new issues and concerns, including climate change, that are forcing water utilities and water planners to consider new ways to meet society’s water needs. These issues, including climate change, require a new planning framework through which water utilities and planners can address long term changes in water supply and demand constraints. Over the last three decades, various approaches have been developed internationally to help water utilities plan for and manage these complex choices and issues. Integrated water resource planning, in which a full range of both supply-side and demand-side options (See Table 5.2.1) are assessed, has emerged as the most robust and comprehensive framework for decision making in this area. The aim of this lecture is to provide an overview of this methodology and show how it can assist the water sector adapt to climate change. We also provide significant further detailed online resources to assist water utilities and water planners develop and implement specific aspects of an integrated water resource planning approach. In doing so, this lecture seeks to provide a succinct overview of leading work in this field, and in particular the world leading work on integrated water resource planning by Professor Stuart White and Andrea Turner of the Institute of Sustainable Futures at the University of Technology, Sydney including their 2008 *Integrated Resource Planning – Demand Management Guide* published by the Water Services Association of Australia.

**Key Learning Points**

1. Over the last three decades, various approaches have been used to help water utilities plan for and manage changes in water supply and demand. Integrated water resource planning has emerged as the most useful framework for decision making in this area.

2. Integrated water resource planning is now used in many countries around the world. Manuals outlining frameworks explaining how to implement integrated water resource planning have been produced in the US, UK and Australia by leading experts for leading water NGOs such as the California Urban Water Conservation Council (CUWCC)\(^1\), the American Water Works

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Association (AWWA)², the UK Environment Agency (UKEA)³ and the Water Services Association of Australia.⁴ This later manual, developed by Andrea Turner, Professor Stuart White and colleagues from the Institute for Sustainable Futures, UTS and colleagues is the first ever freely available detailed integrated resource planning manual for the water sector. This lecture provides an overview of the main elements of this work by Turner, White and colleagues with one extra step added for emphasis – namely the need to undertake a climate change assessment (see Step 2 below). Their work shows that an integrated approach to water supply and demand management planning typically can be described as consisting of several major elements or steps including the following:

3. **Step 1 - Plan the Overall Process**: It is crucial to begin the planning process by agreeing on the broad vision, aim, activities, timeline, and deliverables. Based on this, the next step is to identify which stakeholders will be involved and what role they will take. Next, clarification of what level of resources are needed and what are available needs to take place. Based on this, then decisions need to be made on how best to undertake key parts of the integrated resource planning process. To help inform these decisions in Step 1, the following steps outline for you the core elements of the integrated resource planning process. Further detail on each of these steps can be found from the “Key Reference” material listed at the end of this lecture resource.⁵

4. **Step 2 – Undertake a Climate Change Assessment**: A Climate Change Adaptation assessment is the “practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.”⁶ Climate change impacts for the water supply sector are highly variable and site specific. This highlights the need for a local or regional assessment of how climate change will impact on water supply and demand at a local and regional level. Hence the first step in climate change adaptation assessment is to evaluate the hydrologic impacts of climate change at the local or regional scale. Thus Step 2 focuses on calculating water availability changes out to 2020, 2050 and 2100 from the expected effects of climate change.

5. **Step 3 – Analyse the Situation – to Determine the Supply-Demand Gap at 2020 and 2050**.

In addition to climate change, other factors also influence the supply–demand balance such as demographics, population and economic growth. To calculate the future impact of these factors on the supply-demand gap it is necessary to generate a reference case, or baseline, for projected water demand. This baseline should compare projected demand under a business-as-usual situation against the system’s available water supply. Hence it is vitally important to calculate an “official” projection of growth to the target year (for example 2020,

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2050, 2100) for your water catchment, town, city, region based on applying current rates of water withdrawals and uses to the anticipated size of the population and of the economy for that year. Comparing this official projection, with the likely water availability from the climate change scenario's outlined in Step 2 enables you to assess the likely water supply-demand gap out into the future.

