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Cost Effectiveness Analysis – 2010 Sydney Metropolitan Water Plan

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Prepared for NSW Office of Water

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1 Introduction

Until the summer of 2009-10, greater Sydney's raw water supply was largely reliant on its 11 major dams, one of the largest per capita storages in the world, supplemented by significant water recycling and efficiency programs. In January 2010, the existing supply system was boosted when Sydney's desalination plant began operating.

Rainfall over the catchments for Sydney's dams is highly variable and the future impact of climate change on the inflows to these dams is uncertain. Further, with future population growth, demand is expected to rise. Therefore, even with the operation of the desalination plant, a detailed and flexible strategy is required to manage Sydney's water supply needs in the context of highly variable inflows, increasing population, and the uncertainties regarding future climatic patterns.

Overview of the Metropolitan Water Plan

The first *Metropolitan Water Plan* (the Plan) was introduced in 2004. The Plan sets out the course of action for the NSW Government to ensure a sustainable and secure water system for the greater Sydney's people and rivers. A range of water demand and supply measures was announced in the 2004 Plan to meet this objective. These measures addressed both growth and security needs in the face of a worsening drought at the time. The measures were selected for their cost-effectiveness, or because they offered potential diversification benefits.

Subsequently, the NSW Government reviewed the 2004 Plan and released an updated plan in 2006. The 2006 Plan's objective was to devise a set of measures that reflected the NSW Government's longer-term plan to secure Sydney's water supply, and responded to the deepening drought. The Plan ensures that through a mix of measures, Sydney, Illawarra, Shoalhaven, Southern Highlands and the Blue Mountains will have enough water to meet the region's growth needs to 2015 and to secure drought needs to 2015 and beyond. These measures included increased water recycling and efficiency, and developing the capacity to access deep water in the water supply storages, deploy desalination and groundwater in a timely manner.

The 2006 Plan incorporates an adaptive management approach, which recommends regular reviews to take account of new information and emerging technologies. Specifically, the NSW Government made a commitment to review the Plan every four years. The next water plan is due in 2010.

Against this backdrop, the NSW Government is reviewing the 2006 Plan to ensure that greater Sydney has a secure water supply beyond 2015. The review is being led by the NSW Office of Water (NOW) in collaboration with key government agencies and will lead to the release of the updated plan in 2010.

The context for the next Plan is different to the 2006 Plan where the immediate water security issues were at the forefront of decision making. The development of the 2010 Plan will need to consider options for ensuring Sydney has a secure and reliable supply of water beyond 2015 that meets the demands of population growth, addresses possible prolonged droughts, and provides environmental flows for river health.

This project

The purpose of this project was to analyse the cost associated with a range of different options and their ability to ensure Sydney's future water needs are met.

This project involved developing a detailed economic model to incorporate the different costs, taking account of the detailed hydrological characteristics of the drinking water catchments for Sydney. The model was used to compare different packages of existing, new, or modified water supply and demand measures based on their costs and benefits.

The analysis was undertaken using a framework developed by TheCIE as part of a separate process undertaken for the former Department of Water and Energy and completed in February 2009. The framework is explained in detail in TheCIE's report 'Review of the 2006 Metropolitan Water Plan — Analytical Framework'.

The costs included in this analysis primarily focus on the financial and economic costs, although it also includes the social costs of restrictions. Most environmental and social impacts of the portfolios considered as part of this project were assessed separately by panels of environmental and social experts (convened by NOW). The findings of these panels were combined with the cost-effectiveness analysis help derive a range of possible preferred portfolios.

As part of the project process TheCIE was required to:

- prepare an Excel model to be provided to NOW upon finalising the project. This will ensure transparency in the assumptions underpinning the analysis and will allow the model to be used for further analysis if required; and
- prepare a report outlining the analysis undertaken and the conclusions reached from the analysis.

Stakeholder consultation

As part of this study, TheCIE has sought input from key stakeholders within Government and the Metropolitan Water Independent Review Panel (which reports to the NSW Premier). TheCIE held numerous discussions with these stakeholders and presented preliminary findings of the analysis along the way.

2 *The water supply system and future pressures*

The need for additional investments in the water supply system will depend on the performance of the existing range of measures under current as well as future conditions. Additional options may need to be considered where the ‘pressure points’ become critical. The range of potential options available is discussed in the next chapter.

This chapter:

- outlines existing Government commitments that make up the base case;
- discusses some key factors likely to impact on the need for new investments and the points in time where these pressures are likely to emerge; and
- summarises the performance of existing measures in the short, medium and longer term.

Existing commitments – the ‘base case’

There is a wide range of measures the Government has in place, reflecting past commitments including those made under the 2006 Plan. These include the longstanding assets such as the various dams supplying Sydney, and the recently constructed desalination plant. It also includes water supply sources that have not previously been triggered such as the borefields. They also include the substantial water efficiency and recycled water programs and targets that have been committed into the future.

The existing commitments include environmental flow regimes that are currently in place at the dams, water transfers, from the Shoalhaven system, and drought water restrictions.

All drought restrictions were lifted in mid 2009. Permanent water saving measures (Water Wise Rules) are in place and assumed to be achieving a 3 per cent reduction.

For the purposes of modelling we refer to the current commitments as the ‘base case’, which reflect the operation of the water supply system under all existing Government commitments.

Appendix A provides further details of the existing commitments that are assumed in the modelling.

Future pressures

The key issues likely to influence the decisions on new investments in the water supply system include future climatic conditions and expected changes in the demand for water as population rises. It is the combined effect of both these impacts that is important – for example, the impact of a drought at higher population levels is likely to be more severe than if it occurred today.

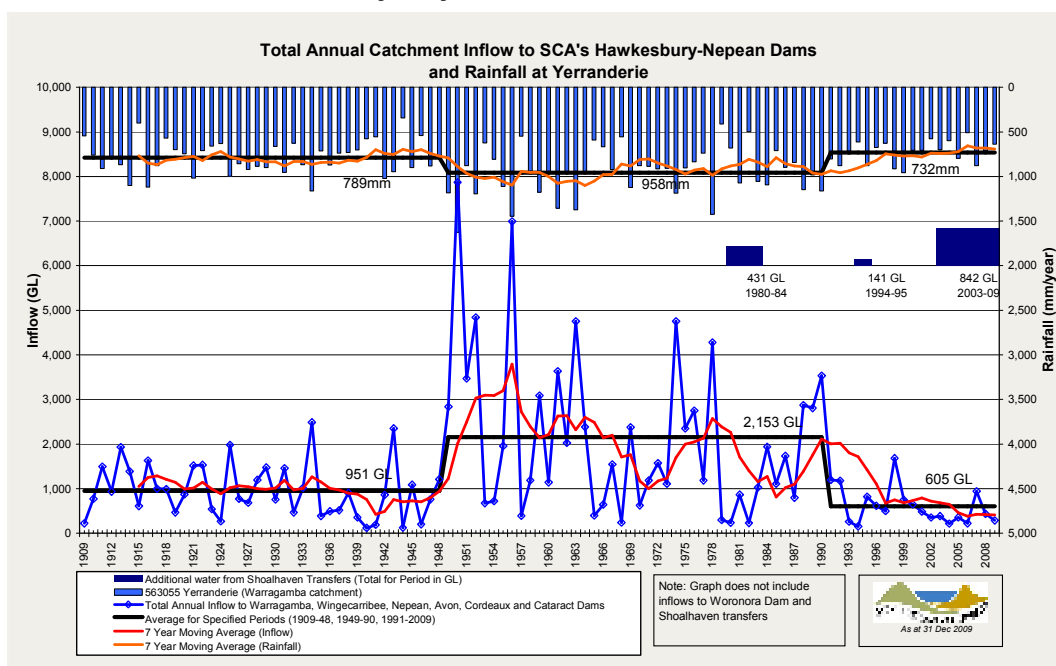
Uncertain climatic conditions

The nature of the water supply system that has been built for Sydney over the past 100 years reflects the characteristics of the inflow patterns into the main storages.

Sydney and its catchment area are subject to infrequent but severe droughts. Over the last 120 years, the greater Sydney region has had three severe droughts: in the 1890s, the 1930-40s, and the recent drought. Because of this, Sydney has much larger water storages than most other cities in the world.

The variable nature of rainfall patterns in Sydney is reflected in the inflows to Sydney's dams (chart 2.1). From 1909 to 1948, inflows into dams were relatively low. However, from 1948 to the early 1990s there were substantially higher inflows into dams compared with the preceding 50 years. However, even during this time the rainfall pattern was highly variable with some years experiencing low rainfall similar to the earlier part of the century. Since the early 1990s, the rainfall pattern appears to have changed and is following a similar pattern to the early part of last century.

2.1 Rainfall and inflows to Sydney's dams from 1909 to 2009



Data source: Sydney Catchment Authority.

The hydrology of the catchments is also highly variable. While there have been long periods of low inflows, there have also been numerous significant inflow events that can fill the storages quickly, even when storages are low. This highlights the importance of the adaptive management approach. Clearly, there are benefits from having strategies that can defer a decision to make a large infrastructure investment by providing more time to capture large inflow events in existing dams.

These uncertainties are inherent in the planning of any water supply system which is beholden to natural events, and the challenge for policy makers is planning effectively to achieve a secure supply cost effectively.

For the longer term future, there is significant uncertainty regarding the climatic state that the drinking water catchments might face. These uncertainties are brought into greater focus in the face of climate change impacts. While the climate change research is still emerging, it appears that the future climate is projected to be more volatile. This and future Plans will need to acknowledge the changing environment and consider how to take account of such impacts.

This requires an understanding of the range of potential climate events that can occur. Typically this has involved using hydrology models that simulate a wide range of possible futures, using historical inflow data and synthetically replicating other possible future inflow scenarios.

Planning for variable rainfall in the short and the longer term is a continuing theme of the Plan. Given the uncertainties of climate change it will be important to understand options that can respond to lower or higher inflows compared with those

that have been experienced over the past 100 years and to have systems that are robust to climate change.

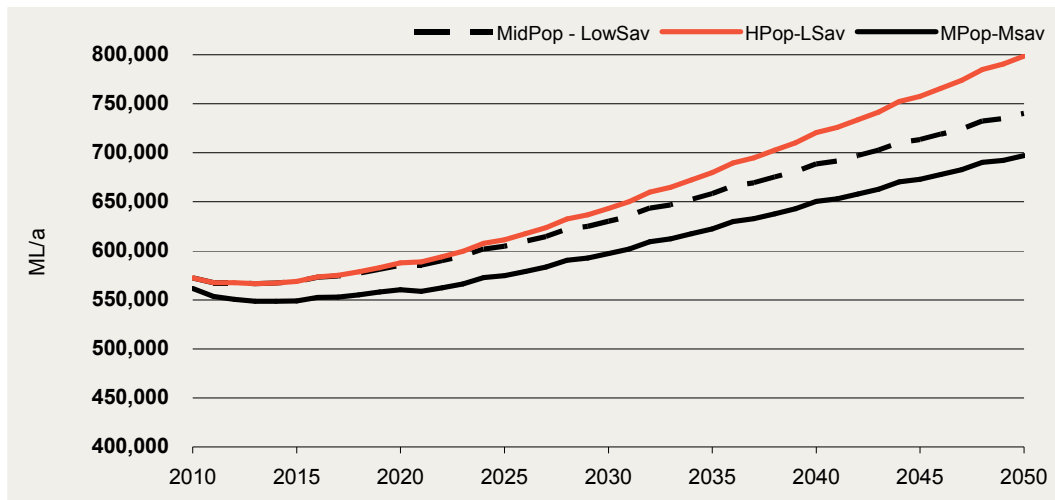
Increasing future demand

A key factor likely to place pressure on the existing supply system is the projected demand for water into the future. Demand projections are influenced by the forecast population growth over the next 30 to 40 years as well as by changes in the estimated savings from efficiency and recycling programs.

The projected demand for water over the next 40 years is presented in chart 2.2. The projections include savings from the suite of efficiency initiatives (including leak-reduction, residential, non-residential and regulatory initiatives) and water recycling measures already committed to under the current Plan. The chart presents three different scenarios of demand forecast based on population growth and demand savings projections forecast from efficiency programs. Where higher savings from these programs are assumed, this results in a lower demand projection into the future. The scenarios are:

- *median* population projection with assumed *low* level of savings;
- *median* population projection with assumed *median* level of savings; and
- *high* population projection with assumed *low* level of savings.

2.2 Future demand forecasts, 2010 to 2050



Data source: Sydney Water Corporation.

Sydney Water's approach to projecting future demand is presented in Appendix B.

Warragamba environmental flows

The 2006 Metropolitan Water Plan stated that 'A final regime of environmental flow releases from Warragamba Dam will not be formally set until 2015, but increases to interim environmental flows will be considered for the period starting 2009, provided sufficient water is available'.

The analysis in this report assumed a 95/20 environmental flow regime for Warragamba Dam to enable planning to cover the period beyond 2018, which is the time when it is considered these flows, could begin, if approved by the Government. This regime is based on the recommendations of the Hawkesbury-Nepean River Management Forum recommendations of 2004.

The introduction of an environmental flow regime of 95/20 would significantly reduce the amount of water that can be drawn from Warragamba Dam for drinking. A key issue for this and future Plans is to consider how significantly the proposed regime influences the water supply availability.

Pressure points

Assuming there are no supply or demand measures introduced beyond existing commitments, rising demand levels, together with environmental flows at Warragamba Dam from 2018, will impact on long-term water supply availability.

As demand increases it is expected to place pressure on the existing system in a number of ways. In particular, it is expected that dam levels will drop more frequently requiring transfers from the Shoalhaven system, the operation of Stage 1 of the Kurnell desalination plant, and implementing drought water restrictions.

The discussion below provides an overview of some of the key pressure points at which additional measures may be required. In order to examine the likely pressure points we used a hydrology model.¹

Short term (2010 to 2020)

The modelling undertaken for this project indicates that the existing portfolio of options will ensure that, if there are five years of low inflow equivalent to the 2001-2007 drought, the city would not run out of water.² It will also provide security to

¹ The SCA's WATHNET hydrology model is explained further in chapter 4.

² It is important to note that the modeling undertaken by the SCA for this report is different to the 'yield' modeling that the SCA regularly undertakes.

2020 for worse droughts than those experienced over the last 100 years. This is based on the existing portfolio of Government commitments under the Plan, including the environmental flows from the upper Nepean water storages. For planning purposes, modelling included the 250 megalitre per day desalination plant triggered when dam levels drop below 70 per cent of total capacity and ceasing operations when dam levels return to 80 per cent of total capacity.

Therefore, while supplies are considered secure over the next 10 years, it is important to monitor storage levels and trends in demand, and to have in place contingency measures available

Medium term (2020 to 2030)

Key factors to be considered in the medium term are the planned introduction of the revised environmental flows regime for Warragamba Dam and increasing demand. Assuming median demand projections, between 2020 and 2030 demand is forecast to increase by approximately 8 per cent or 50 GL. A 95/20 Warragamba environmental flow would significantly increase environmental flows from Warragamba Dam.

In the absence of further measures the combined effect of the Warragamba environmental flows regime with increases in demand for water would reduce the reliability of the system (ie increase the time spent in drought restrictions) and reduce the security of the system (ie increase the likelihood that storages will drop to low levels in an extreme drought).

Longer term pressure points (2030 to 2050)

As discussed, further pressure on the system will occur as population grows, resulting in an increase demand for water, even with existing and planned measures to control demand.

Beyond 2030, the security and reliability impacts of increasing demand would be significant in the absence of additional measures to those identified already. In rare and extreme droughts there would be an increasing probability that the existing measures that have been modelled are not sufficient to stop Sydney from running out of water from the 2030 to 2050 period. The average time in restrictions would also increase significantly to the point where it would be several times the current setting of 3 per cent of the time.

3 Additional measures to achieve objectives

This chapter discusses some of the specific options beyond the current mix of measures that could be employed to secure greater Sydney's water supply in the short to medium term as demand grows.

Overview

The Government has a range of tools to secure Sydney's water supply and to prepare for severe droughts that may occur into the future. Key measures available include:

- providing additional investments to increase supply or reduce demand;
- changing the drought restrictions regime which may mean changing the duration, frequency and severity of restrictions;
- operating existing assets in different ways under different circumstances (ie, optimising the use of existing assets). For example, the desalination plant and the Shoalhaven transfer scheme can be operated in alternative ways in three broad circumstances – with no drought, in anticipation of a drought, and in drought; and
- developing 'response' or 'readiness' strategies to deal with rare and extreme circumstances.

To progress to detailed modelling, the following decision criteria were used to filter the options:

- capital and operating expenditure are known or can be ascertained at an acceptable confidence level;
- contribution to long-term supply/demand balance is confidently known and significant;
- contribution to drought security, alone or in combination with other options, is known and significant;
- environmental impacts are known or assessable, minimal, or can be acceptably managed; and
- the option is not inconsistent with current Government's policy directions.

The resultant measures are outlined in Box 3.1 and described in further detail below.

3.1 Options included in the portfolio analysis

- upgrading the desalination plant to produce 500 ML per day;
- considering the operating rules for the 250 ML per day desalination plant and the 500 ML per day plant;
- augmenting the Shoalhaven transfer scheme and changing the pump mark;
- changes to the existing drought water restrictions regime; and
- introducing emergency drought response measures:³
 - implementing voluntary community water usage target, achieving 10 per cent savings in addition to those achieved by drought water restrictions;
 - halving all environmental flows from dams in emergency situations; and
 - using the agreed minimum operating level (MOL) of -3 metres for Tallowa Dam.

