



Review of the Metropolitan Water Plan: Final Report

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Executive summary

This report was commissioned by the NSW Cabinet Office to review the Metropolitan Water Plan 2004 (DIPNR, 2004a), and was undertaken by the Institute for Sustainable Futures at the University of Technology, Sydney and ACIL Tasman with technical advice from SMEC Australia. In February 2006, our interim review report (ISF, 2006) showed how the supply-demand balance in 2015 could be met with rain-fed supply and a suite of demand management initiatives, and how Sydney's water needs could be secured against the risk of severe drought by having the capacity to deploy groundwater and desalination.

Subsequent to that report, the NSW Government committed, among other initiatives, to increased recycling, groundwater and desalination readiness in the case of severe drought, and the removal of the potentially high cost Level IV/V drought restrictions from the suite of possible drought response options. The current report incorporates analyses of the more recent decisions and presents a deeper examination of implications, risks and opportunities as key considerations for the 2006 Metropolitan Water Plan.

We have assumed that the objectives of the Metropolitan Water Plan remain unchanged – ensuring adequate supply to meet demand through the current drought and forward at least 25 years, and contributing to improved environmental outcomes. We have also worked with the assumption that these objectives are to be pursued with an eye to community acceptability and cost-effectiveness, inclusive of environment and user, as well as water supplier costs.

Broad Picture

The more recent analyses confirm that the package of measures now committed, inclusive of the readiness strategies, will ensure that the supply-demand balance can be met at least out to 2015. The desalination and groundwater readiness, along with accessing deep water from storages, enable security levels to be maintained without the uncertainty and risk of imposing Level IV and V restrictions. Regarding the available water supply from dams, small concerns will remain until the present drought has broken and more 'normal' dam levels have been achieved – but these security of supply risks, previously inevitable in severe droughts, are now capable of being managed to an extent not previously possible.

An additional level of security results from substantial source diversification – through recycling, demand management and groundwater and desalination readiness strategies. This diversification reduces reliance on dam water, provides the option of making more effective use of the existing storage system and introduces an ability to tap into additional supply sources deep in a severe drought, without the need for high-cost pre-emptive investments in advance of such a drought.

The different elements in the strategy complement each other in important ways. The recycling and demand management measures combine to keep the likelihood of needing to introduce groundwater and desalination extremely low – with the result that the likely costs and environmental impacts of groundwater and desalination are also kept very low. Conversely, these readiness strategies provide security against drought conditions of a type, level and cost not feasible with other options, and allow a more cost-effective rate and pattern of rollout of measures (such as

recycling) focused on meeting Sydney's longer term growth, wastewater management and river flow needs.

Furthermore, recycling and demand management measures, and groundwater and desalination readiness measures combine to provide relatively low cost insurance against a range of remaining uncertainties, while limiting the risks of over-investing in long-lived assets that later prove not to have been needed. These uncertainties include trends in rainfall patterns, the true level of underlying demand for water that will emerge after the current drought restrictions are lifted and trends in both technologies and our understanding of technologies, which could deliver more cost effective solutions in the future if investment can be safely delayed. These technology trends include trends toward more cost effective and less energy intensive recycling and desalination plants, and the possibility in the longer term that indirect potable recycling may prove to be safe and acceptable.

As was indicated in the interim report, there may be a need for additional measures beyond 2015, depending on decisions yet to be taken – especially in relation to river flow regimes. A range of measures has been identified that should provide adequate capacity to respond should a greater need arise.

Key Strategy Themes

Three themes have been identified that underpin the case for a significant evolution of strategy beyond that mapped out in 2004:

- The ability to develop desalination and groundwater capacity within a relatively short time, provides the potential to remove Level IV and V restrictions from consideration while maintaining system security at previous levels and provides the foundation for an adaptive management strategy.
- The current and proposed large scale implementation of demand management and recycling measures, in fact the largest such programs in Australia, will provide a greater level of contribution to the supply-demand balance than anticipated in 2004. Coupled with the desalination and groundwater readiness strategy, this has meant that a high-cost augmentation for increased Shoalhaven transfers will not be needed until at least after 2015. Even after 2015, consistent with an adaptive management approach, other options may have emerged which may in future be considered preferable to higher-cost transfer augmentation.
- The combination of these changes means that the relatively deterministic strategy adopted in 2004, which was designed to invest sufficiently to cover 'worst case' possibilities, can be replaced by a more adaptive strategy that can insure against worst-case possibilities at a much lower up-front cost.

Supply-demand balance

The present study has taken an approach to considering demand and supply measures and strategies which is consistent with previous work on options for the Metropolitan Water Plan 2004. In the 2004 Plan, the concept of a supply-demand deficit was used, with measures and strategies compared on their potential to help meet this deficit. Demand management and recycling measures are seen to reduce future demand

while supply strategies are seen to increase the system yield, with the goal being to balance supply and demand over the period of the plan at the least cost to society.

The key difference in analysis between the present study and the previous work is the consideration of groundwater and desalination readiness strategies and therefore the introduction of the concept of risk-weighted costs.

It is estimated that supply availability in the period to 2015 will be approximately 575 GL/annum. This is based on modelling of current and committed operating rules and currently implemented or approved supply strategies. With all the current and committed demand management and water recycling measures in place, demand is estimated to be reduced to approximately 542 GL/annum by 2015. This indicates a surplus in the supply-demand balance for the period to 2015.

It is important to note that these figures will change over time, according to supply-side and demand-side developments. The water availability figure of 575 GL/annum may change relatively soon, to reflect the Government's decision on the new regime of environmental flow releases from Tallowa Dam on the lower Shoalhaven River, about which community consultation is now under way.

The new flow regime will result in the water availability figure decreasing, but is likely to be more than offset by changes to the current operations of the Shoalhaven Scheme (for example by changing the "pump mark" - that is, the level of Sydney's storages at which transfers from the Shoalhaven system commence) or by reducing the surplus or by a further supply or demand option.

In the context of the supply-demand balance the projected level of 'surplus' with demand less than system yield is prudent. It is not, however, desirable to build up a greater and greater surplus, as this would indicate over-investment in either strategies to increase supply yield or measures to reduce demand.

Estimates to 2030 are more uncertain, however current estimates predict the supply-demand balance would be met, but with no surplus. The situation in 2030 would change to a substantial deficit if significantly greater volumes were dedicated to Warragamba environmental flows – with decisions on the future regime yet to be taken.

The principal uncertainties affecting demand are:

- actual baseline demand outside of the current drought (including, in the longer term, the effect of population growth and demographic change); and
- actual savings to be achieved from new demand management and recycling programs.

Factors significantly influencing supply include:

- future environmental flow regimes for Tallowa and Warragamba dams, and the amount of water transferred from the Shoalhaven;
- system reliability criteria and restrictions regime;
- the volume of groundwater resources (still under investigation);
- trigger levels for utilising desalination and groundwater; and
- the remaining course of the present drought.

Climate change may also impact both supply and demand for water. Current studies are assessing the impact of climate change on supply and demand, although such impacts are more likely to impact on the supply-demand balance in the longer term. These studies can be expected to improve our understanding of potential impacts but will not eliminate this source of uncertainty since impacts will be affected by global emission levels over time (which are not knowable now) and uncertain links between greenhouse gas concentrations and global, regional and local climates.

Supply initiatives

New supply initiatives – including deep water access, desalination and groundwater readiness – work by effectively increasing the volume of water that can be drawn from the existing dam systems while maintaining existing levels of security. These initiatives can achieve this goal through their ‘insurance value’, without necessarily producing extra water themselves.

Modelling done for this study suggests, with the now committed measures, a 90 percent chance of the dams spilling in the next 10 years and a minute chance of them reaching dangerously low levels. Climate change trends may alter this assessment, but are unlikely to alter the assessment that the dams will be prone to spilling far more often than they are prone to reaching very low levels. Groundwater and desalination readiness strategies, drought-based restrictions and the operation of an established desalination plant all have the feature that their costs can be *focused* on times when there is a much higher likelihood of needing the water they provide.

These strategies contribute to Sydney supply mainly by allowing more rainwater to be captured and supplied to Sydney via the existing dam system. This is because it is now possible to make use of the historically required buffer of rain-fed supplies (previously held in reserve to meet water needs in severe drought). By doing so, it is possible to increase the amount of ‘headroom’ in the system, thus enabling more inflows to be captured and reducing the frequency with which the system would otherwise spill. By contrast, other strategies that need to be introduced pre-emptively and operated all of the time keep dam levels higher, thus reducing headroom in the system and increasing the frequency of spills.

The flexibility of these instruments makes them particularly valuable contributors to the overall supply-demand strategy. They can be directed at dealing with the security threat imposed by very rare but very severe droughts. Because of the rarity of such events, the risk weighted costs and environmental impacts can also be very low – they work like insurance with a low premium and somewhat higher excess. Indeed, as a means of dealing with the risks of extreme droughts, groundwater and desalination readiness instruments can be dramatically cheaper and lower in greenhouse gas emissions than pre-emptive introduction of recycling *in excess of* that needed to deal with ‘normal’ growth and droughts.

Taking account of these effects across all the available supply and demand management instruments implies that there is a sensible, cost effective *balance* to be struck. The precise form of that balance will change with actual rainfall and runoff and with growing understanding of the uncertainties identified above.

Demand reduction initiatives

The successful implementation of the suite of demand management and recycling initiatives already approved, those developed since the 2004 Metropolitan Water Plan and those announced by the Government in February 2006 are critical to achieving the supply-demand balance. These initiatives represent the largest investment of this kind in Australia, and in terms of demand management one of the most comprehensive and large scale per capita investments in the world. The volume of recycled water that will be produced from these initiatives to reduce the demand from potable supplies will also be one of the largest in Australia.

Vigilant monitoring and evaluation will be required to ensure the delivery of these savings as projected, in addition to committing adequate resources to implementing or continuing these programs. Developing and implementing a mechanism to ensure that this occurs across all programs and agencies is essential.

Adaptive Management and Institutional Arrangements

This reasoning underpins our strong recommendation that the Plan continues, and even increases, the emphasis on adaptive management begun with the February 2006 Progress Report from the Government. The Plan should incorporate ongoing investment in reducing the key uncertainties and in maintaining and expanding options for short lead-time responses during a severe drought.

Options that are not part of the current policy settings, but should be investigated in the future include the use of scarcity-based pricing – at least in respect of volumes consumed above a threshold. Scarcity-based pricing, if it were to be used, might most sensibly be introduced as an element of the strategy *after* the current drought breaks; it might well entail lower water costs in normal times.

There may be a role for indirect potable reuse in the future, which could offer cost advantages relative to dual reticulation supplies of recycled water. However, there would be a need for detailed monitoring of international developments in this area, as well as further investigation of public health and community acceptance issues. It may be that the development of distributed treatment and reuse systems provide cost advantages over indirect potable reuse within similar time frames.

A further option that should be investigated in the near future is modifying the reliability criterion, namely, allowing for a marginal increase in the frequency of lower level restrictions. This option emerges as a result of changes announced in the February 2005 Progress Report from the Government which confirmed desalination and groundwater readiness and changed the restrictions regime by removing Level IV and Level V restrictions. Changing the reliability criterion could provide a significant and potentially low cost increase in supply availability.

The trade-offs associated with the frequency and level of restrictions, transfers from the Shoalhaven and their trigger level, and associated costs of desalination and groundwater readiness are matters that would benefit from community engagement in the decision-making process to ensure that decisions are robust and have the benefit of community support.

With explicit recognition of the need to manage high levels of uncertainty, and with the move toward reduced reliance on dam supplies and the likelihood of increased private involvement in supply and wastewater management, there is a strong case

for ensuring that the institutional arrangements for formal planning and accountability can deal with these developments.

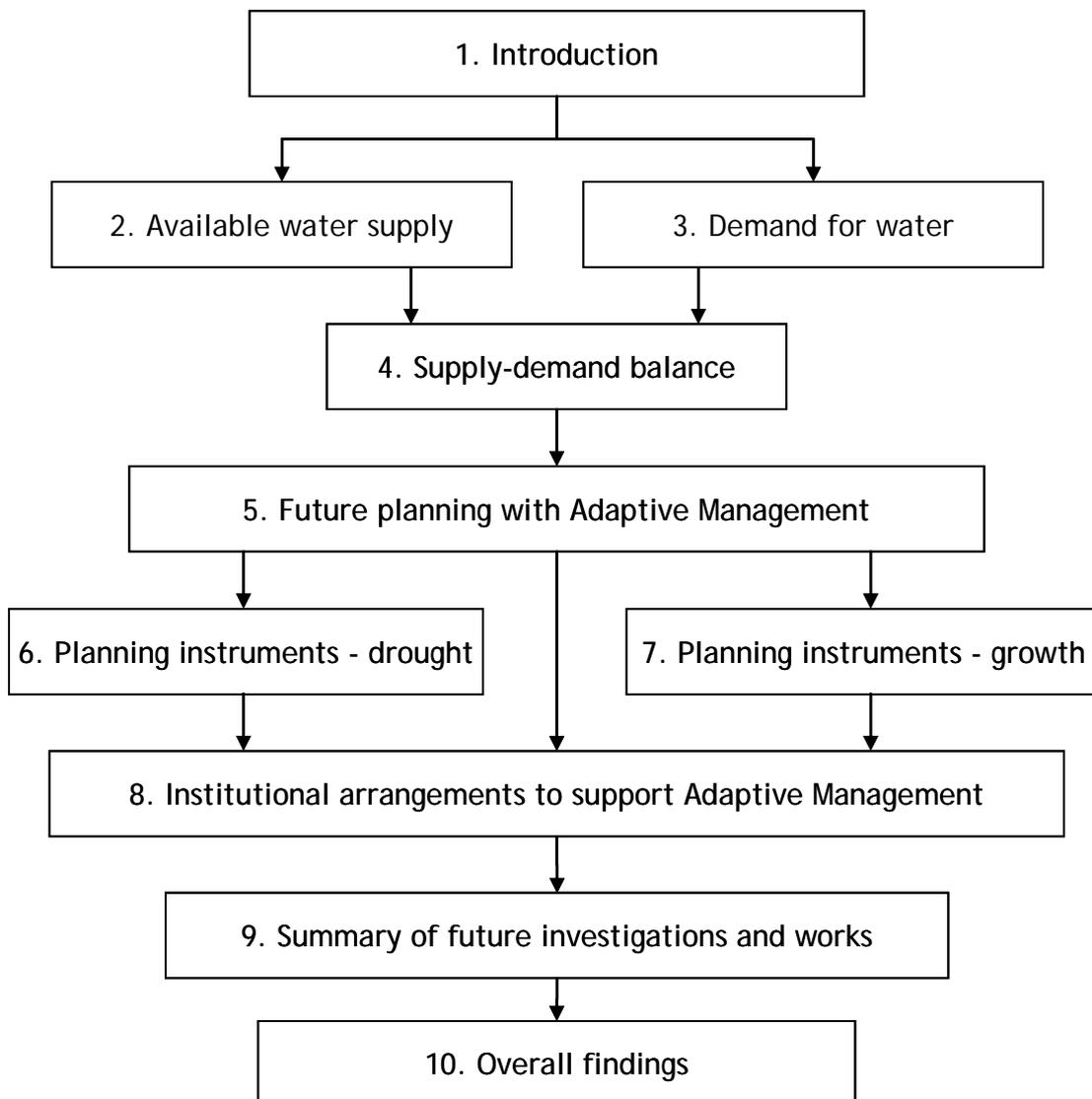
Responsibility for adequacy of supply, including overseeing the implementation of the various components of the Metropolitan Water Plan itself, should be allocated to a body or bodies with the power to pursue the objective both cost effectively and with a view to ensuring decisions are optimal for the system as a whole. There is a continuing need for a high-level coordinating body to tap into the substantial expertise currently held by key agencies and ensure continuing investment in the information needed to support adaptive management efficiently.

1. Introduction

A review of the Metropolitan Water Plan 2004 (DIPNR, 2004a) is presented in this report. In February 2006, an interim review report showed how the supply-demand balance in 2015 could be met with rain-fed supply and a suite of demand management initiatives, and how Sydney's water needs could be secured against the risk of deep drought by having the capacity to deploy groundwater and desalination. Subsequent to this report, the Government then committed to, among other initiatives, increased recycling, and groundwater and desalination readiness in the case of severe drought. Within this new operating environment, this report explores the supply-demand balance and proposes an adaptive management strategy as the preferred approach to ensuring the supply-demand balance is met in future years, including those affected by drought.

An overview of the report structure is shown in Figure 1.

Figure 1 - Overview of report



Sections 2 and 3 explore the status of water supply and demand respectively. The supply-demand balance in the medium term (2006–2015) and longer term (2015–2030) is then evaluated in Section 4. Section 5 describes the shift in approach from conventional to adaptive management and the motivations behind it. Sections 6 and 7 detail the planning instruments for drought and growth needs respectively and how each could be used as part of an adaptive management strategy. In Section 8, the potential conflicts between adaptive management and the current institutional arrangements are described. A future plan of works to support the adaptive management approach is outlined in Section 9. Overall findings are summarised in Section 10.

1.1. The new operating environment

Several factors have changed since the Metropolitan Water Plan 2004:

- the drought has continued but, relative to the rapid decline in storage levels during 2003 and 2004, storage levels have held relatively steady at around 40% since the release of the Metropolitan Water Plan 2004. The lowest point reached was 37.9% in mid 2005, and dams reached 44.6% in early February 2006;
- the introduction of a range of new measures administered by several agencies (Sydney Water Corporation, Department of Planning, Department of Energy, Utilities and Sustainability) that contribute to reducing actual demand, as well as ongoing implementation of existing measures;
- significant progress in developing and implementing recycling schemes, including the recent Government commitment to significant additional recycling schemes;
- better modelling of the supply system including the incorporation of recent drought data; and
- diversification of supply options to include groundwater and desalination readiness in the face of severe drought.

Additionally, there is now a much better understanding of the flexibility offered by the range of now available measures, including desalination readiness and groundwater, to deliver substantial supply benefits if required during drought. The key strengths these measures bring to the new operating environment are their short lead times and the fact that they can be commissioned and operate at full capacity to augment supply *starting* in the depths of a severe drought. In the past, only drought-based restrictions could be introduced with the expectation of sufficiently reducing demand, rather than augmenting supply.

Work done by ISF in 2005 in relation to drought response demonstrated that the use of a diverse portfolio of response strategies including accelerated demand management, groundwater, modified flow releases could defer the time when significant capital expenditure on desalination would be required, and provide a safety margin of time in case the drought deepened rapidly and the process of planning had not sufficiently advanced.

Work done by ACIL Tasman in 2005, relating to the economics of recycling and cost effective approaches to the management of risks - especially severe drought risks - emphasised the potential for exploiting the flexibility of these measures to reduce overall strategy costs greatly. That advice also emphasised the importance of focusing on the way that all the measures interact (among themselves and influencing the likelihood of dam spillage), if the best mix of measures to take advantage of these complementarities is to emerge. Reflecting these points, ACIL Tasman had indicated the scope for a more adaptive approach to supply-demand planning to deliver comparable system security at much lower cost - and presented an early indication of the magnitude of the potential savings. In response, further examination of this proposition was made a key element of the brief for the present review.

Detailed research and analysis on strategy variants has progressed understanding of the way in which supply and demand measures are operated and the timing of major investments. This work has provided deeper insights into how these elements operate and interact as part of a whole-of-system response – and has further emphasised the fact that particular elements cannot sensibly be assessed or even costed, in isolation from wider system settings.

Collectively, these factors support a significant shift in the nature of the response strategy. The Government in its February 2006 Progress Report has already incorporated some important aspects of these changes in approach into policy. Our analysis had confirmed the strategic value of the flexibility then available, and the Government announcement pointed to future exploitation of this flexibility via an adaptive strategy, which responds both to actual dam levels, actual demand patterns and the relative costs of different measures at the time. This report incorporates recommendations for extending this approach.

An added strength of this approach lies in the fact that it allows scope to adapt to improving knowledge of trends in demand, the effectiveness and cost of alternative technologies, our knowledge of groundwater sources, our knowledge of the true cost of various forms of restrictions, and potential climate change impacts.

Fundamentally, adaptive management is designed to provide the benefits – security and supply adequacy – of available supply and demand measures while minimising the risks of unnecessary, or unnecessarily early investment in high cost measures. The analysis done to date indicates that the potential cost savings are very large.

2. Supply availability

The availability of water in the supply system¹ is determined by inflows to dams, the dam capacities, the system's ability to deliver water, the ability to transfer water from neighbouring catchments, the availability of non-rain fed supply options and restriction rules that are employed (Erlanger and Neal, 2005). Current restriction rules are defined in the Sydney Water Drought Response Management Plan (Sydney Water, 2003a:29) and historically have included the very low probability of requiring Level IV and Level V restrictions. Level III restrictions are currently in place. The year 2005 brought dam levels within two percentage points of triggering Level IV restrictions, but levels have since recovered significantly.

To understand the strategy proposed in this Report, it is important to understand how the amount of water available annually from the Sydney storage system is calculated. This is explained in the following section.

2.1. *How water supply availability is currently calculated*

The usable capacity of the Sydney storage system is approximately 2,600 GL (billion litres) when the system is full (including deep storages at Warragamba and Nepean Dams which will be accessible in the coming months). By contrast, the amount that can safely be drawn from the system each year is set at less than one quarter of this. The Sydney Catchment Authority determines the system's annual water supply availability - referred to as the 'yield' of the system - using a water supply system model known as "WATHNET" (the Water Headworks Network model).

This assessment is based on system performance criteria, the current system's capacity and constraints combined with 2000 synthetically generated streamflow sequences based on 96 years (1909-2004) of historical streamflows. To estimate future water availability, WATHNET is adjusted to represent the different system configurations or climatic conditions under consideration. If any of the inputs to the model change, then the calculated amount of water that can be drawn from the system annually also changes.

Model inputs include:

- catchment inflows to dams and weirs;
- evaporation at each dam;
- capacity and surface area of each of the dams;
- transfer capacities and minimum flow requirements of pipes, channels, rivers, canals and tunnels;
- release and demand requirements - such as water supply, environmental and riparian releases;
- storage based triggers for pumping from the Shoalhaven; and
- storage balancing rules.

¹ Available water in the supply system is defined as the annual volume that can safely be drawn from the dam system without compromising system security or triggering unacceptably high frequency of restrictions.

Water Restrictions:

Another key input to the model is a set of assumptions about what restrictions will be imposed in response to drought, and what savings these are expected to deliver. Until now, it has been assumed that five levels of drought restrictions would be imposed. The levels at which such restrictions would be imposed and the savings that they would be expected to deliver are set out in Appendix C.

Level III restrictions are currently in place. The year 2005 brought dam levels within two percentage points of triggering Level IV restrictions, but levels have since increased.

Level IV and V restrictions have never been imposed in Sydney and would be likely to impose significant costs if they were ever to be required, particularly the 50% reduction required under Level V restrictions. In its February 2006 *Progress Report*, the Government indicated that the capacity to deploy desalination during extreme drought means that such restrictions will not need to be imposed in future.

Performance criteria:

The WATHNET model also applies performance criteria to determine how much water can be drawn from the storages annually without imposing restrictions too frequently, for too long, and without imposing an unacceptable risk that the storages will approach emptiness. The current performance criteria for the Sydney supply system are as follows:

- *Reliability*: estimates that, on average, restrictions due to drought will not need to be applied more often than 3.6 months in 10 years: that is, less than 3% of the time. This is often expressed as “97% reliability”.
- *Robustness*: estimates that, on average, not more than 10 years in 100 years will be affected by restrictions due to drought (where a year is considered to be affected by restrictions if restrictions are applied on any one day in that year). This is expressed as 90% robustness.
- *Security*: requires that the dams must not approach emptiness (less than 5% of total storage) more than 0.01% of the time. That is, in a period of 8,333 years, only in one month should the combined level of the operating storages approach emptiness.

Some Australian storage systems use similar design criteria to estimate ‘yield’, however the values used vary to reflect the different characteristics of each system. For example, Melbourne and the ACT use a reliability standard of 95%, which reflects the less variable nature of local rainfall patterns.

To aid in description of the impacts of changes in system configuration, ‘reliability yield’ is the amount of water that can be extracted from the system annually without breaching the reliability criterion (that is, without imposing restrictions for more than 3% of the time). Any action which delays the imposition of Level I restrictions (e.g. water saving and recycling measures which reduce pressure on storages) will have a positive impact on ‘reliability yield’. Any action that increases the rate of storage depletion at the start of a drought (e.g. rising water demand) will have a negative impact on ‘reliability yield’.