6. **Step 4 - Identify Potential Supply and Demand Options**: The next step is to identify potential water efficiency and small-scale source substitution options by considering the water conservation potential of individual sectors and end uses, opportunities for source substitution, use of measures and instruments. In assessing these options it is important to consider all the costs and benefits of each option, including avoided capital and operating costs.

7. **Step 5 - Design a Portfolio of Options** There is a large and growing suite of water efficiency and potable source substitution options from which to choose. Fortunately many have low cost and rapid return on investment. This justifies a portfolio approach where a suite of mutually reinforcing options are chosen from Table 5.2.1. Assessing the costs and benefits of all these options is complex. How to undertake such an analysis is well covered in a range of existing manuals. Several cost analyses have been done and are publically available which act as a guide to what the most cost effective ways to meet the supply-demand gap are.

8. **Step 6: Implement a Portfolio of Options**: Implementing a portfolio approach of demand management and alternative supply augmentation measures is no longer a walk into the unknown. Much can be learnt from a range of cities which have already undertaken such an approach. A number of municipal water suppliers have implemented a suite of aggressive water conservation programs and achieved remarkable results cost effectively. Postel includes an excellent summary of successful municipal programs in Jerusalem, Israel; Mexico City, Mexico; Los Angeles, California; Beijing, China; Singapore; Boston, Massachusetts; Waterloo, Canada; Bogor, Indonesia; Brisbane, Sydney and Melbourne, Australia. Reductions in water demand varied from 20 to 50 percent. Reports and studies of these leading cities are featured in the future reading section of this lecture.

9. **Step 7: Monitoring, evaluation and review**: This step is critical to the operation of integrated resource planning and ensures it becomes an on-going learning process. Although placed here as the final step, in fact it occurs in parallel with the rest of the process. Monitoring and evaluation of water savings achieved, participation rates and costs will be essential to ensure progress against planning objectives is measured.

**Background Information**

There are numerous options and ways water utilities and planners can continue to meet society’s water needs through changes to the mix of water supply and demand. (See Table 5.2.1) Hence what is needed now is a framework which provides a systematic way for water utilities and planners to choose the right portfolio of options to meet the supply-demand gap in the future in

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such a way that is lowest cost whilst also being the best outcome for the community and the environment.

**Table 5.2.1 Examples of Supply-Side and Demand Side Adaptation Options for Various Water-Use Sectors**

<table>
<thead>
<tr>
<th>Water-Use Sector</th>
<th>Supply Side Measure</th>
<th>Demand Side Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Water Supply</td>
<td>Increase reservoir supply</td>
<td>Incentives to use less such as through pricing or rebates.</td>
</tr>
<tr>
<td></td>
<td>Extract more water from rivers or groundwater</td>
<td>Legally enforceable water use standards (eg: for appliances)</td>
</tr>
<tr>
<td></td>
<td>Alter system operating rules</td>
<td>Increase use of grey-water</td>
</tr>
<tr>
<td></td>
<td>Inter-basin water transfer</td>
<td>Reduce leakage</td>
</tr>
<tr>
<td></td>
<td>Capture more rain water</td>
<td>Increase use of recycled water</td>
</tr>
<tr>
<td></td>
<td>Desalination</td>
<td>Development of non-water based sanitation systems</td>
</tr>
<tr>
<td></td>
<td>Seasonable forecasting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>Increase irrigation source capacity.</td>
<td>Increase irrigation-use efficiency.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase use of drought tolerant plants.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alter cropping patterns</td>
</tr>
<tr>
<td>Industrial and Power Station Cooling</td>
<td>Increase source capacity</td>
<td>Increase water-use efficiency and water recycling.</td>
</tr>
<tr>
<td></td>
<td>Use of low-grade water</td>
<td></td>
</tr>
<tr>
<td>Hydropower generation</td>
<td>Increase reservoir capacity</td>
<td>Increase efficiency of turbines; encourage energy efficiency.</td>
</tr>
<tr>
<td>Pollution Control</td>
<td>Enhance treatment works</td>
<td>Reduce volume of effluents to treat such as by charging for discharges.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Catchment management to reduce polluting runoff.</td>
</tr>
</tbody>
</table>