Desalination plant

The desalination plant at Kurnell has an initial capacity of 250ML of water a day, which can be scaled to an ultimate capacity of 500ML/day. The plant began operating in summer 2009/10.

Operating rules for the desalination plant⁴

Analysis previously undertaken by TheCIE for Sydney Water indicate the most effective operation of the 250ML per day desalination plant is based on a regime whereby the plant is 'turned on' when dam levels fall below 70 per cent and 'turned off' when dam levels are at 80 per cent or above (a 70/80 regime). An 80/90 and a 40/50 regime were also modelled by TheCIE. However, these were considered to be less optimal.

- Under the 80/90 rule, there was less airspace available to capture 'cheap' rain water. There was also limited additional reliability and security benefits of operating the desalination plant at higher levels compared with the 70/80 rule.

³ The emergency drought response measures are not designed to increase the supply of water but to reduce the rate of dam depletion.

⁴ In the SCA's WATHNET model the storage trigger levels are based on the eight major dams. It excludes water stored in Tallowa Dam given that only a small proportion of this is available for supplying the Sydney metropolitan area under the current operating arrangements.

- The 40/50 rule, provided limited benefit in terms of improved reliability and only slightly better security outcomes – once dams reach these low levels it is often too late for the plant to make a significant contribution to improving security.

While the 70/80 rule was considered to be optimal (in the CIE's previous analysis), it was recognised that as demand increases with population growth, an earlier operational trigger for the desalination plant is likely to be warranted. As demand increases, dam levels deplete at a faster rate and the desalination plant would need to be switched on earlier to contribute to maintaining reliability and security (assuming all other factors remain constant). This was not assessed in detail in this Review, but should be considered as a possible component of future reviews.

Further, once the second stage of the desalination plant is built at some point in the future, this could also warrant a change the trigger rules for the upgraded plant.. That is, all other things being equal, the operation of a 500ML per day plant could possibly be triggered at lower dam levels (compared to a 250ML per day plant) in order to have the same reliability and security benefits as the smaller sized plant.

For modelling purposes we have assumed a number of operating rules for the first and second stage of the desalination plant (see Table 5.1).

Construction trigger for the second stage of the desalination plant

The second stage of the desalination plant can be built at a fixed point in time or can be triggered based on demand or dam levels. There are limitations of the fixed point approach.

- It does not depend on whether there is an immediate need for water from the plant. For example, if dams were at full capacity it may be several years before water from the desalination plant is required.
- The decision may need to be brought forward anyway in the event that there is a severe drought prior to the initial construction date.

Triggering construction of the desalination plant based on a dam trigger level - similar to the approach adopted in the first stage of the plant - offers greater flexibility in responding to the most current conditions and information. The trigger level needs to be set such that it is not set too high or low, resulting in increased costs or decreased security respectively

Trigger points for the second stage of the Kurnell desalination plant should be reviewed and refined as relevant in future reviews of the Plan to incorporate changes to the system such as increasing demand.

The trigger needs to consider the tendering, design and construction period for the expanded plant. For our modelling we have assumed a two year construction period or 15 per cent drop in total system storage (based on current demand levels),

although this may change in the future based on new information such as global desalination technology.⁵ Further time would need to be added to allow for tendering and design if these were not completed as part of a readiness strategy.

Shoalhaven transfer scheme

The Shoalhaven transfer scheme was built in the 1970s as an emergency drought scheme. When operating, water is transferred from Tallowa Dam on the Shoalhaven River through a series of tunnels, pipelines and canals via Fitzroy Falls Reservoir, to Wingecarribee Reservoir and on to other dams that supply Sydney and the Illawarra.

The scheme makes an important contribution to the water supply system for greater Sydney. During the recent drought, water transfers began when storage levels fell to around 60 per cent in April 2003 and continued until November 2008. During that time, a total of 831 gigalitres were transferred, representing around 30 per cent of greater Sydney's water consumption.

Impacts of current water transfers through the Southern Highlands

The 2006 Metropolitan Water Plan recognised the need to develop and discuss options for the Shoalhaven scheme that would increase the long-term available water supply to greater Sydney and mitigate the impacts of using Southern Highlands rivers as conduits for the transfer of water.

The flow rates for transfers in the Southern Highland river channels are limited to minimise the impact on river ecology, to reduce erosion, and to minimise localised flooding. The existing flow rate limits are 600 ML/day between mid-March and mid-September, 400 ML/day between mid-September and mid-March, and 200 ML/day for transfers commencing between November and January.

Options to reduce the impact of transfers on Southern Highland rivers while increasing supply from the Shoalhaven

The SCA has options to augment the Shoalhaven system transfer water to allow for an increase in supply from the Shoalhaven. The options also significantly reduce run-of-river transfers, and boost security of supply to the Illawarra. There would also be potential for significant energy recovery through hydro generation.

⁵ In the SCA's hydrology modeling the point at which the desalination plant is assumed to commence *operation* is presented. In our modeling, based on advice from Sydney Water, the trigger point was the decision to *construct* the plant which is assumed to be two years prior to the operational trigger.

Further information about options for future modifications to the Shoalhaven scheme can be found in the report NSW Government (2006) *Shoalhaven Water Supply Transfers and Environmental Flows, Discussion Paper*, August (page 46-48).

Raising the pump mark

The Shoalhaven transfers scheme provides greatest benefit to the water supply when operated at higher dam trigger levels, thus reducing the probability of dams falling to low levels. Although this costs more as a greater volume of water is required to be pumped.

Under new operating rules introduced in 2008, transfers from Tallowa Dam begin when the level of all SCA's total storage levels fall below 75 per cent. Pumping stops when the dams rise above 80 per cent full.⁶ Pumping only occurs in those conditions if the level of Tallowa Dam is above its minimum operating level of -1 metre. These rules are embedded in the base case.

Augmenting the Shoalhaven further would allow extra water to meet Sydney's long-term potable water supply needs and could be expected to provide longer term benefits to system security and reliability.

Raising the pump mark means that water transfers can take place in wetter periods and higher flows. This is considered a more effective way to harvest water and will generally take water from the Shoalhaven River when the river downstream of Tallowa Dam is less stressed.

Changes to drought water restrictions regime

In the past, the NSW Government and governments throughout Australia have relied on water restrictions as a key policy instrument for dealing with drought. Restrictions have been critical as the water supply for communities reliant on rainfall dependent dams. Restrictions help ensure that communities can withstand periods of drought without running out of water, and enable governments to defer the need for additional investments in water infrastructure.

Water restrictions have been an important part of managing Sydney's supplies during drought periods. Mandatory water restrictions were in place in Sydney between 2003 and July 2009, with voluntary water restrictions in place for approximately a year before this. With the lifting of drought restrictions, long-term WaterWise rules were introduced in mid 2009.

Changing the trigger points for water restrictions has a bearing on the reliability and security of the system. Introducing restrictions early raises the average time in

⁶ There is currently a three year moratorium of pumping from the Shoalhaven system.

restrictions, although it is likely to have security benefits as well. Lowering the trigger level reduces the time in restrictions (and the associated costs) but can reduce the security of the system. For this study, we have analysed the reliability, security and cost implications of a range of alternative water restrictions regimes.

Measures to respond to extreme drought

In the very rare event that a drought is so extreme that mandatory drought based restrictions are not sufficient to slow the depletion of the dams, there are several measures that can be deployed to further reduce water use and slow the decline.

The key measures considered in this analysis are:

- adopting the Tallowa Dam minimum operating level (MOL) of -3 metres;
- additional water usage targets which are assumed to achieve total savings of 22 per cent (including the other levels of restrictions); and
- halving environmental flows from all of the SCA's dams.

These measures for use in extreme drought have a number of benefits including the following:

- They may provide some extra time to allow conditions to return to more normal levels before committing to large scale infrastructure. While the emergency measures may have a relatively high cost, if they only apply for a short time this cost is likely to outweigh the sunk cost associated with large scale infrastructure that applies for a long period.
- They slow the depletion of storages and provide a buffer in the event there are unexpected delays in building the next proposed infrastructure option (eg upgrading the desalination plant).

However, the effectiveness of emergency measures is not as certain as infrastructure options. It is important therefore, that these measures are further analysed and appropriate consideration of options is undertaken.

Additional demand management or recycling activities

As part of the 2006 Plan, the Government has made significant commitments to expanding demand management programs and recycling activities. Those activities committed into the future have been incorporated into our analysis in the base case.

Given the substantial forward commitment and targets in demand management and recycling activities, this analysis has not incorporated additional demand management and recycling activities.

However, we have also examined (as part of the sensitivity analysis) the impact on the reliability and security of the water supply system, if additional savings can be achieved (medium and high savings). This illustrates the potential benefits that could be achieved if further cost effective demand management or recycling options become available in the future.

4 *The approach*

This chapter discusses the approach for considering the different options discussed in the previous chapter. The approach is based on the analytical framework developed by TheCIE that uses a hydrology model for its outputs. The approach works within certain limitations such as data constraints, and resources required to undertake modelling of a range of alternative scenarios.

The analytical framework

The approach undertaken for this review was based on the analytical framework developed by TheCIE in February 2009. The framework maintains and expands on the least cost portfolio and adaptive management approaches adopted in the 2006 Plan.⁷ The approach also allows the current portfolio of demand and supply options to be included in deciding on the optimal portfolio.⁸ For example, the triggers for different types of restrictions, the Shoalhaven scheme, environmental flow rules and the desalination plant are all flexible components of the water system that can be adjusted to achieve the best outcomes. The preferred portfolio was derived from an assessment of costs as well as qualitative analysis of environmental and social costs that cannot yet be assigned a dollar value.

A portfolio is constructed over a time period (such as 20 years). In constructing the portfolio the approach recognises that decisions made now can have an impact on the measures required in the future. So, for example, adopting more stringent water restrictions can result in deferring the need for additional infrastructure in the future.⁹

⁷ In the recommended approach a portfolio is defined more broadly and could include a set or sequence of projects, timing, rules and trigger points. So, for example, two different portfolios could include the same projects but introduced in different years or at different dam levels.

⁸ Throughout the report we use the term 'optimal' portfolio. However, in practice there is not likely to be all the information required to achieve optimality. Therefore, in practice it may only be possible to reach the 'best' solution rather than the 'optimal' solution.

⁹ The proposed approach also recognises the interrelationship between existing measures in the system. For example, the use of the desalination plant could result in less reliance on water pumped from the Shoalhaven river. Therefore, the portfolio costs represent a *net* cost - the increase in costs by operating the desalination plant is partially offset by lower pumping costs associated with the Shoalhaven pumping scheme.

A central feature of the proposed approach is the need to include risk and uncertainty into the analysis of alternative portfolios of measures. Risk is a crucial element of water planning, particularly for Sydney which has highly variable rainfall patterns and can be subject to extended periods of drought.¹⁰ Therefore, decisions must be taken with incomplete information about future water availability.

The proposed framework also includes a number of other refinements including:

- examining a wider range of costs such as the potential costs of restrictions as well as including environmental and social considerations. In practice, estimating some of the costs, such as the cost of restrictions, is an ‘inexact science’ in the absence of specific studies that seek to measure these impacts;
- frequency and duration of restrictions are assessed as outcomes of the analysis based on an evaluation of the cost and benefits of the options, rather than being pre-determined; and
- maintaining a pre-determined level of water security that must always be achieved. This is consistent with the broad objective of the Plan to ensure that there is a secure supply of water into the future to meet Sydney’s needs. However, rather than initially adopt the water security criterion specified in the SCA’s Licence the assessment was open to the consideration of potential alternative criterion that might be more cost effective, provide improved security and/or be simpler to understand and communicate to decision makers and the community.

There is limited current knowledge on the potential impact of climate change on water availability in the Sydney basin and the impact of prolonged restrictions and water conservation programs on unrestricted demand. Under the analytical framework, decision makers will still be required to make a range of judgements in developing the best strategy to meet the objectives of the Plan. This may require additional input from the community on, for example, the level of risk that they are willing to bear. Therefore, the results of the community engagement strategy that has been undertaken is likely to play an important role in the development of the Plan.

Incorporating environmental and social impacts

Various techniques are available to enable specific ‘dollar’ values to be placed against the environmental and social costs and benefits of the Plan such as benefit transfer techniques. However, due to the limited information available to place values on the environmental and social impacts of the various measures assessed as part of the Review it was determined that these techniques would not be incorporated into the

¹⁰ We use the terms risk and uncertainty interchangeably throughout this report to refer to events about which there is a known or sensibly estimated probability distribution of possible outcomes. However, we recognise that there is a clear distinction between the terms in a technical sense.

analysis. Data was only available to place reasonable values on the environmental impacts associated with greenhouse gas emissions and Shoalhaven transfers costs.

In order to capture the broad range of environmental and social impacts associated with alternative portfolios of measures, the NSW Office of Water established two separate panels of experts from government agencies combined with some input from external experts. The two panels were responsible for separately considering the issues of environmental and social impacts and establishing a methodology that allowed a ranking of the portfolios. The approach adopted by the two panels was largely based on qualitative analysis. The approaches also included a methodology for placing scores on the impacts, although the scoring system differed between the two groups.

The challenge for this study has been to incorporate the analysis of the two panels into the cost effectiveness analysis. Our approach to incorporating this information is discussed further below in discussions on portfolio rankings.

Decision rule

A cost effectiveness analysis typically incorporates a time dimension to take account, for example, of additional investments in infrastructure that may be required at different points in time. We have adopted this approach, using a discounted cashflow analysis, using a real discount rate of 7 per cent, with sensitivity analysis undertaken on other rates.

When ranking different portfolios the net present value decision rule suggests that the option with the highest net present value would be preferred, subject to that option meeting the specified criterion. In this analysis we have assumed a specified security criterion that portfolios are required to meet.

However, it is also important to take account of the fact that some portfolios may offer significantly higher levels of security above the security criterion. Therefore, the ranking of alternative portfolios needs to consider both the net present value of costs associated with alternative portfolios as well as the level of security offered by that portfolio. In some instances portfolios may clearly 'dominate' other portfolios on both cost and security grounds. However, in other cases, there may not be a clear ranking of portfolios.

In addition, the conclusions regarding the preferred portfolios will need to take account of the findings of the environmental and social panels regarding the potential impacts of these projects. This additional information is expected to provide a clearer ranking of portfolios.

The security criterion

The specification of the security constraint to be used in the analysis of alternative portfolios is a key factor that can influence the ranking of alternative portfolios. The primary focus of the analysis is over the immediate to medium term planning period. Therefore, the security criterion was primarily applied to the period 2010 to 2030.¹¹

For the purposes of this analysis, alternatives were considered to the current security criterion set in the SCA Operating Licence.¹² Alternative levels of security were considered to test the cost implications of each. Some alternative specification of the security criterion was also considered. This was intended to ensure that the security criterion chosen was simple to understand and could be readily communicated to decision makers and the community.

The PCG considered that using an absolute (as opposed to a probabilistic) criterion was more intuitive for policy makers and the community to understand. The PCG considered a security level of 5 per cent was broadly consistent with the security criterion specified in the SCA's Operating Licence.¹³

In establishing the security criterion it recognised that while an absolute security criterion is set, this does not guarantee that a security criterion can always be met in all future situations. Our analysis of the performance of alternative portfolios against the security criterion is based on the results of the hydrological modelling. It is possible that there may be future droughts that are worse than that generated by the hydrological models. In this sense, it is important that policy-makers continue to monitor situations and continue to enhance their knowledge of alternative measures that could assist in managing against unexpected events in the future.

It is also important to test the cost of alternative portfolios under slight changes to the security constraint (once it is established). It is possible that, for example, the cost of the optimal portfolio can be significantly reduced by adopting a slightly lower security constraint.

¹¹ Our modeling has incorporated information from the period 2010 to 2050, although the key period of interest is that between 2010 and 2030. It was also recognised that in the longer term, additional measures would be required to meet water security objectives. However, there was uncertainty regarding the nature and cost of these additional measures which warrants a focus on the shorter term planning period.

¹² In the SCA's Operating Licence the security criterion specifies that the level of water in storage should not be allowed to fall below 5 per cent of capacity more than 0.001 per cent of the time, on average.

¹³ The SCA has advised that adopting a 10 per cent absolute security criterion would result in a more conservative outcome than the security criterion specified in their current Operating Licence.

The reliability criterion

As noted above, the reliability criterion (ie the average time spent in restrictions) has not been fixed in this analysis. Rather a cost has been assigned to the time in restrictions so that this aspect can be considered as part of the cost effectiveness analysis. Sensitivity testing has also been undertaken on the cost of level 1 water restrictions being reduced. The SCA's Reliability Criterion states that restrictions should not be in place for more than 3 per cent of the time.

Portfolio analysis

For the purposes of this analysis, we interpret a portfolio to comprise a set or sequence of projects, timing, and rules.

The current infrastructure for providing Sydney's water forms the portfolio of assets that ensure that there is sufficient water available to meet the water demand from consumers. The existing portfolio also includes the existing policy decisions such as the current water restrictions regime.

A new portfolio could include additional measures such as new infrastructure or changes to the existing portfolio of measures (including current policies). For instance, we interpret a new portfolio to be formed if the existing portfolios of measures are amended slightly (such as through the introduction of a new restrictions regime).