The 'security yield' is the amount of water that can be extracted annually without breaching the security criterion. Any action that slows the depletion of the dams in the latter stages of a drought will have a positive impact on 'security yield' (e.g. constructing and operating a groundwater borefield or desalination plant). Any action that accelerates the depletion of dams in the latter stages of drought (e.g. less harsh water restrictions) will have a negative impact on 'security yield'.

The overall system yield is determined by the demand which satisfies all performance criteria of reliability, robustness and security.

Traditional system planning is based on analysing the historic record and providing additional system capacity to cover the uncertainty of the most extreme *conceivable* rainfall patterns. Planning for the Sydney water supply system has recognised the limitations of the traditional approach for such a large system and has adopted a statistical approach to management of such risks - delivering a very low and 'acceptable' level of risk but not eliminating it. New options enable the Government to adopt a different approach to meeting the security criterion - as discussed below.

2.2. Changes to supply availability since 2004

The supply availability accepted at the time the Metropolitan Water Plan 2004 was developed was 605 GL/annum, based on assumptions and measures in place then. This has since been modified in the following ways:

- the 90 years of recorded inflows, which are used to calibrate the supply availability model (WATHNET), have been extended to include the six years up to 2004, which has the effect of reducing the modelled supply availability by 25 GL/annum. Effectively, the frequency of severe drought in the historical time series on which the model is based has been increased;
- a range of other changes to the WATHNET model have been made to model more accurately riparian releases at Tallowa Dam, environmental releases at several smaller storages and hydropower releases. Collectively, these changes reduce supply availability by 15 GL/annum;
- the approved environmental flows for the Upper Nepean reduce the supply availability by approximately 25 GL/annum; and
- accessing the deep water in Warragamba and Nepean storages increases the supply availability by 40 GL/annum, up from the estimate of 30 GL/annum in the 2004 Metropolitan Water Plan.

Since these decisions and changes, the NSW Government in its February 2006 Progress Report announced the following initiatives:

- it will establish and maintain the ability to construct desalination capacity in the event of a severe drought, should storages fall to around 30% of extended storage capacity (inclusive of deep storages), providing an increase in supply availability of between 30 and 70 GL/a;
- investigation of groundwater resources will continue through 2006 and the construction of borefields to extract groundwater during drought is proposed to be triggered at around 40% of extended storage levels, providing an effective increase in supply availability of between 5 and 10 GL/a;

- Level IV and V restrictions, which have never been triggered in Sydney, and which require 30% and 50% reduction in demand respectively during severe droughts, will be removed from consideration;
- water recycling projects recently approved include the Western Sydney Water Recycling Initiative, incorporating a component of flow substitution, which when constructed, will replace the current flow releases from Warragamba Dam, increasing the supply availability from the system by an estimated 18 GL/a during non-drought periods², and will make a substantial contribution (approximately 30 GL/a) towards substituting for likely future environmental flow releases in the post-2015 period;
- the investigation of the impact of and potential for increasing the pump mark for transfers from the Shoalhaven system, thus increasing the frequency of transfers and increasing the overall yield of the system; and
- the decision not to proceed with significant modification to the Shoalhaven Transfers Scheme (including increasing the height of Tallowa Dam and, longer term, the construction of a tunnel for transfers from the Shoalhaven).

2.3. Other factors influencing availability

Many other factors influence the water availability of the Sydney system. A number of key factors are listed below and described in more detail in Appendix A,

- reliability criterion (limit on frequency of restrictions);
- trigger levels for restrictions;
- number of restriction levels;
- Shoalhaven pump mark;
- Shoalhaven environmental flows;
- Tallowa Minimum Operating Level (MOL);
- Tallowa Dam augmentation – Full Supply Level (FSL);
- Shoalhaven pumping capacity;
- Wingecarribee transfer constraints;
- deep water access;
- Upper Nepean environmental flows;
- Warragamba flow releases;
- desalination trigger level; and
- groundwater trigger level.

The proposed Western Sydney Recycled Water Initiative is a major undertaking in the final stages of development, with an Expression of Interest to be issued in June 2006.

² During the current drought, flow releases from Warragamba have been halved, and will remain so until Level III restrictions are lifted.

One component of this scheme is to provide return flows to substitute for water currently released from Warragamba Dam for agricultural and river health purposes. This would have the effect of increasing supply availability by approximately 18 GL/annum by 2015.

2.3.1. The role of non-rain fed supply sources

As described in Section 6.1.2, groundwater resources offer a source of water that is accessible during drought periods. The more certain groundwater resources (15 GL/annum during drought) in the Upper Nepean, if developed and used during drought periods would have the impact of increasing supply availability by a net 5 GL/annum. In other words, access to this 'bank' of drought insurance allows normal levels of annual usage from the dam, even outside of drought, to be increased by 5 GL/a without lowering system security. Further groundwater sources which could provide an additional 15 GL/annum during drought are currently under investigation and could increase supply availability, on average, by a further 5 GL/a.

These figures reflect an aspect of water supply planning assessments that is a recurring theme through this report. This increase in availability arises even though *average* annual volumes of water supplied from these groundwater sources are relatively small – because the conditions needed to trigger the use of these sources are likely to occur extremely rarely. In this case, a supply source that directly delivers a *very limited volume* of water over time nonetheless delivers to Sydney the ability to draw safely a substantial volume of additional water from the dams, year after year.

The reason for this lies in the scope for targeting the times when the water is produced at the periods when it is most valuable – and least likely to be used unnecessarily. By providing extra security for dealing with these times of shortage, groundwater readiness allows the extra yield to be sourced from a proportion of the volumes of water that would otherwise periodically go over the top of the dam walls during floods – not from the groundwater itself. Without the groundwater (and, as is discussed below, desalination) readiness, the demands for system security would require that higher volumes be maintained in the dams as insurance (limiting availability), thus reducing the scope for capturing and reserving water from flood flows.

This source of supply – inflows not now captured as a result of periodic system flooding – should not be under-rated in assessing supply alternatives. For reasons developed below and later in this report, it can be very low cost, with very low energy intensity, and has a crucial role to play in determining the cost effective package of response measures. In particular, it plays a key role in determining how far and fast Sydney should push into using other measures. It does not alter the case for pushing into these other measures, including recycling and demand management as sources of growth water. Indeed, without these other sources, the cost of the groundwater and desalination readiness strategies would rise dramatically, because there would be a much higher likelihood of needing to make and use these investments. However, groundwater and desalination readiness have a key role to play in striking the right balance of measures to deliver a secure and reliable system at costs (environmental, as well as user costs) that are not excessive. Using other options to meet security needs may impose unnecessarily high costs.

Historically, the main option for accessing flood flows as source of supply has been a combination of dam building and the potential for recourse to deep restrictions. A wider set of potentially much lower cost instruments for accessing this supply source is now available through groundwater and desalination readiness strategies.

Planning and preparation for a desalination plant in Sydney changes the supply availability, by increasing the security of supply, merely through the ability to construct such a plant during times of severe drought. Desalination readiness increases supply availability by approximately 30-70 GL/a. The exact figure depends on the trigger level for building and operating the plant together with other operating variables for Shoalhaven transfers and the resultant limiting performance criteria for the system (i.e. security, robustness or reliability). As was noted earlier, the existing planning and preparation work means that the lead-time for construction has decreased to about 26 months. This means that it is not necessary to trigger the decision to build such a plant until storage levels drop to around 30% of extended storage capacity. There is only an extremely small probability of reaching this trigger level over the next ten years, even with reasonably pessimistic assumptions about rainfall patterns over that period.

While in the short term it is important to ensure that we are able to deal with the current drought situation, once dam levels move back to normal pre-drought levels, the risks of triggering desalination will drop dramatically for many subsequent years.

Of crucial importance is the fact that desalination can operate in a manner that is strongly analogous with the above discussion of groundwater. For the same reasons, desalination readiness can deliver an increase in water availability out of all proportion to the average volume of water produced from the desalination plant. Again, the extra availability is sourced largely from periodic floodwater, not from the desalination plant itself. The function of the desalination readiness, as with groundwater readiness, is to allow 'advance drawings' of future floodwater, by allowing dam levels to be at a lower level than would otherwise be needed for security, because of the system security offered by the groundwater and desalination readiness strategies³. Put another way, the readiness strategies allow Sydney to make use of the buffer historically retained in dams to ensure security of supply against the risk of severe drought.

Effectively, this allows some costs of pre-emptive measures to maintain dam levels, for example the costs of pumping more water from the Shoalhaven, to be avoided. These measures involve up front costs – capital costs in rollout of infrastructure and operating costs including substantial energy use and greenhouse gas generation. The costs may well be justified, but past a certain point the likelihood that the extra volumes delivered will not in fact get used – because of dam spillage – rises dramatically. As a result, the cost of these measures escalates the further they are pushed. A point is reached where the costs of the readiness strategy are more than competitive, and this is when a sensible balance involving all instruments can be struck.

³ The same is true of drought-based restrictions – the readiness to implement such restrictions can also increase (secure) availability *in advance of* dam levels dropping to a point where the restrictions are triggered. As a result, the increase in availability can be well in excess of the average reduction in consumption – with the difference again being made up by accessing the resultant extra dam headroom to capture more of the periodic flood flows.

2.4. Meeting growth demands

There are a number of options available to increase the available supply beyond the levels implied by current and approved measures, *should this be required* due to the emergence of a supply-demand gap in the medium or longer term. These options include:

- A marginal increase in the frequency of low-level restrictions (Levels I to III under the current restrictions regime) would have a significant impact on supply availability. This is achieved by increasing the trigger level for implementation of restrictions, and has the effect of changing the reliability criterion from 97% to (say) 96% or 95%⁴. As an indication, a change to 96% reliability could increase supply availability by approximately 15-20 GL/a depending on the Shoalhaven operating criteria, and result in an increase in the frequency of restrictions by less than 1 month every 10 years, from a current average of 3.6 months every 10 years. Given the removal of Level IV and V restrictions, and the implementation of a strategy of groundwater and desalination readiness to improve security, there is a strong argument for this option being further investigated as a strategy for increasing supply availability if this is required in the medium or longer term. While there are social costs associated with increasing restriction frequency, there is also strong public support (Taverner Research, 2005; Sydney Water, 2003b). See also Sections 7.2 and 7.3.
- Increased transfers from the Shoalhaven through changes to the operational arrangements – that is, increasing the trigger level for pumping from the current 60% to (say) 80% of the total system storage level. This can increase the current supply availability by up to 40 GL/a depending on the Shoalhaven environmental flow and operating regime, and can compensate for the decrease in yield that is likely to be created by increased environmental flows and a revised minimum operating level (MOL). There are environmental and social costs associated with increasing transfers, notably an increase in greenhouse gas emissions and an increase in the biophysical impact of transfers.
- In the February 2006 Progress Report, the NSW Government decided not to proceed with any immediate and significant modification to the Shoalhaven Transfers Scheme. However, in the longer term, in particular post-2015 once a decision regarding the environmental flow releases for Warragamba Dam has been made (thus potentially decreasing system yield), if further increases in supply availability were to be sought from Shoalhaven transfers, this may require major capital works to augment Tallowa Dam, and/or to increase the transfer capacity through a pipeline or tunnel. These major infrastructure works could increase the supply availability by up to a total of 115 GL/annum, at a high capital cost (approximately \$800 million). There are environmental and social costs associated with the increased use of water from the Shoalhaven system, with scope for reducing these impacts, at a cost, through the construction of a pipeline or tunnel. See also Sections 7.3 and 7.4.

Should short-term drought conditions trigger the need to invest early in desalination, then the relative economics of alternative supply sources can be expected to change

⁴ Other jurisdictions, including Melbourne and the ACT, have a reliability criterion of 95%.

dramatically. The operation of the established plant could be increased even after the drought breaks to act as a source of growth water. The relevant costs in weighing whether this makes sense relative to other alternatives would be the operating costs of the desalination plant (inclusive of any costs attributed to any carbon emissions), since the capital costs would by then be sunk costs. It would also be important to consider whether other options will be able to meet future security needs and, if not, whether the insurance value of the option is best maintained by deploying other options to meet growth needs. However, the likelihood of this situation arising during the current drought remains very low.

2.5. Supply availability to 2015

The available supply in the period to 2015, based on current and approved measures, is expected to be within 570 GL/annum to 580 GL/annum with a median value of approximately 575 GL/annum. This excludes the yet to be determined volumes that will be dedicated to the Shoalhaven system for environmental flows and does not include any of the possible sources of additional supply outlined in Section 2.4. In addition to uncertainties in some of the input parameters, the WATHNET model itself has a relative accuracy of ± 5 GL/annum. This supply availability assumes all existing and approved measures, including:

- a readiness to construct desalination capacity, based on a 125 ML/day plant upgradeable to 500 ML/day, and modelled as a 500 ML/day plant, available to supply water into the system at 15% of the expanded storage;
- groundwater availability, resulting in an impact on supply availability of between 5 and 10 GL/a;
- Upper Nepean environmental flows, based on 80/20 flow release rules;
- accessing deep storage at Warragamba and Nepean;
- flow substitution for the existing flow releases from Warragamba; and
- three levels of the existing restrictions regime, triggered at 55%, 45% and 40% of the expanded storage.

The supply availability as described above is based on the current flow release regime for the Shoalhaven system, a minimum operating level of -3m and a pump mark of 60% of the existing storage. This is the current situation.

There is, at present, technical analysis and stakeholder consultation being undertaken to determine an appropriate environmental flow regime and operating rules for the Shoalhaven system. This work, the technical component of which is expected to be complete by mid 2006, is investigating the impact of changing three main variables:

- flow release rules;
- the minimum operating level (MOL); and
- the magnitude of the transfers, based on the pump mark for transfers from Tallowa Dam to the Sydney system.

The impact of changing these three variables is borne by different stakeholders. Increasing flow releases is expected to improve downstream water quality in the river and estuarine environment. Decreasing the magnitude of the MOL reduces the negative impact on landholders in Kangaroo Valley owing to level fluctuations in Lake Yarrunga. Increasing the transfers has an impact on landholders on the Wingecarribee and could have effects on the aquatic life and riverbank. Therefore these represent trade-offs that need to be better understood, resolved and managed, and some of which can be mitigated, such as the transfer impacts.

In terms of the impact on supply availability, the ability to change these three variables means that the reduction in supply availability that will result from an increase in environmental flow releases, or a reduction in the minimum operating level should that be decided, may require an increase in transfers from the Shoalhaven or the utilisation of a further supply or demand option to maintain the supply availability at 575 GL/a.

The supply availability estimate is sensitive to the value of many variables and operating parameters. Most significant are:

- the reliability criterion, which specifies the maximum percentage of time that customers are subject to restrictions (currently 3%, i.e. on average 3.6 months every 10 years);
- the various levels at which restrictions are triggered and the assumed percentage savings;
- the pump mark, or trigger level, for water transfers from Tallowa Dam; and
- the trigger level for water supply from a desalination plant and groundwater.

There are still uncertainties in a number of factors that affect supply availability, including:

- the yield associated with groundwater resources that have been identified but not 'proved up';
- the Shoalhaven environmental flows and operating rules (that are currently the subject of consultation); and
- the estimated impact of long-term climate change on rainfall and run-off patterns, importantly including changes in average rainfall, in the frequency of flooding, and in the frequency and depth of severe droughts – with these trends possibly operating in offsetting directions.

In addition, as indicated in Section 3, there is uncertainty associated with the estimated projections of demand due to uncertainty in the baseline demand and the demand reduction that will be achieved from the range of demand management and water recycling measures that are committed and approved. This uncertainty is inevitable and has been balanced by the use of conservative estimates of savings. What is important for water planning is an understanding of the trend in demand, adjusted for the demand management and water recycling measures. This trend will be able to be determined with far greater precision once the current drought restrictions can be lifted and the response monitored.

The unavoidable level of uncertainty in key parameters supports the need for an approach that is adaptive, that allows for a regular re-assessment of the demand projections, as well as the estimates of supply availability. The ability to construct desalination capacity and/or bring in groundwater sources during severe drought provides increased security within the adaptive approach. Other available options (such as the ability to modify the reliability criterion, or increase transfers from the Shoalhaven by raising the pump mark) can be considered for increased supply availability for growth if needed.

3. Demand for water

This section explores the predicted demand for water from the water supply system and the effect of current and future options on mitigating this demand. Rain-fed supplies to dams dominate the current water supply system; however, this system would also include desalination and groundwater if these were ever commissioned.

There are two components to understanding the actual demand for water:

- a) the 'base case' demand, also called 'reference case' demand (this is the underlying demand for water, not including the impact of water efficiency options, recycling schemes and restrictions); and
- b) the impact of water efficiency options and recycling schemes (which substitute water from storages with an alternate source of water or with a technology that requires less water).

The *projected demand from the water supply system* is calculated by subtracting the savings that are achieved through demand reduction measures from the base case demand.

It is important to recognise that great precision in estimating either of these two individual components is not currently possible – and may never be possible. Recent community experience of the drought may have influenced base case demand by modifying attitudes to water usage, though the extent to which this will hold after the drought breaks is not well understood. In parallel with potential for change in attitudes, there have been progressive roll-outs of measures that will alter demand – ranging from regulated BASIX measures through to voluntary investments in roof tanks and lower water use landscapes and gardens.

The data on per capita consumption trends that will emerge following the lifting of drought-based restrictions are likely to point far better at the net impact of these two trends than at the size of the individual trends. It will make sense to base any adaptive response most heavily on the progressively improving understanding of this net trend, though it is likely that improvement in understanding of the components will emerge from better end use data and associated modelling. At the same time, improving understanding of trends in demands, and especially of the impacts of end-use trends, will prove valuable in refining demand instruments further.

While current restrictions are in place, there is still a need to make a robust assessment of the adequacy of established and approved supply and demand measures – and this needs to be based to an extent on modelling of the forward demand trend before it can be observed. From a modelling perspective, it is easier to model the two components separately, and then to combine them, than to model the net trend directly.

Each of the two components is discussed in more detail in Sections 3.1 and 3.2 respectively.

3.1. Base case demand

The current approach to estimating the projected total system demand for water in Sydney is to estimate the water demand per capita per day and multiply this by the projected population to give the total demand⁵. The Metropolitan Water Plan 2004 used a per capita demand estimate for the base case of 426 litres per capita per day (lcd), deemed as constant over the period to 2030. This projection was originally based on a compromise between two different projections, one increasing and one decreasing over time. While the value (426 lcd) is consistent with trend analysis (Sydney Water Corporation, 2005; MMA, 2004), this Review considers this estimate too high when used as a forecast, as it does not rely on analysis of water end-uses or sector breakdowns, and particularly does not take into account the impact of urban consolidation which is expected to decrease the per capita demand in future.

Future demand will be a function of actual population growth, changes to the mix of dwelling types (e.g. apartment, single dwelling - including the garden size and type which will influence demand), the occupancy rates of dwellings as well as changes to behaviours and technologies that use water.

This highlights the need to improve the estimation of the base case demand forecast through continued improvements in the SWC end-use model and the use of this model to estimate the baseline demand. Work towards a re-calibration of the end use model is currently being completed. In particular, further analysis of the base case demand will be possible once the drought ends and can be used to inform the appropriate response as part of an adaptive approach.

To be conservative, the figure of 426 litres per person per day has been used in analysis in this report. Further details about the individual demand reduction measures are provided in Section 3.2. Given the uncertainty regarding the reference case demand, if an illustrative – but plausible – future figure closer to 400 litres per person per day were to be used, then demand in 2015 could be as much as 40 GL/a less than when a reference case of 426 litres per person per day is assumed.

3.2. Demand reduction measures

The water efficiency and recycling measures act to reduce the demand for potable water from the system supply. Even though some measures could be considered to augment supply (e.g. recycling, water from rain tanks), the convention adopted in this report is that they act to reduce demand for potable water from the central water supply system⁶. Consequently, the reference case demand minus the impact of

⁵ This estimate of per capita demand includes the total demand from storages, often called the 'bulk production', and includes the residential demand, non-residential demand and system losses. This is divided by the estimated residential population for each year. The quoted data for per capita demand in other jurisdictions often refers to only the residential component, or the total customer metered demand excluding non-revenue water. Regarding population estimates, the Urban Growth Team at Sydney Water Corporation developed the population figures through to 2031, using detailed Local Government Area (LGA) mid level projections by the (then) Department of Infrastructure, Planning and Natural Resources (DIPNR). After 2031, total population is projected using the mid series from the average growth rates for Sydney in DIPNR (2004b).

⁶ One exception to this convention is the treatment of recycled water for flow substitution which is considered in Section 2.1. Another would be if indirect potable reuse were ever commissioned in

water efficiency and recycling measures gives the actual projected water demand. There is a range of current and approved water efficiency options and recycling schemes that reduce the actual demand from the base case. These are summarised in Table 1 and full details are given in Appendix B.

Table 1 - Demand reduction measures and their estimated demand reduction by 2015

| Option / Sector | Estimated demand reduction* by 2015 (GL/a) | Description |
|--|--|--|
| Non-residential | 38 | Combination of regulatory (Water Savings Action Plans), funding (Water Savings Fund) and cooperative partnerships (Every Drop Counts Business Program) and other smaller programs to work with organisations to reduce water use. |
| Recycling | 35 | Involves the use of recycled water replacing potable water use in industry (notably BlueScope Steel), at sewage treatment plants and in residential houses through dual reticulation. Note: recycled water for flow substitution is treated as augmenting supply and included in Section 2.1. |
| Pressure and leakage reduction | 33 | Includes Active Leak Detection Program, Pressure Reduction Program and Improved break / leak response time. |
| BASIX | 23 | The Building Sustainability Index (BASIX) is an assessment tool that mandates a level of water demand reduction in new and renovated homes and apartments. |
| Outdoor: • Stepped tariff for pricing and Ongoing outdoor water savings measures • Rainwater tank rebate and landscape assessment programs | 24 | Includes the introduction of step pricing as recommended by IPART (2005). The outdoor water saving measures involve the introduction of ongoing low level outdoor water saving measures commencing at the end of the current drought and supported by ongoing community education. This estimate also includes the targeted landscape assessments program and rainwater tank rebate program. |
| Appliance Standards and Labelling ⁷ | 15 | This program involves the introduction of mandatory labelling followed by minimum performance standards for a range of water-using appliances (specifically showerheads and clothes washers) under the Commonwealth Government's Water Efficiency Labelling Scheme (WELS). |
| Residential indoor | 12 | Increases the use of water efficient appliances in the home through retrofits and rebate programs. |
| Total | 180 | |

* The estimated savings per component have been rounded to nearest GL/annum, with total savings based on actual (rather than rounded) values, consistent with Appendix B.

future as this would feed water back through the dams to the water supply network and be considered an inflow to the water storages in the same way that rain is considered an inflow. This, however, is not included in the modelling as it is not agreed Government policy.

⁷ Note that minimum performance standards have been proposed by NSW and are assumed to be implemented for modelling purposes. However such standards are not yet in place under the WELS scheme. See section 3.3. For this reason a conservative uptake rate has been used as a contingency for any delay in implementation of standards.

Whilst the projected demand reduction is the same, the figures in Table 1 are differently allocated to those in the February 2006 interim report (ISF and ACIL Tasman, 2006). This is mostly due to the incorporation of additional data from the first round of grants for the Water Savings Fund which was unavailable in February 2006. This report has changed the categorisation of savings to a sector-based approach (rather than by administering agency for some categories in the February 2006 interim report) which results in minor changes due to rounding.

It is worth noting that efficiency measures represent the largest portion and least costly demand reduction measures, compared with recycling and the introduction of alternative sources of supply. See Appendix B for a summary of costs.

Further, for all existing and approved demand reduction measures, these savings must not be taken for granted. In addition to a commitment to the investment required to implement or continue these programs, vigilant monitoring and evaluation will be required to ensure the delivery of these savings as projected. Developing and implementing a mechanism to ensure that continuing monitoring and evaluation occurs across all programs and agencies is essential – particularly as different agencies are responsible for different demand reduction and recycling measures. The coordination between programs is very important and is discussed further in Section 3.3 in relation to specific programs and in Section 8.1 in relation to future institutional arrangements.

As part of the on-going monitoring and evaluation process, there is a need to continue to aggregate savings by end-use and sector to facilitate the comparison of savings estimates against a 'conservation potential' for each sector, supported by local and overseas experience and literature. The 'conservation potential' refers to the maximum savings that are likely to be achieved within a sector or end use⁸. The concept of the conservation potential can be used as a check on the savings within a sector or end use to avoid double counting of estimates from different programs and agencies within the same sector.

3.3. Further considerations for specific demand programs

This section describes the programs that will require particular attention in relation to development, coordination, monitoring and evaluation or review.