*(Adapted from Arnell, et al, 2001\(^\text{10}\) and Kundzewicz et al. 2007\(^\text{11}\).)*

Over the last three decades, various approaches have been under development internationally to help water utilities manage these complex choices and issues. Integrated water resource planning, in which a full range of both supply-side and demand-side options (See table 5.2.1) are assessed, has emerged as the most useful framework for decision making in this area. Since the 1990s, leading thinkers and practitioners have developed new ideas about integrated resource planning for the water industry to improve demand management. Leading the efforts in this field in


the USA have been the California Urban Water Conservation Council (CUWCC)\textsuperscript{12} and the American Water Works Association (AWWA)\textsuperscript{13} have developed methodologies to better forecast water demand and design and assess water conservation options. (See Key References below) In the UK, the UK Environment Agency (UKEA) have developed methodologies to ensure that water utilities manage both water demand as well as supply. Current practice for all UK water utilities is to consider both demand and supply options in the same framework, as proposed by the Integrated Resource Planning approach.\textsuperscript{14}

In Australia, especially since the drought of the last decade, there has been a number of water utilities implementing detailed demand management and recycling plans as part of a professional integrated resource planning approach. Many of these water utilities have been working with Professor Stuart White, Andrea Turner and colleagues from the Institute of Sustainable Futures, University of Technology, Sydney, who have developed the first ever freely available integrated resource planning manuals for the Australian water supply industry (see Key References below)).\textsuperscript{15} In their extensive publications White, Turner and colleagues have developed a significant portfolio of resources to help all water supply sectors successfully undertake integrated water resource planning. Their detailed work is important and much needed, as integrated water resource planning to optimise demand management outcomes represents a significant paradigm shift for the water sector, that still many nations are yet to fully adopt. Table 5.2.1 summarises the key differences between integrated resource planning and traditional water planning approaches and thus highlights the critical need for new training materials in this area.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
Criteria                                                                 & Traditional                                                                 & Integrated Resource Planning                                                                  \\
\hline
Planning orientation                                                     & Addressing supply-demand gap: Supply options with little diversity         & Supply management and demand management options, efficiency and diversity.                     \\
\hline
Resource ownership and control                                           & Centralised and utility-owned                                              & Decentralised utilities, customers and others                                                  \\
\hline
Scope of planning                                                        & Single objective, usually to add to supply capacity                        & Multiple objectives determined in the planning process                                         \\
\hline
\end{tabular}
\caption{Differences between Traditional and Integrated Resource Planning}
\end{table}


<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Maximise reliability and minimise process</th>
<th>Multiple criteria, including cost control, risk management, environmental protection, community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource selection</td>
<td>Based on a commitment to a specific option</td>
<td>Based on developing a mix of options</td>
</tr>
<tr>
<td>Planning process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature of the process</td>
<td>Closed, inflexible, internally oriented</td>
<td>Open, flexible, externally oriented</td>
</tr>
<tr>
<td>Judgement and preferences</td>
<td>Implicit</td>
<td>Explicit</td>
</tr>
<tr>
<td>Conflict management</td>
<td>Conventional dispute resolution</td>
<td>Consensus- Building</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Utility and its rate-payers</td>
<td>Multiple interests</td>
</tr>
<tr>
<td>Stakeholders’ role</td>
<td>Disputants</td>
<td>Participants</td>
</tr>
<tr>
<td>Planning issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply reliability</td>
<td>A high priority</td>
<td>A decision variable</td>
</tr>
<tr>
<td>Demand Forecasting</td>
<td>Utilises historical water demand forecasting using per capita demand.</td>
<td>Utilises methodologies that involve disaggregation of water demand into sectors and sub-sectors</td>
</tr>
<tr>
<td>Environmental quality</td>
<td>A planning constraint</td>
<td>A planning objective</td>
</tr>
<tr>
<td>Cost considerations</td>
<td>Direct utility system costs</td>
<td>Direct and indirect costs, including environmental and social externalities</td>
</tr>
<tr>
<td>Role of pricing</td>
<td>A mechanism to recover costs.</td>
<td>An economic signal to guide consumption and way in which to share costs and benefits between different stakeholders</td>
</tr>
<tr>
<td>Efficiency</td>
<td>An operational concern</td>
<td>A resource option</td>
</tr>
<tr>
<td>Trade-offs</td>
<td>Trade-offs hidden or ignored</td>
<td>Trade-offs openly addressed</td>
</tr>
<tr>
<td>Risk and uncertainty</td>
<td>Should be avoided or reduced</td>
<td>Should be analysed and managed</td>
</tr>
</tbody>
</table>