Portfolios may also differ in terms of the timing of the introduction of new measures. For example, for the purposes of our analysis we would treat the following to be two separate portfolios:

- Portfolio 1: The existing portfolio of measures plus additional demand management programs being introduced from 2010; and
- Portfolio 2: The existing portfolio of measures plus additional demand management programs being introduced from 2015.

Under the portfolio approach, individual changes to the water system are considered in the context of the existing portfolio of measures. This recognises the interaction effects between the different parts of the system.

Assessment of portfolios

The practical assessment of portfolios has to acknowledge the resource constraints faced in portfolio evaluation. These are:

- limited resources to run the hydrological model WATHNET;
- limited information that causally links water flows to environmental and social outcomes;

- limited information on the risk attitudes of the government and community;
- limited information on the future financial constraints on water investments; and
- limited information on the cost of water restrictions.

Once the individual options were selected, TheCIE began analysis of these options in combination with the range of measures that are currently in place (ie portfolio analysis). That is, the options are added to the existing measures to form a new portfolio of measures. Even with the limited range of options considered for further analysis, these can be combined in different ways such as to generate a large number of portfolios that need to be analysed.

In order to minimise the number of portfolios to be analysed a two step approach was adopted:

- testing the security performance of the portfolio which provided a filtering mechanism to select portfolios to progress to the next level of analysis;¹⁴ and
- conducting the 'full' analysis on the selected portfolios using the full set of future inflow scenarios generated by the WATHNET model and considering ensured both the security and reliability of the water supply system were considered.

Portfolio ranking

We have adopted the following approach:

- Step 1. We have first considered whether a portfolio meets the security criterion. Portfolios that do not meet the specified security criterion are excluded. Portfolios that do not meet the security criterion (but only by a small margin) are not discarded because they may be substantially lower cost compared with portfolios that may only have marginally better security outcomes.¹⁵ Further, these portfolios could also have environmental and social merits that need to be considered in the next steps.
- Step 2. For those portfolios that meet the security criterion we compare these portfolios on cost and security grounds.
- Step 3. We then test whether the ranking of these portfolios changes by incorporating environmental and social impacts.

¹⁴ This involved choosing the most extreme simulated drought scenario (Replicate 1449) of the first 2 000 scenarios generated by the hydrology model and examining the performance of alternative portfolios in this context.

¹⁵ There is no information available that will allow us to test the risk preferences of Sydney households and their willingness to pay for additional levels of security.

The WATHNET model

In order to evaluate how alternative portfolios impact on the existing costs of operating the system and contribute to reducing the time in restrictions and the likelihood of low dam levels, we use the results from a complex hydrology model, the WATHNET model. This model is used by the SCA to optimise the use of its infrastructure and to calculate the impact on system yield of specific changes to the water supply system.

The model allows historical inflow data to be replicated by stochastic modelling to provide simulated inflow sequences (known as Replicates).¹⁶ The model was not designed as an inflow-forecasting tool although it produces results in each month over the next 50 years. Therefore, the Replicates are scenarios rather than forecasts.

The WATHNET model produced a range of output to assist in examining how the alternative portfolios impact on the supply system. Key pieces of information produced by the modelling include:

- the amount of time in restrictions;
- storage levels over time and storage behaviour (ie depletion curves);
- the volume of water pumped from the Shoalhaven scheme in each month – the pumping from the Shoalhaven system is triggered by overall dam levels;
- the volume of water produced by the desalination plant in each month;
- the volume of water released from dams into the downstream rivers, which includes environmental releases, spills and other miscellaneous releases; and
- the volume of ‘shortfalls’ at different points in the system to supply needs to be transferred to meet the demand at that point in time.

The assumptions and inputs underlying the WATHNET model include the physical infrastructure of the system,¹⁷ the operating regime for this infrastructure, the demand and other release requirements (eg environmental flow releases, riparian releases) and the hydrologic behaviour of the catchment.

¹⁶ In our analysis we initially used 2 000 Replicates and increased this to 10 000 Replicates on a more limited range of portfolios that have been selected to progress to the ‘next step’. The key benefit of the 10 000 Replicates is that it provides further information on the potential ‘extreme’ events that could be faced at different points in time over the next 50 years and how the alternative portfolios perform in the extreme situations.

¹⁷ All water recycling initiatives are treated by the model as ‘negative demands’.

5 *Portfolio impacts and portfolio costs*

This chapter summarises the physical performance of alternative portfolio options we have modelled. The portfolio performance is compared against the modelling results for the base case or existing measures that have been committed by the Government.¹⁸ The reporting of the results has been divided into three broad time periods (the immediate, medium and longer term). This is important because there are expected to be significant changes at different points in time (such as the introduction of the revised Warragamba environmental flow regime, and increase in demand). Therefore, it is useful to consider how these changes result in different outcomes compared with the earlier periods.

The second part of this chapter reports the costs (in net present value terms) and compares how the costs of the portfolios differ. The next chapter combines the cost information and the physical characteristics to provide an initial portfolio ranking.

Summary of portfolios analysed

For the base case a flow regime for Warragamba Dam of five ML/day is assumed and 80/20 regimes for all other dams. In all runs presented in the table below we assume a revised environmental flow regime of 95/20 for Warragamba Dam and 80/20 regimes for the other dams.

For all the runs (except Run 22) we have assumed that the operation of the existing desalination plant is triggered when dam levels go below 70 per cent of capacity and switched off when dam levels reach 80 per cent. For Run 22 the existing desalination plant is assumed to operate at full capacity from 2018 to 'balance' the impact of the revised Warragamba environmental flows regime which is assumed to be introduced at that point in time.

A description of the emergency measures was provided in chapter 3. Unless otherwise specified, the trigger levels used were:

- 40 per cent storage levels for triggering changes to the minimum operating level for Tallowa dam; and

¹⁸ In the analysis in this section we use the demand projections that include median population projections and low savings from demand management programs. In the sensitivity analysis section we report on the impact of alternative demand projections.

- 35 per cent storage levels for triggering water usage targets and halving of environmental flows in all storages.

5.1 Summary of modelling portfolios

<i>Run</i>	<i>Upgrading Desalination</i>	<i>Upgrade Sh Transfers</i>	<i>Shoalhaven Pump Mark</i>	<i>Water restrictions</i>	<i>Emergency measures</i>
Base case	None	None	75/80	L1@55%, L2@45%, L3@40%	No
Base case with E'Flows	None	None	75/80	As above	No
Run 13	2018/, 70/80	2018	85/90	As above	No
Run 15	30%, 30/80	None	75/80	As above	Yes ^a
Run 17	30%, 30/80	2024	85/90	As above	Yes ^a
Run 18	20%, 70/80	2034	85/90	As above	Yes ^a
Run 19	15% to 2024, 70/80 20% after 2024, 70/80	2034	85/90	As above	Yes ^a
Run 20	15% to 2024, 70/80 20% after 2024, 70/80	None	75/80	As above	Yes ^a
Run 21	15% to 2024, 70/80 20% after 2024, 70/80	2034	85/90	As above	Yes, 40% trigger Tallowa MOL, 35% trigger for halving eflows. Excluding water usage targets.
Run 22	15% to 2024, 70/80 20% after 2024, 70/80	None	75/80	As above	Yes ^a
Run26	20% to 2030, 70/80 30% after 2030, 70/80	2035	85/90	As above	Yes 35% trigger Tallowa MOL, 25% trigger for halving eflows and water usage targets.
Run 27	20% to 2030, 70/80 30% after 2030, 70/80	2025	85/90	As above	Yes, 35% trigger Tallowa MOL., 25% trigger for halving eflows and water usage targets.
Run 28	20% to 2030, 70/80 30% after 2030, 70/80	2035	85/90	L1@50%, L2@40%	Yes, 35% trigger Tallowa MOL, 25% trigger for halving eflows and water usage targets.
Run 29	20% to 2030, 70/80 30% after 2030, 70/80	2035	85/90	L1@60%, L2@50%	Yes, 35% trigger Tallowa MOL, 25% trigger for halving eflows and water usage targets.
Run 30	20% to 2030, 70/80 30% after 2030, 70/80	2025	85/90	L1@50%, L2@40%	Yes, 35% trigger Tallowa MOL, 25% trigger for halving eflows and water usage targets.

^a 'Emergency Measures' include the following: 40 per cent storage levels for triggering changes to the minimum operating level for Tallowa dam; 35 per cent storage levels for triggering water usage targets and halving of environmental flows in all storages

Note: The trigger for upscaling the desalination plant refers to the assumed point which the plant commences operation. The trigger to commit to construct has been modelled at 15 per cent higher than this level.

Portfolio impacts

In this section we report on the changes to the reliability and security of the system. A wide range of the parameters noted above are incorporated directly into the modelling of costs.

Additional infrastructure in 2018 (Run 13)

This portfolio (Run 13) takes the base case and includes the revised environmental flow regime for Warragamba Dam commencing in 2018. We have included both the Shoalhaven augmentation and the second stage of the desalination plant. In Run 13, this additional infrastructure is assumed to commence in 2018, at the same time the new environmental flow regime begins. The second stage of the desalination plant is assumed to operate according to the same rule (a 70/80 rule) as the existing desalination plant.

The security and reliability outcomes of this new portfolio are presented in the tables below. The probability of falling below 10 per cent increases substantially, particularly from 2030 onward. Likewise, the revised regime also contributes to lowering the minimum storage levels reached.

5.2 Security outcomes – Probability and minimum storage levels

	Up to 2020		2020-30		2030-50	
	Probability <10%	Minimum storage	Probability <10%	Minimum storage	Probability <10%	Minimum storage
	%	%	%	%	%	%
Base case	0.1	5.5	0.3	2.2	3.3	0.0
Base case – Eflows 95/20	0.1	5.5	0.7	0.0	6.8	0.0
2018 Infrastructure (Run 13)	0.1	5.4	0.1	13.4	1.2	0.0

Source: SCA Wathnet model.

Introducing the additional infrastructure in 2018 significantly lowers the probability of falling below 10 per cent storage levels and raises the minimum storage level reached. However, in the longer term, both these measures do not stop the storages from potentially running out of water in extreme droughts.

5.3 Reliability outcomes - average time in restrictions

	Up to 2020	2020-30	2030-50
	%	%	%
Base case	5.0	3.6	6.9
Base case – Eflows 95/20	5.1	5.7	10.7
2018 Infrastructure (Run 13)	4.9	2.8	5.9

Source: SCA Wathnet model.

Introducing the additional infrastructure in 2018 also has a significant impact on the time in restrictions. The new infrastructure has the effect of lowering the time in restrictions from 10.7 per cent back to 5.9 per cent in the final period.

Additional desalination plant combined with emergency measures

Constructing stage 2 of the desalination plant at a fixed point in time does not provide flexibility to incorporate new information, such as storage levels at that particular point in time. For example, storages may be at full capacity in 2018 when the second stage of the plan is assumed to commence. In this situation there is likely to be significant benefit of delaying the construction of the plant for several years until dam levels fall. Therefore, for this scenario we have considered triggering the construction of the desalination plant according to a dam level trigger. In the scenarios below we assume that the upgraded plant starts operating when dam levels reach the specified level. This means that a decision would need to be made in advance (at a 15 per cent to 20 per cent higher dam levels) to ensure the construction of the plant can be completed and it can start operating at the specified dam level.

To slow the depletion of dams further during the construction of a desalination plant, we have also incorporated emergency measures that are also triggered at low dam levels. We have also considered the performance of this portfolio with and without the upgrade to the Shoalhaven transfer scheme.

5.4 Security outcomes – Probability and minimum storage levels

	Up to 2020		2020-30		2030-50	
	Probability <10%	Minimum storage	Probability <10%	Minimum storage	Probability <10%	Minimum storage
	%	%	%	%	%	%
Base case	0.1	5.5	0.3	2.2	3.3	0.0
Base case – Eflows 95/20	0.1	5.5	0.7	0.0	6.8	0.0
Desal 2 30 per cent operating, 30/80 rule Emergency measures (RUN 15)	0.0	18.6	0.0	12.6	0.6	0.3
Desal 2 30 per cent operating, 30/80 rule SHP Upgrade 2024 (Run 17)	0.0	18.7	0.0	12.8	0.4	0.3
Desal 2 20 per cent operating 70/80 rule Emergency measures SHP Upgrade 2034 (Run 18)	0.0	15.9	0.0	10.0	0.9	0.2

Source: SCA Wathnet model.

Beyond 2020, the base case scenario with or without environmental flows for Warragamba falls below 5 per cent minimum storage levels and requires augmentation. Up to 2030, upgrading the desalination plant, even if it commences

operating when dam levels are at 20 per cent of capacity, can significantly improve the security outcome of the water supply system, particularly when combined with the emergency measures that slow the depletion of the dams. In the longer term beyond 2030, as water demand rises, the security of the system is significantly reduced even if these measures are in place.

5.5 Reliability outcomes - Average time in restrictions

	Up to 2020	2020-30	2030-50
	%	%	%
Base case	5.0	3.6	6.9
Base case – Eflows 95/20	5.1	5.7	10.7
Desal 2 30% operating, 30/80 rule, Emergency measures (RUN 15)	5.1	5.5	10.1
Desal 2 30% operating, 30/80 rule, Emergency measures SHP Upgrade 2024 (RUN 17)	5.1	5.2	8.7
Desal 2 20% operating, 70/80 rule, Emergency measures SHP Upgrade 2034 (RUN 18)	5.1	5.6	9.3

Source: SCA Wathnet model.

The additional measures do improve the reliability of the system but not significantly. Augmenting the Shoalhaven transfer scheme does offer a reliability benefit, although it doesn't make a significant contribution to security.

Changing the desalination plant trigger points over time

In this part of the modelling we have tested the impact of lowering the assumed operating trigger level for the second stage of the desalination plant until demand increases in future. In these scenarios we have assumed that, up to 2024, the operation of the second stage of the plant is triggered when dam levels reach 15 per cent. After 2024, as demand is projected to rise, we have assumed that the second stage needs to start operating when dams reach 20 per cent.

We also test how these new trigger levels perform with the emergency measures, but also in combination with augmenting the Shoalhaven transfer scheme, and operating the existing desalination plant at full capacity from 2018 onwards.

5.6 Security outcomes – Pr<10 per cent and minimum storage levels

	Up to 2020		2020-30		2030-50	
	Probability <10%	Minimum storage	Probability <10%	Minimum storage	Probability <10%	Minimum storage
	%	%	%	%	%	%
Base case	0.1	5.5	0.3	2.2	3.3	0.0
Bas case – Eflows 95/0	0.1	5.5	0.7	0.0	6.8	0.0
Desal 2 15 per cent to 2040 and 20 per cent onwards, 70/80 rule Emergency measures (RUN 20)	0.0	12.4	0.0	10.1	0.8	0.3
Desal 2 15 per cent to 2040 and 20 per cent onwards, 70/80 rule Emergency measures Desal 1 operating at 100 per cent from 2018 (RUN 22)	0.0	12.4	0.0	11.0	0.5	0.3
Desal 2 15 per cent to 2024 and 20 per cent onwards, 70/80 rule Emergency measures SHP Upgrade 2034 (RUN 19)	0.0	12.4	0.1	10.0	0.8	0.2

Source: SCA Wathnet model.

The modelling shows that lowering the assumed trigger level for the second stage of desalination does not provide any significant benefit in terms of security (for example, Run 19 above and Run 18 in Table 5.4). Also, running Stage 1 of the desalination plant at 100 per cent from 2018 (Run 22) offers minimal additional benefit in security to 2030.

5.7 Reliability outcomes - Average time in restrictions

	Up to 2020	2020-30	2030-50
	%	%	%
Base case	5.0	3.6	6.9
Base case – Eflows 95/20	5.1	5.7	10.7
Desal 2 15% to 2024 and 20%onwards, 70/80 rule, Emergency measures (RUN 20)	5.1	5.6	10.2
Desal 2 15% to 2024 and 20%onwards, 70/80 rule, Emergency measures Desal 1 operating at 100% from 2018 (RUN 22)	5.1	4.2	7.1
Desal 2 15% to 2024 and 20%onwards, 70/80 rule, Emergency measures SHP Upgrade 2034 (RUN 19)	5.1	5.6	9.3

Source: SCA Wathnet model.

While these measures would induce no change in the average time spent in water restrictions until 2020, marginal declines would be achieved post 2020, with the proportional decrease greater post 2030. In particular, the operation of the existing desalination plant at full capacity from 2018 onwards reduces the average time spent in restrictions by around 1.5 per cent between 2020 and 2030 and 3.6 per cent between 2030 and 2050.

Changing triggers for the measures deployed in extreme drought

As noted in the previous sections, the emergency measures can make a significant contribution to the security of the system. However, these measures may come at a relatively high cost to the community and environment and, therefore, are for in extreme situations, more work needs to be done to refine costs and actions.

Further, there is also some uncertainty regarding whether the water usage targets can achieve the level of savings assumed. Given this, we have considered changes to the trigger levels for implementing the emergency measures as well as changes to the trigger levels for commencing the operation of the second stage of the desalination plant. We have also considered an option without water usage targets.