BASIX (Building Sustainability Index)

BASIX is an assessment tool that mandates a level of mains water demand reduction (approximately 40% relative to average household demand) in new and renovated homes and apartments. It requires monitoring and evaluation to determine the actual savings on the ground. Monitoring is being proposed, and the systems for undertaking that monitoring have been established. However, as the program has been in place for a relatively short time, it is very important to gather data at an early stage to confirm how future savings will be achieved and to provide input to any necessary

⁸ The conservation potential reflects the fact that improving water efficiency in a sector generally costs more as you achieve greater savings. Therefore, at any time, there is a level of savings that are cost-effective relative to the next best option. This can change over time with the development of new technologies, and the increased uptake of existing ones, so that the conservation potential for (say) clothes washers in 2015 will be higher than it is today.

program changes required to achieve projected savings. The BASIX program represents a significant portion of future savings against which Sydney Water Corporation (SWC) is audited, yet is administered by the Department of Planning which will necessitate effective coordination, evaluation and reporting requirements between agencies (discussed further in Section 8 on institutional arrangements). The rules for BASIX, including the inclusions and exclusions would benefit from a review at this time, in order to determine the potential for improvements that could be made to BASIX requirements *while maintaining the current projected levels of savings*, and possibly increasing the certainty of these savings and decreasing the costs of compliance.

Water Efficiency Labelling Scheme

The Water Efficiency Labelling Scheme (WELS) involves the introduction of mandatory labelling to inform consumers about the water efficiency of certain water using appliances. This is now being implemented with all appliances to which the system currently applies to be labelled after 1 July 2006⁹. In the case of toilets, the Scheme requires minimum standards of efficiency.

The NSW Government, through the responsible agency (DEUS) has put forward to the other States and the Commonwealth a proposal to implement performance standards in addition to mandatory labelling for showerheads¹⁰ and washing machines, and the savings projected in this category have assumed that this will be successful, with such standards introduced by 2009. While there is evidence of support from the majority of states, should this not prove possible, other measures will need to be introduced to capture these savings, or adjustments to the expected demand reduction will need to be made. Apart from the low unit cost savings that this instrument provides, it is important in terms of protecting the investment (by avoiding appliance turnover that would erode savings achieved) in the EDC Retrofit Program (now WaterFix), DIY kits and the Smart Showerhead Program, worth over \$30m since 1998.

Projected savings from WELS have been discounted to allow for overlaps with other programs, in particular:

- the retrofit and rebate programs being implemented by Sydney Water; and
- BASIX multi-residential, through potential for washing machines to contribute to BASIX score in multi-residential dwellings.

The non-residential sector

Several supporting programs target savings in the non-residential sector, namely:

- Sydney Water's Every Drop Counts Business Program: targeted programs with the manufacturing, commercial, hospitality, education, health and government sectors to identify and overcome barriers to reducing water use;

⁹ See <http://www.waterrating.gov.au/about/index.html> for further details [accessed 13 Mar 2006].

¹⁰ It is worth noting that the US Government has had such a requirement for toilets, taps and showerheads as a requirement of the Federal Energy Act (1992) since 1994.

- The Water Savings Fund (also the Enhanced Water Savings Fund and the prior program, the Pilot Water Savings Fund), a program administered by the Department of Energy, Utilities and Sustainability (DEUS), which helps fund water saving projects put forward by businesses, councils or other government agencies, organisations or community groups; and
- Water Savings Action Plans, a DEUS-administered program that requires large water users to develop plans that describe current water use and identify potential savings.

Given that these programs do not all target unique organisations within the non-residential sector, this Review assumes the conservation potential for this sector is 20-30%, based on national and international experience (White, 1998; Vickers, 2001). That is, of the approximately 160 GL/a used in the sector, it would be reasonable to expect that the potential for water to be conserved within this sector (conservation potential) is 32-48 GL/a. Estimates from agencies suggest that savings of 36 GL/a could be achieved by the combination of these programs¹¹. Each program supports the realisation of savings in different ways, using a combination of incentives (Water Savings Fund) and regulation (Water Saving Action Plans), and tailored advice and support (Sydney Water Every Drop Counts Business Program), each of which is important.

Consequently, a transparent and collaborative relationship is required between DEUS and Sydney Water to ensure effective coordination between the EDC Business Program, Water Savings Fund and Water Savings Action Plans and to achieve optimal results from the investment in these programs. Such coordinating arrangements should also establish clear communications to assist businesses to understand the relative roles of each program and administering agency with regard to water savings.

Following analysis of the submitted plans in early 2006, consideration could be given to mandating the implementation of water savings identified through the Water Saving Action Plans, to increase the level of implementation of cost-effective savings (payback period 2-3 years). This requirement could be supported and complemented by the Sydney Water Every Drop Counts Business Program and the Water Savings Fund.

Residential outdoor water use

Three programs aim to reduce residential outdoor water use. The residential outdoor water use assessments program is targeted at high water users, to assist in improving water use efficiency in a permanent structural way, after restrictions are lifted. This applies particularly to the use of automatic reticulated sprinkler systems, which have the potential to use significant amounts of water. The step pricing and ongoing outdoor saving measures are expected to provide smaller savings but for a greater number of residential water users. In particular, these options are aimed at changing the outdoor water using behaviour or practices including hosing down hard surfaces,

¹¹ Specific additional programs that do not overlap with the above programs in the non-residential sector (Leak Detection in Schools, Enhanced NSW Government Efficiency, Rainwater Tanks in Schools Rebate Program, Every Drop Counts in Schools) account for an additional 1–2 GL/a savings.

as well as improved watering times for lawns and gardens. The introduction of ongoing water saving measures would capitalise on the outdoor water saving behaviours learned during the drought. The change in pricing would reinforce this. In the modelling of savings from these two programs, this Review has reduced the total savings from the combination of them to 19 GL/a. An additional 3 GL/a saving results from the Residential Landscape Assessment Program and a further 2 GL/a saving from the Rainwater Tank Rebate Program.

There is a strong need to monitor evaluate the savings that result from these initiatives, in climate corrected terms. This will not be possible until after restrictions are lifted and it will take at least 12 months until the real impact of the removal of restrictions is felt.

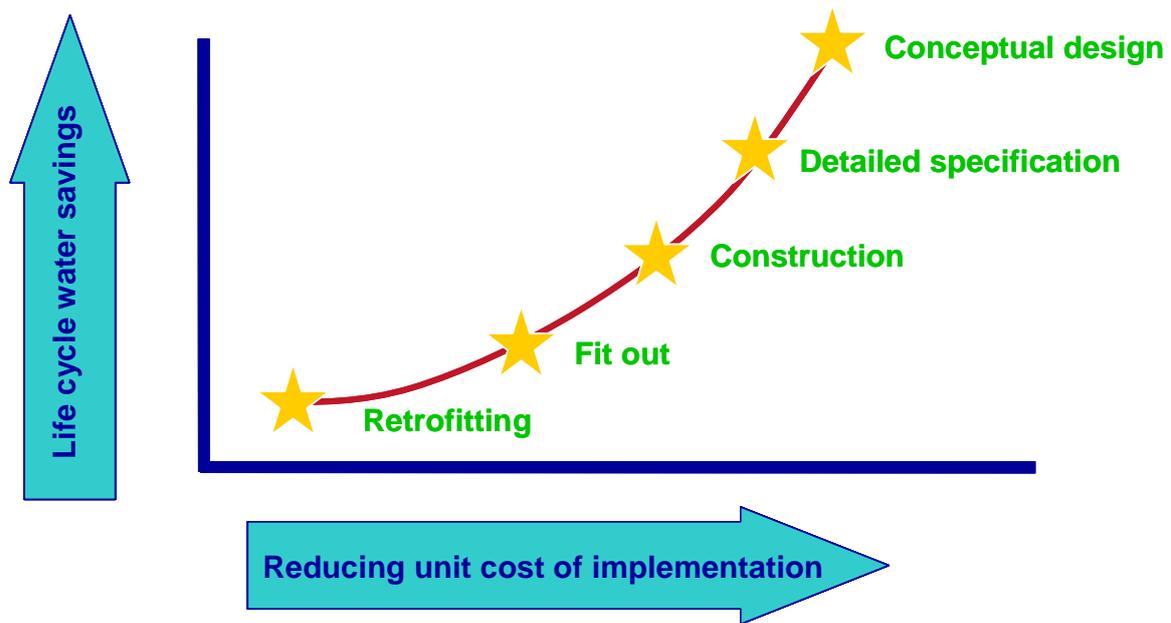
There is a need for further investigation and analysis of the most effective way to implement these programs, particularly the ongoing outdoor water saving measures. This option represents a significant opportunity to improve the efficiency levels of this sector and end use combination (outdoor water use in the residential sector). This sector and end use is responsible for approximately 100 GL/a (Sydney Water, 2005, p.11) of water demand and the savings that can be achieved are likely to be significant and at low unit cost. In addition, this is a sector and end use that has not been the subject of as significant a level of investment as others in the roll out of the Sydney Water Every Drop Counts program. It will be important to ensure adequate investment in the program components that Sydney Water already has underway, including significant work with trade and professional allies (e.g. nursery and landscape industry), the communications strategy to support this program, and the linkage and integration with other programs and NSW Government initiatives, particularly advertising and education programs.

In addition, as indicated in Section 7.2, the review of the appropriate drought restrictions regime that is proposed for when this drought ends will need to take into consideration the potential demand hardening that will result from the implementation of these options. Demand hardening refers to the potentially increased difficulty of achieving reductions in water use once water efficient practices become the norm. This will need to be monitored closely, and subjected to further detailed modelling as these measures are introduced and as restrictions are lifted.

Efficiency in new buildings

As well as ensuring that the range of programs in place are directed to achieving the conservation potential in each sector, it is important that different types of measures and instruments are included that seek to realise the efficiency potential in both existing and new stock. Figure 2 illustrates the principle that hardwiring efficiency into new buildings is more cost effective and can achieve greater savings than later retrofit decisions, highlighting the importance of identifying and implementing efficient options at the design stage. Applying this philosophy is fundamental to BASIX for residential dwellings, but should also be taken in the case of other buildings including schools, factories and hospitals. This is reflected in proposals for extending the principles of BASIX to the non-residential (commercial and industrial) sector in Section 7.6.1.

Figure 2 - Life cycle savings from effective planning (adapted from ISF, 2006)



The role of Government

The NSW Government, in addition to overall responsibility for ensuring the implementation of the various programs in the Metropolitan Water Plan, can play a leading role through its place in the economy. There are at least two aspects to this.

The first is in relation to the water use in buildings owned and leased by NSW Government departments and agencies. Water use in non-residential Government buildings alone was more than 10 GL/a in 2005. Many of these Departments are already participating in water saving measures, including the Department of Housing, which is retrofitting a large proportion of its housing stock in cooperation with Sydney Water. Many large NSW Government users will be required to prepare water saving action plans.

One issue worthy of note, is that the Sydney Water EDC Business Program still faces the challenge of bringing many Government agencies 'over the line' in terms of implementing highly cost effective savings. The availability of loan funding support under the Government Energy (and Water) Efficiency Investment Program may not be sufficient to ensure participation to a level that is appropriate given the need for the NSW Government to be seen to be 'leading by example'. Additional performance requirements and measures could be examined to ensure maximum participation.

The second is the potential for the NSW Government to support market transformation in the specification and procurement of efficient appliances and technology. An option is for the NSW Government to adopt a preferencing policy for efficient water products in all its procurement activities. This would ensure overall water savings in the sector and deliver recurrent cost savings to agencies.

3.4. Total estimated demand reduction

The total potable water savings from water efficiency and recycling schemes in 2015 and 2030 are shown graphically in Figure 3. Note that recycling for flow substitution will augment water availability by approximately 18 GL/a and is included among the measures discussed in Section 2.1. The measures whose full potential will not yet be reached by 2015 are BASIX, WELS / Appliance Standards and recycling.

Figure 3 - Demand reduction by 2015 and 2030

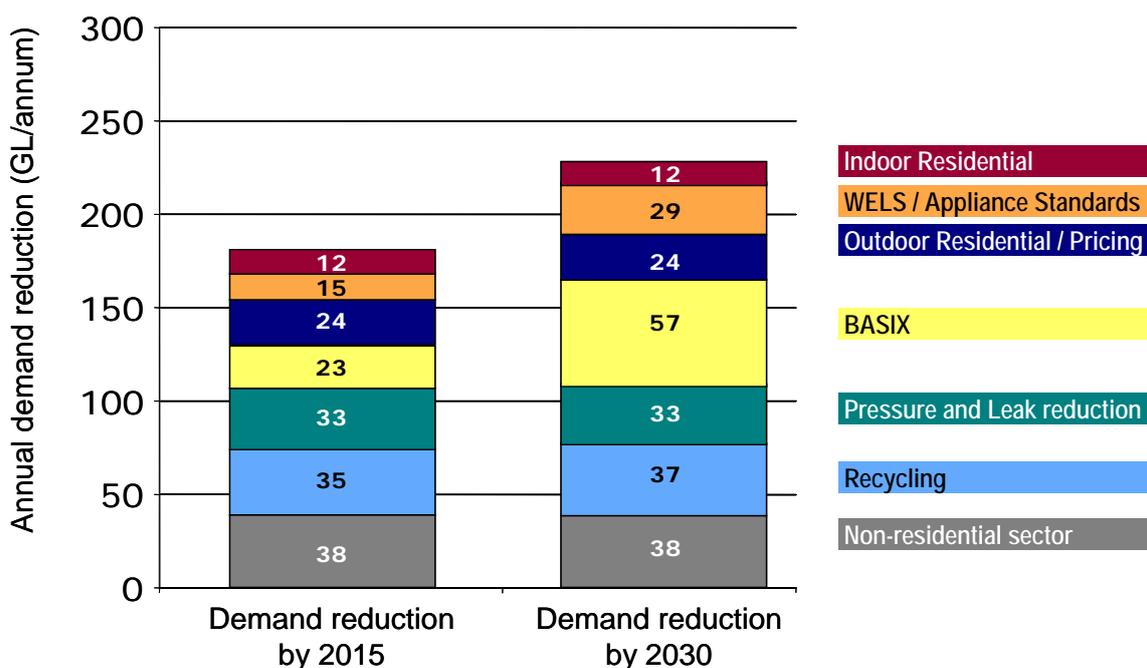


Figure 3 shows that the majority of savings are attributable to water efficiency options. These estimates are based on current information from the agencies responsible and have been discounted and reduced where necessary to avoid double counting of savings. A conservative rate of washing machine sales has been used to estimate the savings from WELS/Appliance Standards in 2015 as a contingency for any delay in introduction. However, for 2030 the savings attributable to WELS/ Appliance Standards and BASIX have been re-apportioned and their collective total has been reduced by 5 GL/a (compared with the February 2006 report) to be conservative for this longer term projection.

The unit costs for individual programs are provided in Appendix B, along with estimated greenhouse gas emission impacts. However, as noted earlier, the unit costs for individual programs can be misleading - what is important is to consider how each program contributes to a cost-effective *portfolio* of measures.

The recycling initiatives total approximately 55 GL/a by 2015, of which approximately 35 GL/a is for direct supply to customers (as shown in Figure 3) and the balance of approximately 18 GL/a offsets environmental flows. This will represent one of the largest potable demand offsets from recycling in Australia.

Water savings offered by some of these programs, such as recycling, have a relatively high unit cost. However, the rationale for recycling schemes extends well beyond

water supply – these schemes can offer significant benefits in reduced costs of wastewater management and/or reduced adverse impacts from nutrient discharge to the environment. Nonetheless, across this range of measures there is likely to be scope for achieving progressive improvements in cost effectiveness through fine tuning of the ‘portfolio’ of measures.

3.5. System benefits of demand reduction measures

In addition to reducing demand for water to meet the supply-demand balance, demand management and recycling measures offer a number of system wide benefits. These include:

- As part of an adaptive management strategy, at a time when significant investment is being made in better understanding demand trends and climate change, demand management that does not require large up-front investment in long-lived assets has particular attractions. As with the readiness strategies, by avoiding or deferring such investments it provides flexibility, as the investments in better understanding demand trends and climate change mature. This flexibility to adapt to new information without the risk of ‘stranding’ large capital investments means that demand management has a particularly valuable role to play in system risk management.
- Demand management also allows the avoidance of other system costs to the extent that less water is pumped and treated, including avoidance of the treatment costs of the additional supply treatment and the costs of managing the wastewater streams that are reduced by demand management, with the associated greenhouse gas reductions¹².
- Recycling schemes (including agricultural reuse) can deliver substantial benefits via reduced nutrient discharge to the rivers. This can deliver direct river health and amenity benefits, and can allow the avoidance of other system costs that would arise because of environmental regulation. These benefits are potentially large. The planning for recycling has incorporated assessments of benefits - both the avoided cost of otherwise meeting the Department of Environment and Conservation's 'bubble licence' (which regulates sewage treatment plants in Western Sydney, including the discharge of nutrients to the river) and other regulatory requirements and assessments of the value the community would attach to lower nutrient discharge via reduced risks of algal blooms and other benefits. The growth in these benefits appears to plateau as recycling volumes grow - as does the cost of the recycling schemes - but for very substantial volumes, the benefits are considerable.
- All these measures deliver some additional insurance against potential climate change impacts. Given the adaptive function of the groundwater and desalination readiness strategies, the insurance provided by these demand management and

¹² These greenhouse gas reductions are associated with both the reduced electricity for pumping and treating water and sewage, and also, and most significantly, with the reduced hot water use from improved showerhead, tap and washing machine efficiency. For example, the impact of the hot water savings from the Sydney Water EDC Retrofit Program (half a million households) is to effectively offset over half of the greenhouse footprint of Sydney Water’s operations.

recycling measures mainly takes the form of reducing the likelihood and cost of needing to trigger groundwater and desalination, rather than substantially increased security of supply. However, a drought that resulted in an extended period during which rates of inflow were lower than any previously recorded (considered highly unlikely) could challenge even the readiness strategies. Diversity of supply and demand management can certainly strengthen the buffer against such events.

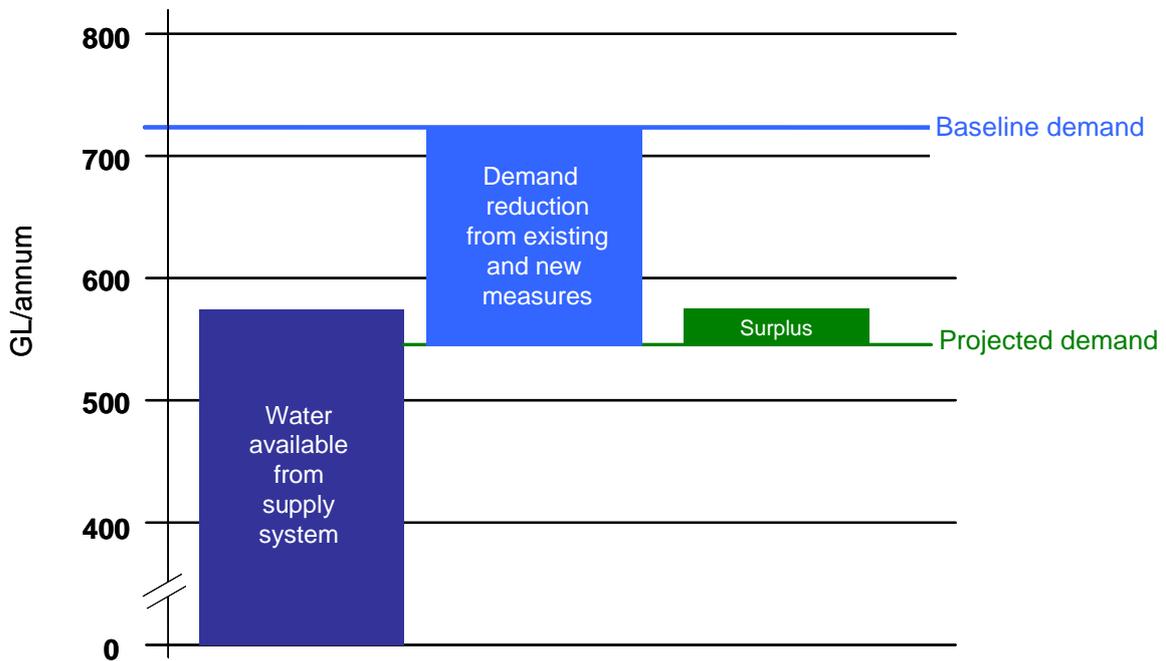
4. Supply-demand balance

Sections 2 and 3 have discussed the status of options for supply and demand. This section now evaluates the supply-demand balance to 2015 and 2030 and discusses the implications of these results in the context of an adaptive management planning strategy.

4.1. Medium term (2006—2015)

The estimated supply-demand balance for 2015 is shown in Figure 4 indicating a projected surplus.

Figure 4 - Supply-demand balance for 2015



The supply availability of the Sydney water supply system in the period to 2015, with all the currently committed and approved supply-related measures in place, is estimated to be approximately 575 GL/a. This supply availability is based on the current reliability criterion, which limits restrictions to, on average, 3% of the time. It is also based on current trigger level for transfers from Tallowa Dam, 60% of total system storage. The other key parameters are listed in Section 2.2 and further described in Appendix A.

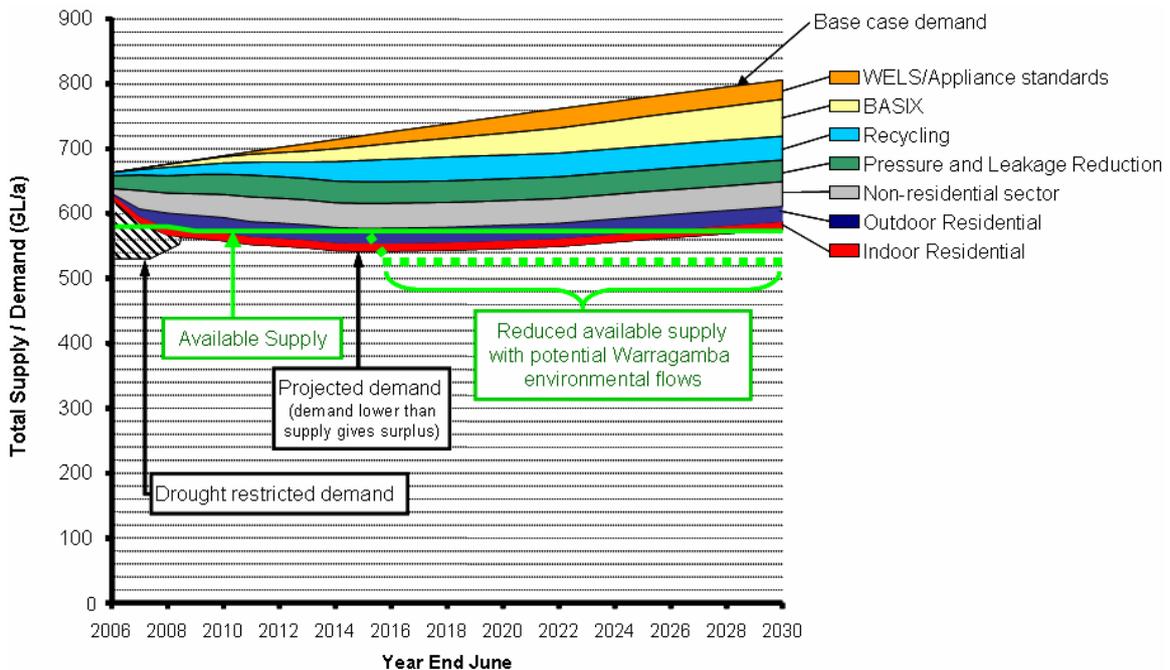
In this same period, based on conservative values of demand, the supply-demand balance is met, with the demand expected to be approximately 542 GL/a, based on the estimated impact of current and committed water recycling and demand management measures (180 GL./a), and assuming the current estimate for baseline demand of 426 litres per person per day (which equates to a base demand of 722 GL/a in 2015). In the future, it is expected that 426 litres per person per day will represent an overestimate of baseline demand, because of the impact of urban consolidation and underlying efficiency improvements in the stock of water using appliances, particularly toilets. If for example, the per capita demand were closer to

400 litres per person per day, this would represent an additional surplus in 2015 of up to 40 GL/annum.

It is important to note that actual figures will change over time according to supply-side and demand-side developments. The water availability figure of approximately 575 GL/a will change to reflect the Government's decision on the new regime of environmental flow releases from Tallowa Dam on the lower Shoalhaven River, about which community consultation is now under way. The new flow regime will decrease water availability, but can be offset either by changes to the current operations of the Shoalhaven Scheme (for example by changing the pump mark), or by reducing the surplus, or by an additional supply or demand option.

Figure 5 provides additional detail that shows the contribution of individual demand reduction measures to the supply-demand balance through time.