(Source: Adapted from Beecher, J. in Turner et al, 200816)

The global water industry has strong expertise in increasing supply options to manage the supply/demand gap. But the global water industry is now experiencing a growing need to better understand and manage the demand for water as part of an integrated resource planning framework. Specifically, practitioners need new skills in understanding how to do detailed demand forecasting and how to develop, implement and evaluate demand management programs. This involves developing the skills needed to undertake sophisticated integrated water planning to successfully adapt to climate change. This lecture is thus a summary of the many reports and

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manuals now available to assist. This lecture will provide a synthesis of the key elements of these reports, all of which provide proven methods to assist the water sector’s short and long term planning to successfully adapt to climate change.

Integrated Water Resource Planning – A Framework to Assist Water Utilities Adapt to Climate Change

**Step 1: Plan the overall process:** It is crucial to begin the planning process by agreeing upon the purpose, form and scope of all steps of an integrated resource planning approach as integrated resource planning marks a significant change compared to traditional approaches to managing water supplies. This means agreeing on the broad vision, aim, scope, timing, and outcomes. Based on this, the next step is to identify which stakeholders will be involved, what role they will take and seeking clarity about the resources available for the planning process (i.e. funding and personnel). Since the Integrated Water Resource Planning process can be followed at different levels of detail in this step you will need to determine the appropriate depth of analysis required for the other steps, depending on timing and context (i.e. strategic/first cut or more detailed). Based on this, decisions then need to be made on what training is needed for staff to undertake the IRP process effectively. Decisions on how best to calculate or model key parts of the process are then needed to help inform these decisions, the following steps outline for you the core elements of the IRP process.¹⁷

**Step 2 – Undertake a Climate Change Assessment:** Climate change impacts for the water supply sector are variable and localised. Hence the importance for local or regional climate change assessments to determine how climate change will impact on water supply and demand at a local and regional level. Hence the first step in climate change adaptation assessment is to evaluate the hydrologic impacts of climate change at the local or regional scale. These need to be evaluated ideally out to 2020 and 2050 to determine the expected effects of climate change. There are two alternative approaches to determine the changes in temperature and precipitation associated with climate change.²⁰

1. Using mathematical relationships to downscale global climate modelling (GCM) output, or
2. Hypothetically modifying temperature and precipitation inputs by some arbitrary amount, for instance, 10 per cent in precipitation.

GCMs have evolved over the past 50 years since their original conception by Phillips.²⁰ Currently GCMs are representations of the coupled atmosphere-land-ocean-ice systems and their interactions. These models provide information on the response of the atmosphere to different scenarios of greenhouse gas concentrations.²⁰ However, at approx. 200km, the spatial resolution of GCMs is insufficient for hydrologic models, as is their temporal resolution. In an attempt to redress GCMs inability to resolve complex

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topography and sub-grid scale processes, a number of methods have been developed, including statistical downscaling, delta/ratio methods, and dynamic downscaling, or nested, models. GCM output can be downscaled to surface variables at river basin scale using these methods. A more simple and direct approach is to develop hypothetical scenarios of changes in temperature and precipitation. Proposed hypothetical climate scenarios in these studies include changes in temperature covering the plausible range for the twenty-first century (e.g. +2 to +5°C). Since projections of precipitation are less consistent and include both increases and decreases, hypothetical scenarios are selected within this range. The advantage of the hypothetical scenario approach is its simplicity in representing a wide range of alternative scenarios. These scenarios can be used to determine the sensitivity of a particular basin to changes in climate conditions. These changes are then input into a more detailed regional hydrologic model to stimulate stream-flows under altered climatic conditions. Simulated stream-flows can then be input into system simulation models to determine the potential impacts on water resource systems. Such an approach is recommended by Vicuna and Dracup.21