5.8 Security outcomes – Pr<10 per cent and minimum storage levels

	Up to 2020		2020-30		2030-50	
	Probability <10%	Minimum storage	Probability <10%	Minimum storage	Probability <10%	Minimum storage
	%	%	%	%	%	%
Base case	0.1	5.5	0.3	2.2	3.3	0.0
Bas case – Eflows 95/0	0.1	5.5	0.7	0.0	6.8	0.0
Desal 2 15 per cent to 2040 and 20 per cent onwards, 70/80 rule Emergency measures, No Water Usage Targets SHP Upgrade 2034 (RUN 21)	0.0	10.7	0.1	5.2	2.3	0.2
Desal 2 20 per cent to 2030 and 30 per cent onwards, 70/80 rule Emergency measures, lower triggers SHP Upgrade 2035 (RUN 26)	0.0	14.8	0.1	7.1	0.7	0.1
Desal 2 20 per cent to 2030 and 30 per cent onwards, 70/80 rule Emergency measures, lower triggers SHP Upgrade 2025 (RUN 27)	0.0	14.8	0.1	7.1	0.7	0.1

Source: SCA Wathnet model.

The removal of water usage targets (Run 21 compared with Run 19) reduces the modelled minimum storage level reached from 10 per cent to around 5 per cent to 2030, demonstrating the influence that these measures are predicted to have during an extreme drought period. Even so, Run 21 still just meets the 5 per cent minimum storage level. The delayed trigger level (Runs 26 and 27 compared with Run 19) also demonstrates a reduction of about 3 per cent in minimum storage level reached (from 10 per cent to 7.1 per cent) up to 2030.

These measures increase the average time spent in restrictions up to 2020, but achieve a reduction in average time spent in restrictions thereafter.

5.9 Reliability outcomes - Average time in restrictions

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base case	5.0	3.6	6.9
Base case – Eflows 95/20	5.1	5.7	10.7
Desal 2 15% to 2024 and 20%onwards, 70/80 rule, Emergency measures, No Water Usage Targets SHP Upgrade 2034 (RUN 21)	5.1	5.6	9.3
Desal 2 20% to 2030 and 30%onwards, 70/80 rule, Emergency measures, lower triggers SHP Upgrade 2035 (RUN 26)	5.2	5.7	9.3
Desal 2 20% to 2030 and 30%onwards, 70/80 rule, Emergency measures, lower triggers SHP Upgrade 2025 (RUN 27)	5.2	5.4	8.8

Source: SCA Wathnet model.

Changing the existing levels of restrictions

As a final step in the scenario analysis, we have considered the performance of the portfolios described in the previous section under different restrictions regimes. We have considered two alternative restrictions regimes:

- Option 1: Level 1 restrictions commencing at 50 per cent storage levels and Level 2 at 40 per cent saving 10 per cent and 11 per cent of demand respectively; and
- Option 2: Level 1 restrictions commencing at 60 per cent storage levels and Level 2 at 50 per cent saving 10 per cent and 11 per cent of demand respectively.

5.10 Security outcomes – Pr<10 per cent and minimum storage levels

	<i>Up to 2020</i>		<i>2020-30</i>		<i>2030-50</i>	
	<i>Probability <10%</i>	<i>Minimum storage</i>	<i>Probability <10%</i>	<i>Minimum storage</i>	<i>Probability <10%</i>	<i>Minimum storage</i>
	%	%	%	%	%	%
Base case	0.1	5.5	0.3	2.2	3.3	0.0
Base case – Eflows 95/20	0.1	5.5	0.7	0.0	6.8	0.0
Desal 2 20 per cent to 2030 and 30 per cent onwards, 70/80 rule SHP Upgrade 2035 Option 1 Restrictions (RUN 28)	0.0	14.2	0.1	6.9	0.8	0.1
Desal 2 20 per cent to 2030 and 30 per cent onwards, 70/80 rule Emergency measures – lower triggers SHP Upgrade 2035 Option 2 Restrictions (RUN 29)	0.0	15.3	0.1	7.6	0.6	0.3
Desal 2 20 per cent to 2030 and 30 per cent onwards, 70/80 rule Emergency measures – lower triggers SHP Upgrade 2025 Option 1 Restrictions (RUN 30)	0.0	14.2	0.1	6.9	0.8	0.1

Source: SCA Wathnet model.

The Option 1 alternative restrictions regime (Run 28 compared with Run 26) has little impact on the security of the system (minimum storage to 2030 reduced from 7.1 per cent to 6.9 per cent) as does the Option 2 regime (minimum storage to 2030 increased from 7.1 per cent to 7.6 per cent). However, average time in restrictions would decline markedly under a scenario which imposes Option 1 restrictions, but would actually increase significantly under Option 2 restrictions.

5.11 Reliability outcomes - Average time in restrictions

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base case	5.0	3.6	6.9
Base case – Eflows 95/20	5.1	5.7	10.7
Desal 2 20% to 2030 and 30%onwards, 70/80 rule, Emergency measures - lower triggers SHP Upgrade 2035			
Option 1 Restrictions (RUN 28)	2.9	3.9	6.8
Desal 2 20% to 2030 and 30%onwards, 70/80 rule, Emergency measures - lower triggers SHP Upgrade 2035			
Option 2 Restrictions (RUN 29)	8.6	7.9	12.1
Desal 2 20% to 2030 and 30%onwards, 70/80 rule, Emergency measures - lower triggers SHP Upgrade 2025			
Option 1 Restrictions (RUN 30)	2.9	3.7	6.5

Source: SCA Wathnet model.

Cost information of the base case compared with various new portfolios

In this section we compare total costs of the base case (including the environmental flows regime of 95/20 for Warragamba Dam) against the various alternative portfolios discussed above. Each of the portfolios will change a range of key parameters which, in turn, impact on the costs of the portfolio.

The key items used in the cost-effectiveness analysis include:

- the costs associated with the desalination plant, including the capital costs of the second stage of the desalination plant and the operating costs of the plant (which incorporates the higher cost of green energy);
- the pumping costs associated with the Shoalhaven transfer scheme and the cost of greenhouse gas emissions associated with this pumping;
- the augmentation of the Shoalhaven transfer scheme including the upfront capital costs and the ongoing operating costs associated with the project, including the energy offsets achieved through a hydro generation plant;¹⁹
- the cost of quantitative water restrictions;
- the costs of supply shortfalls at particular parts of the system which is assumed to only occur if dam levels fall below 10 per cent;
- the costs of pumping water from existing groundwater systems; and
- the cost of emergency response measures.

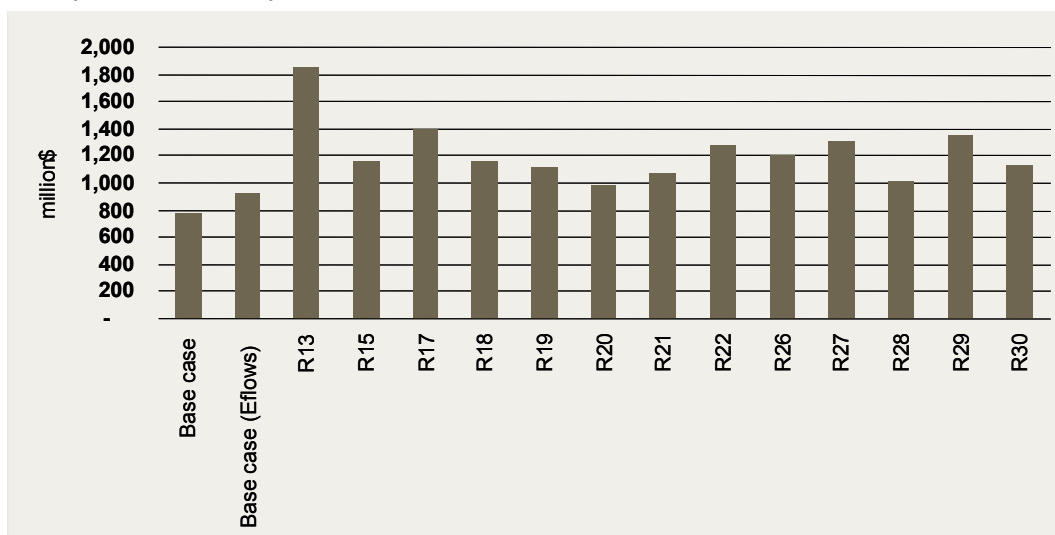
¹⁹ This also includes capital costs associated with additional infrastructure for the Shoalhaven system.

An explanation of how each of these cost elements is calculated is provided in Appendices E and F. For a large number of these costs, we have relied on cost information provided by the various NSW water agencies.

Chart 5.12 below presents the total costs of the alternative portfolios. The costs reflect the probability weighted net present value of the costs at different points in time up to 2050 using a seven per cent discount rate.²⁰

It is important to note that the base case portfolio is not strictly comparable to the other portfolios modelled because it doesn't include the revised environmental flow regime. However, we have presented it in the chart below to illustrate the impact on the portfolio costs of including the revised flow regime.

5.12 Probability weighted net present value of alternative portfolios up to 2050 (2009/10 dollars)



Data source: The CIE. Calculations.

In the next chapter we compare the alternative portfolios on security and cost grounds.

²⁰ The term probability weighted NPV is used to indicate that cost predictions are based on the probabilistic outputs of the WATHNET model. For example, the second stage of desalination might be triggered in only several of 2000 replicates modelled within a Run, and so the modelled NPV cost for this component is relatively low due to the low probability of this event occurring.

6 *Ranking of portfolios*

The information presented in the previous section illustrates the different characteristics of each of the portfolios in terms of security, reliability and cost. The reliability of the water supply system is implicitly incorporated into the cost using the cost of drought water restrictions. For the cost effectiveness analysis the key characteristics are, therefore, the cost and security of the portfolios. This chapter compares the portfolios according to their cost and security characteristics.

Where the impacts have not been explicitly valued and included into the costs, these characteristics also need to be considered. These primarily relate to the environmental and social impacts which are the topic of the next chapter.

Overview of ranking approach

As discussed, our approach to ranking the portfolios involves three steps.

The first step is to exclude those portfolios that do not meet the specified security criterion. A criterion of five per cent of storage levels for the period up to 2030 is used. It was acknowledged that new measures (in addition to those modelled in this study) would be required in order to meet the criterion over a longer term period. There is significant uncertainty regarding these new measures and the associated costs. Given this, the medium term period up to 2030 was chosen for the ranking of alternative portfolios.

The second step is to rank those portfolios that have successfully passed the first hurdle. We retain portfolios that clearly dominate others on cost and security grounds. However, where there is no clear dominance, we retain these portfolios for further consideration in the final step.

The final step involved incorporating additional information on environmental and social impacts to examine how this additional information changes the rankings of the portfolios selected in step 2.

Step 1 Excluding portfolios based on security criterion

Table 6.1 below details the probability weighted net present value of costs to 2050 and minimum storage levels achieved up to 2030.

6.1 Probability weighted NPV of costs to 2050 and security outcomes to 2030

	<i>Minimum storage level</i>	<i>NPV of costs</i>
	%	(\$'m)
Base case	2.2	786
Base case – with Eflows	0.0	920
R13	5.4	1 854
R15	12.6	1 165
R17	12.8	1 403
R18	10.0	1 160
R19	10.0	1 114
R20	10.1	987
R21	5.2	1 074
R22	11.0	1 278
R26	7.1	1 204
R27	7.1	1 314
R28	6.9	1 018
R29	7.6	1 347
R30	6.9	1 130

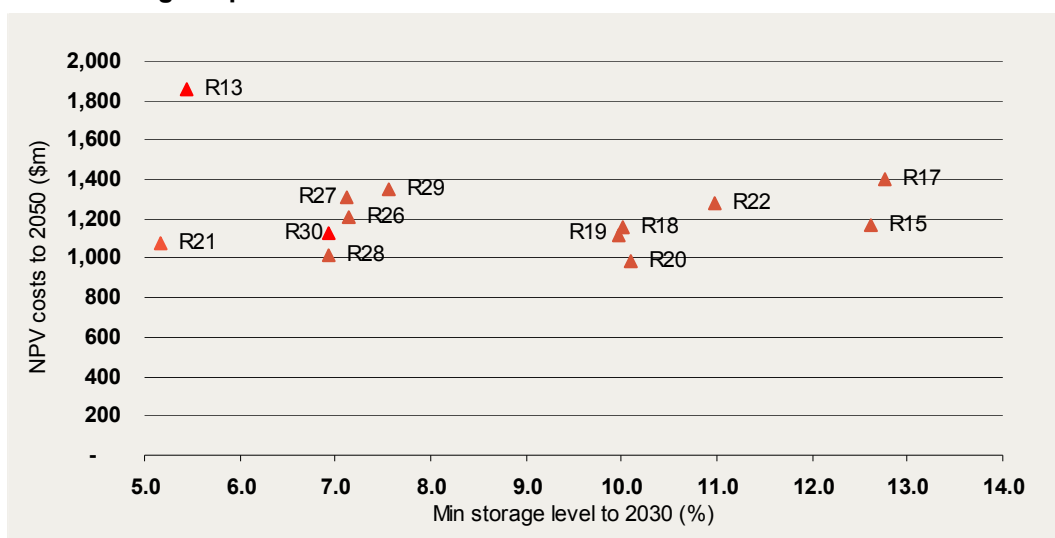
Source: TheCIE calculations.

Based on these results only the two base case runs are excluded as these do not meet the security criterion and are, therefore, excluded from further analysis. Runs 13 and 21 meet the security criterion but only by a small margin.

Step 2 Comparing portfolios that meet security criterion

Chart 6.2 plots the security and cost characteristics of those portfolios that meet the security criterion.

6.2 Rankings of portfolios — all scenarios



Data source: The CIE calculations and SCA Wathnet model.

It is apparent from the chart there are a number of clearly dominant portfolios on cost and security grounds:

- Run 20 have lower cost and better security outcomes than all portfolios to its left (that is, all portfolios except Run 22, 15 and 17). Run 20, therefore, is considered to dominate the portfolios to its left in the chart above.
- Run 15 offers greater security and at a lower cost than Run 22. Run 15 also offers similar security to Run 17, but at a significantly lower cost. Run 15 is, therefore, preferred to Runs 17 and 22.

This leaves Runs 15 and 20 as preferred portfolios based on security and cost. It is not possible for us to distinguish between these two portfolios given that there is limited information of the risk preferences of consumers. With detailed information on risk preferences it would be possible to analyse whether consumers would be willing to pay for the additional levels of security offered by Runs 15 compared with Run 20.

It should be noted that Runs 15 and 20 rely on triggering the water usage targets when dam levels reach 35 per cent. There is significant uncertainty regarding the potential water savings that could be achieved through these water usage targets. Therefore, an alternative portfolio such as Run 28 (that does not rely as heavily on the water usage targets) should also be considered.

Run 28 has similar costs to Run 20 but lower security. However, if the assumed savings from the water usage targets could not be achieved then Run 20 would achieve a lower security outcome and higher cost than presented in the chart above. Given this, we believe that Run 28 should also be considered as part of the set of dominant portfolios on cost and security grounds.

In the next chapter we consider which portfolios rank highest on environmental and social characteristics.

7 *Environmental and social impacts*

In the analysis presented in previous chapters we have not sought to quantify and place values on the environmental and social impacts of alternative portfolios.²¹ The reason for this approach is that it is largely to the limited information available to value these impacts. Given this, we have relied on the findings of the panel of experts that have been formed to evaluate the potential environmental and social impacts of alternative portfolios.²²

It should be noted that given the timing of their assessment, the Expert Environmental Panel (EEP) was not able to directly consider portfolios modelled beyond Run 27 (that is Runs 28, 29 and 30 which looked at alternative restrictions regimes). Similarly, the timing also limited the ability of the Expert Social Panel (ESP) to consider the social impacts of Run 30. In the situations where the expert panels had not reviewed the portfolio, the NSW Office of Water has interpreted the potential environmental and social impacts of these portfolios based on the key similarities between the assessed and unassessed runs.

This chapter reports some of the key physical changes resulting from each of the portfolios. It also draws together the conclusions of the social and environmental panels that have been separately tasked with reporting on the potential environmental and social impacts of alternative portfolios.

Overview of approach to incorporating environmental and social impacts

In the previous chapter we presented those portfolios that were dominant according to cost and security outcomes.

Given that the environmental and social panels have relied on qualitative analysis with different scoring systems (discussed further below), it is difficult to use this information where there are significant differences between the cost and security

²¹ The exception to this is the impact associated with the greenhouse gas emissions.

²² It is important to note that the social impacts of water restrictions have already been quantified and incorporated into the costs discussed in the previous chapter. Therefore, care must be taken to ensure that there is no double counting of the social impacts of water restrictions as part of this chapter.

outcomes of the final portfolios. That is, the information from the environmental and social panels can inform the likely direction of change (for example, whether a portfolio has a positive or negative environmental impact). However, it does not provide information on the order of magnitude of this change.

Given this, we have presented the findings of the environmental and social panels and compare this against the portfolio rankings based on cost and security outcomes (presented in the previous chapter). This will allow a more limited range of portfolios that can be considered by decision makers taking account any further information that may come to bear such as the community's willingness to pay for additional levels of security.

Expert Environmental Panel assessment

In this section we summarise the approach adopted by the EEP and their findings on preferred portfolios. A detailed description of the approach is provided in the EEP's report.