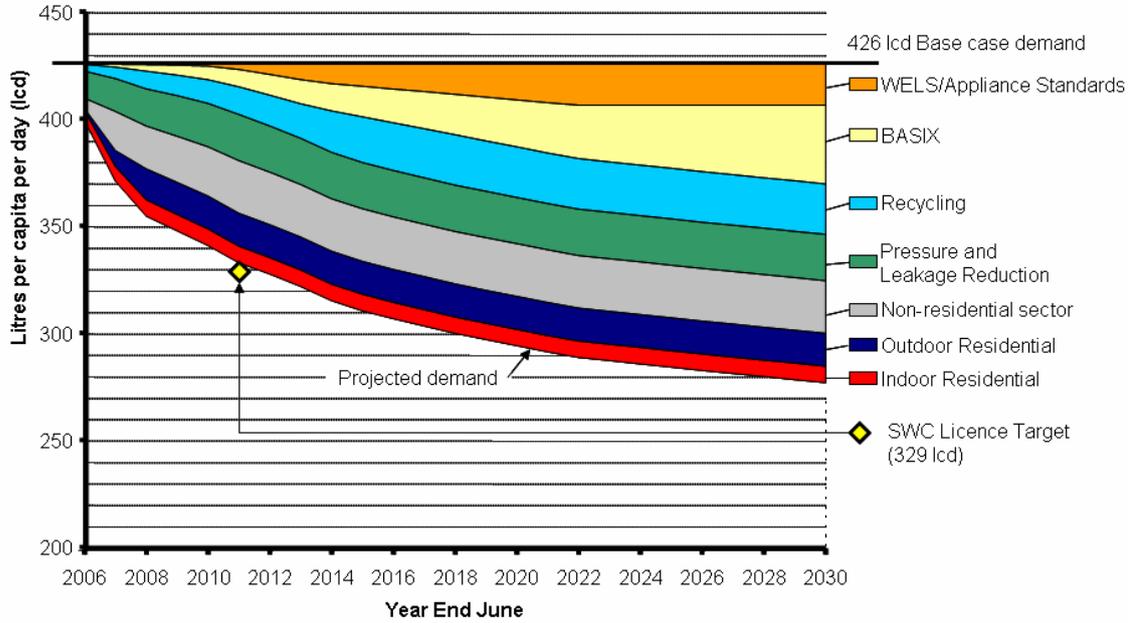
Figure 5 - Supply-demand balance through time. Note that the drought restricted demand is assumed to end in 2008.



Actual demand is calculated by subtracting the effect of demand management measures from the base demand. This is shown in Figure 5 based on an assumption of per capita demand of 426 litres per person per day for base case demand and population assumptions described in Section 3.1. The top line represents base case demand and the reduction from each demand management measures is then shown subtracting from the base case demand. With all measures in place, the projected demand is represented by the bottom of the red region for 'residential indoor'. Available supply is shown in bright green and this illustrates that demand is lower than supply until 2015. Note that demand affected by drought restrictions which is shown as a black region is assumed to end in 2008 for modelling purposes.

The demand supply balance is shown in Figure 6 in per capita terms, with the Sydney Water Operating Licence target shown in 2011.

Figure 6 - Supply-demand balance through time expressed as litres per capita per day



These projections of demand indicate that, if the demand reductions that have been estimated as a result of these programs are realised, then the 2011 target will almost be met. In fact, given the anticipation that the base case demand represents an overestimate in future years, due to land use changes (urban consolidation) and improving appliance efficiency, then it is likely that demand could be lower than this. Despite this, unless there is a significant and unforeseen change in the estimate of supply availability, an important focus will be the need to maintain vigilance in implementing committed demand reduction programs, monitoring savings and modifying programs where needed to ensure that the estimated savings are achieved.

4.2. Longer term (2015—2030)

In the longer term, two principal issues will affect the supply-demand balance. First, the proposal to dedicate water for Warragamba environmental flows. In the 2004 Plan, the Government recognised that improving the health of the Hawkesbury-Nepean river system requires new environmental flow releases from a number of Sydney's water reservoirs. That Plan foreshadowed, that by 2015, the Government will have the information needed to decide the environment flows to be provided to the Hawkesbury River from Sydney's largest dam: Warragamba. Whilst this has significant environmental and river health benefits, it could also reduce supply availability by approximately 80 GL/annum. However, the Western Sydney Recycled Water Initiative is expected to substitute for approximately 30 GL/a leaving a nett effect of approximately 50 GL/a.

This potential deficit of approximately 50 GL/a needs to be considered in light of the 30 GL/a surplus that is estimated to be available in 2015 as a result of the existing mix of supply and demand side measures. This surplus may be considerably larger, if it is found that per capita demand estimates used in this review are unduly conservative, potentially increasing the size of the surplus by a further 40 GL/a.

The second issue affecting the supply-demand balance is that, beyond 2015, population growth may start to drive demand back up as the current suite of low cost water efficiency measures and recycling schemes will have been implemented before 2015 (though they will continue to deliver benefits well beyond 2015). However, the relative cost-effectiveness of future efficiency measures may have improved in the intervening period.

The environmental flows and population growth could lead to a supply-demand gap in the post-2015 period on current estimates. However, this report highlights a range of options available to close this gap. These include changing the drought restrictions regime, revising the reliability criterion, increasing transfers from the Shoalhaven, increasing the probability of triggering desalination or a combination of one or more options.

There is also likely to be further cost effective water efficiency and recycling potential that could in future, help to reduce any potential supply-demand gap.

Importantly, there is sufficient time for planning within an adaptive management framework, and ensuring that there is a level of community engagement in this decision making process that is commensurate with the significance of, and public interest in the decisions.

5. New planning paradigm – adaptive management

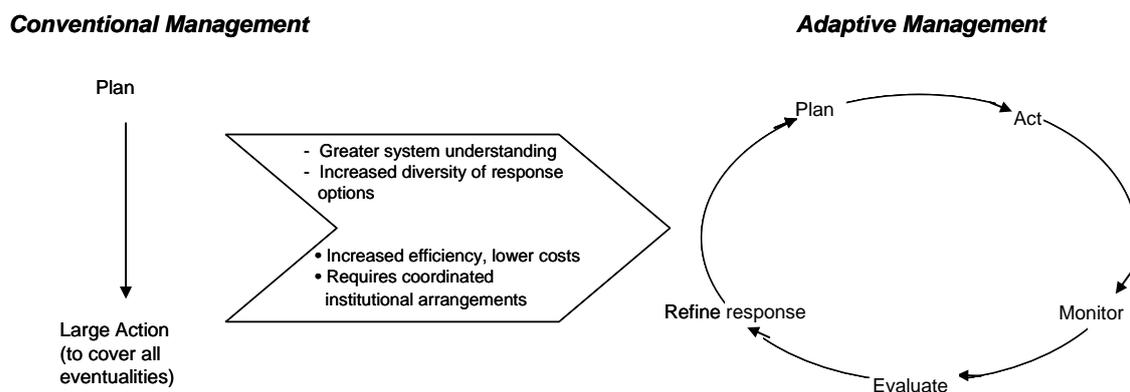
5.1. Adaptive management overview

As is the case with many natural resource issues, planning for Sydney’s water supply is more complex and requires more detailed consideration than is suggested by a ‘once and for all’ solution that attempts to cater for all eventualities. The reasons for this are:

- Pursuing any single solution is likely to incur unreasonably high costs.
- Confidence in any one solution is not high enough to guarantee that it will stand the test of time and not require further fine-tuning at high cost. This is because of uncertainty regarding a number of factors including:
 - trends in per capita demand;
 - future climate and hydrology;
 - future changes in technology; and
 - community attitudes, public health concerns and pricing policy.
- The analysis required to achieve least cost, safe strategies for the system is significant in terms of the time, resources and skills required. Unavoidably, this analysis is iterative, and a large up-front investment in capital works is likely to be less cost-effective than investments made in smaller initiatives over time.
- A short-term uncertainty that may fundamentally alter the shape of the most cost effective strategy is the future course of the present drought.

These considerations call for a rolling, *adaptive response* as shown in Figure 7.

Figure 7 - Comparison between conventional and adaptive management



Adaptive management is an increasingly mainstream approach to environmentally and economically cost effective management. It includes a combination of sound risk management - including minimising the risks of unnecessary, high-cost investment - and making investments when and where they do offer good value, given the information available at the time. The principles involved are virtually identical to

those finding increasing attraction in planning and managing a wide range of investments under circumstances of uncertainty – where the language of adaptive planning, of real options and of taking account of flexibility when comparing alternatives is increasingly used.

This shift comes from the recognition of serious bias in traditional investment planning and analysis methods that rely on modelling only the expected or most likely outcomes, such as has long been common in discounted cash flow modelling. Starting in the mid-1980s there has been growing recognition that the combination of uncertainty, of the scope for investing in obtaining better information that reduces uncertainty, and of flexibility to adapt the investment strategy to the new information means that traditional valuation and selection of the single least cost (or highest net benefit) solution can be seriously biased.

The economic principles underpinning this approach to planning are commonly grouped under the title of 'real options planning' (see McDonald & Siegel, 1986; Trigeorgis, 1995). However, the term adaptive management has been in wide use in natural resource management (Jiggins, 2000) for much longer than this, and more effectively captures the underlying principle. The options terminology does, however, serve to emphasise the value in investing explicitly in ways designed to deliver greater flexibility and reduced risk of high cost investments that subsequently prove to have been unnecessary, or to have been delivered much earlier than was necessary. The Auditor-General's report on Planning for Sydney's Water needs (The Audit Office of New South Wales, 2005) highlights that beyond the continual monitoring element of adaptive management, for a system to be able to respond to external shocks it must necessarily have 'adaptive capacity' which, for example, the desalination and groundwater readiness strategies now provide.

Flowing from this, one of the key advantages of this approach to planning is that it often points to opportunities to reduce downside risks while keeping access to upside opportunities – and where there is a lot of uncertainty, this can point to dramatically more cost effective investment possibilities. Indeed, this has proven to be the case in respect of Sydney's water planning – with identification of the scope for shifting from pre-emptive investment in desalination, to a desalination readiness strategy that exploits the flexibility offered by the combination of short lead-time and the ability to operate in a severe drought.

More generally, an adaptive response may include a suite of options such as recycling, demand management, desalination, groundwater, dams and restrictions. It can include an identified set of trigger conditions and ongoing review of the best choice of both instruments and trigger conditions.

Such a *portfolio of demand-supply management options* may (and in fact does, as is discussed in Section 8) imply that more institutions will appropriately be involved and accountable, and that more complex institutional arrangements will be required than has been necessary using traditional water planning tools. From a sustainability perspective however, the greater efficiency and flexibility associated with this approach have led to adaptive management being widely recognised as better suited to environmental resource planning. Indeed, the extension of responsibilities across multiple agencies would simply formalise arrangements that have emerged in the

context of the present drought planning – a case study in its own right in adaptive management.

A key feature of this adaptive approach, focused on developing and maintaining options of high value, is an emphasis on on-going investment in better information on which to base more cost effective planning. It can involve continuing investment in establishing and maintaining readiness to implement response strategies, such as desalination, with lead times short enough to reduce the likelihood of needing to make such investments.

This approach will certainly require monitoring of technological improvements that reduce high cost constraints on the system. It could include investment in water factory technologies with lower energy intensity or in technologies and strategies that reduce the user costs of water restrictions, such as drought- or scarcity pricing.

This adaptive management approach will sensibly incorporate the following elements:

- investment in building a better understanding of the true costs of water restrictions and an improved understanding of their effectiveness, community acceptance and alternatives for future drought management such as drought pricing or scarcity pricing;
- investment in improved understanding of the environmental implications of various options, and how these costs and benefits should inform policy settings;
- continuation of the research already under way and directed at building a better understanding of how climate change is likely to impact on catchment hydrology;
- progressive analysis of a wider spread of possibilities, including desalination and groundwater lead times (reflected in lower trigger levels), and in source diversification;
- on-going investment in monitoring indirect potable supply systems elsewhere and in reviewing the appropriate policy position for NSW on public health grounds and engaging the community on the acceptability of the option;
- investigation of the potential costs and benefits of strategies for distributed water supply and reuse in new developments, in which the high cost of duplicating reticulation systems can be reduced;
- bringing these strands of analysis together to provide guidance as to the appropriate package of measures, including investment in supply and demand measures, and further research to allow more accurate planning; and
- innovative approaches to community engagement (See Section 8).

This work needs to be set in the context of delivering an evolving, *cost-effective portfolio of supply and demand responses across the system*. It is crucial that costs and benefits be assessed at the portfolio level – because project-level costs and benefits can be misleading. For example, the unit costs of a desalination plant pre-emptively constructed and operating at full capacity will be very different to the unit cost of a desalination readiness strategy operating in combination with a range of

other supply and demand side measures. The former will have a lower unit cost but the latter will be far more cost-effective from a whole of portfolio perspective.

5.2. Adaptive response to current supply-demand balance

To ensure that the supply-demand balance continues to be met, the adaptive management strategy proposes responses to each category of uncertainty. The range of uncertainties and risks associated with the water supply-demand balance, and the impact of these are summarised in Table 2, along with the appropriate response.

Table 2 - Uncertainty, impact and response associated with the supply-demand balance

| Risk / Uncertainty | Impact | Response |
|---|--|--|
| Lower than expected rainfall for remainder of current drought | Dam levels fall significantly | Trigger the construction of groundwater capacity at around 40% of extended storage levels (that is, including the deep water currently being made accessible) and desalination capacity at around 30% of extended storage levels |
| Groundwater estimates | New groundwater found; or reserves not proven up | Examine options to meet any emerging drought needs |
| Desalination readiness | Improved technology or decreased lead time to construct | Reduce trigger to build |
| Demand management and recycling | Demand management and recycling programs have lower impact than expected | Redesign programs, add new programs or examine options to increase supply availability as above |
| Environmental flows | Warragamba environmental flows post-2015 cannot be met with current supply availability plus operational changes | Review and advance proposals for measures assessed to be most cost effective and suitable, e.g. additional demand management or recycling, Shoalhaven augmentation etc |
| Restrictions regime | Key variable that can be adjusted to maintain supply-demand balance | Periodically review to ensure appropriate to current operating environment |
| Shoalhaven operating criteria | Key variable that can be adjusted to maintain supply-demand balance | Periodically review to ensure appropriate to current operating environment |
| Desalination trigger | Ultimate variable to guarantee supply security | Periodically review trigger level to minimise costs |
| Effect of climate change | Supply availability is revised downwards (or upwards) | Monitor supply-demand balance and implement measures assessed to be most cost effective and suitable |

Should there be any unexpected changes in the supply availability or the demand, there are several options available to ensure that the demand supply balance is maintained as discussed in Section 2.4.

5.3. *Adaptive responses to future droughts and growth needs*

The adaptive capacity of the water supply system means that adaptive management can be used to respond to both future droughts and the growth needs of Sydney's water demand in the longer term.

The specific planning instruments used to respond to drought are discussed in Section 6 and for on-going demand and future growth in demand in Section 7.

6. Planning Instruments – drought

This section describes the planning instrument types and how they would be used as part of an adaptive management strategy to respond to both the current and future droughts. The discussion of future droughts considers both more regular but less severe droughts and the extremely rare very deep droughts such as the current drought.

6.1. Current drought

6.1.1. Background

Since the release of the Metropolitan Water Plan 2004, the drought has continued but, relative to the rapid decline in storage levels during 2003 and 2004, storage levels have held relatively steady at around 40%. The lowest point reached was 37.9% in mid 2005. While storage level rose to 44.6% in early February 2006, as at the first week of April 2006 they were 40.9%.

Assuming that dam levels in the coming years trend towards pre-drought levels, this drought will be remembered as the second worst on record from the perspective of the Sydney catchment. The drought from the mid-1930s to mid-1940s was slightly worse – and would, if repeated recently, have driven dam levels a little lower, while leaving in excess of 30% of dam capacity (inclusive of extended system storages) still available at the lowest point. The overall pattern of the two droughts is quite similar. The only other drought on record of broadly comparable severity was that of the 1890s. These points reinforce the fact that drought planning and response is built around the risk of the Sydney catchment experiencing a drought significantly worse than any yet recorded.

The very considerable capacity of the Sydney storage system, combined with the new groundwater and desalination readiness strategies, serve to address the concerns expressed in the Auditor-General's report (The Audit Office of New South Wales, 2005) regarding planning for 'worst case' scenarios.

6.1.2. Possible responses

This ability to access to deep water in the Warragamba and Nepean storages will make extended system storages available in the coming months. As at the first week of April 2006, supplies inclusive of this deep water represent approximately 45.4% of this expanded supply capacity. As deep water access becomes available, percentages would be expressed as a percentage of the total extended system storage. A conversion table showing relative percentages of current and expanded system storages is given in Appendix C.

Groundwater sources that could be used to provide 15 GL/annum of water during drought have been confirmed, with the potential for an additional 15 GL/annum identified. These cannot be run indefinitely – offering indicative supplies at this rate for up to three years, followed probably by about seven years recharge time. However, they are illustrative of a persistent theme through the present review. A gigalitre of water available when supplies from other sources are very low has much greater value – 'punches above its weight class' – than does a gigalitre of rain-fed

supply. The strategic value of such water, in limiting risks, extending supplies and possibly allowing the deferral of high-cost infrastructure investment can be considerable.

The ability to construct desalination capacity in a short time (26 months) is the result of the planning, approval and testing processes that are almost completed, and which collectively have reduced the lead-time to construct by at least 12 months – to about 26 months. This readiness greatly increases supply security by allowing a plant to be committed, constructed and started late in a severe drought in sufficient time to avoid breaching security requirements. This in turn limits the risks of committing to a high cost construction project, only to have the drought break, with adequate supplies still in storage – effectively resulting in a wasted investment¹³. Clearly, further reduction in this lead-time can reduce these risks even further, though analysis in Section 6.3 indicates that a trigger point at around 30 percent already delivers most of the potential for savings because of the very low implied likelihood of dam levels falling below this level for many years.

The ability to construct desalination capacity within a 26-month period will mean that security levels will be maintained, even in the event that storages fall to levels of less than 30% – an event with an extremely low probability based on the latest hydrological modelling – even with allowance for significant change in risks due to climate change.

It is notable that, so far during the second worst drought on record, dam levels have not fallen below 37.9 percent of capacity (or around 43 percent of extended storage capacity) and that methods have been developed that would allow a much deeper drought to be managed. Drought continues to be a serious issue for Sydney, and careful management is crucial – but in many respects this recent history, which has not required the imposition of Level IV or Level V restrictions, should be viewed as pointing to the robustness of the established system as well as to the value of sound planning.

6.2. Future droughts

Security against the extremely rare but much deeper than ‘normal’ droughts has traditionally had a major role to play in shaping Sydney’s water supply arrangements. In a world in which the major instrument for meeting both growth and security demands has been dam capacity, Sydney’s dam system has necessarily evolved with an excess of capacity ‘almost’ all the time. As has been noted already, current capacity is such that no drought event so far recorded would have run capacity below 30 percent. The low point in the current drought has been 38 percent of the old capacity – or about 43 percent of the capacity of the system expanded by deep water access.

This points to an existing capacity to cope with a drought worse than any yet seen. The supply availability that is surplus to normal and even severe demands will

¹³ Of course, the investment may still be needed in the longer term – however, that longer term is likely then to be many years out. The combination of this long delay, the costs of finance, and likely trends towards lower cost and more energy efficient mean that, in effect, a high proportion of the cost of the investment would have been wasted.

remain. However, if other cost effective ways of delivering system security can be found, then there may be scope for accessing some of this buffer as a low cost source of growth water. This could be in place of other strategies – such as some of the Shoalhaven transfer strategies, or some of the more costly recycling schemes that might otherwise be needed. Of course, any such planning must be done in conjunction with assessment of demand side as well as supply side measures.

A range of instruments could be considered for meeting future security needs:

- additional dam capacity;
- reliance on deep cuts in consumption during a severe drought, noting that demand hardening could increase the costs of such cuts in the future;
- development and maintenance of the capacity to augment supplies during a severe drought – rapid implementation of large-scale recycling, desalination and/or groundwater access; and
- acceleration of existing demand management programs, and/or introduction of new water saving measures, to slow storage depletion rates in drought, reduce the probability of needing to invest in or upgrade groundwater and desalination capacity and, in a very prolonged drought, to ensure that security options and inflows are together sufficient to meet Sydney's water needs.

There are potential synergies here. Combinations of these measures can be used to meet security objectives. Investments in water for security might – in time – be used to meet growth demands, with new security sources being tapped on an as-needs basis. Of course, it will be important to consider whether other options will be readily available to meet future security needs and, if not, whether the insurance value of the existing security options is best maintained by deploying other options to meet growth needs. Importantly, any source diversification that reduces reliance on rain-fed supply can reduce the demands for security water from that source. A sound portfolio response to Sydney's future water needs will exploit a range of these possibilities.

There is a potential for accelerated demand management to play a role during drought, as indicated above. Once these options are implemented, they contribute to the longer term supply-demand balance, requiring the projections to be revisited. Consistent with this approach, and informed by work undertaken by ISF in 2005, the NSW Government has implemented five additional water saving measures in response to the current drought - as announced in the February 2006 Progress Report.

6.3. General principles for drought response strategies

Additions to the dam system, or equivalent reductions in demand for water from the dams, have greatest value when the dams are lowest, and when the risks of restrictions or real shortages are highest.

In economic terms, the opportunity cost of drawing water from the system then is greatest - as is the value in avoiding drawing the water. This suggests that supply instruments that can deliver water to the system in a way that is negatively correlated with dam levels could be particularly valuable in contributing to supply.

Equivalent reductions in demand that occur only when dam levels are low are likely to be far more valuable to overall system security than the same level of demand reduction averaged over high and low dam levels.

A 500ML/day desalination plant, coupled with minimum background inflows under the most severe drought modelling, appear sufficient to meet demand. The same is not true of 125ML/day, but a plant of this size capable of being rapidly upgraded to 500ML/day could suffice. Planning around a 125ML/day plant has been predicated on providing this scalability. Desalination that is only switched on when needed to secure the system is likely to be switched off most of the time. The larger that capability, the less likely it is to be needed in any time period, and the lower its average annual utilisation, including energy use and brine discharge.

Ideally, a strategy would be developed that meant the plant was built as late as possible, consistent with it being available when needed. If this could be done, not only would the operating costs of the plant (including carbon emissions and brine discharge) be largely avoided, but so too would the capital costs - at least to the extent that they might be deferred by many years. In practice, it takes time to construct and commission a plant. This requires commitment to significant costs even though there will be a high probability of the drought breaking before the plant is commissioned.

The same reasoning points to the fact that there may be a lot of value associated with measures that reduce the time needed to build and commission a plant or otherwise allow greater deferral. Possibilities here include:

- Tapping into available groundwater as a means of delaying the trigger point.
- First committing to a smaller desalination plant than the size that might be needed, and upgrading it later as the need becomes established. This should allow further delay in the trigger point for the large plant, reducing the likelihood that the higher investment will be needed. However, possibly sizing the initial plant to be larger than the absolute minimum, because this will in itself allow both later commitment to the initial plant, and a lower risk of needing to then upgrade.
- Using drought-based restrictions to push out not just the trigger point, but also the time taken to reach that trigger point - again allowing time for the drought to break before an irreversible commitment to a large infrastructure investment is necessary.
- In time, possibly considering the use of water pricing that is reflective of the opportunity costs based on current dam levels and other system features - again encouraging greater restraint when it would be most valuable.
- Increasing the diversification of the package of normal supply and demand measures to reduce the positive correlation with dam levels. Again, this can serve to allow both lower trigger points and longer times needed to reach any such trigger points.

Cost effectively tapping into a range of such measures will be the essence of sound security planning in the new environment.

Based on SCA hydrological modelling, it is possible to gain insights into the value of these ‘deferral options’, and to set up a basis for assessing the best mix of measures to use.

The Sydney dam system is still in drought, with dams below 50 percent full. Already this implies a higher than typical risk of dams running dry, and an elevated likelihood of needing to trigger groundwater/desalination investments. However, as was noted earlier, the likelihood remains small - with it now being much more likely than not that the dams will return to ‘normal levels’ before any such extreme response measures will be needed.

To help assess the value and appropriate level of deferral, SCA has provided the consultants with a set of 2000 replicates of the Sydney dam system being managed in line with the measures discussed earlier. All these replicates commence with the dam at close to current levels. This has been imposed as a constraint and the effect of this constraint is to reduce the value of deferral, relative to starting with dams full, or at levels that are more typical. If it is possible to emerge from this drought without having had to trigger investment in desalination, then the value of the option to continue to defer as part of an adaptive strategy will rise significantly.