![Diagram: Methodology to Evaluate Hydrological Impacts of Climate Change](Source: Vicuna and Dracup, 200722)

Current initiatives are working to identify the impacts of climate change on groundwater-surface water interactions by incorporating the geophysical surveying (satellite imagery) of water movement with climate change projections. Recently, the International Hydrological Programme arm of UNESCO, which conducts research into water resource management, initiated a program called Groundwater Resources Assessment under the Pressures of Humanity and Climate Changes (GRAPHIC). GRAPHIC models possible non-linear responses between groundwater hydrology and atmospheric conditions correlating to climate change.23 Through these methodologies, data can be obtained to see how climate change will affect water supply yield for:

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- different surface and groundwater resources
- the number and capacity of the surface reservoirs
- the characteristics of the surface water catchment feeding the surface water reserves (e.g. vegetation growth, fires in the catchment)
- the rainfall and inflow patterns.

Enhancements in modelling the hydrology of the water catchments under climate change scenarios indicate that less water will be available. In Sydney new climate and water inflow data, coupled with data from the Sydney catchment WATHNET hydrological simulation model, indicate that Sydney's yield will decrease. In Western Australia between 1997 and 2006, average total inflow into the dams that provide half of the Perth’s drinking water was just 31% of the 1911 to 1974 average. Groundwater recharge has been observed to have diminished in parallel, with resulting drops in groundwater levels leading to the closure of a number of bores. These figures point to a need to decrease the amount of water sourced from Perth's catchment. Modelling of climate change can also estimate the probability of the likelihood of increased frequency of drought conditions under the increased likelihood of more frequent El Nino effects.

Step 3 – Analyse the Situation to Determine the Supply-Demand Gap at 2020 and 2050: In addition to climate change, factors that influence the supply–demand balance include demographics, population and economic growth. These factors should also be analysed using scenarios to assess the potential risks facing water supply in a region.

The first step is to create a ‘reference case’ scenario for projected water demand under a ‘business as usual’ scenario against the water supply availability of the system. The difference, or ‘balance’, is the volume of water that will need to be filled by potable supply, potable source substitution and/or demand-side options. By investigating both the water supply availability and the business as usual reference case, a water authority can determine when the supply-demand balance may become an issue.

Accurately projecting the short and long term supply-demand balance is essential for effective planning to meet that supply-demand gap in time. It is vitally important to calculate an “official” projection of growth to the target year (2020, 2050, 2100) for your water catchment, town, city, or region based on applying current rates of water withdrawals and uses to the anticipated size of the population and economic activity for that year. Comparing this projection with the likely water availability from the above climate change scenario enables you to assess the likely water supply-demand gap in the future.

Water planners and service providers are already familiar with how to calculate the water supply availability of their respective water supply systems, and there is significant guidance in how to do this by Erlanger and Neal. However, they are less familiar with assessing and forecasting future water demand. So we consider how to do this next.

There are three key methods used for demand forecasting. We will consider each in turn and their pros and cons.

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**Historical demand forecasting:** This method is quick and easy to use. It works by calculating how much of a product or service customers will consume based on per capita demand e.g. determining user demand in litres per capita per day based on how much they use now, or have used in the past. This can be done by making a study of a) bulk water records and b) how many people consumed the water, then multiplying that information by c) projected population growth over a set time-frame. A useful source of information for this is the Australian Bureau of Statistics website. This resource supplies statistics on projected population growth, household numbers and occupancy ratios, in addition to useful links to state and territory departments and agencies. The following two ABS catalogues provide data on projected population growth for Australia:


Figure 5.2.3 illustrates the main weakness in this approach, namely that it is possible to obtain very different results depending on how the “line of best fit” is drawn.