Overview of approach

There are a wide range of environmental impacts that cannot be easily quantified and included in the portfolio costs associated with each of the options. These include, for example:

- physical and chemical conditions in aquatic and terrestrial environments;
- high conservation status species and ecological communities listed under legislation;
- high conservation value habitats and landscapes recognised as National Parks, protected areas and reserves; and
- long-term ecosystem functioning.

The EEP compared the various portfolios using a multi-criteria analysis comprising the four criteria listed above. Greenhouse gas impacts of the portfolios were not considered by the EEP as relevant carbon costs were included in the financial analysis. The following weightings were given to each of the four criteria as shown in Table 7.1.

7.1 Criteria and weighting adopted

<i>Criteria</i>	<i>Weighting</i>
Physical and chemical changes due to management actions, principally driven by river flows	22
Ecological status of populations and communities listed under threatened species and environmental protection legislation;	45
Ecological status of habitats and ecosystems with conservation value recognised through land-use classification and zoning	17
Overall, long-term ecosystem functioning, including resilience and stability.	16

Source: Expert Environmental Panel.

Weighted scores were then allocated for each portfolio in seven different areas. The weightings were not applied based on the size of the areas. Rather, areas were chosen to reflect where the major environmental impacts or benefits were expected to occur under the various options.

The EEP used two primary timeframes for comparing environmental performance – from 2010 to 2020, and from 2020 to 2030.

Performance on these four criteria was scored using a standard risk assessment approach characterising risk as a combination of likelihood and consequence. In particular, for consequence, a range of -3 for negative impacts to +3 for positive benefits was used while the four categories of likelihood employed were (1) Very likely, (2) Likely (3) Unlikely. Scores were assigned relative to the Base Case.

The key data used in the assessment of the performance of options on the four criteria were:

- percentage of time Shoalhaven transfers were operating over 2010-2020 and 2020-2030;
- percentage of time desalination was operating over 2010-2020 and 2020-2030; and
- percentages of time emergency drought measures were in operation over 2010-2020 and 2020-2030.

Findings

It should be noted that given the timing of their assessment, the EEP was not able to directly consider portfolios modelled beyond Run 27 (that is Runs 28, 29 and 30 which looked at alternative restrictions regimes). However, the Office of Water has interpreted the results based on the key similarities between the assessed and unassessed runs and advised TheCIE of the following:

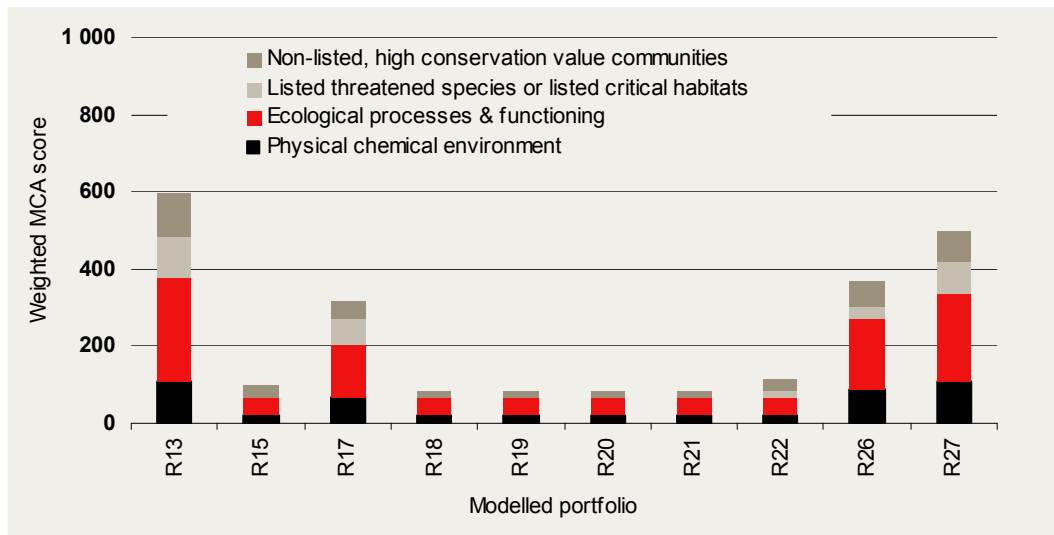
- Runs 28 and 29 can be considered to have scored the same as Run 26.
- Run 30 can be considered to have scored the same as Run 27.

These runs are shown in the following discussion in brackets to indicate where results have been extrapolated by the Office of Water. The EEP also considered

several earlier runs (ie prior to Run 13) however these were ‘test’ runs to investigate the behaviour of individual measures and are not considered further in this Report.

The results of the EEP assessment are shown in the following chart.

7.2 Assessment of portfolios by Environmental Expert Panel



Data source: NSW Office of Water.

Based on the approach described above some of the findings of the EEP included:

- Options which led to environmental flows from Warragamba Dam would lead to significant benefits for areas below Warragamba Dam across all four environmental criteria and therefore positive scores in those Areas.
- Runs 13, 17, 27 (and 30) were generally scored positively because they incorporate increased Warragamba environmental flows and early augmentation of the Shoalhaven scheme.
- Runs 26, (28 and 29) achieve all of their benefits to 2030 from the Warragamba environmental flows as the augmented Shoalhaven scheme does not commence operation until 2035.
- Runs 17, 27 (and 30) were penalised to some degree because they had negative impacts on the mid Shoalhaven Estuary due to the potential for decreased flows to the Shoalhaven River. No impacts were identified for the lower Shoalhaven estuary.
- Other flow benefits from Run 17 were also slightly discounted because of halved environmental flows when storage reached 35 per cent or less. The discounting was not as marked for Runs 27, (28, 29 and 30) due to a later trigger point (25 per cent storage levels) for these measures.
- Insofar as any negative environmental impacts were scored, these mainly related to construction of the desalination plant rather than the frequency of operation, or capacity. The EEP noted the findings of the environmental assessment undertaken

for the planning of the plant, including only very minor localised impacts on fish larvae and the reef.

In other words, the impact of the various options on environmental flows to key river systems was a major driver of the scoring on the four criteria. The EEP also commented that ‘Measures and options that maintained ecological conditions were preferable to those that resulted in a worsening situation that would have to be redeemed at a later time. A negative impact, even for a short time, may require a long recovery period, so measures such as reducing environmental flows during severe drought contributed to lower scores in the assessments’.

On balance the EEP concluded that Runs 13, 27 (and 30) were regarded as the best performing portfolios assessed.

Expert Social Panel assessment

An ESP was established to provide a quantitative and qualitative assessment of non-monetised social considerations.

Overview of approach

The ESP based its assessment on:

- a review of social research literature;
- the findings of Phase 1 and Phase 2 of the community consultation for the Review; and
- the prior knowledge and experience of the ESP members and, in the case of the government members, their agencies.

Through the steps listed above, key social values were identified as criteria for assessing the portfolios under consideration. Workshops were then held where the ESP grouped the social considerations under key categories and undertook a detailed ranking exercise to ascribe a weighting to each category and the values attributed to it. The values aligned under each category were also scored in relation to each other and the means aggregated and multiplied by the category rating to provide an overall weighting for each value. Finally, the resulting social values with their weighted scores were grouped into those values that could be categorised as ‘Community planning principles’ and those that could be categorised as ‘Community’s planning actions’.

However, ultimately only the social values grouped under ‘Community planning principles’ were used in the ranking assessments made by the ESP. Specifically, the ESP examined 10 of the options (namely runs 12, 13, 15, 17, 20, 21, 26, 27, 28, and 29) against the Base Case to produce a ranked order of selected portfolios by scoring each portfolio against the 13 Community Planning Principles (CPP).

Run 30 was not available for analysis at the time the ESP met. However, the Office of Water has interpreted the results based on the key similarities between the assessed and unassessed runs and advised TheCIE that Run 30 can be interpreted in the analysis to have scored slightly higher than Run 28 – ie an upper mid ranking against the other portfolios.

Options were scored -1 against a social value embodied in the CPP list if it was considered a negative change when compared with the Base Case, 0 where there was no change and +1 to indicate a positive change based on the social value. The CPP list is set out below along with the weight attached to each social value in the list.

7.3 Community Planning Principles

<i>Criteria</i>	<i>Weight</i>
Provide water that is safe to drink	10.4
Balance human and environmental needs - one not more important than the other	5.9
Ensure a dependable water supply	5.8
Maximise water recycling, especially capturing stormwater	5.2
Restore clean healthy waterways and reduce pollution	5.1
Maximise efficient water use, enforce Water Wise Rules or introduce restrictions if needed	4.8
Ensure the Government and the community jointly take responsibility for water management	4.2
Ensure healthy catchments to support healthy rivers	4.2
Ensure everyone has access to affordable water for basic living needs	4.2
Share water fairly to meet the needs of all sectors of the community	3.6
Invest in planning and research for long-term, innovative solutions	3.4
Ensure Sydney's supply is not at the expense of other regions and catchment communities	3.3
Manage water sources within sustainable limits	3.1

Source: Expert Social Panel.

The ESP noted problems assessing performance on some of the social values on the CPP list. For instance, several could not be applied to the portfolios under examination because the portfolios did not specifically address that community value. Similarly, some social values could not apply because the value was assumed for the Plan as a whole but not the subject of an individual portfolio, such as 'Provide water that is safe to drink'. In addition, some issues of importance to the community were not captured within the portfolios being considered, such as innovation.

Summary of results from social assessment

The results of the ESP's assessment are summarised in the table below. The portfolio ranked highest by the ESP was Run 20. This portfolio ranked highest because water usage targets were activated five per cent before the desalination upgrade was triggered *and* it contains Warragamba environmental flows. Run 15 was equal first.

The Shoalhaven upgrade on its own (Run 12) scored third highest. Run 12 was a ‘test’ run to investigate the behaviour of individual measures and is not considered further in this Report.

7.4 Summary of ESP findings

Portfolio	Mean total on social indicators	Rank
Run 12	28.3	3
Run 13	-0.3	9
Run 15	28.9	1
Run 17	26.7	4
Run 20	28.9	1
Run 21	-0.8	10
Run 26	8.2	7
Run 27	7.7	8
Run 28	17.2	5
Run 29	14	6

Source: Expert Social Panel.

Impact of findings of environmental and social panels on portfolio rankings

As discussed, in the previous chapter we have ranked portfolios based on the cost and security outcomes associated with each portfolio. Run 15, Run 20 and (to a lesser extent) Run 28 are the preferred portfolios based on cost and security grounds.

The ESP concluded that Runs 15 and 20 have the lowest social impacts and were therefore, considered to be the highest ranked portfolios on social grounds. The EEP concluded that, on balance, that Runs 13, 27 and 30 were regarded as the best performance portfolios when considering the environmental impacts of these portfolios.

Given that the EEP has selected a different set of preferred portfolios to the ESP, it makes it more difficult to reach a conclusion regarding the preferred portfolios that should be considered for inclusion in the 2010 Metropolitan Water Plan. Additional information would be required to understand the *magnitude* of the environmental and social impacts and the community’s willingness to trade-off these impacts, as well as the cost and security impacts.

In the absence of such information it is difficult for us to distinguish between these portfolios. Further investigation would be required to be undertaken by the PCG to consider the magnitude of the environmental and social impacts and how this might change the rankings of the portfolios.

Given that the preferred ranking of the portfolios on cost and security grounds is similar to ESP we believe that this is the most useful starting point. We would recommend that the following runs be considered for further investigation:

- Runs 15 and 17 are similar portfolios, the only difference being that Run 17 includes the additional investment in upgrading the Shoalhaven transfer scheme in 2024. Run 17 offers similar security outcomes but cost approximately \$200 million more than Run 15. Run 17 would be preferred to Run 15 if the environmental and social benefits associated with the Shoalhaven transfer scheme are greater than the \$200 million cost differential.
- Run 20 does not include upgrading the Shoalhaven transfer scheme which is considered to have both positive environmental and social impacts. Run 18 has similar cost and security outcomes as Run 20, but also include upgrading the transfer scheme in 2034. Although this is later in the period, it is possible that Run 18 would be preferred to Run 20, once the environmental and social factors are incorporated.
- Runs 28 and 30 do not rely as heavily on the water usage targets, as these are triggered at a lower storage level. The difference between these portfolios is the earlier commencement of investment to upgrade the Shoalhaven transfer scheme. If the earlier commencement of this investment results in substantially lower environmental and social impacts then Run 30 may be preferred to Run 28.

Based on this, there are six portfolios (Runs 15, 17, 18, 20, 28 and 30) that should be considered for inclusion in the 2010 Metropolitan Water Plan.

These portfolios highlight the tradeoff that exists between the level of security of a portfolio and social, environment and financial cost of achieving this security. A more secure portfolio is generally more expensive. Without further information on the risk preferences of consumers, it is difficult to differentiate between these portfolios on cost and security alone. Further, without information on the magnitude of the environmental and social impacts associated with each portfolio and information on the community's willingness to tradeoff these factors it is difficult to draw more firm conclusions regarding the preferred portfolios.

Policy makers may also be able to differentiate between these portfolios by reviewing the robustness of some of the underlying assumptions in the model. For example, the security benefits offered by Run 18 relies on the relatively early implementation of personal water usage targets (at around 35 per cent total system storage) that are assumed to deliver savings of 22 per cent (when combined with the other levels of water restrictions) however, these have not been discretely costed. To the extent that this savings assumption is not achieved it would reduce the security advantages of this portfolio.

The portfolios also highlight the benefits of the new alternative restrictions regime commencing at 50 per cent storage levels compared with 55 per cent. This regime has

been modelled in runs 28 and 30. By keeping the average amount of time the community is in restrictions to around 3 per cent, significant cost savings can be achieved with little effect on system security. This can be expected to change beyond around 2025 when rising demand places increasing pressure on the system.²³

²³ The reliability criterion in the SCA's Operating Licence is likely to be considered further as part of the next Licence review.

8 *Conclusions*

The modelling result from this project indicates that, under the base case, Sydney's water supplies are secure over the next 10 years. The system is expected to meet the security (minimum storage levels reached) and the reliability criteria (average time in restrictions) embedded in the SCA's operating licence. Over this period modelling has indicated the minimum storage level reached is 5.5 per cent in an extreme drought. This is based on the existing portfolio of Government commitments under the Plan, including the planning assumption that the operation of the 250ML per day desalination plant is triggered when dam levels drop below 70 per cent of total capacity.

It should be noted that the conclusion is based on the wide range of rainfall/inflow scenarios modelled by the SCA. This includes worse droughts than that experienced in the 1940s and the recent drought. Nevertheless, it is possible that worse droughts than these may occur in the near future which would place greater pressure on water security. Further, it is possible that demand is greater than projected in this project which would also place greater pressure on the security of supply.

Therefore, while supplies are considered to be secure over the next 10 years it is still important to continue to monitor storage levels and trends in demand and to have in place contingency measures that can be implemented over a relatively short timeframe such as the second stage of desalination and the response measures for extreme drought considered in this report.

In the medium term (defined in this study as 2020 to 2030), there is expected to be greater pressures on the reliability and security of the water supply system due to the revised environmental flows regime and as demand begins to increase. Additional measures are likely to be required to meet these medium term pressures, particularly in light of uncertainties around climate change and its impact on supply and demand.

In the longer term, the increasing demand due to population growth will place significant pressure on the water supply system which will decrease the reliability and security of the system. This could be further exacerbated by climate change impacts.

There is a range of options currently available to address the short and medium term. In the longer term, however, a range of new measures will need to be considered.

This analysis has assessed more than 20 unique portfolios ('Runs') to determine the most appropriate mix of measures to ensure a secure supply of water for Sydney into the future.

There are group of six preferred portfolios (Runs 15, 17, 18, 20, 28 and 30) that have emerged from this analysis. Each of these portfolios involve upscaling the desalination plant (at low dam levels), combined with measures for deployment in extreme drought. Each of these portfolios has slightly different cost and security characteristics, as well as offering different environmental and social outcomes.

Runs 15 and 20 do not include additional investment in the Shoalhaven transfer scheme. If it is considered that the quantum of water secured, the environmental and social benefits of these projects and longer term water security benefits are sufficiently large then Runs 17 and 18 may be preferred.

The portfolios with the alternative restrictions regime triggered at 50 per cent total system storage (Runs 28 and 30) offer lower costs to Run 18 due to the reduced average time in restrictions. There is also not a significant loss in security by adopting the lower levels of restrictions. Although the modelling indicates that a change to the restrictions regime might not be strictly necessary until 2020, the lower costs to the community are such that it should be considered as part of the 2010 Plan.

Run 18 offers increased security benefits due to the earlier commencement of extreme drought measures, however Runs 28 and 30 with a later commencement are also secure. Further work to confirm the likely savings from these measures is needed along with further assessment of appropriate triggers should storage levels drop to an identified level, say, below 40 per cent (<2 per cent chance to 2025).

Further investigation by the PCG would be required to assist in filtering these portfolios further to a single portfolio for inclusion in the 2010 Metropolitan Water Plan. It should, however, be noted that (consistent with the adaptive management approach) each of these portfolios discussed above are sufficiently flexible to allow further refinement of the portfolios over time. They do not lock in major investments in the water supply system over the next few years but allow new information – such as cost of water restrictions, impact of climate change, population growth – to be utilised to improve understanding and develop the most cost effective portfolio over time.