Figure 8 - Conservative savings (NPV) from deferral of desalination based on dam levels

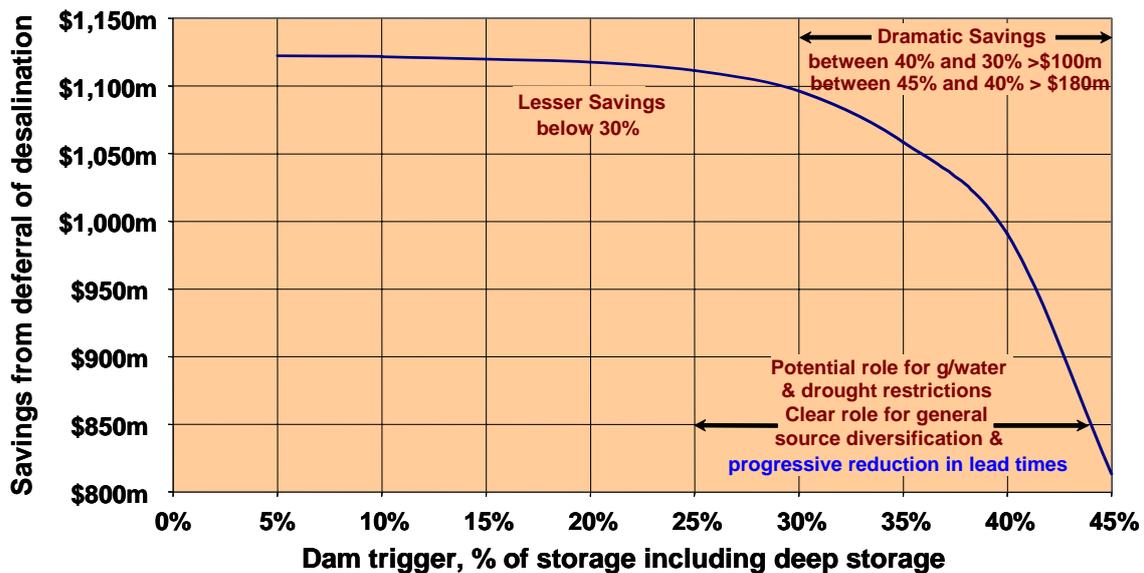


Figure 8 has been developed based on the 2000 replicates. It plots estimates of the cost savings associated with waiting till a dam level trigger point is reached, relative to the costs associated with moving immediately to building a 125 ML/day desalination plant, capable of being scaled to 500 ML/day. The figures include only capital cost savings, and all the figures are expressed as current dollar savings (using a net present value calculation, based on a discount rate of 7 percent, the base rate set out in the NSW Treasury guidelines for economic assessment of major projects). The capital cost figures relate only to the initial 125 ML/day plant – inclusion of operating costs and the possibility of needing to further upgrade would result in greater savings. These estimates are therefore conservative.

The curve represented here shows savings relative to an up-front capital cost of \$1.3b, from basing the commitment around different dam trigger levels. As the trigger drops from 45% to 30% of extended storage capacity, the estimated savings rise from about \$800m to about \$1.1b. Below 30%, the rate of improvement in savings tails off substantially, but the numbers remain large in absolute terms. Nonetheless, being in a position to delay triggering the desalination investment until the dams drop below 30% appears to offer the majority of the potential gains. This is the position taken by the Government in its February 2006 Progress Report, announcing a trigger level of around 30%. This offers most of the savings now, while being amenable to some fine-tuning over time as more detailed information becomes available. Current indications are that it should be possible to lower the trigger point somewhat further, but the 30% trigger affords the priority to security pending further information, including in respect of climate change patterns, becoming available.

The ability to work with this trigger level is conditioned on having access to groundwater as a further component of the deep drought strategy. As has been discussed earlier, the scale and production characteristics of the groundwater sources are still being assessed, and environmental approvals would still be needed.

The current position announced by the Government assumes that the groundwater would be accessed should dam levels drop to around 40% of extended storage capacity. This appears to be a conservative position that supports the 30% trigger level for desalination. Given that the groundwater sources are likely to be substantially lower cost sources than desalination, this approach makes sense.

However, the basic features of Figure 8 apply equally to groundwater development – only the scale on the vertical axis needs to be changed. The shape of the curve is driven by two factors – the hydrology modelling with the associated likelihood of triggering the need for investment, and the discount rate applied to the assessment of the present value of savings. Neither of these changes between investment in desalination and groundwater.

It follows that the effective cost of accessing groundwater could be reduced substantially were it possible to lower the trigger level from about 40 percent – to about 30 percent or even lower.

It may seem sensible to access the groundwater ahead of committing to the desalination but in fact, that need not be the most cost effective use of the groundwater options – and might not be necessary in order to allow desalination to be deferred. Using water from the dams is still likely to be cheaper than accessing the groundwater and both water sources are substitutable as part of a strategy to delay commitment to desalination. Knowing that the groundwater is available and can be brought into supply in time allows safe use of more dam water. It allows the dams to be drawn down to a lower level while still leaving enough time to construct desalination.

It is possible, therefore, that the most cost effective way of using groundwater could be to delay its use too, so that the chances of incurring the infrastructure costs are minimised – subject to the water becoming available in time.

Until the groundwater sources are more thoroughly proven up, it is difficult to be definitive about the appropriate trigger point. For now, the proposed 40% trigger appears conservative and to offer a robust means of reducing the likelihood and cost of desalination. As the resources become better characterised, there is likely to be scope for further delay in the trigger point and, as suggested by Figure 8, reaching a stage where groundwater could be progressively introduced starting at or below 30% dam levels, could offer a significant reduction in both the cost of the groundwater strategy, and the likelihood of needing to access the groundwater. As such, it should further reduce any remaining environmental concerns. We are not in a position to recommend such a lowering at this stage, but as the resource assessment proceeds, review of the trigger level will make sense, and will probably yield cost savings.

Drought-based restrictions represent the third instrument in this 'countercyclical' group. The stronger these restrictions – involving both the severity of constraint that applies when they are in place and the frequency with which they are triggered – the lower will be the likelihood of triggering the need for either desalination or groundwater. The above summary of analysis shows that it is possible to estimate the cost savings from deferral. It follows that there is a well-defined question as to whether a change in the restrictions regime, coupled with a compensating change in both the groundwater and desalination trigger points and the expected times till those trigger points are reached, would be cost effective – would deliver greater value to the community.

The on-going development of the water strategy would sensibly seek better information into the true cost of restriction in a drought context; information that is currently not available. Studies could be tailored for maximum efficiency in addressing the trade-offs between the different instruments that have now been identified.

Of course, drought-based restrictions could also take the form of water pricing that varies with the scarcity of supply, so that water prices might be lower than at present levels when dam levels are high or overflowing, and higher than present levels, at least for consumption above base levels, when dam levels are low. Such an arrangement would reflect the true economics of water usage – as dam levels drop, the implications for system costs of consumption rise rapidly, because they increase the likelihood of triggering high cost responses, such as desalination. It is possible to estimate the option value extinguished by water consumption at different dam levels, and this could support a soundly based scarcity-pricing scheme¹⁴. Such an approach could also help reduce the financial impact on utilities of reduced consumption during drought periods, combined with higher costs (e.g. due to pumping water from other catchments and investing in other drought response options).

However, it is noted that this option is not currently being considered by the Government. Indeed, care should be taken prior to adopting this approach as:

- it has not been seriously considered to date by Government and there is a diverse range of complex issues that will need to be worked through; and

¹⁴ Such a system is used in Denver, Colorado and elsewhere (see Duke and Ehemann, 2004)

- this measure is likely to involve lower costs and greater cost effectiveness if introduced in advance of a severe drought, rather than during such a drought. If the pricing arrangements are understood, water users will have the time and flexibility to adapt their behaviour to minimise the cost to them of such arrangements.

6.4. Issues for using recycling as a drought response

We have previously mapped out, and factored into evaluations, the crucial role of supply diversification in limiting the need to trigger either very deep restrictions or desalination/groundwater responses. We have also recognised a valuable role for recycling as a source of growth water.

A range of recycling schemes that can be implemented at low to moderate nominal cost¹⁵ has been identified, and are included in the earlier supply-demand assessments as an effective means to meet growth needs. However, over time, as the lower cost scheme options are implemented and hence no longer available to achieve additional savings, and as the options move more strongly into large-scale residential recycling, costs will rise rapidly.

Therefore, while recycling could substitute to a substantial extent for desalination and groundwater as severe drought response measures the costs are likely to be very high - and very much higher than the risk-weighted cost of these readiness strategies. A feature of large-scale recycling is that it cannot practically be rolled out fast during a drought. The lead times for dual reticulation supply arrangements are effectively tied to the rate of land development. Roof tanks of a size that can make much difference during a drought are commonly very expensive if retrofitted - and the cost would rise if there were an attempt to increase the rate of installation. There is limited scope for environmental flow substitution, but this is already being largely addressed with approved schemes.

It follows that recycling used as a substitute for desalination readiness would need to be implemented pre-emptively if it were to substitute for the security benefits of the readiness strategies. Given that recycling projects are generally operated continuously once installed, and assuming they rely on reverse osmosis, this means that the energy required to drive these schemes would be called on all the time - in sharp contrast to the energy demands of groundwater and desalination readiness, where operation for a tiny fraction of the time is envisaged.

This quality of treatment and associated carbon emissions may well be justified - but would need to be justified on environmental grounds. Pre-emptive investment in and steady use of recycling in this way (as a source of security water - on top of the recycling investment undertaken to meet growth needs alone) would be much more expensive than, and involve much higher levels of carbon emissions, than the groundwater and desalination readiness package that delivers equivalent security on top of recycling investment undertaken to meet growth needs alone.

¹⁵ Even here, care is needed. Most cost estimates for recycling schemes reflect the production costs of water from these projects, these are likely to seriously underestimate the cost of the corresponding contributions to system availability.

This statement may be contrary to widely held views, but it largely follows from the analysis summarised in Section 6.3. The benefits of groundwater and desalination readiness, in terms of long term deferral of the need to invest, and scope for relatively rare use even after investment, underpin the low effective cost of these strategies (even factoring in carbon and brine discharge costs). In practice, even the project costs of a desalination plant run steadily are likely to be more than competitive with those of large scale recycling. However, it is also important to factor in the external impacts of such measures. Desalination run continuously will entail significant energy use and bring discharges. Recycling also entails energy use and brine discharge (though significantly less than for desalination), but delivers benefits for river health by reducing nutrient discharge levels. As such, recycling can play an important role in meeting growth water needs and improving river health, but its capacity to provide security water needs must be considered in light of the relative costs of other options, like desalination, that are well suited to meeting water needs in severe drought.

The case is different for indirect potable reuse. It might be possible to introduce indirect potable reuse in a timeframe that allowed it to be used as a readiness strategy, similar to groundwater and desalination. If it were to become a feasible option, then this might offer a readiness strategy that was competitive with desalination readiness, although detailed comparative analysis has not been undertaken. The public health concerns would need to be addressed in full before any such strategy could be considered. Nonetheless, if indirect potable is to become feasible in the future, then there may be value in investing in resolving this issue; any such investment would of course need to be accompanied by an investment in ensuring the wider community understands the choices and their implications.

However, the other feature of the groundwater and desalination readiness strategy is that it is available now, in the present drought, when there are still legitimate if low-level concerns with supply security. The only practical alternative to these strategies for dealing with a deep return to drought conditions would be Level IV/V restrictions and these would begin to be triggered ahead of, and with far greater likelihood than, the desalination alternative. In addition, the amount of savings that would be achieved by Level IV/V restrictions is uncertain, in contrast to the more certain volumes that would be produced by groundwater and particularly by a desalination plant.

Recycling beyond measures already underway offers very little scope for mitigating risks associated with the current drought. After this drought breaks, and as more recycling is introduced to the system, the greater share of recycling is likely to have the effect of reducing the risk-weighted cost of groundwater and desalination strategies (by reducing the probability that storages fall to trigger levels) and this capability will appropriately be factored into the detailed planning and determination of the appropriate rate of extension of recycling.

7. Planning Instruments – on-going demand and growth

This section explores the planning instruments that would be used to address both current and future 'growth water' needs within an adaptive management strategy.

Several issues require on-going investigation to ensure that an adaptive management strategy is ready to respond to meeting the supply-demand balance in a changing environment, including meeting the need for growth water. Growth water is additional water that is needed to supply Sydney's growing population and to protect river health. Since approximately 1980, demand has been relatively constant despite increased population in Sydney, due to land use change and demand reduction measures that have reduced per capita demand. Beyond 2015, depending on the level of technological innovation, it is plausible to consider that the efficiency savings achieved through, for example, water efficient appliances will be approaching their current economic limit for reducing per capita consumption. Consequently, as population grows and river health needs are addressed, an adaptive management strategy must be able to plan for an increased demand from supply storages or further demand reductions in order to continue to meet the supply-demand balance.

7.1. Maintaining existing savings from demand management and recycling

The first priority to position Sydney for meeting the supply-demand balance in the longer term is to create effective monitoring, reporting and accountability for delivering the projected savings from demand reduction initiatives and recycling. This is particularly necessary for programs such as BASIX, the Water Savings Fund and Water Saving Action Plans where savings in the field are yet to be evaluated. Potential changes to institutional arrangements to ensure delivery of the projected savings are discussed in Section 8.

In addition, further demand management and recycling options should be explored as discussed in Section 7.5.

7.2. Optimising restriction regime

In comparison with the Metropolitan Water Plan 2004, two of the most significant factors to have changed are the removal of Level IV and Level V restrictions and the inclusion of desalination and groundwater readiness into the supply mix. Level IV and Level V restrictions, although never invoked, were an available instrument for significantly restricting demand in times of drought. Effectively, these deep restrictions have been removed and replaced with desalination readiness as a strategy to guarantee security of supply. As a result, the current restrictions regime that we are left with needs to be reviewed in consultation with the community, to update and optimise the rules to take into account:

- desalination and groundwater readiness;
- measures to ensure ongoing outdoor water saving behaviours when the current drought ends; and

- potential demand hardening, e.g. through the adoption of permanent water saving measures / behaviours, particularly for outdoor water use.

The extent of the work to optimise the restrictions regime should consider:

- a) the depth of each level of restrictions, including the potential to impose a deeper restriction than the current Level III in times of severe drought; and
- b) guides to trigger levels for restrictions, i.e. the percentage of system storage at which they are invoked and at which they are lifted.

As part of an adaptive management strategy, it would be sensible not to indefinitely fix a new set of rules for restrictions, but to establish a review process (e.g. every five years) that reflects the diversity of the supply and demand options that are in place at the time.

Further, it is worth highlighting the willingness of the community to accept some responsibility for meeting Sydney's supply-demand balance in times of drought and its current willingness to accept restrictions. Further investigations into both the cost of restrictions and the community's willingness to accept them would be necessary decision making factors for an optimised restrictions regime.

This section has discussed the restrictions regime in terms of the depth and trigger levels. Section 7.3 looks at the related question of the acceptable frequency of restrictions and the effect this has on the water that can be drawn safely from system storages.

7.3. Changing operating criteria — reliability

As outlined in Section 2, there are two main rules that limit the amount of water that can be safely drawn from system storages when modelling available supply (the third rule regarding robustness is rarely the limiting rule):

- security (there must be a very low probability, 0.01%, of approaching emptiness in the dams, defined as reaching 5% of total system storages. This equates to only one month in 8,333 years); and
- reliability (with a reliability of 97%, this means that, *on average*, the system cannot be in restrictions for more than 3% of the time, which equates to 3.6 months every 10 years).

The same security criteria should continue to apply in future planning; however, there is room for the current reliability criterion to be reconsidered in response to the new operating environment.

Historically, there were two motivating factors for it being appropriate to set the reliability criterion at 3%:

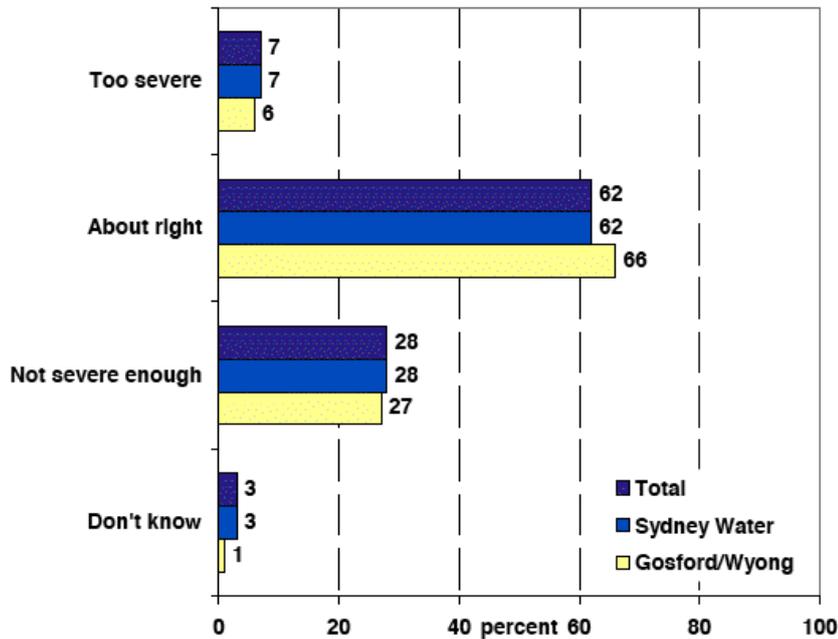
- a) without desalination readiness, running the water supply system in restrictions too often was considered 'uncertain territory' as there was uncertainty around achieving the projected demand reductions for the deeper level restrictions during a drought, in order to meet supply-demand balance.

- b) the cost to the community and perceived consumer willingness to accept a higher frequency of restrictions.

Sydney’s reliability criterion is higher than other Australian cities, however, point (a) above was particularly specific to Sydney which experiences rare but deep droughts and where there has been no readily available alternate water supply to supplement rain-fed supplies, compared to (say) Perth with groundwater availability and Adelaide with Murray River water. This led to a view of the importance of added caution.

As a result of desalination readiness, point (a) is no longer the dominant consideration, and the reliability criterion can be re-examined from the perspective of the cost to the community and their willingness to accept restrictions. Given this, comparisons with Melbourne, which has a 95% reliability criterion, are more relevant – reflecting the community's willingness to accept. The work of Taverner (2005) also shows strong support for restrictions in Sydney, as shown in Figure 9. Note that residents of Gosford-Wyong, who at the time of the survey had been in deeper restrictions for longer, also show strong support for restrictions. In addition, Gosford-Wyong has an even greater proportion of householders in single residential households more likely to be affected by restrictions than does Sydney.

Figure 9 - Community attitudes to restrictions (from Taverner 2005:p. 44)



The motivation for a focus on the option of changing the reliability criterion (in conjunction for example, with changing variables associated with the operation of the Shoalhaven transfers) is the large potential effect that it can have on water available from the supply systems which can be used to supply growth water (both for urban water and river health needs). This is shown in Figure 10.

Figure 10 - Water supply with changes to reliability criteria and Shoalhaven variables

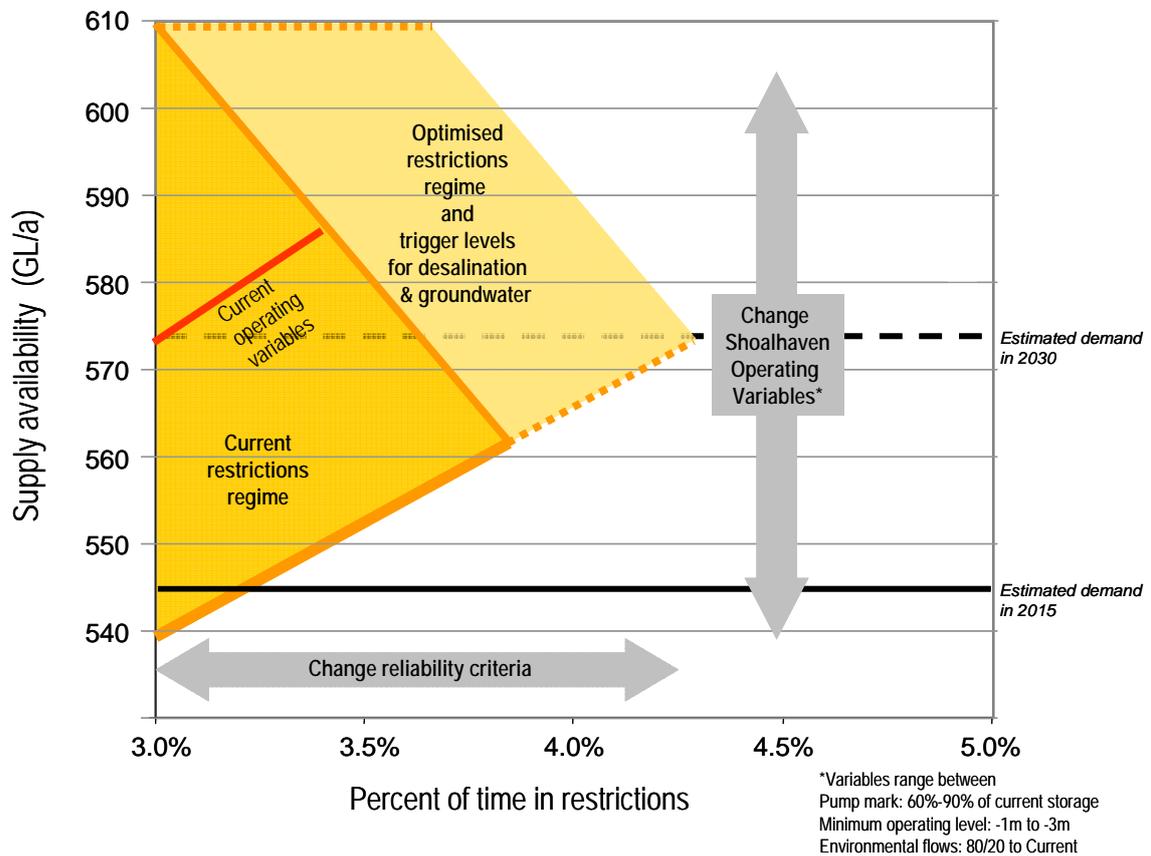


Figure 10 shows the effect of three sets of variables on the yield (supply availability):

- the reliability criterion;
- the restrictions regime together with trigger levels for desalination and groundwater;
- Shoalhaven operating variables.

Changing the reliability criterion can increase supply availability, but only up to a point whilst using the current restrictions regime. Only by optimising the restrictions regime together with groundwater and desalination trigger levels can the further benefits of changing the reliability criterion be fully realised. Another alternative for increasing supply availability is to change the Shoalhaven operating variables which is discussed further in Section 7.4.

In any case, changes to these three sets of variables (indicated by the shaded areas) have the potential to increase the supply availability to above the estimated demand in 2015 and also in 2030 (keeping in mind that, even with no changes to these variables, the supply-demand balance in 2015 is already met). Note that the estimated demand in 2030 indicated by the dashed line in Figure 10 is without

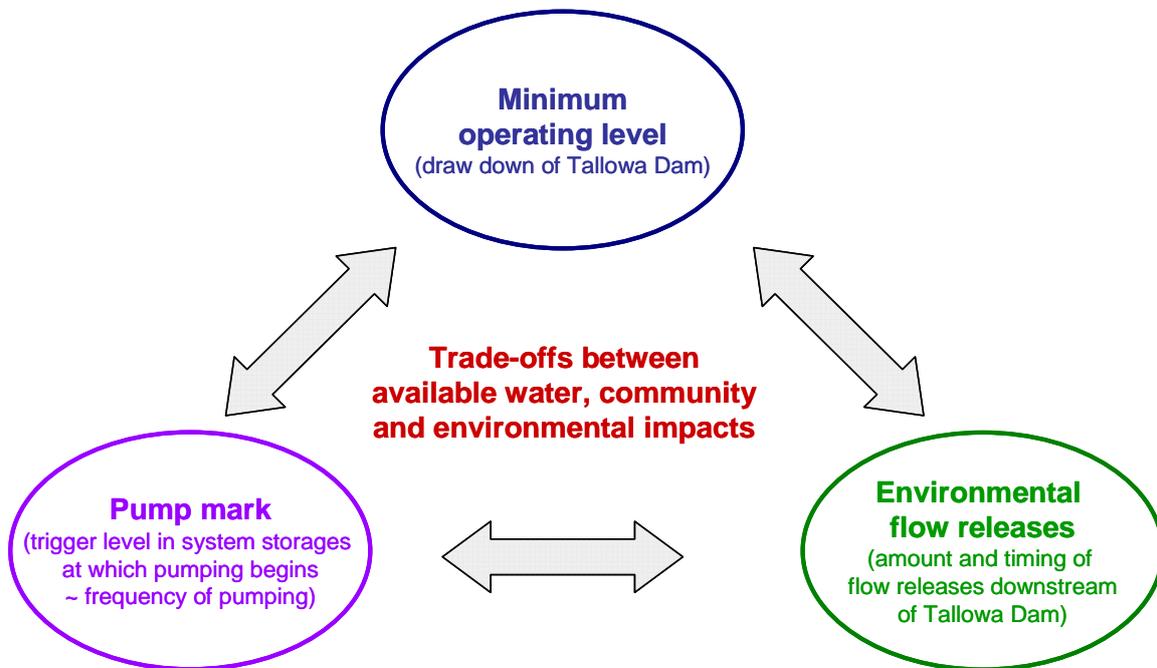
additional water being dedicated to Warragamba environmental flows, the details of which are yet to be decided.