![Historical demand forecasting of per capita demand](image)

**Figure 5.2.2** Projection of demand based on per capita demand using different time periods
(Source, Botica, R., and White, S. 1996)

**Disaggregation of demand into sectors:** This method separates historical water demand data into different sectors to determine how much water each sector uses. Typically, sectors are comprised of single and multi residential, commercial, industrial, institutional and non revenue consumers;

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and the top 100-200 consumers.\textsuperscript{27} Once we know how much water each sector has used we can determine how changes in temperature and precipitation affect water demand in each sector.

**Disaggregation of demand into sectors and end uses:** This method is quite similar to the one above with the addition of a process known as end use analysis.\textsuperscript{28} This is where, for example, household consumption is broken down into indoor (toilets, showers) or outdoor (garden watering, swimming pools) uses. The Australian Bureau of Statistic's (ABS) survey *Environmental Issues: People's Views and Practices* provides information on the environmental behaviour and practices of Australian households. The 2004 ABS edition of *Water Use and Conservation* summarises changes in our water supply options and end use behaviours for domestic households for the years 1994, 1998, 2001 and 2004. The ABS also produces some regional reports on water that can be useful, for example: ‘Domestic Water Use, Western Australia’ \textsuperscript{29}, ‘Domestic Water Use, NSW’ \textsuperscript{30}, and ‘Domestic Use of Water and Energy, SA’. \textsuperscript{31} Data is also available on residential water end uses for appliances (e.g. dishwashers, washing machines) and for evaporative air conditioner ownership for the years 1994, 1999 and 2002.\textsuperscript{32}

There are a range of models that can be used to undertake this assessment. The choice of model used to calculate the demand forecast will affect the data and format required. Therefore, the decision of which model to use must be made in conjunction with decisions about the method of demand forecasting adopted, the data to be collected, how and when it will be collected and who is available for data collection and associated analysis. To help water planners and water supply utilities choose which approach to use the Water Services Association of Australia (WSAA) has published a detailed manual, the development of which was led by Andrea Turner of the Institute for Sustainable Futures UTS, on Integrated Resource Planning\textsuperscript{33} that walks you through the different options and different ways to source relevant data.

The Integrated Supply Demand Planning (iSDP) model, adopted by the WSAA, is recommended for use by providers who undertake sector and sector/end use-based demand forecasting. It has been developed so that refinements made by individual water service providers to particular elements of the model can be easily shared with other users. There are numerous other models, including the US Army Corps of Engineers’ IWR-MAIN, the decision support system (DSS), developed for regional water service providers in NSW, and others developed by private consultants.

The Water Services Association of Australia has also published an *End Use and Demand Management Training Kit* in 2005\textsuperscript{34} that also assists understanding of how to use these models.


\textsuperscript{29} ABS Catalogue No. 4616.5.55.001

\textsuperscript{30} ABS Catalogue No. 4616.1

\textsuperscript{31} ABS Catalogue No. 4618.4

\textsuperscript{32} ABS Catalogue No. 4602.0


These disaggregation models allow relatively accurate demand forecasting and thus enable water supply utilities to more accurately estimate the supply demand gap due to climate change and other factors. When done well, the disaggregated sector-based urban integrated resource planning shows how much water is used over time per person and household in the residential sector and per property within each of the non-residential sectors. This new information will be of significant benefit to the next step in the integrated resource planning, which is assessing

- the potential to reduce water demand over time
- a diversity of water supply options,
- the potential for reductions in water loss and wastage in the non-revenue water sector.

**Step 4 - Identify Potential Options:** The next step is to identify potential water efficiency and small-scale source substitution options by considering the water conservation potential of individual sectors and end uses, opportunities for source substitution, use of measures and instruments, and consideration of costs and benefits, including avoided capital and operating costs, peak and average, wastewater, energy and other avoided costs. It then involves populating and developing an options model such as the Water Services Association of Australia iSDP Model. The following further outlines the key tasks required for Step 4.