Appendixes

A Existing commitments

- Assessment based on inflow hydrology from 1909-2008.
- Desalination module 1 250 ML/d:
 - Run continuously from 1 Jan 2010 to 31 December 2011 (noting start time now around April 2010 – this will not effect hydrology).
 - From 2012:
 - … On when total storage <70 per cent.
 - … Off when total storage >80 per cent.
- Environmental flows:
 - 80/20 environmental flow from all four Upper Nepean dams (including Avon) and weirs as at 1/1/2010.
 - 80/20 environmental flow from Tallowa Dam (commence June 2009, assuming restrictions are lifted).
 - Current Warragamba environmental (33.3ML/d) and riparian (10 ML/d) flows replaced by Western Sydney Recycling Scheme as at 1/1/2010. Minimum flow of 5 ML/d to be maintained from Warragamba in the Warragamba River.
- Tallowa Dam operation:
 - -1m maximum depletion, -3 maximum depletion in emergency situation.
 - Shoalhaven transfer pump mark (once e-flows for Tallowa Dam start).
 - … On when total storage is <75 per cent.
 - … Off when total storage is >80 per cent.
 - … Shoalhaven moratorium for 3 years unless storage is <60 per cent.
- Groundwater borefields: 2 borefields commencing at 40 per cent total storage for 2-3 years.
- Deepwater access.
- Water releases and demand distribution across the water supply network including:
 - Supply to Metropolitan Sydney, Woronora and Illawarra – with spatial variation of demand based on daily supply to water treatment plants.
 - Water restrictions applied to supply during times of drought. This includes an estimate of these restrictions on the magnitude of demand reduction achieved during current drought (after the commencement of permanent water conservation measures).

- Water restrictions.
 - Level 1 introduced at 55 per cent Total Storage: achieves a 7 per cent reduction.
 - Level 2 introduced at 45 per cent Total Storage: achieves a 11 per cent reduction.
 - Level 3 introduced at 40 per cent Total Storage: achieves a 12 per cent reduction.
- Current demand projections: low demand management savings and median population projections (including 2008 Department of Planning projections).
- Permanent water saving measures achieving 3 per cent reduction once all restrictions are lifted.

B Sydney Water's approach to forecasting future water demand

Sydney Water's forecast demand for potable water involves three steps:

1. Forecast potable water demand without water conservation programs ('Baseline' demand). Baseline demand in each year is equal to the forecast population multiplied by an assumed 426 litres per person per day potable water use.
2. Estimate the savings from water conservation (demand management, leakage reduction and recycling) programs in each year.
3. Deduct forecast savings from water conservation programs from baseline demand in each year.

Population forecast

Three forecasts of population to 2050 were estimated: low, medium and high.

The medium forecast is based on population forecasts developed by the New South Wales Department of Planning (DoP), adjusted to Sydney Water's area of operations. The last year included in DoP's forecast is 2036. Growth rates implicit in the Australian Bureau of Statistics' (ABS) medium forecast for the Sydney Statistical Division (SD) are used to extend the DoP forecast to 2050 (ABS, 2008).²⁴

Differences between growth rates in the ABS (2008) high, medium and low forecasts for the Sydney SD were analysed to develop a high and low forecast. The high and low scenarios reflect higher and lower assumptions about the main drivers of population growth, ie fertility, life expectancy at birth, net overseas migration and net interstate migration.

Under the medium forecast, the population served by Sydney Water grows to about 6.3 million (from about 4.3 million in 2009) in 2050. Under the low and high growth scenarios it grows to about 6 and 6.8 million, respectively.

²⁴ ABS, 2008. Population Projections, Australia, 2006 to 2101 (cat. no. 3222.0). Australian Bureau of Statistics, www.abs.gov.au.

Water conservation

Three forecasts of water conservation savings to 2050 were estimated: low, medium and high. Each forecast contains the same water conservation programs. The three forecasts differ by the assumptions about the level of savings achieved from individual programs through time. The water savings from programs may vary due to:

- expected participation and savings per participant (eg WaterFix, washing machine rebates, EDC business program);
- dwelling growth (eg BASIX);
- regulatory requirements (eg Water Efficiency Labelling Scheme); and
- forecasts of recycled water supplied by recycling schemes.

For the medium population growth scenario, the forecast savings from water conservation at 2030 and 2050 are shown below.

B.1 Savings from water conservation programs, 2030 and 2050, GL

<i>Year</i>	<i>Low</i>	<i>Medium</i>	<i>High</i>
2030	206	239	263
2050	241	284	318

Source: Sydney Water Corporation.

C *The impact of the key infrastructure decisions*

In the preliminary modelling undertaken we have examined the impact on security and reliability of water supply by introducing key infrastructure measures to the base case. This helped provide an understanding of the performance of the individual measures which assisted in incrementally developing the portfolios into a broader mix of measures.

Impact of upscaling the desalination plant

Two scenarios for upscaling the desalination plant have been modelled:

- firstly, we consider the scenario where the upscaled desalination plant commences operation in 2018 and is switched on when dam levels hit 20 per cent of total storage capacity and switched off when dam levels hit 80 per cent (a 20/80 rule); and
- secondly we consider a similar scenario of the desalination plant commencing operation in 2018 but where the rule used is 40/80.

Water security

In Table C.1 below we set out the resulting projections for our security indicator of the probability that storage levels would fall below 10 per cent comparing the base case against these two desalination scenarios.

C.1 Probability of storage levels <10 per cent under various desalination scenarios vs. base case

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base case MP/LS	0.1	0.3	3.3
desal2 20/80 MP/LS (Run 8)	0.1	0.2	2.1
desal2 40/80 MP/LS (Run 9)	0.1	0.0	0.8

Source: SCA Wathnet model.

Intuitively one would expect that having the desalination plant up and running would improve performance on water security issues by increasing the potential supply of water and thus increasing potential storage levels through time. However this depends on how the desalination plant is operated. As can be seen from the table above, running the desalination plant according to a 20/80 rule makes only a slight

difference in performance on security relative to the base line until the 2030-2050 periods. By contrast running the desalination plant according to a 40/80 rule appears to make a larger difference to performance. The risk of storage levels falling below 10% becomes negligible up to 2030. It is only in the 2030-2050 period that the risk rises to almost 1 per cent again. It is clear from the comparison in the table that running the desalination plant at 20/80 still leads to an unacceptably high risk of storage levels falling below 10 per cent over the medium to long term and at least in the medium term (2020-2030) the improvement relative to the base case is negligible. This suggests that the benefits of the desalination plant are better leveraged by operating it other than according to a 20/80 rule.

Water reliability

We next consider projections for reliability under these three scenarios. The projections for reliability as measured by average time in restrictions is summarised in Table C2.

C.2 Average time in restrictions under various desalination scenarios vs. base case

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base case MP/LS	5.0	3.6	6.9
Desal2 20/80 MP/LS (Run8)	5.0	3.6	6.9
Desal2 40/80 MP/LS (Run 9)	4.8	3.4	6.5

Source: SCA Wathnet model.

Intuitively one would expect that having the desalination plant up and running would improve performance on reliability issues because by increasing the potential supply of water, it would reduce the need to have to ration water using non-price based measures in scarcer times. However, in this instance, given that the trigger levels for the second stage of the desalination plant are set at relatively low dam levels the improvement in reliability is only minor.

Impact of the Shoalhaven augmentation

We have already considered one possible option for enhancement of supply to deal with drought, namely proceeding with stage 2 of the desalination plant. Another option for securing water supplies for growth is augmenting the Shoalhaven scheme.. This is represented under a scenario which contains the base case assumptions of median population and low savings but combined with changes to Shoalhaven scheme

This scenario would be expected to lead to improved performance on both security and reliability. This is borne out in the tables C3 and C4.

*Water security***C.3 Probability of storage levels <10 per cent for base case scenario vs. Shoalhaven upgrade**

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base Case MP/LS	0.1	0.3	3.3
Shoalhaven MP/LS 2018 (Run 12)	0.1	0.3	3.1

Source: SCA Wathnet model.

Augmenting the Shoalhaven scheme does not generate improvements in water security until the 2030-2050 period though even in that late period the improvements are only slight, reducing the risk of low storage by 0.2 per cent.

*Water reliability***C.4 Average time in restrictions for base case scenario vs. Shoalhaven upgrade**

	<i>Up to 2020</i>	<i>2020-30</i>	<i>2030-50</i>
	%	%	%
Base Case MP/LS	5.0	3.6	6.9
Shoalhaven MP/LS 2018 (Run 12)	4.9	3.1	6.0

Source: SCA Wathnet model.

However, more noticeable improvements can be seen immediately for water reliability. Up to the 2020 period, average time in restrictions is reduced slightly, and the reductions in time spent in restrictions are even higher over the next two periods, 2020-2030 and 2030-2050. Nonetheless it is worth noting that the risk of low storage levels is unacceptably high by 2030-2050 as is the average time in restrictions. Thus these tables again indicate that without a more significant portfolio of upgrades the outcomes for both performance and reliability will not be sufficient to meet community expectations.

Proceeding with the Shoalhaven augmentation alone is insufficient to address the need to ensure appropriate levels of water security and reliability.

D Cost elements

The analysis of the cost items has been conducted in the context of the costs related to a particular portfolio. The cost of an individual portfolio is made up of a range of individual cost elements which combine to form the portfolio costs. The calculation typically involves the application of a cost 'factor' which is multiplied by the output from the WATHNET model to calculate the total cost related to that cost element. The difference in the costs of alternative portfolios largely relates to how the output from the WATHNET model differs between the different portfolios. The portfolio costs are discussed in Chapter 5.

Overview of the cost items

The key items used in the cost-effectiveness analysis include the following.

- The pumping costs associated with the Shoalhaven Transfer Scheme and the cost of greenhouse gas emissions associated with this pumping.
- The augmentation of the Shoalhaven transfer scheme including the upfront capital costs and the ongoing operating costs associated with the project.²⁵
- The costs associated with the desalination plant, including the capital costs of the second stage of the desalination plant and the operating costs of the plant.
- The costs of supply shortfalls at particular parts of the system; and
- The cost of quantitative water restrictions. We have calculated the costs of quantitative water restrictions using economic theory and data undertaken from recent studies in Sydney and other jurisdictions.

An explanation of how each of these cost elements is calculated is provided below. The costs of water restrictions, is discussed in the next chapter. For a large number of these costs, we have relied on cost information provided by the various NSW water agencies.

All costs are presented in 2009/10 dollars unless specified otherwise.

²⁵ This also includes capital costs associated with an additional pipeline (the 'Illawarra Spurline' that also assists in the transfer of water from the Shoalhaven system.

Costs of Shoalhaven Transfer Scheme

Pumping costs of Shoalhaven

An important cost item that varies between the alternative portfolios is the costs of pumping water from the Shoalhaven system to Sydney's main supply system.

The volume of water that needs to be pumped from the Shoalhaven system varies according to the underlying hydrology and the range of other alternative sources of water in place. For example, if the operation of the desalination plant is operated more frequently this will reduce the need to pump water from the Shoalhaven system. This is because the desalination plant will enable (on average) higher dam levels to be maintained, thereby reducing the need to trigger the pumping of water from the Shoalhaven river.²⁶

The changes in energy costs for the Shoalhaven pumping scheme is therefore dependent on the volume of water required to be pumped (which varies between the portfolios). In order to calculate this cost it involves considering the cost per unit of water pumped and changes in the volume of water pumped. The volume of water required to be pumped from the Shoalhaven system under alternative portfolios is assessed under the WATHNET model.

Unit cost of water pumped from the Shoalhaven

The SCA has indicated that the marginal pumping costs for the Shoalhaven system are \$71.75 per ML in 2009/10 dollars.²⁷

The energy used for pumping water from the Shoalhaven has additional environmental costs, through greenhouse emissions. We base estimates of these costs on:

- changes in the energy use from Shoalhaven pumping — a combination of the volume of water extracted from the Shoalhaven (from WATHNET), with an average energy use of 1.92 MWH per ML of water pumped;²⁸

²⁶ It should be noted that the Shoalhaven pumping scheme will still remain an important source of water into the future, even with the desalination plant operating and other new measures. The desalination plant expands the portfolio of options available to the Government to provide a secure and sustainable water supply system into the future.

²⁷ SCA (2008), *Submission to IPART's review of prices for the Sydney Catchment Authority*, September, p. 40.

²⁸ This is based on SCA's reported volume of extraction from the Shoalhaven of 150,475ML in 2005-06 and 175,115ML in 2006-07 (SCA website). The SCA's annual report 2006-07 (p. 71) also reports energy use of 294 200MWH in 2005-06 and 331 500MWH in 2006-07.

- emissions intensity — an emissions intensity of 0.96 tonnes of CO₂ emissions per MWH, based on the average forecast by IPART for 2012 of between 0.946 to 0.983 tonnes of CO₂ emissions per MWH;²⁹ and
- a time series of carbon prices over the next 40 years based on Australian Treasury modeling. The price in 2010 is approximately \$23.60 per tonne of CO₂-e, rising to \$40 per tonne by 2030 and \$130 per tonne by 2050.³⁰

For those portfolios that include additional investment to upgrade the Shoalhaven transfer scheme, there is a 30 per cent offset in the total pump energy. This reduces the direct energy and carbon emissions costs associated with portfolios that include the Shoalhaven transfer scheme.

The calculation of the costs of carbon emissions is likely to be more contentious given that there is not a carbon market in place at the moment and the price of carbon is required to be estimated based on existing modelling. Rather than seek to specify an exact price of carbon, it is more appropriate to adopt an indicative price that is within a reasonableness range and, as part of the sensitivity analysis, test the impact of alternative carbon prices on the ranking of portfolios.

Costs of upgrading the Shoalhaven Transfer Scheme

Upgrading the Shoalhaven Transfer Scheme involves the construction of a tunnel to Avon Dam. It is intended to replace the existing 'run of river' transfers.

The capital costs associated with the project is estimated to be \$500 million which is distributed according to table 5.3 below. The capital costs are assumed to occur in the 7 years prior to the modelled starting date of the scheme. The capital costs include costs associated with a 140MW hydro facility which will result in 30 per cent reductions in the total energy costs of pumping water from the Shoalhaven system.

It is important to recognise that to the extent that the timeframe for implementing the Shoalhaven infrastructure can be significantly reduced into the future, this can generate significant cost savings.

An annual operating and maintenance cost of \$0.5 million is forecast. These ongoing operating costs are assumed to commence in the first month the scheme starts.

Augmenting the Shoalhaven infrastructure means a greater volume of water can be pumped from the Shoalhaven system. Drawing a greater volume of water from the

²⁹ BDA and Gillespie Economics (2006) use an emissions intensity factor of 0.835 tonnes per MWH in its study of the Shoalhaven transfer scheme.

³⁰ This is the average price of emissions from Australian Treasury modelling of various emissions trading scenarios in *Australia's low pollution future*, Canberra, November, p. xii.

Shoalhaven system improves reliability and security but it also results in higher pumping costs of drawing a greater volume of water from the system.

Costs of desalination facilities

A key cost item that needs to be considered is those costs associated with the construction and ongoing operation on the desalination plant.

For the purposes of this analysis we treat the capital costs of the first stage of the desalination plant (the 250ML per day plant) and its associated infrastructure as sunk costs. This is appropriate as these costs are incurred no matter which operating rule is chosen for the desalination plant. The sunk costs form part of the fixed costs noted above.

The cost items that are important for this analysis include the:

- operating costs of the existing desalination plant which vary according to the different trigger levels; and
- upfront capital and ongoing operating costs related to the second stage of the desalination plant.

There are also indirect costs of pumping water if the desalination plant is required to supply water to residents in the western parts of Sydney and the potentially reduced payments to filtration plant operators for the reduced cost of filtration. These cost differences have not been incorporated into our analysis, and it is unknown as to whether they would change the relative ranking of projects particularly in relation to stage 2 of the desalination plant.

Operating costs of Stage 1

Our primary concern is with changes in operating costs of the plant under different operating regimes. Due to the confidential nature of the operating costs we have not separately disclosed these calculations which are embedded into the model. The main operating expenditure categories include:

- costs paid to the Blue Water Consortium (the operator of the plant) for operation and maintenance of the desalination plant and associated infrastructure, as specified in the contract;
- electricity costs – payments for electricity supply and renewable energy credits (as the plant will use 100 per cent renewable electricity). These payments will vary significantly depending on the levels of production of the plant and the level of plant efficiency; and
- other expenditures – this includes all of the operating and maintenance costs borne by Sydney Desalination Plant Pty Ltd and not the operator. These costs may include, amongst other things, insurance costs (eg relating to property, business

interruption, products and public liability, professional indemnity) and contract management costs.

The costs that are affected by the extent to which the plant is operated are smaller and include:

- variable operating costs — these include electricity costs and the costs of the Renewable Energy Certificates for amounts above a minimum;
- costs of shutdown — these include the costs of shutting down the plant, the standby costs and the costs of restarting the plant. The magnitude of these costs depends on the duration of the shutdown period; and
- costs avoided by shutdown — these can include maintenance costs and costs of replacing membranes that change depending on the amount the plant is operated.

The expected variable costs associated with the plant in the future are dependent on the future rainfall patterns and storage levels. For example, where storage levels are high for long periods of time the desalination plant is generally switched off, unless the trigger for the operation of the plant is at high dam levels.