7.4. Potential for increased Shoalhaven transfers

Increased Shoalhaven transfers are a further option to consider for meeting the demands of growth water – at relatively low unit cost – but with environmental and social impacts due to the impact of the transfers themselves (especially in the Wingecarribee) and the reduced downstream river flows, as well as the energy use for pumping and the associated increase in greenhouse gas emissions. Increasing transfers from the Shoalhaven increases greenhouse gas emissions by up to 250,000 tonnes/annum.

There are three variables that affect the amount of water that can be drawn from the Shoalhaven, and therefore the supply availability for the Sydney system, as shown in Figure 11. A more extensive set is listed in Section 2.2.

Figure 11 - Trade-offs between operating variables for Shoalhaven



Changing any one of these variables has an impact on different stakeholders. Technical studies and community consultation to determine the appropriate levels for these variables are currently being conducted, and the next stage of technical studies are due for completion by mid 2006.

The impact of changing these three variables is borne by different stakeholders. Increasing flow releases improves downstream water quality in the river and estuarine environment. Decreasing the magnitude of the MOL reduces the negative impact on landholders in the Kangaroo Valley due to level fluctuations in Lake Yarrunga. Increasing the transfers has an impact on landholders on the Wingecarribee and on the aquatic life and riverbank. Therefore these represent trade-offs that need

to be managed, and some of which can be mitigated, such as the transfer impacts which can be reduced through channelisation, and pipework.

In terms of the impact on supply availability, the ability to change these three variables means that a solution should be possible that provides increased environmental flows and reduced MOL, compensated for by increasing the pump mark, and thus resulting in no nett decrease in overall supply availability from the current situation, and potentially increasing the supply availability overall by up to 40GL/a.

7.5. Further options to meet future supply-demand balance

The further options to meet the future supply-demand balance have been grouped into three main areas: demand reduction initiatives, distributed infrastructure for new developments and indirect potable reuse.

7.5.1. Demand reduction initiatives

The programs and measures to reduce the demand for water implemented or approved in Sydney represent the largest of such programs in Australia and one of the largest in pro-rata terms in the world. A key strength of the suite of demand reduction initiatives is the fact that the savings are well characterised, and for many of the programs, have been the subject of monitoring and evaluation (Turner et al 2005). Another strength is that it is comprehensive, and covers all sectors (viz. residential, non-residential and system) and end uses (e.g. showers, outdoor water use, washing machines). This comprehensiveness means that, for several sectors and end uses, it is likely that the 'conservation potential' will be tapped to a significant degree by these measures.

For example, assuming that minimum performance standards for water using appliances including showerheads and clothes washers are introduced as proposed, this will mean that, over time, the least efficient stock will be replaced by more efficient stock, in the same way that this has occurred with toilets¹⁶. Nonetheless, there remains scope to optimise programs in order realise further cost-effective savings in those sectors targeted to date (e.g. the residential sector) and in sectors which have not yet been comprehensively targeted (e.g. the commercial sector). It will also be important to ensure that savings are maintained over time, and that highly cost-effective measures such as additional minimum performance standards continue to be implemented over time.

In particular, there are three important areas where further savings can be tapped in the near term. These are described below.

Point of sale water efficiency for residential dwellings

The first is in the area of improved efficiency of indoor water use in showers, taps and toilets that would not otherwise be picked up by the EDC Retrofit Program and

¹⁶ In the case of flush toilets, the introduction of the dual flush toilet in the 1980s and subsequent reductions in average flush volumes, means that today less than 40% of all existing stock in Sydney houses and businesses are single flush. This has resulted in a saving of over 25 GL/a compared to the base case of single flush only.

its extensions including Department of Housing (both of which target existing houses), the DIY Kits (also target existing houses) or the various forms of BASIX (which targets new houses and alterations and additions). An option is available to extend the 'reach' of the EDC Retrofit Program by incorporating a requirement to improve the efficiency of water using appliances (mainly showers, taps and toilets) at the time of property sale, which occurs on average every seven years.

The relative unit cost of this option would vary depending on how it was implemented. Estimates undertaken for the 2004 Metropolitan Water Plan (ISF & CIE 2004) indicate a savings potential of 5-10 GL/a, at a unit cost of 95¢–\$1.40/kL.

The regulatory impact of this program on vendors could be reduced by integrating it with the existing EDC retrofit program, thus providing financial support to vendors where improvements are required at time of sale. This would not alter the unit cost or savings potential, since both customer and utility/ government costs are included.

A range of possible options is also available for tapping the water savings potential in existing residences.

Commercial and industrial development consent conditions

The second option would operate in a similar way to BASIX, by requiring a minimum efficiency performance standard for new buildings and developments (commercial buildings, industrial enterprises) in the non-residential sector. This would be the last remaining sector and end use to be the subject of the water efficiency or recycling initiatives, and therefore the last remaining area of conservation potential.

Again, the unit cost of the option would vary depending on the way in which it was implemented. It could operate on the basis of requiring all developments over a certain size (value) to submit plans for review in terms of the proposed water using equipment and processes. It is worth noting that there are many processes and tools currently under development that will assist in this process. Many of the changes required to improve efficiency have a relatively low marginal cost, such that the benefits of regulating at the point of design and construction will significantly reduce the costs to the community relative to retrofitting through other programs at a later time.

The work undertaken for the 2004 Metropolitan Water Plan (ISF and CIE, 2004) indicate that the potential savings from this program would be 2.6 GL/a in 2011 and 5.4 GL/a in 2029, with a unit cost of approximately 23 ¢/kL.

Multi unit metering

As endorsed by the Auditor-General's report (The Audit Office of New South Wales, 2005) this option would install individual meters in new multi-unit buildings and developments with the intention of providing a price signal to residents. It is estimated that savings would be approximately 10% of average multi-unit usage. A savings potential of 5-10 GL/a is estimated. It would also be possible to retrofit existing buildings, but costs would be higher.

7.5.2. Distributed infrastructure for new developments

A number of novel approaches to urban water servicing which focus on smaller scale systems are now maturing in Australia and internationally. These approaches are based on water sensitive urban design and wastewater interceptor systems, maximising water efficiency, rainfall harvesting and wastewater recycling. Such approaches hold the promise of proving to be both cost effective, and of increasing the potential for water conservation and reuse in new development areas, both greenfield and infill.

Reconfiguring wastewater and stormwater infrastructures could see smaller, community scale, systems designed around a site's water cycle. Such systems do not require new developments to be within easy access of an existing STP for recycling to occur.

As Lens *et al.* (2001) state, "each situation is unique and has its own optimum solution and optimum scale for that solution". Similarly, Pinkham (1999) has argued that, in a resource-limited and increasingly complex urban environment, a multiplicity of appropriate solutions will be required.

The potential for reducing costs while promoting sustainable management of water resources requires further analysis, together with assessment of the existing barriers to small-scale systems providing urban water infrastructures.

7.5.3. Indirect potable reuse

Indirect potable reuse involves the treatment of recycled effluent to a high level, followed by discharging into the water supply system, in most instances into major storages, such as Warragamba Dam. This option has, at various times since 1990, been analysed and costed but has not proceeded to full feasibility study. Indirect potable reuse is carried out in Windhoek, Namibia and in Singapore to varying extents.

Prior to any decision to proceed down this path, there would be a need to ensure that the public health and community acceptance issues had been fully addressed. This would include a close monitoring of the emerging international experience, and a process to engage the community in the decision making process on this issue, preferably in an informed and deliberative way. There are cost advantages associated with indirect potable reuse relative to the use of dual reticulation (third pipe systems) due to the decreased cost of reticulation and the increased 'yield' of the end uses that can be met. However, it is possible that the type of distributed infrastructure (localised treatment and reuse, including rainwater harvesting in new developments) described in Section 7.5.2 will provide a cost and yield advantage relative to dual reticulation before indirect potable reuse became available as a supply option.

8. Institutional arrangements

8.1. *Rationale for change*

A range of developments combines to suggest strongly that an integral part of the future strategy should incorporate important changes to the institutional arrangements for future water planning, approval and accountability. These developments include emerging trends in the ways in which Sydney's water and wastewater management needs are being met, specific decisions already taken by Government and further strategy developments indicated by our analysis.

The following points outline the key issues lying behind this assessment. A discussion of possible approaches follows.

Source diversification & demand management trends – accountability vs. control

With increasing diversification in the supply and demand mix – recycling, roof tanks, desalination readiness – and with a broad base of demand management measures being rolled out, SCA controls a decreasing share of the assets that underpin supply security, and a decreasing share of the range of instruments likely to be used to address supply security concerns in the future.

- This alone raises questions as to whether SCA controls, and in the future will control, enough of the 'levers' for matching supply to demand to continue to assume primary responsibility, under its operating licence, for system security.
- This is not simply a volume question – for a long time to come, the dams operated by the SCA will supply the overwhelming majority of Sydney's water supply. However, effectively, those dams will be fed substantially by the demand management and source diversification strategies as well as by rainfall. In addition, the availability of water for safe supply will be supported substantially by desalination and groundwater readiness even if these have not been constructed.

Need for coordinated response across agencies

Given the decision to locate operational responsibility for some demand management programs and for implementation and operation of the desalination strategy with Sydney Water, Sydney Water in combination with SCA would control a significant proportion of the instruments – though not all.

- Together, they may be able to take responsibility for the residual security of the system, but there may arise circumstances in which decisions that they may take alone would not provide the optimal outcome from a whole system or portfolio perspective. At worst this could 'lock-in' high cost solutions to the detriment of smaller scale alternatives.
 - Major capital works are currently dealt with at Cabinet level in any case, however, this strengthens the case for having a coordinating body ensure that decisions taken are consistent with an optimal outcome from a portfolio perspective. This body could also oversee the introduction of any incentives for third party access to the system, and any future competitive entry into

water markets (in both the supply of services and in the development of innovative strategies that can contribute to a more cost effective and secure overall system).

- In the context of an on-going adaptive management strategy, even the decision that Sydney Water should have responsibility for implementation and operation of the desalination strategy should be subject to periodic review.
 - It is possible that – with increasing market maturity and with the development of more innovative instruments for allowing the outsourcing of services even where the frequency and even pattern of operation is not firm – this decision could usefully be revisited in advance of the need to invest in desalination being triggered. It is quite plausible that it will be many years before that trigger point is reached.

Demand reduction target

Sydney Water currently has an operating licence target to reduce demand from storages to 329 litres per person per day by 2011. Sydney Water has historically had control over the majority of the programs designed to contribute to reaching this target, including leakage detection and repair, pressure management, the residential retrofitting program, and the Every Drop Counts Business program and some large scale recycling projects. In the last two years, this has changed significantly to a situation where a significant proportion of the programs required to meet the target are the responsibility of other agencies, including DEUS and the Department of Planning.

This means that additional effort will be needed to ensure coordination and monitoring of these programs, and particularly to ensure that the programs are rolled out in an optimal manner, without duplication of effort. This is particularly important where programs are aimed at the same sector, such as the Every Drop Counts Business Program administered by Sydney Water, and the Water Savings Fund and Water Saving Action Plans administered by DEUS. These issues are also discussed in Section 3.3.

Need to effect high-level trade-offs across the community

Almost certainly, for many years to come sound security and reliability planning will entail complex trade-offs that will need to be made at a whole of system level, in respect of quite subjective values:

- Trade-offs between frequency and depth of restrictions against other forms of demand management and against system supply-side management through supply augmentation with associated potential for environmental impacts.
- Trade-offs between water pricing and conservation measures and the likelihood and expected cost of triggering desalination.

Reliability targets have long been built into utility operating licences, but any review of these targets – with an ongoing reassessment as their cost changes or as alternative approaches become available – would seem most appropriately the function of a wider Government process.

Community engagement

The tradeoffs that are outlined above are issues that should appropriately be subject to the input of a cross-section of citizens, in a deliberative process that provides considerable information and an opportunity to wrestle with its complexity. There is a growing body of experience in the effective use of innovative approaches to community engagement that can allow this deliberation to happen amongst a representative sample of citizens (Carson and Gelber 2001, Fung and Wright, 2002, Gastil and Levine 2005). There is a key role for a 'process champion', a body or responsible agency that can ensure that participatory processes are implemented and appropriately designed. With careful design, and appropriate application, these processes have great potential to help build consensus and to provide more robust and lasting decisions, especially when integrated with and informed by other decision-making tools and processes such as least system cost analysis, environmental assessment and the like. Further, an agency can have considerable confidence that the final decision is one that has enhanced legitimacy in the eyes of the public.

Role of IPART and environmental regulation

Moving to an adaptive management regime involves the maintenance of 'readiness options' coupled with continual review of the mix of environmental, reliability and other regulatory settings, alongside service pricing arrangements, and periodic updating of the operating regime in the light of new information. Such an approach will pose particular challenges and opportunities for the economic and price regulation function of IPART.

- While these requirements can probably be accommodated within the powers of the current Act, it will almost certainly require some significant changes to procedures, time horizons etc to ensure both:
 - That the less deterministic nature of the planning process is not abused as a basis for introducing unnecessary or inefficient costs – when the purpose of the adaptive management is to deliver lower cost ways of meeting the supply and demand requirements and
 - That the pricing and cost-recovery arrangements in this less certain environment do not unnecessarily discourage efficient investments, especially in readiness options and other instruments that may allow the avoidance of very large infrastructure costs.
- It seems highly likely that joint consideration of the costs and benefits of different environmental standards alongside the costs and benefits of different forms of infrastructure investment and system operation would allow for the discovery of more cost effective ways of balancing the complex demands on the supply and wastewater management systems.
 - It is possible that the IPART assessment process could therefore usefully be better integrated with the environmental regulation process – providing feedback and shadow pricing of restrictions to the environmental regulator and allowing for joint determination of pricing and regulatory settings.

8.2. Possible responses

We have not attempted here to map out in detail alternative institutional arrangements. There is a range of possible models and the decision will need to emerge from detailed deliberations within Government. However, the following observations and guidance are provided.

First, it is important to recognise that in the course of the present drought, responsibility for system security has effectively been vested in a senior level interagency committee (Drought Executive Committee), activated in accordance with previously agreed drought management plans, which provides advice to Cabinet regarding matters requiring decisions. Planning for the drought and beyond has been centrally coordinated by the Cabinet Office and has relied heavily on cross agency analysis and planning, commissioning specific strategy assessments (including the present one) and extensive work by Sydney Water and SCA to validate and inform the process and to develop and assess options. The process has included regular briefings and feedback from the CEOs of all relevant agencies (Government departments as well as utilities).

This approach represents one model that would address many of the above issues. A possible difficulty lies in the likelihood that, once the drought breaks and restrictions have been lifted, the priority of this activity will fall. It will be important to maintain and even build the hydrology and demand modelling capabilities that have been built up within Sydney Water and the SCA.

It would also seem crucial that there be an on-going audit and accountability function that operates at a higher level. IPART may have some capacity to test proposals for overall cost effectiveness, but periodic engagement with a group representative of the wider interests would seem necessary. It will also be important that this group have access to the ability to probe the analyses for reasonableness and to challenge any strategy recommendations that are emerging. This probing should address unnecessary constraints on the development of competition as well as opportunities for other solutions.

As long as water in storage is around planned normal levels, the demand is tracking as anticipated, and as long as there are no major strategic applications to modify the system – for example through an application for substantial system access from a third party – then the high level process may well be needed quite rarely. Perhaps a periodic process to review and audit a status report prepared with input from relevant agencies and utilities could suffice. However, the higher level process would need to be triggered by major changes in short-term supply security, or by prospective system changes that could have longer-term implications for either the security or the cost effectiveness of the system.

8.3. Comments on planning objectives

The present study and its conclusions have been predicated on the assumption that the objective of the water planning process is to deliver, at the lowest social cost, a strategy for ensuring that Sydney's water demand can safely be met. The uncertainty inherent in both demand and hydrology, and the requirements of sensible adaptive

management, mean that least cost should be interpreted as a risk-weighted cost. Social cost logically incorporates agency costs, user costs and wider costs associated with environmental and public health impacts. This approach is consistent with the approach taken in the Metropolitan Water Plan 2004, but with the addition of risk-weighted costs for the readiness strategies.

Traditionally, the idea of 'safely' meeting Sydney's water demand has been interpreted as implying a very high level of security against approaching emptiness in the dams (i.e. less than 5% of total storage) – only one month in a period of 8333 years can approach emptiness based on detailed hydrology simulations. For reasons outlined earlier, dam-based supply strategies were never able to offer absolute security, though the willingness to impose drought restrictions of escalating severity has enabled very high security to be delivered. This is evident in the fact that none of the three very deep droughts so far recorded would have dropped available water below 30 percent of capacity under the supply and demand management practices used in the most recent/current drought.

In practice, this standard has been predicated on assuming that the last 100 years of recorded rainfall patterns are reflective of the same underlying statistical propensities as those that will apply in the future – and that the underlying modelling of these statistical propensities is highly accurate. On the first point, concerns for climate change, and even the very different rainfall patterns between the first and the last halves of the 20th century mean that some caution is needed here. On the second point, it is appropriate to recognise that simulating stochastic processes of this kind can be done with great care, and can be highly accurate most of the time – but this type of modelling is most vulnerable in its ability to predict the extreme tail behaviours of the process. In other words, the scope for error is greatest in forecasting the frequency and intensity of the extreme floods and droughts, these being the events least represented in the available rainfall history. This has always implied a limitation on the scope for delivering absolute security unless a strategy is followed that almost certainly entails massive over-investment.

In principle, substantial diversification away from direct rain-fed sources, backed up by drought-based restrictions and desalination and groundwater readiness during an extremely deep drought, can overcome this traditional constraint. For reasons set out earlier, it is still cost effective to use a range of other demand management measures, but supply can in principle be secured without requiring massive over-investment, at least until such time as dams have dropped to very low levels.

This does not mean, however, that the cost of some of the source diversification measures – including large-scale recycling and roof tanks, such as those installed under BASIX arrangements – is not high. The high cost of these measures, especially as they are extended further, provides the basis on which an economic balance can be struck between these measures, the risks of triggering desalination and the extent of use of high cost measures to reduce demand, such as recycling and rainwater tanks.

In respect of reliability, a related approach has traditionally been used. SCA has long been required as part of its operating licence to plan to deliver supply without any drought-based restrictions on usage at least 97 percent of the time. The figure of 97 percent is inherently subjective and has at no time been determined on cost-

benefit grounds. The comparable figure in Melbourne and the ACT is 95 percent and the basis for the higher figure in Sydney relates to the variability of rainfall, and the historic lack of access to other sources than rain fed supply.

The removal of Level IV and V restrictions in light of the groundwater and desalination readiness strategies means in reality that the reliability of supply has been increased, even if drought-based restrictions still apply 3 percent of the time. This suggests some scope for trading between frequency and depth of restrictions, at no increase in social cost. This possibility has been raised and discussed earlier in Section 7.

In terms of planning objectives, we are of the view that the reliability level should not be locked in as a constraint on a long-term basis. With changing technological options – such as those now revealed by the desalination readiness strategy – and with increasing adoption of water efficient technologies etc, the most cost-effective level at which to pitch any reliability target will naturally move. A harder problem is to determine what the cost effective level is now and into the near future. Realistically, it will not be possible to make a reliable assessment of this until the current drought restrictions are eased and it is possible to track new demand levels. A natural function of the early planning will be to develop a better assessment of the cost of restrictions in the new environment – and to review the reliability policy after that.

Similar comments apply to environmental and other regulatory requirements. The cost of complying with environmental regulations will change as the system structure changes. It may well become cost effective to strengthen some environmental objectives because compliance costs have fallen – for example, because of source diversification. If a least system cost paradigm is to be used, then it will carry with it the need for periodic reassessment of the trade-offs involved in setting the entire range of restrictions and incentives.

Some people may feel uncomfortable with the notion of addressing trade-offs between the environment and consumptive uses and wastewater discharge. The fact is, though, that these trade-offs are already in place. River flows have been dramatically altered, nutrient discharge is occurring on a wide scale. Until relatively recently, an additional dam was part of the forward planning. More recent developments have allowed the dam to be removed from the forward supply strategy. Recycling and agricultural reuse will offer scope for favourably altering the economics of nutrient reduction and this is an opportunity for the community.

Against this backdrop, we are suggesting a relatively unconstrained planning objective, designed to deliver the greatest value to the community across all dimensions of water supply, wastewater management and environmental management. While formal constraints on strategy will almost certainly remain key elements of short-term planning, the level and form of any such constraints would seem sensibly amenable to change should the analysis suggest a higher value system solution could be delivered with such change.

9. Summary of future investigations and works

A range of studies and actions, either currently underway or proposed as part of this Review, will be needed to ensure that Sydney's water supply is secured into the future. In the case of the further studies and investigations, these will help to refine and improve understanding of key parameters, and in the case of capital works and program implementation, these actions represent necessary components of maintaining the supply-demand balance.

This Section provides details on this range of actions and strategies and is split into four sub-sections: current investigations, program implementation and capital works, new investigations, and coordination, monitoring and evaluation.

9.1. Current investigations

The following studies are currently being undertaken or have been commissioned by the agencies specified.

9.1.1. Climate studies

There are four key climate change studies underway, commissioned by the SCA, which will contribute further understanding to an appropriate response as part of an adaptive management strategy. These studies are to be completed over the next one to three years.

Project 1: Climate Forecasting - Multi-site Probabilistic Forecasting for the SCA Water Supply Catchments and its use in Reservoir Operations (UNSW)

The proposed research consists of two related parts: (a) formulating a model that issues meaningful probabilistic forecasts at multiple locations within the catchment and at time-scales of relevance to the operation of the system, and (b) evaluating forecast performance in the context of water resources management, so as to allow development of operational strategies that are structured to best utilise the multi-site probabilistic forecasts.

Project 2: Methods of forecasting SCA inflows on multiple timescales using simple indices of climate (University of Newcastle)

The project aim is to assess a range of methodologies in the prediction of SCA reservoir inflows. Specifically, this project will build on recent research insights into the role of different modes of climate variability in dictating reservoir inflows at multiple locations and on multiple timescales. A predictive model of future expected inflows will be developed - this will enable probabilistic forecast of variables at seasonal through to multi-decadal time scales. Importantly, this model may be evaluated with regard to seasonal-interannual climate variability over the period of the research.

This research aims to build on recently developed insights into El Niño Southern Oscillation (ENSO) and IPO (Interdecadal Pacific Oscillation) controls on East Australian climate.

Project 3: Derivation of long-term hydroclimatic sequences for water resources engineering, management and planning. (University of Newcastle)

The SCA has commissioned Dr Stewart Franks of the University of Newcastle to undertake a research project entitled: Hydroclimatic sequences (isotopic analysis of limestone cave deposits). This project aims to extend the hydrological data from the Warragamba catchment over 1000 years, in order to improve our understanding of long-term climate variability in the region. Flood history will be recreated through the investigation of floodplain sediments and drought history will be recreated by isotopic analysis of stalagmites at Wombeyan caves. Findings from this research are expected to be available in 2009.

Project 4: A Stochastic downscaling framework for catchment scale climate change impact assessment (UNSW)

The study aims to develop a framework for climate change impact assessment at the catchment scale through the following methodologies:

- simulating the likely rainfall at the catchment-scale, based on climate change simulations;
- simulating catchment runoff based on the simulated rainfall scenario; and
- assessing the full uncertainty associated with downscaled stream flows.

Project 5: Climate change and its impact on water supply and demand in Sydney

To further improve understanding, the NSW Government has commissioned a study to examine the potential impacts of climate change on both water supply and demand across the whole of Sydney. The study will produce estimates of the potential impacts of climate change on water availability and projected water demand in 2030 and beyond. Contributors to the study include CSIRO, the University of New South Wales, Sydney Catchment Authority, Sydney Water Corporation, the Australian Greenhouse Office and the NSW Greenhouse Office. The results from this study will be available in two to three years time and will inform future iterations of the Metropolitan Water Plan.