- **Identifying and Quantifying the Water Conservation Potential for Urban Water Systems:** To calculate the water conservation potential for an urban system the first step is to identify and include all major water end use sectors – residential (single and multi-dwelling for private and public housing), non-residential office buildings, commercial buildings, industry sectors, and institutional sectors (hospitals, education, council ovals and landscaping). The level of disaggregation feasible for residential and non-residential sectors will depend on the customer water meter database and data entry fields used by a particular water service provider. By disaggregating end use water demand in this way a water service provider has a greater ability to then determine the potential water savings for each of these sectors. A water service provider or water planner can then assess, like we did in Module B, the potential water savings for each major water using sector in a specific city, and thereby calculate the overall water conservation potential for that city (or a part of a city). There are water conservation potential studies of whole cities that can help guide efforts here. The most comprehensive freely available urban water conservation study is of Californian cities by The Pacific Institute.\(^{35}\) It found that 30 per cent water savings could be cost effectively made for Californian cities overall.

- **Residential Sector:** To guide a water conservation potential study of the residential sector, there are a number of reports available.\(^{36}\) Also, as explained above, Australian Bureau of Statistics data already exists at least for some cities to help undertake such analyses. Breaking down water end use into the indoor and outdoor components of demand and subsequently into water efficiency levels of the existing stock of household appliances enables modellers to calculate the water conservation potential for this sector. Specifically,


knowing the percentage of 5-star rated showerheads and appliances in households and the volume of use or associated flow rate of that stock (e.g. 3-star rated showerheads of < 9 L/min) enables modellers to calculate exactly the water conservation potential for this sector. Having identified the conservation potential in terms of stock of appliances and their technology flow rates/usage the water service provider also needs to consider the behaviour patterns of the community. For example, current average shower duration and washing machine loads per week. They also need to determine whether there is conservation potential available for the community to change these behaviour patterns (e.g. reduce shower duration from 7 to 5 minutes and washing loads from 5 part loads to only 3 full loads per week through awareness campaigns). Figure 5.4 highlights the wide range of water saving measures available in the residential sector through both technical and behaviour change.

**Figure 5.2.3 Water Saving Options in the Residential Sector:**
(Source: Turner, A et al, 2008)

- **Commercial, Industrial and Institutional Sectors:** As we showed in Module B, there are many opportunities for commercial, industrial, and institutional (CII) customers to use water more effectively. Lectures 2.3-2.4, 3.1-3.3, 4.1-4.3 all show that best practice Australian case studies of businesses in these sectors are saving 30-80 per cent of the average water usage in these sectors. International experience suggests similar results.

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- Identify potential for potable water source substitution: Having a picture of the conservation potential of a region by sector, sub-sector, customer type and end use enables a good understanding of the potential for potable water source substitution. This means substituting for potable water with treated effluent (as in dual reticulation); with water from private groundwater sources (bores); and rainwater or stormwater. There are many options available for utilising these sources at a building, subdivision or city scale. All of these options need to be considered in the context of the local health regulations and an appropriate economic evaluation. All these options for augmentation will be considered in detail in Lectures 6.1-6.3 and Lectures 7.1-7.3.

Step 5 - Design a Portfolio of Options: There is a large and growing suite of water efficiency and potable water substitution options from which to choose. Fortunately many have relatively low costs and rapid return on investment (See Table 5.2.3 and Figure 5.2.4). This justifies a portfolio approach, where a suite of mutually reinforcing options are chosen.

Table 5.2.3 A Portfolio of Demand Management and Supply Options with Estimates of Costs per kL saved. (Source: Turner, A. et al, 2005)