The current modelling of the desalination plant in the WATHNET model assumes that the plant is either at full capacity or at zero capacity and that the plant can be switched on or off without a notification period. In practice, however, a notification period is required before the plant can be switched on or off. The notification period may vary depending on how long the plant has been out of operation. This is likely to make little difference to the result, particularly if short-term climate forecasts can partially offset the impacts of a notification period.

The total annual cost of operating the plant at full capacity is currently estimated to be approximately \$73 million per annum, which includes some costs which do not vary according to the volume of water produced.

Cost of Stage 2 of the desalination plant

As noted above, the costs of Stage 2 of the plant relate to the upfront construction costs and the ongoing operating costs of the plant. Sydney Water has advised that the operating costs of Stage 2 of the plant are the same as the first stage.

The capital cost of the Stage 2 of the plant is estimated at \$900 million (in 2008/09 dollars). The plant is anticipated to be constructed over a two year period with \$500 million incurred in year 1, and \$400 million in year 2.

It is important to recognise that to the extent that the timeframe for constructing the plant can be significantly reduced into the future, this can generate significant cost savings if the construction of the plant is triggered by dam levels (or some other measure of the level of water security). To the extent that the construction of the plant can be delayed until the 'last minute' (without significantly compromising

security) it offers more time to capture high inflow events. Given the volatility of the underlying inflow patterns in Sydney it is reasonable to seek to capture these high inflow events.

Cost of supply shortfalls

It is important to recognise that while the supply system in total may be performing adequately, there may be pockets in the system where supply cannot be adequately met.

One example of this is the limited ability of the desalination plant to provide water to parts of Sydney that are further away from the point in Erskineville at which the desalinated water meets the trunk supply.

The WATHNET model generates outputs that estimate the shortfall at different points in the system at different points in time.³¹ We have assumed that shortfalls only occur when dam levels fall below 10 per cent dam levels.

The shortfall variable generated by the WATHNET model reports the volume of restricted demand that cannot be met by the supply system for the particular month.

In the unlikely event of such a shortfall, we have been advised there are means of making up the supply in these types of water supply zones. Based on past experiences of the NSW Office of Water of similar incidents, the SCA has estimated the cost of making up the supply in these pockets would be \$25 000 per ML

While we have incorporated these costs into the analysis it is important to recognise that this is not a situation that the NSW Government is planning to occur. In practice, a wide range of additional measures is likely to be undertaken to prevent such events occurring in the future. Nevertheless, it is important to understand these costs which will assist in future planning to avoid these situations.

Groundwater pumping costs

The costs associated with pumping groundwater have also been included in the analysis. Groundwater is rarely triggered in the modeling, therefore, the probability weighted costs are small. The following pumping costs (in 2009/10 dollars) have been included in the analysis:

³¹ The WATHNET model assumes that the water from the desalination plant can be supplied to Prospect North, Ryde, Potts Hill (excluding Sutherland), Prospect East and Prospect South. When dam levels drop the model incorporates decisions that allow supply areas to be readjusted

- \$440.75 per ML for pumping from the Orchard Hill and Warragamba aquifers; and
- \$461.25 per ML for pumping from the Nepean aquifer.³²

Other factors

It should be noted that we have not included a number of items in the analysis such as changes:

- in the operating costs at the major water filtration plants if more water is drawn from the desalination plant (which is already filtered) rather than from the dams;
- to Sydney Water's pumping costs if there lower demand due to the imposition of a more 'harsh' water restrictions regime; and

³² Pers correspondence with SCA, 7 December 2009. The aquifers do not directly match those include in the modeling and so we sought separate advice from the SCA to clarify this.

E Cost of Restrictions

Restrictions are limits on how and when people can use water. They aim to reduce the amount of water demanded at existing prices. There are currently three levels of restrictions applied in the Sydney Metropolitan Area.

Quantitative water restrictions are a key policy instrument for dealing with drought. The use of quantitative water restrictions has, in the past, ensured that communities could withstand periods of drought without running out of water. It also enabled governments to defer the need to undertake additional investments in water infrastructure. Restrictions could continue to have these benefits in the future.

While the benefits of restrictions are well recognised, there is growing recognition that restrictions also have costs on the community, although the extent of these costs is debatable.

This chapter discusses how the costs of water restrictions can be calculated and incorporated into the cost effectiveness approach.

Elements of the cost of restrictions

The costs of restrictions potentially accrue to a number of different groups within the community, including consumers (for example, households, businesses and community groups), governments and water utilities.

Some of the costs of water restrictions include, for example:

- time and inconvenience costs — for example, hand watering of gardens at specific times;
- investment in high cost water sources — for example, rainwater tanks, domestic recycling systems;
- flow on effects to businesses as a result of reduced demand for services — for example, garden centres;
- reduced profitability of water utilities; and
- costs of administering water restrictions — for example, advertising and compliance costs.³³

The key elements of the costs of restrictions are summarised in table E.1 below.

³³ Further discussion on the cost of restrictions can be found in Allen Consulting Group (2007) and ISF and ACIL Tasman (2007).

E.1 Elements of the cost of water restrictions

<i>Group affected</i>	<i>Aspect of activity affected</i>	<i>Description</i>	<i>Potential data sources</i>
Households	Activities around the home	Mostly related to outside activities such as gardening and swimming pools.	Statistical estimation of demand curve Targeted surveys (for example, WTP or Choice Modelling) Combination survey and behavioural modelling
	Activities elsewhere (sport and recreation)	Cost of changes in recreation options	Estimates based on time use Surveys (choice modelling)
Business	Water dependent activities	Business cost arise through increased water costs or through reduced sales of products that require water (for example, plants or swimming pools)	Statistical estimation of demand curve Choice modelling Economywide modelling
	Tourism		Economywide modelling
Community facilities	Street trees	Death of street trees leading to a loss of amenity	Replacement cost Surveys
	Parks and playing fields	Reduced value of amenities provided by parks and playing fields	Surveys Equivalent private facilities
Government	Other costs	Other costs incurred by government	Can be directly estimated
Water utility	Monitoring and enforcement costs Lost revenues for utilities due to underutilisation of fixed infrastructure	Cost of advertising restrictions, cost of enforcing restrictions	Can be directly estimated

Data source: The CIE.

One of the most important of these groups is likely to be households who experience costs of restrictions both because of their use of water around the house and because of their reduced recreational options. It should, however, be noted that the costs of water restrictions vary between the different groups and will vary considerably between the different regions within the Sydney metropolitan area. For example, the coastal regions of Sydney generally receive substantially higher rainfall than inland regions and have more moderate temperatures. Therefore, water restrictions are likely to have lower impacts in these areas, compared with inland areas.

This disparity of impacts across the metropolitan region is also likely to be different for the other groups. For example, sporting facilities in the inland areas of Sydney are likely to be more affected by drought conditions compared with the same facilities located in coastal areas. The diversity of impacts of restrictions is also likely to be

significant for the business sector (which is typically a heterogeneous group) according to different levels of water use.

The cost of restrictions to consumers

Restrictions reduce the quantity of water consumed by Sydney's households and businesses. They do not put a strict quota on water use but rather impact on water use by affecting how and when water can be used. This involves additional time costs for water users or less amenity from using water in particular ways.

Lower demand

The cost of restrictions can be considered as reducing the demand for water at a given price, as set out in Grafton and Ward (2008). In this case, the marginal cost of water to the user is unchanged with restrictions, but the change in what can be done with water lowers the demand for water. This is set out in chart E.2.

Restrictions shift demand down for some part of the demand curve. The quantity of water demanded falls from Q_0 to Q_1 . The loss in utility is represented by the shaded area. This area approximates the cost of restrictions to consumers and can be measured if sufficient information is known about the impact of restrictions on the quantity of water used and the price sensitivity of demand for water. All the water below point A on the chart is assumed to be indoor usage and quantities above point A relate to outdoor usage. Given that restrictions only relate to outdoor usage the slope of the demand curve only changes after point A. If the demand for water is not very sensitive to price, then restrictions that lower demand by 10 per cent have a greater cost to consumers.³⁴

³⁴ The approximate method of estimating the cost of restrictions to consumers based on the loss in utility is:

$$C = \frac{S \cdot \Delta Q}{2 \cdot P \cdot \varepsilon}$$

Where C is the cost of restrictions, S is the share of water uses affected by restrictions, ΔQ is the change in quantity of water consumed due to restrictions, P is the variable price of water and ε is the price elasticity of demand.

E.2 Impact of restrictions through demand



Notes: Q_0 is the quantity of water consumed under no restrictions. Q_1 is the quantity of water consumed under restrictions.
Data source: The CIE.

Evaluating the cost of restrictions

The cost of restrictions will depend on the exact nature of the restrictions imposed and the characteristics of the population and geographical area on which restrictions are imposed. The costs are also likely to depend on the need for restrictions, as people are more likely to accept restrictions when dam levels are low, as they can internalise the costs of running out of water or finding alternative water options.

Currently, the quantitative information on the cost of restrictions in Sydney is limited. Restrictions can currently be evaluated through measuring the area in chart E.3. Alternatively, and preferably, estimates can be gathered from choice modeling or willingness to pay studies.

Estimates of costs to water consumers

In the absence of additional resources to undertake specific studies to better estimate the cost of restrictions in Sydney, the costs of restrictions should be measured using the price elasticity approach, cross-checked with willingness-to-pay estimates from other jurisdictions, where available.

Both these methods have weaknesses.³⁵ This suggests that portfolios should be subject to sensitivity testing.

For our main analysis we calculate the cost of restrictions assuming a price elasticity of -0.17 as estimated by Grafton and Ward (2008) for Sydney. This means that for a

³⁵ ACIL Tasman and ISF (2007), p. 33; and ACIL Tasman and ISF (2009).

1 per cent increase in price, we expect the quantity of water consumed to fall by 0.17 per cent. This is the most recent study undertaken for consumers in Sydney and it is an approximate mid-range of the information currently available on price elasticity of demand (see CIE 2009a). This estimate of the price elasticity of demand is broadly consistent with recent surveys by Sydney Water and IPART that indicate that price is not a major issue for consumers.³⁶ This is also consistent with Sydney Water's observations that consumers do not change their consumption significantly to changes in prices.

We use an estimate of 30 per cent of water use (without restrictions) is allocated to activities that are affected by restrictions, such as outdoor water uses.³⁷ We can then calculate the shaded figure in chart E.4.

For portfolios modeled that include 'voluntary water usage targets', we apply scale up costs based on the additional costs of moving from level 3 to this new level of restrictions and the amount of water expected to be saved. This reflects concerns about relying overly on a price elasticity for large changes in water use.

For commercial and industrial water users, a price elasticity of -0.3 is used. The number of studies estimating the elasticity of demand for industrial water users is relatively small compared with households and irrigators. However, there are a range of studies from overseas that can be used.³⁸ For example, for Canadian industries the median elasticity is approximately -0.3.³⁹

The estimates of costs of restrictions derived in this way are set out in table E.3, reported as costs per household. The figures are based on plausible estimates of the price elasticity of demand, cross-checked against previous studies, as reported in CIE (2009a).

³⁶ IPART (2007), *Residential energy and water use in Sydney, the Blue Mountains and Illawarra*, November, pp. 45-48.

³⁷ Early estimates from Sydney Water's end-use model suggest that outdoor use for single dwelling residential properties is 38 per cent of total use and 32 per cent for multiple dwelling residential properties.

³⁸ Industrial firms use water for a variety of purposes — for cooling intermediate inputs, producing high pressure steam, moving intermediate inputs, sanitation, and as a direct input. The major issue affecting accurate elasticity estimates for industry as a sector is its heterogenous composition and the uneven distribution of water use across industries. Therefore, there are limitations of using a single elasticity figure. Nevertheless, in the absence of more detailed information we have relied on a single elasticity figure but recognise its potential limitations.

³⁹ CIE (2003), *Literature review of the price elasticity of urban water demand*, prepared for the Sydney Catchment Authority, p. 21.

E.3 Cost of restrictions to consumers

Consumer type	Level 1	Level 2	Level 3	Level 4
	2009/10 \$/ household	2009/10 \$/ household	2009/10 \$/ household	2009/10 \$/ household
Residential	113	178	195	362
Industrial	11	52	57	107
Commercial	33	17	18	28
Total	157	247	270	497

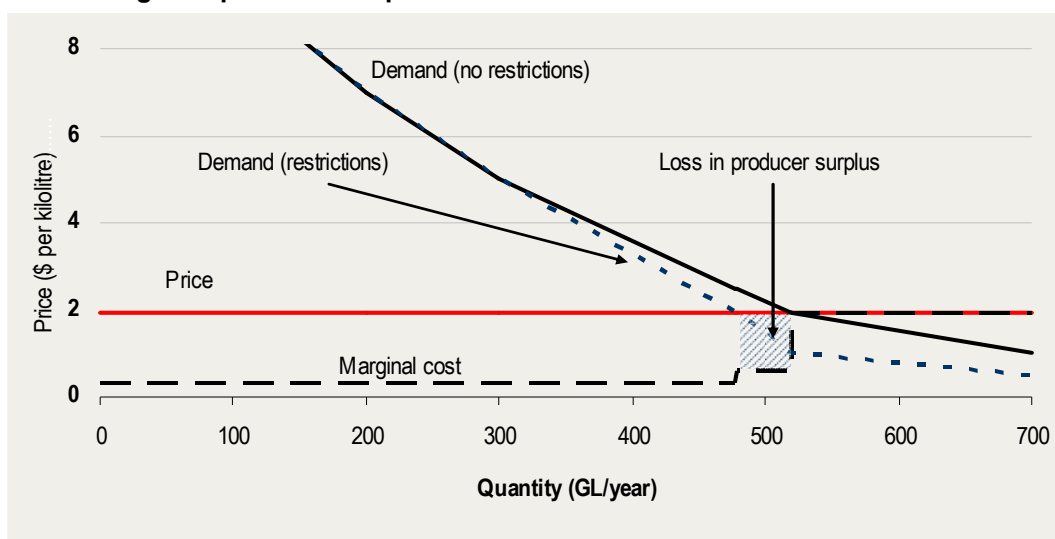
Source: CIE calculations.

Other elements of the cost of restrictions

Producer costs

Restrictions lower the amount of water that has to be supplied. This reduces the costs for Sydney Water and the SCA, as well as potentially reducing the need for investments in the future. However, it also reduces revenues from selling water at the regulated price. The net of these effects is the change in the producer surplus (chart E.4).

E.4 Changes in producer surplus from restrictions



Data source: TheCIE.

The extent of the cost reductions will depend on the relationship between water use and costs. This, in turn, will depend on the particular sources of water that are no longer required under lower water use. The costs of alternative sources of water are explicitly included in the modelling as set out in chapter 5. Aside from elements related to different investment options and operating costs of the desalination plant, modelling is based on \$82 per ML filtering cost for Sydney Water and \$71.75 per ML for the Shoalhaven transfers for Sydney Catchment Authority (in 2009/10 dollars).

The change in revenue from selling water is calculated at the regulated 2011/12 price of \$1.93 per kL (in 2008/09 dollars).⁴⁰ No change in price is included through time, although potentially IPART's regulated price could respond to the long run marginal cost of water at the time of each review, which would depend on dam levels. No changes in price have been incorporated into demand forecasts.

Monitoring and enforcement costs

There are a range of costs incurred by Sydney Water in relation to administering the restrictions regime. This includes the costs of advertising the restrictions that apply at a given point in time and the cost of enforcing the restrictions. It is important to recognise that where infringement notices have been issued that the utility can gain some additional revenue. Therefore, these additional revenues should be 'netted off' the costs. Cost estimates below from Sydney Water have been incorporated into the modeling. For Level 4 restrictions, administration cost estimates (in 2009/10 dollars) were increased based on the marginal cost of administration for additional reductions in water from data provided for Levels 1 to 3.

- Level 1 – \$5.5 million per year.
- Level 2 – \$7.7 million per year.
- Level 3 – \$10.3 million per year.
- Water usage targets – \$35.9 million per year.

⁴⁰ IPART 2008, *Review of prices for Sydney Water Corporation's water, sewerage, stormwater and other services*, Determination and Final Report, June 2008, p 20.

F Sensitivity analysis

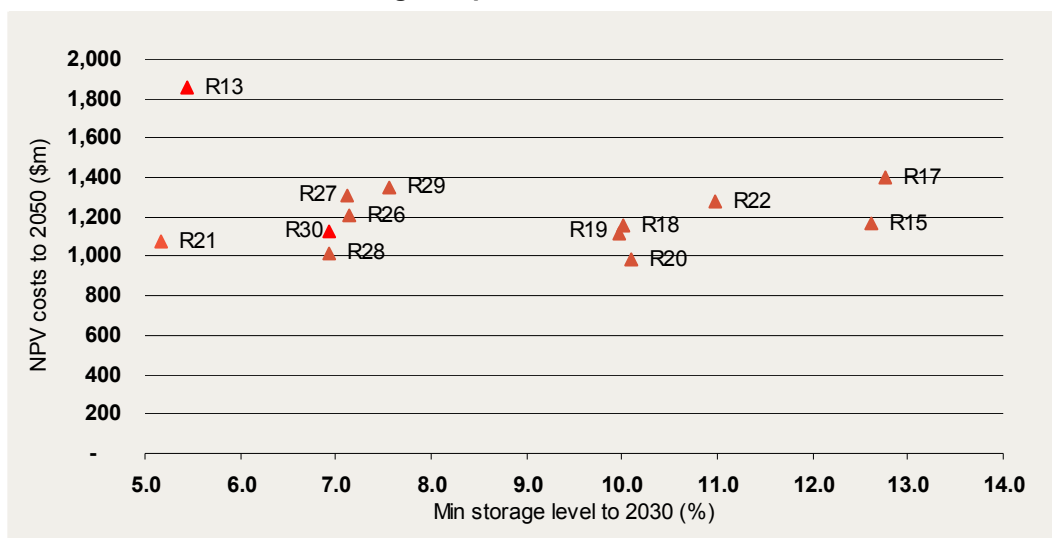
Risk and uncertainty are key themes that need to be considered in the development of any water supply strategy. Future rainfall patterns, and their impact on dam levels, are the most important type of risk in considering water investments. Variation in rainfall is the major driver of the need for additional investments in water and hence the cost of providing water to Sydney. There are also aspects of the analysis where there is some uncertainty regarding the level of detailed information required.