9.1.2. Shoalhaven environmental flows and operating rules

Technical studies that will investigate the environmental consequences of different operating rules and environmental flows will be complete by mid 2006. Several variables will be investigated including environmental flow regimes, minimum operating level and transfer regimes/pump mark. Community consultation regarding these issues will also take place (see also Section 9.4.2).

9.1.3. Groundwater availability

Studies commissioned following the 2004 Metropolitan Water Plan are investigating the availability of groundwater in the Sydney region, and its potential contribution to Sydney's water supply availability during drought.

An initial study of seven priority sites will be completed in June 2006. Additional studies on Kangaloon will also be completed in June 2006 and further studies on Leonay will be completed later in 2006.

9.1.4. Reference case (baseline) demand

A study is currently being completed, which represents Stage 2 of a process of recalibration and updating of the Sydney Water End Use Model. This is used to provide a forecast of demand for water in Sydney, based on projected changes in land use, particularly urban consolidation, demographic changes (population, household occupancy), sectoral changes (commercial, industrial) and appliance changes (e.g. changing efficiency of toilets, washing machines). Currently the baseline demand used for modelling purposes and in this review is assumed to be 426 litres per person per day, and is not based on a disaggregation of demand. The results of this study should be incorporated in the demand forecast.

In addition to this Study, Sydney Water has recently called tenders for a major study aimed at analysing a considerable volume of residential customer demand data, relative to demographic, climate and land use variables. This Study may also provide more detailed insight into the impact of these variables on demand, and allow improved forecasts.

9.2. Program implementation or capital works

Several programs are being implemented and developed that will underpin Sydney meeting its supply-demand balance into the future - in particular desalination readiness and then a range of demand management and recycling programs.

9.2.1. Establish and maintain desalination readiness

Desalination readiness is a significant component of the mix of supply options that helps underpin Sydney's ability to meet supply-demand balance into the future through an adaptive management response. Full desalination readiness will occur later in 2006 (when design blueprints are finalised etc) and then on-going maintenance of the readiness will be required.

Over the next 10 years Sydney Water expects the approximate cost to be between \$7 million to \$12 million (in present value terms). The annual expenditures may vary between \$0.3m/ year to \$3.5 million/year.

These costs include the rates and maintenance of the site at Kurnell, maintaining a watching brief on changes in technology (water treatment and construction) and periodically updating the Blueprint design.

9.2.2. Implement demand management and recycling programs

Demand management programs for BASIX, WELS, indoor and outdoor residential as well as for leakage / pressure reduction and the non-residential sectors will continue to be implemented. It is essential that the implementation of these programs be monitored and evaluated to enable their savings to be measured and the programs to be modified or adjusted if necessary to deliver the projected savings. This applies particularly to BASIX, the non-residential sector programs and residential outdoor sector.

Recycling programs committed in the February 2006 Progress Report will involve significant capital works as part of their implementation, including several local projects and the Western Sydney Recycled Water Initiative. The completion of the

flow substitution component of the WSRWI is scheduled for 2009, which will coincide with the planned commencement of Upper Nepean environmental flow releases.

9.3. New investigations

This Review has proposed that the following investigations take place. In some instances, these proposals are an extension of existing studies or activities.

9.3.1. Reliability criterion and restrictions

The water available from system storages is directly affected by the reliability criterion (frequency of restrictions) as well as the form of the drought restrictions regime, namely the number of restriction levels, the trigger levels when they apply and how much water they are designed to save.

Several recent changes to the operating environment make the case for a detailed investigation of optimising drought restrictions and the reliability criterion:

- the removal of Level IV and Level V restrictions which has significantly reduced the water which is able to be safely drawn from system storages;
- the remaining regime, comprising Level I, II, III restrictions, should be optimised given the introduction of desalination readiness as a means of supplying water during severe drought; and
- the need to investigate any drought hardening effects associated with the introduction of ongoing outdoor water saving measures.

9.3.2. Trigger levels for desalination and groundwater

The trigger levels for desalination and groundwater should be optimised for minimum cost whilst maintaining their ability to provide security of supply during a severe drought. The optimum trigger level will change through time as the mix of elements in the supply-demand balance changes through time (for example if more groundwater is discovered or if technology improvements mean that lead times can be shortened). Consequently, the optimal trigger levels should be re-examined periodically (for example every 5 years).

9.3.3. Improved environmental valuation techniques

It will also be important to develop improved environmental valuation techniques in order to allow consistent analysis of various supply and demand side options. This will facilitate informed deliberations and decisions about necessary trade-offs, such that the overall portfolio of measures is able to minimise both economic and environmental costs.

9.4. Coordination, community engagement, monitoring and evaluation

To date, the most effective way to coordinate, monitor savings and evaluate programs has received limited attention. This is an essential component of successfully delivering an adaptive management strategy.

9.4.1. Coordination of adaptive management strategy

The importance for a strong coordinating role to oversee the adaptive management strategy was discussed under institutional arrangements. The form that this coordination role itself takes should be subject to periodic review.

9.4.2. Community engagement

Community engagement is an essential part of evaluating the effectiveness of implemented programs and to provide input toward resolving tradeoffs, for example regarding the mix of operating variables that determine Shoalhaven transfers. The community should also be engaged when assessing costs and willingness to embrace restrictions.

9.4.3. Monitoring and evaluating program outcomes

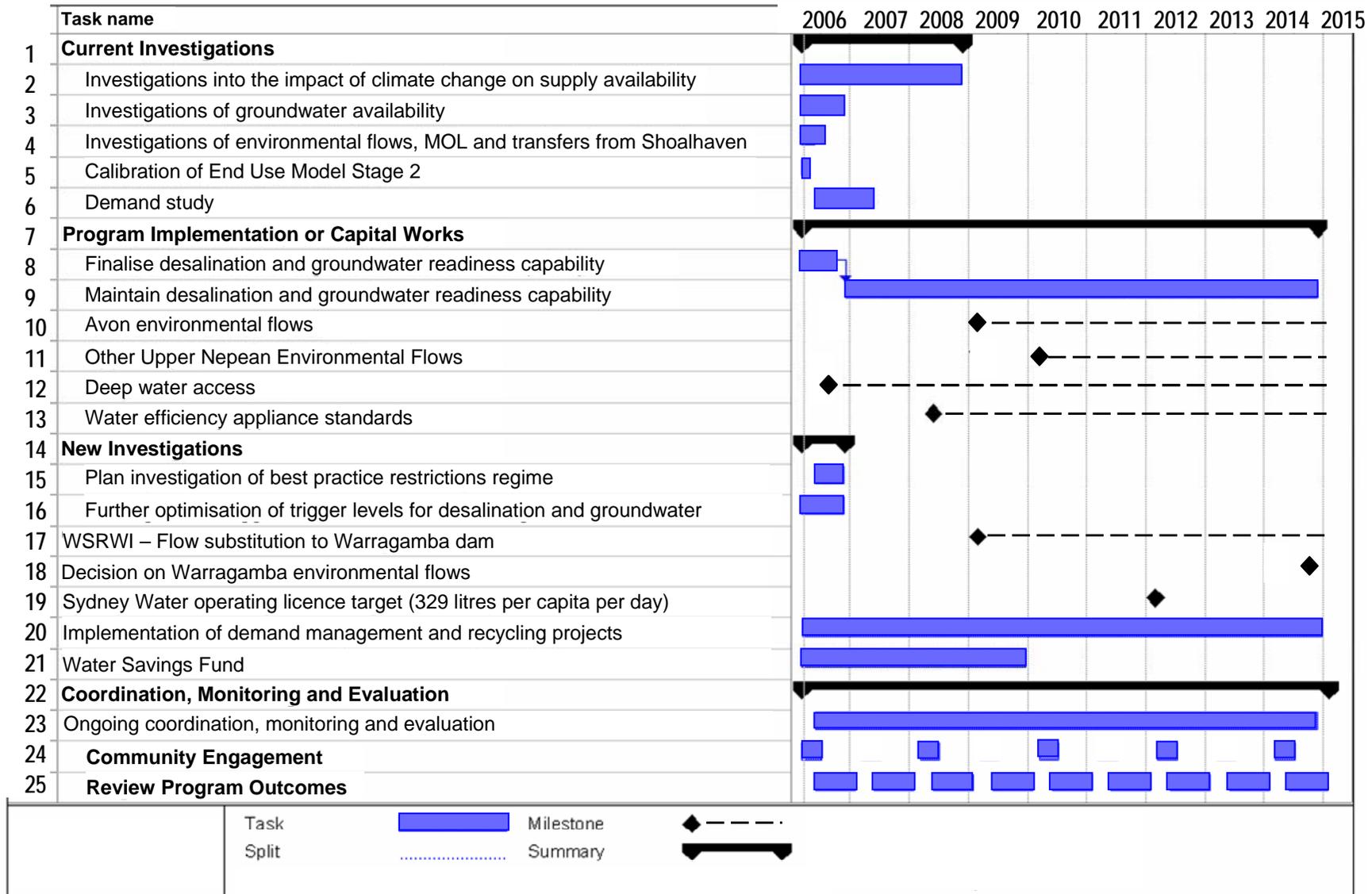
For all existing and future demand reduction initiatives, a monitoring and evaluation procedure should be established. This would evaluate savings in the field and provide feedback on the program. Early feedback is important for two reasons:

- strategically for the coordinating authority to assess savings achieved and the impact on supply-demand balance and any further response required as part of an adaptive management strategy; and
- operationally to the authority responsible for delivering the program in order to improve the program to ensure it delivers the savings as projected.

9.5. Plan of works

Table 3 overleaf shows a work plan of tasks and times that will be useful in monitoring the progress of essential elements to be undertaken to deliver a successful adaptive management strategy.

Table 3 - Plan of works for adaptive management strategy



10. Overall findings

The analysis in this report indicates that the supply-demand balance in Sydney will be met through the current drought and to 2015, and that Sydney now has the capacity to secure its water needs against the risk of severe drought to 2015 and beyond. This is based on the expected impact of demand reduction and recycling initiatives already in place and new initiatives announced by the Government in February 2006, and new supply-side measures that include access to deep water from system storages, plus the addition of desalination and groundwater readiness to the supply system.

The ability to develop groundwater and desalination capacity in a relatively short time reinforces the adaptive approach to meeting the supply-demand balance. This adaptive approach will allow for re-evaluation of how best to meet the supply-demand balance (e.g. every five years), contrasting with the traditional planning approach which sought to build dam capacity large enough to give a supply surplus that would cope with all eventualities. The benefit of an adaptive approach is that security of water supply can be achieved at a lower cost by not investing in new large capital infrastructure until required. Actual future demand for water will depend on changing demographic, technological and behavioural factors. The diversity of response options available means the adaptive management strategy can effectively respond to future droughts, the potential for climate change, and future increases in demand.

Being able to meet the supply-demand balance until 2015 will be underpinned by the implementation of current and newly committed demand management and recycling measures, the largest programs in Australia. Such programs allow for returning water to rivers for environmental flows in the Avon and Upper Nepean.

A key challenge for the future is maintaining the commitment to adequate investment in demand management programs, recycling, and desalination and groundwater readiness, particularly as storages return to pre-drought levels. Structured processes for monitoring and evaluation of water efficiency and recycling programs must be established. This will reduce the uncertainty of projected savings and enable programs to be modified where necessary to achieve target savings. Further investigations should also be undertaken to reflect more accurately the reference case or base case unrestricted demand using an end-use approach.

Revised institutional arrangements are required that provide an effective central planning and coordination role for planning to maintain the supply-demand balance, and to oversee follow up work arising from this review. They would also establish robust and timely processes for monitoring and evaluating savings achieved from demand reduction programs.

By 2015, decisions will need to be made regarding the implementation and magnitude of environmental flow releases from Warragamba Dam. Based on current estimates, this could result in a supply-demand deficit, depending on the level of flows, and the underlying demand at that time. A plausible flow regime could reduce supply availability by approximately 80 GL/a, or a nett amount of approximately

50 GL/a after flow substitution from the proposed Western Sydney Water Recycling Initiative is taken into account.

This potential deficit of 50 GL/a needs to be considered in light of the 30 GL/a surplus that is estimated to be available in 2015 as a result of the existing mix of supply and demand side measures. This surplus may be considerably larger, if it is found that per capita demand estimates used in this review are unduly conservative, potentially increasing the size of the surplus by a further 40 GL/a. In addition, this report has highlighted a number of measures that could further contribute to the supply-demand balance and address any deficit that arises - such as revising the reliability criterion and increasing transfers from the Shoalhaven.

Key areas for further investigation to ensure the effective delivery of an adaptive strategy include:

- optimising the reliability criterion (frequency of restrictions) and restrictions regime (trigger levels and expected savings), including the potential for demand hardening;
- investigating impacts and operational requirements for increased Shoalhaven transfers in consultation with the community;
- incorporating the findings of studies that are currently underway to assess the influence of climate change on supply availability and water demand;
- further investigating the appropriate trigger levels for desalination construction and groundwater supply, in particular reducing the potential time to construct a desalination plant as newer technologies become available; and
- implementation of an ongoing strategy for community engagement to ascertain citizen preferences in relation to key strategic decisions.

Overall this review provides a positive outlook for Sydney's future supply-demand balance. However, new resources, investigations and institutional arrangements are required to sustain the adaptive management approach.

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Glossary and acronyms

BASIX: Building Sustainability Index, a flexible regulatory tool for achieving water and energy savings in new houses, apartments and residential alterations and additions.

Conservation potential: a practical maximum amount of water that could be expected to be saved in a sector, may also be expressed as a percentage of water use in that sector

Desalination readiness: The ability, in terms of resources and technical feasibility, to construct a desalination plant within 26 months.

DEUS: Department of Energy, Utilities and Sustainability. Responsible for administering the Water Savings Fund and Water Savings Action Plans.

Drought restrictions: A set of mandatory rules for water use with the purpose of constraining water consumption.

End use: the specific use to which supplied water is put, for example, toilet flushing, showering, watering the garden

Environmental flow releases: Purposely released flows of water which restore or maintain river health. The environmental flow regime is commonly expressed in terms of a fraction, for example 90/20. In this case, '20' is the percentage of flow that is released continuously, and '90' is the critical percentile at which all flows are released.

Minimum Operating Level: The level below the top of the dam at which water extractions should cease. It is expressed as a negative number, with the zero point taken as the top of the dam. Used with reference to Tallowa pumping, it is a key Shoalhaven operating variable (along with pump mark and environmental flow releases)

Pump mark: The level in system storages at which Shoalhaven Transfers Pumping begins

Reliability: The system operating criterion that states the average time with which the system can be operated in restrictions (currently 3% = 3.6 months in 10 years)

Sector: Total water usage may be broken down by sector, for example, residential, non-residential, system losses. In this report the residential sector is further split into indoor and outdoor.

Security: The system operating criterion that has a very low probability of dams approaching emptiness (less than 5% of total storage). That is in a period of 8,333 years, only in one month should the combined level of storages approach emptiness.

Trigger level: Expressed as a percentage, this is the level of storage at which alternative supply options are invoked, such as desalination or groundwater abstraction.

Appendix A: Supply Availability

This Appendix provides a further description of factors that influence supply availability.

| Factor | Description |
|--|---|
| Reliability criterion | This represents the percentage of time that customers will be required to be in restrictions, <i>on average</i> . Currently this is 3% of the time, <i>on average</i> , or for example, 3.6 months in 10 years, reflecting '97% reliability'. The supply availability is very sensitive to this factor. |
| Trigger levels for restrictions | This is the point at which the different restriction levels are triggered in terms of total system capacity. At present the trigger for Levels I, II and III restrictions are 55%, 45% and 40% respectively. Increasing the trigger levels can increase the supply availability but reduces the reliability by triggering restrictions more often, or it decreases the supply availability if the reliability criterion is unchanged. |
| Shoalhaven pump mark | This is the trigger point as a percentage of total dam system capacity when pumping of water from Tallowa Dam commences, currently 60%. |
| Number of restriction levels | All recent runs have been undertaken with Levels IV and V restrictions removed. These levels would have been triggered at 35% and 25% respectively. |
| Shoalhaven environmental flows | These flows are currently under investigation, so there is no agreement on the exact flow regime. For the purpose of the current study, current flow releases, 90/10 and 80/20 have been modelled. |
| Tallowa Minimum Operating Level (MOL) | This describes the minimum level for drawdown from Tallowa Dam, and is under current investigation alongside the environmental flow regime. For the purpose of the current study, the most recent results have modelled a MOL of -1m and -3m. |
| Tallowa Dam augmentation — Full Supply Level (FSL) | This describes the impact of the raising of Tallowa Dam. Modelled at current (FSL = 0) and at a FSL of +5m and +7m. |
| Shoalhaven pumping capacity | This describes the capacity to pump water from Tallowa, modelled at current levels (46/ 64 GL/month) and at 73/73 GL/month for the two transfer routes. |
| Wingecarribee transfer constraints | This describes the capacity to transfer water along the Wingecarribee River, modelled at current, and unlimited, and unlimited to Avon only with either 600 ML/d capacity for Nepean transfers or 750 ML/d. |
| Deep water access | This describes the impact of the current capital works to access deep storage at the Warragamba and Nepean storages, due to be completed by August 2006. |
| Upper Nepean environmental flows | These environmental flows have been modelled at 80/20, and are approved but not yet in place. |

| Factor | Description |
|----------------------------|---|
| Warragamba flow releases | The current flow releases represent an impact on supply availability of approximately 18 GL/a. These flow releases have been halved during the current drought. The magnitude of the environmental flow releases post-2015 have not been confirmed, but may have an estimated impact on supply availability of approximately 80 GL/a. |
| Desalination trigger level | This is the trigger level for the availability of supply from a desalination plant, initially 125 ML/d upgradeable to 500 ML/d. Modelling has been undertaken for large range of trigger levels from 10% of system capacity to 90%. Recent modelling has focussed in the range 10-20% of system capacity. |
| Groundwater trigger level | This is the trigger level for the availability of supply from borefields, modelled as an additional 5-10 GL/a impact on the annual supply available. |

Appendix B: Demand reduction initiatives

This appendix provides information on the estimated savings and costs for demand reduction initiatives as well as the methodology used to calculate uncertainty.

B.1. Estimated future savings for demand reduction initiatives

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|---|---|--|----------------------------|----------------------------|
| Residential Indoor | | | | |
| Targeted Retrofits | The program offers householders water efficient retrofits (AAA showerheads, tap flow regulators & flush arresters for single flush cisterns). | * Assumes average savings of 20.9 kl/hh/yr (based on ongoing statistical evaluations of the Retrofit program) * Number of retrofits completed to 30 June 2005 is 274,312 * Number of retrofits planned: 118,000 over three years | 8.2 | 8.2 |
| Department of Housing (DOH) Retrofits | Targets Department of Housing (DoH) tenants with the offer of water efficient retrofits (AAA showerheads, tap flow regulators & flush arresters for single flush cisterns for example). | * Assumes savings of 20.9 kl/hh/yr (based on ongoing statistical evaluations of the Retrofit program). * Assumes 25,000 DoH properties retrofitted over 3 to 5 years | 0.5 | 0.5 |
| DOH Retrofit (Expanded) | Agreement between DoH and SWC to retrofit dwellings is expanded by 50,000 dwellings (move up) | * Assume 20.9 kL/hh/yr water use reduction in retrofitted households. | 1.0 | 1.0 |
| DIY Water Saving Kits | A Do-It-Yourself Water Savings Kit that is distributed free to participating households. The kit contains two 6 litre per minute flow regulating aerators for bathroom basins, two 9 litre per minute flow regulators for showers and one 9 litre per minute flow regulating aerator for a kitchen tap. | * Assumes 155,000 kits distributed over 3 years and 52% installed * Assumes the savings are 20 kL/hh/yr if fully installed | 1.6 | 1.6 |
| Washing Machine Rebate (2003 Pilot) Program | The program offered a \$100 rebate for Sydney Water customers who purchased 4A or 5A accredited washing machines between 5 June and 31 July 2003. | * Water savings per rebate of 18 kL/yr * Number of rebates paid : 6,546 | 0.1 | 0.1 |
| Washing machine rebate | A rebate of \$150 will be offered to residential customers and tenants in Sydney Water's area of operations for the purchase of new water efficient washing machines (either 4 star or 5A) | * Average of 1,760 rebates per month * Share of 5A/4-star machines increases from 4% to 22% * Savings range from 10 kL/yr to 36 kL/yr depending on type of conversion | 0.4 | 0.4 |
| Total Residential Indoor | | | 11.8 | 11.8 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|--|---|---|----------------------------|----------------------------|
| Residential Outdoor | | | | |
| Outdoor education and water use controls | Introduction of mandatory low-level outdoor water use controls, commencing at the end of the current drought restrictions, supported by ongoing community education campaigns similar to Sydney Water's previous "Every Drop Counts" and "Go Slow on the H2O" campaigns. | * Savings based on an analysis of savings from Level 1 and 2 restrictions * Savings from restrictions were adjusted to account for controls being less strict than restrictions | 19.0 | 19.0 |
| Pricing | This program involves the introduction of higher usage prices and a step price for high water usage. Progressive increase in usage price to \$1.23/kL (+CPI increase) by 2008. Step tariff for residential single dwellings using over 100 kL/quarter from 2006 increasing to \$1.84/kL (+CPI) by 2008. | No savings are attributed directly to increased water prices, rather they are assumed to support / prompt involvement in other programs. This avoids double counting between pricing and other programs. Pricing has been included in the residential outdoor category as it is expected to have the largest impact in this sector. | - | - |
| Residential Landscape Assessment | An onsite assessment of residential landscapes to determine its irrigation demand, based on a number of measured variables including soil type and depth, vegetation, shading, aspect. | * 41,925 landscape assessments over 6 years * Average saving of 65 kL/yr per participating household | 2.7 | 2.7 |
| Rainwater Tank rebate program | A rebate scheme that promotes the installation of rainwater tanks for garden use plus toilet flushing and washing machine, where feasible. Amount of rebate depends on size of tank and installation arrangements (i.e. higher rebate if connected for toilet flushing and/or washing machine). | * Program will continue in current form until July 2008. * 13200 tanks to be installed each year based on results to date. * Savings of 35 - 60 kL/year, depending on size and installation arrangements. * Evaluation of savings progressing. | 2.1 | 2.1 |
| Total residential outdoor | | | 23.8 | 23.8 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|--|--|-------------|----------------------------|----------------------------|
| Non-residential | | | | |
| EDC Business Program and Water Savings Fund | Partnership program targeting major industrial, commercial and institutional water consumers. Following establishment of a MOU between Sydney Water and the customer, management diagnostics and water audits are undertaken to develop and implement an ongoing water management improvement program. | | 35%-45% | 35%-45% |
| Water savings fund | Proposed \$15 million annual fund for 4 years to support the implementation of water efficiency, reuse and recycling projects, primarily in business. | | 30%-40% | 30%-40% |
| Pilot water savings fund and Enhanced water Savings Fund | Pilot Water Savings Fund represents \$2.5 million funding provided to government agencies for water saving projects, 25 projects have been approved. Enhanced Water Savings Fund is \$10 million to target high users administered by DEUS | | 10%-15% | 10%-15% |
| Water savings action plans | Requirement for large users and councils to identify water savings The specific volume of water savings attributed to this program has been estimated as the first action plans are being received by DEUS at the end of March 2006. It is expected that part of the future savings attributed to the EDC Business Program and Water Savings Fund will occur as a result of the Water Savings Action Plans. | | 10%-20% | 10%-20% |
| Subtotal | Note that all the above programs target the same non-residential sector | | 36.3 | 36.3 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|---|--|---|----------------------------|----------------------------|
| Non-residential (continued) | | | | |
| Leak Detection in Schools | SWC will trial the installation of permanent smart monitoring and alarm systems on water meters in 20 schools. | * Average school consumption is 10 kL/day * Water savings per school are 30 % | 0.02 | 0.02 |
| Enhanced NSW government Efficiency | Sydney water will commission water efficiency audits on NSW government sites. | * 64 sites to be implemented over 20 months * Daily savings per site of 44 kL/day | 1.0 | 1.0 |
| Rainwater tanks in schools rebate program | The program offers schools a rebate of up to \$2,500 toward the cost of purchasing and installing a rainwater tank in the school and connecting to toilets or a fixed irrigation system. | * The number of schools receiving rebates over 2 years is 100, with 90 using them for outdoor use only and 10% using the water for toilet flushing as well. * The average tank yield is 198 kL/year/school or 306 kL/year/school if also connected for toilet flushing | 0.02 | 0.02 |
| Every drop counts in Schools | The every drop counts in schools program targets reducing water use in primary schools by increasing the awareness of water conservation. | * Schools participating = 200 * Average water saving of 40% on average usage of 7.7 ML/day | 0.20 | 0.20 |
| Total non-residential sector | | | 37.5 | 37.5 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|--|---|---|----------------------------|----------------------------|
| Pressure and Leakage reduction | | | | |
| Active Leak Detection Program | * Active detection and repair of hidden leaks in the water distribution system, in addition to normal operational repair of reported leaks. 18,000 km of mains to be inspected each year. | Savings are estimated based on accumulation of individual leakage items and by the Global Water Balance | 21.9 | 21.9 |
| Pressure reduction | Assumes 255 pressure reduction schemes installed over six years with associated water system adjustments to isolate new pressure zones. Savings achieved through reduced leakage in Sydney Water and customer water systems. The implementation of this accelerated program is subject to approval processes. Progressive \$69 million capital investment over six-year implementation. | Water savings based on system analysis and experience in other jurisdictions. | 10.9 | 10.9 |
| Improved break / leak response time | Improvements in the response times to water main breaks and leaks through targets provided in the operating licence. | Savings are 2 ML/day. Estimate based on assessments of data on response times and leakage rates | 0.7 | 0.7 |
| Total pressure and leakage reduction | | | 33.5 | 33.5 |
| Water recycling | | | | |
| Sydney Water STPs | Existing recycling scheme | | 2.4 | 2.4 |
| WRAMS (SOPA) | Existing sewer mining and stormwater | | 0.9 | 0.9 |
| Warwick Farm Race Course, Ashlar Golf, Richmond Golf, Castle Hill Golf, UWS Hawkesbury | Existing recycling schemes | | 0.2 | 0.2 |
| Rouse Hill Stg 1+2 | Existing recycling | Saving of 1.4 GL/a | 1.4 | 1.4 |
| Rouse Hill Stg 3 | New recycling | Assume saving in excess of BASIX of 40 kL/hh/a Assumes 10,100 homes by 2015 Additional 10,100 homes by 2030 | 0.4 | 0.8 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|------------------------------------|--|---|----------------------------|----------------------------|
| Water Recycling (continued) | | | | |
| Hoxton Park Stg 1 | Stage 1 commissioned 2009, provides recycled water for outdoor use, toilet flushing and washing machine use | * Approx 13,000 lots by 2015, 16,000 by 2030 * Approximately 40 kL/hh/a savings additional to those already counted in BASIX * Also 0.6 GL/a non-residential saving by 2015 | 1.1 | 1.3 |
| North Head STP | New treatment facility to recycle wastewater and displace current approximately 1.5 ML/day of potable use. | * Assumes commissioning in 2005/2006, high water saving certainty. | 0.6 | 0.6 |
| Bondi STP | New treatment facility to recycle wastewater and displace approximately 300 ML/year of potable use. | * Assumes commissioning in 2010/2011. * Assumes 0.08 ML/day water savings | 0.3 | 0.3 |
| Malabar STP | New treatment facility to recycle wastewater and displace approximately 329 ML/year of potable use. | * Assumes commissioning in 2008/2009. * Assumes 0.9 ML/day water savings | 0.3 | 0.3 |
| BlueScope Steel | Highly treated recycled water supplied to BlueScope (Port Kembla) from Wollongong STP to displace 20 ML/day of potable water use | * Assumes 20 ML/day | 7.3 | 7.3 |
| Wollongong | | * Assumes 11 ML/day | 4.0 | 4.0 |
| Botany Reuse Scheme | Treats groundwater and supplies it to industrial and irrigation users near the plant. | * Assumes 6 ML/day recycling | 3.0 | 3.0 |
| Camellia | The scheme will supply recycled water to the industrial and open space users in the Rosehill/Camellia area. | *Assumes 16 ML/day recycling | 5.8 | 5.8 |
| Kurnell Peninsula Reuse Scheme | The scheme would require a water reclamation plant that would take tertiary treated effluent from the Cronulla STP discharge pipeline and treat it further before distribution to two major users - Caltex and Continental Carbon. | *Assumes 6 ML/day recycling | 2.2 | 2.2 |
| Homebush | The WRAMS scheme is amplified to provide an additional 1.1 GL/yr of recycled water for domestic developments | *Assumes 3 ML/day recycling | 1.1 | 1.1 |
| Botanic Gardens | The Woolloomooloo Water Reclamation Scheme is a sewer-mining proposal providing recycled water to the Royal Botanic Gardens. | * Assumes 0.5 ML/day recycling | 0.2 | 0.2 |
| Penrith STP Scheme | A multi-customer recycled water scheme in the Penrith area is proposed using the effluent from Penrith STP. | *Assumes 3.8 ML/day recycling | 1.4 | 1.4 |