<table>
<thead>
<tr>
<th>Option</th>
<th>Levelised Cost (AUD$/kL saved)</th>
<th>Savings Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information – public education programs</td>
<td>0.08</td>
<td>Simplified assumption of 5% of 75% of single residential houses</td>
</tr>
<tr>
<td>AAA rated showerhead, dual flush toilet and washing machine rebates</td>
<td>0.22</td>
<td>16.5 kL/household/annum.40</td>
</tr>
<tr>
<td>Dual Flush Toilet Program</td>
<td>0.59</td>
<td>37 and 23 kL/household/annum for single and multi residential households respectively</td>
</tr>
<tr>
<td>Residential indoor water audit/tune up</td>
<td>0.42</td>
<td>21 kL/household/annum for single residential.41</td>
</tr>
<tr>
<td>AAAA washing machine rebate</td>
<td>1.02</td>
<td>50% reduction compared to top loading machines.42</td>
</tr>
<tr>
<td>Residential Outdoor Assessment</td>
<td>0.50</td>
<td>Assuming 20 per cent reduction in water demand.</td>
</tr>
<tr>
<td>Government Housing indoor audit and tune up – retrofit of AAA showerhead, and dual flush toilets.</td>
<td>0.42</td>
<td>21 kL/household/annum for single residential.43</td>
</tr>
</tbody>
</table>

Identifying the conservation opportunities in the commercial, industrial, and institutional sector. Paper presented to the American Water Works Association annual meeting, June, Atlanta, Georgia.


<table>
<thead>
<tr>
<th>Source Substitution</th>
<th>0.50</th>
<th>Assuming around 20 per cent reduction in water demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government housing outdoor assessment</td>
<td>0.09</td>
<td>50 kL/household/annum for single residential</td>
</tr>
<tr>
<td>Residential Development regulations – requiring water efficient options to be used and dual reticulation.</td>
<td>0.03</td>
<td>25 per cent savings</td>
</tr>
<tr>
<td>Minimum Water Efficiency Performance Standards.</td>
<td>0.37</td>
<td>20 per cent savings</td>
</tr>
<tr>
<td>Non residential general commercial/industrial and institutional audits/retrofits</td>
<td>0.22</td>
<td>25 per cent savings</td>
</tr>
<tr>
<td><strong>Source Substitution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater tank rebates (existing houses)</td>
<td>10.62</td>
<td>35 kL/household/annum for a 5kL tank in a single residential household.</td>
</tr>
<tr>
<td>Rainwater tank rebates (new houses)</td>
<td>4.45</td>
<td>55 kL/household/annum for a 10kL tank in a single residential household.</td>
</tr>
<tr>
<td>Greywater system rebates (existing houses)</td>
<td>5.13</td>
<td>50% of outdoor use single residential household.</td>
</tr>
<tr>
<td>Greywater rebates (new houses)</td>
<td>4.87</td>
<td>50% of outdoor use single residential household.</td>
</tr>
</tbody>
</table>
Step 6: Implement a Portfolio of Options: Turner et al provide detailed instruction on the processes needed to undertake a successful implementation of a portfolio approach to meeting the supply-demand gap. Briefly,

After identifying the preferred response, the management team, timing, budgets, details of the individual programs, communication and plans for monitoring and evaluation need to be developed. All these factors make up the detailed implementation plan. Conducting pilots of individual options will be necessary to work out costs, logistics and effectiveness. The implementation plan may also require new institutional and cost sharing arrangements for specific programs, which will need to be included in the plan. The implementation itself will require appropriately skilled staff and the stakeholder participation according to agreed responsibilities.45

Step 7: Monitoring, evaluation and review: All effective strategies for changes to any organisation or process require ongoing monitoring, evaluation and review to further improve and refine the changes made. Water savings achieved, participation rates and costs will be essential to ensure progress against planning objectives is measured.

To conclude, there is much evidence to demonstrate the value of undertaking an integrated water resource planning approach with an emphasis on demand management. Numerous cities have now achieved 30 per cent water reductions per capita over the last decade. In 2009, Cooley et al reported that Seattle, USA has reduced per capita water usage by 35 per cent since the 1990s.46

As reported in Lecture 5.1, Sydney Water has achieved 1970 levels of per capita water usage in Sydney through its demand management programs. This has lead to a flattening of water demand in leading cities which thus shifts the economics in favour of alternative augmenting supply options such as stormwater harvesting.

Key References

Integrated Resource Planning Resources for the Water Industry


Guide to Demand Management Planning


Case Studies – integrated Resource Planning and Demand Management