| Sector / Program | Description and key assumptions | Assumptions | Water saved in 2015 (GL/a) | Water saved in 2030 (GL/a) |
|--|---|--|----------------------------|----------------------------|
| Water Recycling (continued) | | | | |
| Quakers Hill | The Quakers Hill / Rooty Hill Effluent Reuse Scheme provides 0.365 GL/yr of potable substitution by recycling tertiary treated effluent from Quakers Hill STOP to industrial and irrigation users in the Rooty Hill area. | * Assumes 1 ML/day recycling | 0.4 | 0.4 |
| Western Sydney Reuse Initiative | Dual reticulation for new homes in western Sydney | * Assumes 40kL/hh/a in excess of BASIX * 43607 homes by 2105, additional 82043 homes by 2030 | 1.7 | 3.2 |
| Total recycling | | | 34.7 | 36.6 |
| Other programs | | | | |
| BASIX | Building Sustainability Index | * Assumes BASIX single dwelling commencement from July 2004 and multi unit from October 2005, also assumes contribution from BASIX Alterations and Additions * This modelling assumes all new dwellings will use 40 per cent less water than the current Sydney average for the dwelling type. N.B. BASIX requires new dwellings in Sydney to achieve a 40% potable water reduction based on a NSW per capita water benchmark (90,340 litres/capita/annum) multiplied by the projected occupancy of the dwelling. | 23.0 | 57.0 |
| Mandatory appliance rating and labelling | Water Efficiency Labelling Scheme (WELS) and Appliance Standards | * Assumes mandatory rating and labelling begins 2005/06. * Assumes minimum water efficiency performance standards are introduced for showers and washing machines from 2009 and savings accumulate consistent with stock turnover in the market. A conservative take up rate has been assumed as contingency for any delay in Standards introduction. If introduced on time, savings could be up to 3 GL/a higher by 2015. N.B. WELS savings already attributed to BASIX have been discounted from WELS to avoid double counting. By 2030 all washing machines and showerheads are assumed to be efficient. | 15.4 | 29.0 |
| Overall total GL/a (rounded) | | | 180 | 229 |
| Uncertainty (See Appendix B.3) | | | ±5 | ±6 |

B.2. Costs for demand reduction initiatives

The following table indicates the unit cost of the demand management and water recycling initiatives that are committed or approved, in addition to two potential measures that are described in the report text. The approximate unit costs refer to total resource costs. Also shown is the greenhouse intensity of each of the options, where a positive figure indicates a nett greenhouse gas emission, and a negative figure represents a net greenhouse reduction.

| Options | Water saved or supplied by 2015 (GL/a) | Approx. unit costs (¢/kL) | Greenhouse intensity (tonnes/ML) |
|--|--|---------------------------|----------------------------------|
| <i>Demand side</i> | | | |
| Residential indoor - retrofits and rebates | 12 | 50 - 60 | -31 |
| Residential outdoor (excluding raintanks) | 22 | 10 - 20 | -0.26 |
| Raintank rebates - residential and schools | 2 | 300 | 3.0 |
| Non-residential ¹ | 36 | 30 - 50 | -3.6 |
| Pressure and leakage reduction | 30 | 20 | -0.26 |
| Western Sydney Recycled Water Initiative ² | 2 | 580 | 2.1 |
| Committed/approved recycling schemes ^{2,3} | 28 | 100 - 300 | 1.5 |
| BASIX ⁴ | 23 | 30 - 400 | -15 |
| Appliance standards and labelling | 15 | 4 - 5 | -13 |
| <i>Potential demand side</i> | | | |
| Commercial and industrial development consent conditions | 4 | 30 | -4 |
| Point of sale water efficiency for residential dwellings | 5-10 | 95-140 | -31 |

¹ Excludes programs in schools and enhanced NSW Government efficiency

² Figures nett of BASIX requirements to avoid double counting

³ Excludes existing recycling

⁴ The greenhouse intensity figure for BASIX relates to savings from the water efficiency targets of BASIX but not the energy efficiency targets.

As noted in the main body of this report, the unit costs for individual programs can be misleading when considered in isolation- what is important is to consider how each program contributes to a cost-effective portfolio of measures.

B.3. Uncertainty

To evaluate the uncertainty surrounding the estimates for water savings the methodology recommended by the US National Institute for Standards and Technology (NIST) was adopted (Taylor and Kuyatt, 1994). For each option, the uncertainty in the result quoted for water savings was converted to a standard uncertainty by treating it as if a normal distribution had been used to calculate it with a 95% confidence interval. The quoted uncertainty was then divided by 1.96 to calculate the standard deviation in water savings for each option. The "root-mean-sum-of-squares" method was used to determine the standard deviation of all the options combined, that is the upper and lower bounds for the estimate in water savings.

Appendix C: Restriction levels and dam storage levels including deep water

C.1 Restrictions regime as at January 2006

| Restrictions | Total storage level (%) | Demand reduction level | Targeted demand reductions |
|--------------------------------|-------------------------|------------------------|----------------------------|
| Voluntary restrictions | 65 | | |
| Level 1 Mandatory Restrictions | 55 | Level I | 7% |
| Level 2 Mandatory Restrictions | 45 | Level II | 12% |
| | 40 | Level III | 20% |
| Level 3 Mandatory Restrictions | 35 | Level IV | 30% |
| Level 4 Mandatory Restrictions | 25 | Level V | 50% |

From Sydney Water's *Drought Response Management Plan 2002-2012*

Level IV and Level V have subsequently been removed following the February Progress Report for the 2006 Metropolitan Water Plan. It is proposed in this Review that further investigation into optimising the restrictions regime is conducted.

C.2 Conversion between current and expanded storages

This details the storage volumes and percentages before and after deep water access which will be in place in August 2006.

| | |
|---|-----------|
| Total current storage (ML) | 2,373,635 |
| Total added from deep water access (ML) | 199,000 |

| Percentage of 2005 storage capacity | Existing Volume (ML) | New Volume (incl. deep storage) (ML) | New percentage | Approx change |
|--|-------------------------|---|-------------------|------------------|
| 0% | - | 199,000 | 8% | 7.7% |
| 5% | 118,682 | 317,682 | 12% | 7.3% |
| 10% | 237,364 | 436,364 | 17% | 7.0% |
| 15% | 356,045 | 555,045 | 22% | 6.6% |
| 20% | 474,727 | 673,727 | 26% | 6.2% |
| 25% | 593,409 | 792,409 | 31% | 5.8% |
| 30% | 712,091 | 911,091 | 35% | 5.4% |
| 35% | 830,772 | 1,029,772 | 40% | 5.0% |
| 40% | 949,454 | 1,148,454 | 45% | 4.6% |
| 45% | 1,068,136 | 1,267,136 | 49% | 4.3% |
| 50% | 1,186,818 | 1,385,818 | 54% | 3.9% |
| 55% | 1,305,499 | 1,504,499 | 58% | 3.5% |
| 60% | 1,424,181 | 1,623,181 | 63% | 3.1% |
| 65% | 1,542,863 | 1,741,863 | 68% | 2.7% |
| 70% | 1,661,545 | 1,860,545 | 72% | 2.3% |
| 75% | 1,780,226 | 1,979,226 | 77% | 1.9% |
| 80% | 1,898,908 | 2,097,908 | 82% | 1.5% |
| 85% | 2,017,590 | 2,216,590 | 86% | 1.2% |
| 90% | 2,136,272 | 2,335,272 | 91% | 0.8% |
| 95% | 2,254,953 | 2,453,953 | 95% | 0.4% |
| 100% | 2,373,635 | 2,572,635 | 100% | 0.0% |

Appendix D: Trigger level modelling

Dam Trigger Level Modelling and Basis for Modelling Deferral Options for Desalination and Groundwater

The discussion in the main body of the report presents estimates of the potential savings from deferring the irreversible commitment to desalination until a dam trigger level is reached. It also extends the same logic to potential gains from deferring groundwater development. The attachment sets out the basis on which these calculations have been done.

For reasons already outlined on the body of the report, great precision in estimating effects such as the savings cannot be achieved. Uncertainty in respect of demand trends and climate change, and even the relatively short history of hydrology records, introduce significant uncertainty. What we have done is sought to work with the statistical simulation data provided by SCA, based on historical hydrology, and to develop conservative estimates built around these hydrology patterns. They are intended as indicators only.

Hydrology data

The primary hydrology modelling data used here has been a set of 2000 random simulations of 10 years of dam system hydrology, recorded monthly¹. These have all been constrained to commence with dam levels at 48 per cent of extended system capacity (that is, inclusive of deep storage). Otherwise, the modelling parameters have been set to reflect the basic assumptions used throughout this report in relation to demand and supply measures and trends. This starting level setting differs from that used for most of this type of modelling - where runs usually commence with the system full or near average levels. System security and reliability objectives are assessed over time starting at normal levels, not at deep drought levels.

The effect of this constraint is both to more closely approximate the immediate context in which decisions on water strategy is to be taken, and to greatly increase the likelihood of dam levels dropping below trigger points in the near term.

As a result, these estimates of savings are substantially lower than would be produced using a full or average dam level starting point - and understate the scale of the benefits from such 'virtual supply strategies' where they are implemented outside of severe drought conditions. We consider this appropriate for the immediate term. We also note however that, should dam levels rise towards average levels before triggering investment in desalination or groundwater (considered highly likely), then the forward savings from the strategy will be

¹ These simulations are random *within the assumptions* used in the modelling process. They rely on estimation of a 'stochastic' or chance process that determines month on month inflows - and this process has been specified using parameters estimated from historical rainfall and other patterns. Both the short hydrology history and the likelihood of climate-based trends mean that the term 'random' should be interpreted with some caution.

substantially greater than at present. There is an immediate threat to be dealt with that elevates the chances of needing these investments; if we get through this threat without needing to make the investments, then the risk-weighted savings, will be a lot higher.

Constraining the starting level of the dam system in these simulations does not have a big impact on most characteristics of the resulting data - mean dam levels and even most percentiles. This is because of the very high likelihood of a fairly rapid bounce back. However, setting a low starting level does have a substantial impact on the short term probabilities of very low dam levels being reached in the first few years. At one extreme, setting the start point at 48 per cent raises the chances of dam levels getting below 50 per cent at 100 per cent - much higher than would otherwise be the case. More importantly, it systematically increases the likelihood of levels dropping below 40 per cent, 30 per cent etc in the next few years - and especially the probability of dropping to near empty.

Even without triggering desalination or groundwater, none of the 2000 replicates resulted in the system running out of water. However, one of the replicates did see dam levels dropping below 5 per cent in the near term before recovering. It seems highly probable that given the Government policy announced in the February 2006 Progress Report, under these circumstances, drastic measures would be triggered well ahead of this point - if not through a desalination strategy, then through recourse to much more severe restrictions.

Measure of cost savings

The base against which the deferral options have been assessed is one involving immediate commitment to construction of a desalination plant. The strategy that had been envisaged prior to the Government issuing its Progress Report on 8 February involved initial commitment to a 125ML/day plant, but with key components that are not readily scalable sized to allow rapid expansion to 500ML/day. Realistically, having committed to a 125ML/day plant there would be reasonably high likelihood of needing, within a few months, to commit to the upgrade. 125ML/day, coming in when dam levels are very low, offers only limited additional security. However, it does allow further deferral of the irreversible commitment to the upgrade, and much of its value lies here².

A strategy that allows deferral, while continuing (in conjunction with other measures that are in any case justified) to offer adequate security for the system, offers cost savings in several ways:

- Expenditure deferred has a level of expenditure saved built in via the arithmetic of discounting cash flows.

² A 125ML/day plant commissioned at much higher dam levels, and running hard could make a bigger difference, but at a much higher cost and with a very much higher likelihood of involving effectively wasted investment and energy use. Really we are dealing with a decision to commence work on the major pipes as late as possible - these being the items on the critical path, and then committing to the size of desal plant appropriate to the dam levels that apply a few months after commencing the works.

- NSW Government guidelines³ for economic appraisal clearly specify the use of discounted cash flow measures of costs, with the primary discount rate specified to be 7 per cent real, before tax.
- In effect, if an expenditure can be deferred by, say, 15 years and then implemented at the same real (inflation-adjusted) cost, then the effective cost viewed now is reduced by more than 60 per cent - reflecting the opportunity value of the funds, suitably invested in other ways across the 15 years. Deferral for 30 years on the same basis saves over 85 per cent of cost.

There are long established productivity trends in water factor technology - with falling costs and rising overall efficiency over time - that mean that a deferred project will probably be available later at a lower real cost - these savings would be on top of the effect of discounting.

If deferral is possible, then the general development of the water strategy will involve progressively greater source diversification and probably greater demand management.

- These factors will progressively lower the probability of needing to trigger the desalination investment as a source of insurance against very deep droughts - by effectively lowering the demand for dam water and rate of depletion of the dams.
- It may be that, in time, desalination would emerge as a cost effective source of supply for reasons other than very deep drought insurance, especially if the above productivity trends continue, but the analysis in the body of this report suggests that this is some way in the future.
- What this reasoning does suggest is that the hydrology set used for the calculations here is likely to underestimate the average lengthly of deferral that will be possible, given on-going trends towards greater supply diversification - this would in turn imply some underestimation of savings.

In estimating cost savings, we have only worked with the first of these elements - the direct benefits of discounting. Furthermore, we have only accounted for the savings in capital costs of the 125ML scheme. Deferral is likely also to allow avoidance of operating costs that would subsequent prove, in a high proportion of cases to have been unnecessary. The extent of any such savings would depend on decisions on the operating regime for desalination once established. We believe it likely that quite low levels of operation, averaged over time, would be cost effective, though there is a trade-off. Starting desalination earlier may reduce the likelihood of needing to upgrade.

The measure of cost savings reported here is the reduction in the probability-weighted net present value of capital costs for a 125ML/day plant, comparing commencement now to commencement when produced as the result of a dam trigger level. Effectively, we work with 2000 possible futures, each resulting in the need to commit to the desalination at some point in the future.

³ NSW Office of Financial Management (1999), *Economic Appraisal, Principles and Procedures Simplified*, Treasury Policy Paper TPP 99-1.

Calculation

In almost all cases, no need for the plant arises in the next 10 years. It does not follow that it will never be required. We have used a conservative approach to inferring the time till the investment is needed as follows:

- If the data for a particular replicate involves dam levels dropping below the trigger point in the first 10 years, then the time till the investment is triggered is set as the time till the first month when this happens.
- If the trigger level is not reached in the first 10 years, and the end month dam level is lower than the starting level of 48 per cent, then we assume the investment is triggered at year 10.
 - This is highly conservative - the true trigger level is likely to be substantially higher.
- For all other entries, the estimate is 10 years plus the result of reproducing the calculations through 2 more 10 year cycles, based on average results across all 2000 replicates.
 - This allows for maximum deferral of 30 years (again conservative), but with a chance of investment being triggered in the years 11 to 20 and, if not triggered in this period, then again a chance of being triggered in the period 21-30 years.

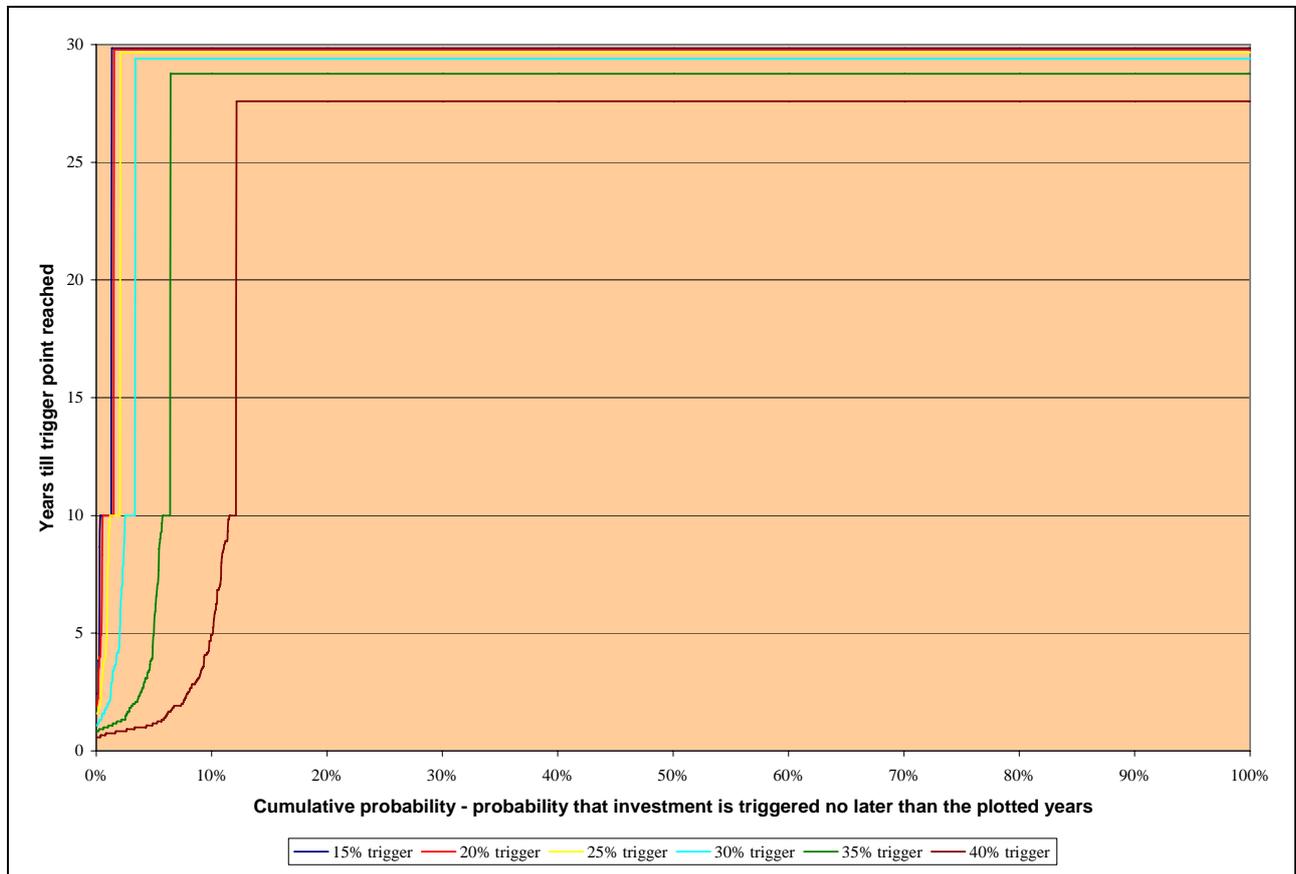
These calculations are not intended to be analytically precise - however, they are systematically weighted in favour of overestimating the likelihood of triggering the need for investment. It is inherent in the approach that it produces artificial blocks of triggers at 10 years and 20 years - and it forces triggering at 30 years, if not triggered earlier.

There may be some offsetting option value associated with building now. This would allow earlier operation, deferring the likelihood of needing to upgrade, but the calculations do suggest you would not want to start pumping too pre-emptively, because of the very low likelihood of reaching an upgrade trigger. Once built desalination may have value as a source of growth water, but its costs would then need to be compared to other growth water sources - and these costs include energy and brine discharge costs that are likely to fall over time if deferral can be achieved. More generally, these option values are likely to be offset by the other sources of savings listed above, that have not been factored into the calculations. Again we stress that the calculations are intended to provide a probably conservative order of magnitude on the cost savings - and this appears enough to imply some strong strategy conclusions.

Results

The following chart provides a plot of the statistical distribution of the time till desalination commitment would be triggered, across a wide range of trigger values.

Figure D1: Distribution of time till dam trigger reached (conservative estimates)



The chart clearly shows the artificial bunching at 10 years. The most striking feature, though, is the steepness with which the curves rise, suggesting a very high likelihood of the trigger points not being reached for a very long time - though for the higher trigger levels the chances of triggering in less than 30 years are not negligible. The pattern appears consistent with the observed historical pattern of very deep droughts that would have resulted in dam levels dropping below 40 per cent.

Armed with these figures, and the capital cost of the desalination plant, it is relatively easy to calculate the benefits of discounting across this distribution, and to report these as risk-weighted reductions in NPV. Those calculations feed into Figure 8 in Section 6.3. Calculations have been done replicate by replicate and then averaged to produce risk-weighted figures.