The appendix tests how the ranking of the alternative portfolios changes with changes to some of the key input parameters in the analysis.

Varying the discount rate

We have tested alternative discount rates to examine whether this impacts on the ranking of the projects. The rankings presented in the main part of this report were based on a 7 per cent discount rate. The ranking of the portfolios based on the 7 per cent discount rate are presented in chart F.1 below.⁴¹

F.1 Baseline Portfolio Ranking — 7 per cent discount rate

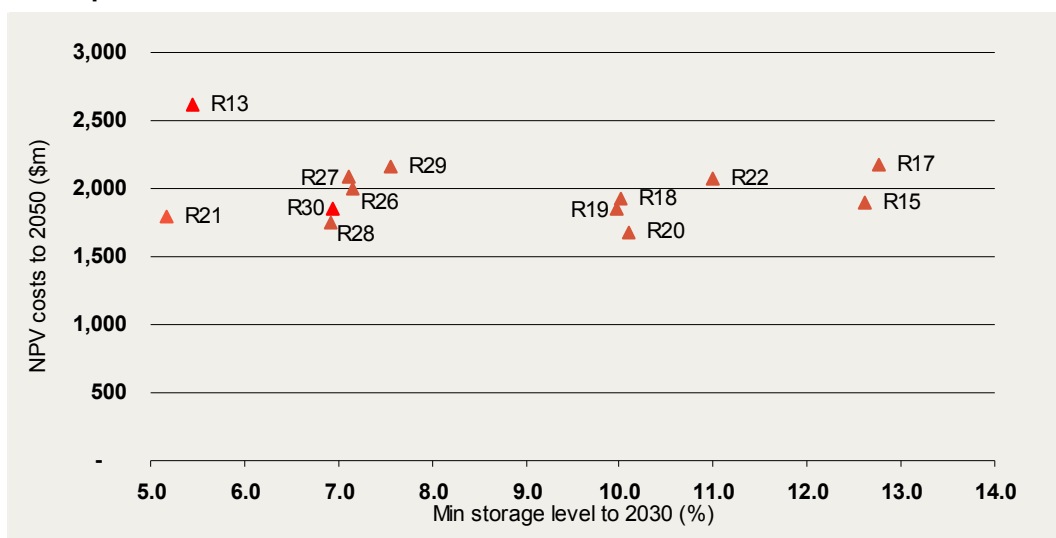


Data source: TheCIE calculations.

⁴¹ It is important to note in the charts presented below we have adjusted the scale on the graphs so as to highlight differences in the relative rankings of the alternative portfolios.

Changing the discount rate does not substantially change the rankings of the portfolios. Adopting a lower discount rate of 5 per cent (chart F.2) does not substantively change the ranking of the portfolios. The key change is that using a lower discount rate cements Run 20 as a preferred portfolio to Run 28 based on cost and security criteria.

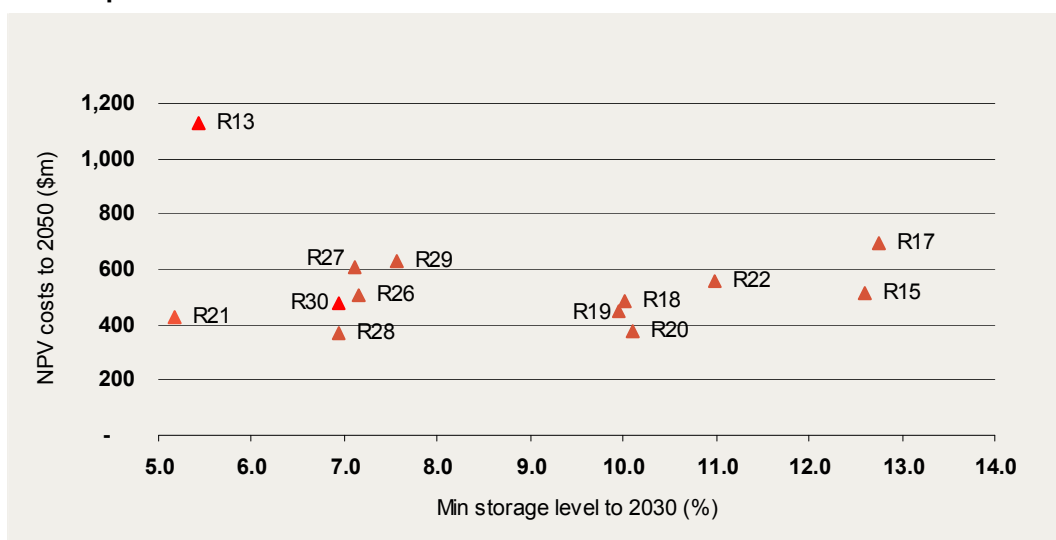
F.2 5 per cent discount rate



Data source: TheCIE calculations,

Increasing the discount rate to 10 per cent (chart F.3), does change the ranking slightly with Run 28 now being marginally cheaper than Run 20. This is largely because Run 28 includes the costs associated with upgrading the Shoalhaven Transfers Scheme which results in a lower cost (in net present value terms) when using a higher discount rate.

F.3 10 per cent discount rate



Data source: TheCIE calculations,

Lower average inflows

Climate risk is a key risk that is likely to impact on the ranking of portfolios. The SCA's Wathnet model generates a wide range of potential inflow scenarios that could occur into the future. The inflows are based on the inflow characteristics that have occurred in Sydney over the last 100 years. In the analysis presented in the main body of this report, we have used the 'average' climate result of the inflow scenarios generated. However, it is important to recognise that there is a distribution around this average.

In order to test these alternatives we have considered how the rankings of the portfolios changes if the inflows into Warragamba Dam were 20 per cent lower than currently expected using the SCA's Wathnet model. This is broadly in line with the CSIRO's recent projections that the longer term impact of climate change is expected to result in 20 per cent lower inflows in Warragamba Dam.⁴²

It should be noted, however, that this sensitivity test is not intended to provide a sophisticated understanding of the potential climate change impacts. Climate change is not just about lowering average inflows but also about changing the underlying characteristics of the inflow patterns. For example, it could result in greater volatility in inflow patterns or greater duration of drought events. Therefore, the analysis presented below should not be considered to be a detailed 'climate change' analysis of the potential climate change impacts.

If future inflows into Warragamba dam are 20 per cent lower than the average result generated by the Wathnet model using the past 100 years of data, then this will significantly change the costs of each portfolio of options. For example, it will result in lower dam levels which will increase the frequency of triggering water restrictions and triggering the operation of the desalination plant.

Table F.4 indicates the proportion of time that the first stage of the desalination plant is operating using the average inflows generated by the WATHNET model and where average inflows are 20 per cent lower into the Warragamba Dam. In all the runs, except for Run 22, lowering the average inflows results in the desalination plant operating over 6 per cent more time than under the baseline inflow conditions.

⁴² SCA (2009), *Climate Change and its impacts on Sydney's Water Supply, Technical Report*, October.

F.4 Desalination first stage — per cent of time operating 2010-50

	Baseline	20 per cent reduction	Difference
	%	%	%
Base Case	21.7	27.8	6.1
Base case — with Eflows	31.7	35.8	9.4
R13	22.6	29.2	6.7
R15	27.7	35.1	7.4
R17	25.5	32.6	7.1
R18	26.6	34.0	7.4
R19	26.6	34.0	7.4
R20	28.0	35.4	7.5
R21	26.6	34.0	7.4
R22	87.4	88.2	0.8
R26	26.6	34.0	7.3
R27	25.7	32.9	7.2
R28	26.7	34.1	7.3
R29	26.4	33.5	7.2
R30	25.8	33.0	7.2

Note: In Run 22 the first stage of the desalination plant is assumed to be operating at full capacity from 2018.

Source: TheCIE calculations,

Table F.8 illustrates the impact of the lower inflows on the time in restrictions. It substantially increases the time spent in restrictions. For example, under Run 15 the average time in restrictions is anticipated to be 7.6 per cent based on the last 100 years of inflows. However, under the 20 per cent lower inflows scenario the average time in restrictions is anticipated to rise to 11.1 per cent.

F.5 Average time in restrictions 2010-50

	Baseline	20 per cent reduction	Difference
	%	%	%
Base Case	5.5	8.3	2.8
Base Case — with Eflows	10.8	16.4	5.6
R13	4.9	7.5	2.6
R15	7.6	11.1	3.5
R17	6.9	10.2	3.3
R18	7.2	10.8	3.5
R19	7.2	10.7	3.5
R20	7.7	11.3	3.6
R21	7.2	10.8	3.5
R22	5.8	8.9	3.1
R26	7.2	10.7	3.5
R27	7.0	10.3	3.4
R28	5.0	7.7	2.7
R29	10.0	14.2	4.2
R30	4.8	7.4	2.6

Source: TheCIE calculations,

The lower average inflows would also impact on a range of other factors such as the frequency (and volume) of pumping water from the Shoalhaven system and from groundwater sources.

The cost implications of assuming lower average inflows are presented in table F.6 below. It illustrates that changing this assumption has a significant impact on the costs of the portfolio. While the costs have increased across all the different portfolios, the cost increase is relatively higher for a number of the portfolios.

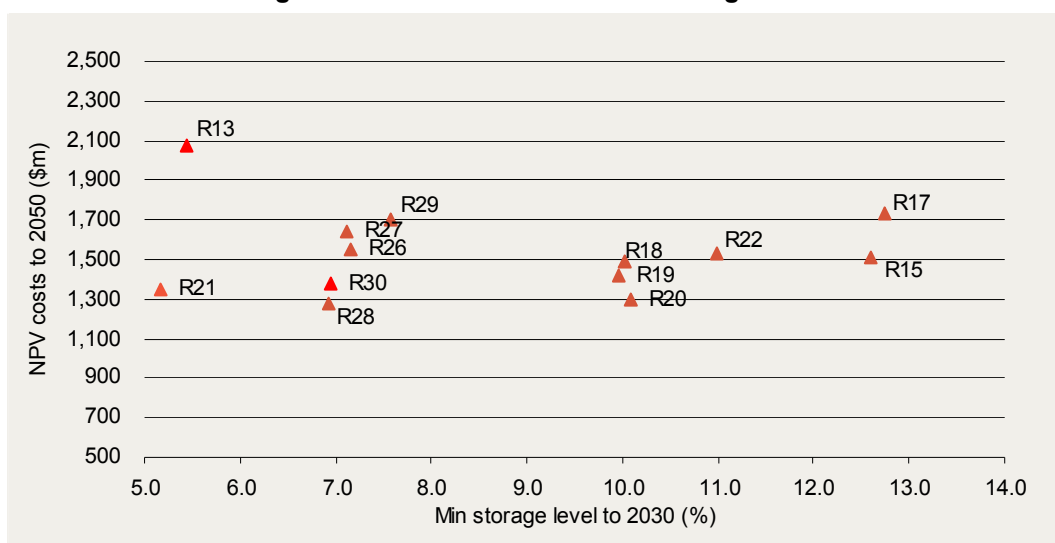
F.6 Net Present Value of Costs to 2050 — 20 per cent reduction in inflows into Warragamba Dam

	<i>NPV Costs Baseline</i>	<i>NPV Costs 20 per cent reduction in inflows</i>	<i>Difference</i>
	\$m	\$m	\$m
Base Case	786	1 002	216
Base Case — with Eflows	920	1 223	303
R13	1 854	2 075	221
R15	1 165	1 513	348
R17	1 403	1 733	330
R18	1 160	1 488	327
R19	1 114	1 423	309
R20	987	1 303	316
R21	1 074	1 353	278
R22	1 278	1 534	256
R26	1 204	1 547	344
R27	1 314	1 646	332
R28	1 018	1 280	262
R29	1 347	1 698	351
R30	1 130	1 384	253

Source: TheCIE calculations,

Chart F.7 presents the rankings of the portfolios using the cost and security criteria. The chart indicates a change in the relative costs of some portfolios. Run 30, for example, is now cheaper than Runs 18 and 19. A key change is that Run 28 is now marginally lower cost than Run 20. As a result, Run 28 is likely to remain in the feasible set of preferred portfolios, along with Run 15 and Run 20.

F.7 Portfolio Ranking — reduction in inflows into Warragamba dam



Data source: TheCIE calculations.

Security outcomes under more extreme events

As noted previously, the SCA's WATHNET model simulates a wide range of alternative inflow sequences that can occur into the future. In the modelling presented above, the minimum storage levels reported were based on using 2000 possible alternative inflow sequences that could occur in the future. These inflow sequences include droughts that are worse than the droughts that have occurred in recent history, as discussed later in this section.

While the modelling of the 2000 alternative inflow sequences provides information on extreme outcomes (with droughts more severe than experienced over the last 100 years), it is useful to consider how the portfolios perform under events that lead to more extreme security outcomes. The more extreme outcomes are a combination of a number of factors:

- The severity and duration of the drought. There is no precise definition of a drought and it is important to recognise that droughts can differ according to their severity and duration. For example, one drought may have the lowest annual inflow on record for a single year where another drought may have the lowest average inflow over a five year period.
- The storage level at the point in time when the drought commences. For example, if dams were full at the start of a drought then the drought would need to be more severe to generate more extreme security outcomes compared with the impact of a drought that occurred when dams were at 60 per cent of capacity.
- The demand level at the point which the drought commences and during the drought period. For example, the drought that occurred over the past seven years would have more severe impacts on dam storage levels if it occurred 20 years into

the future where demand levels is anticipated to be significantly higher compared.

In order to examine how the portfolios perform under different combinations of these factors that lead to extreme security outcomes, the SCA has increased the number of simulations to 10 000 alternative inflow scenarios. The minimum storage levels generated by these additional simulations are presented in table F.118 **check ref **below.⁴³

F.8 Security outcomes — minimum storage levels up to 2020

	<i>2010 to 2020</i>
	%
Base Case	0.0
Base Case — with Eflows	0.0
R15	9.2
R17	9.6
R18	6.0
R19	4.7
R20	4.7
R21	0.1
R22	4.7
R26	2.8
R27	1.1
R28	2.2
R29	3.5
R30	2.2

Source: SCA Wathnet model,

In the table we have focused on the first part of the planning period, 2010 to 2020, to illustrate the performance of the portfolios under these more extreme outcomes. The portfolios that provide the greatest security are portfolios 17 and 15. In both these portfolios the second stage of the desalination plant is assumed to be operating when dam levels reach 30 per cent.

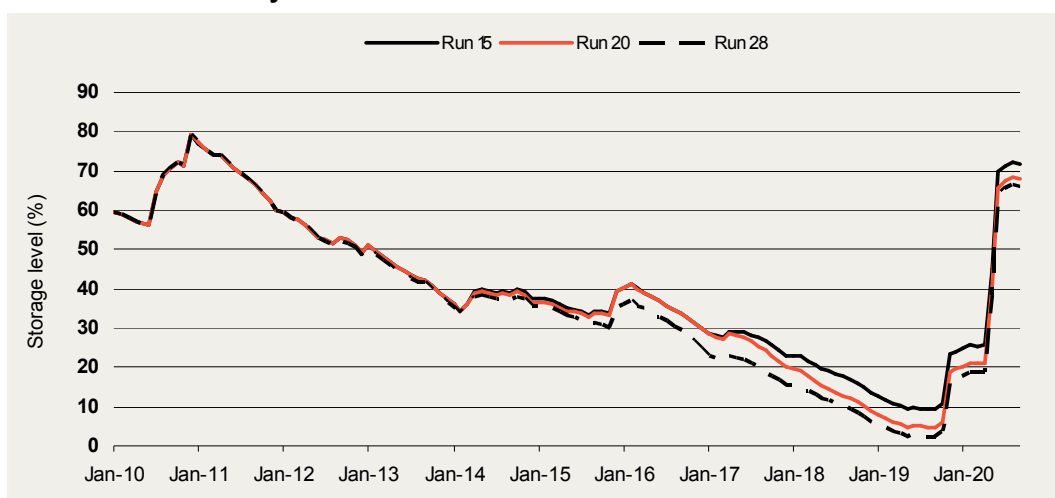
In chart F.9 we illustrate how storage levels decline using the worst case outcome generated by the 10 000 replicates modelling. We illustrate this using the two preferred portfolios (Runs 15 and 20) as well as Run 28. The differences between these results reflect the different storage trigger levels for the:

- operation of the second stage desalination plant. In Run 15 the second stage of the plant is assumed to commence when dam levels reach 30 per cent, compared with 20 per cent for Run 28 and 15 per cent for Run 20;

⁴³ It should also be noted that each of these more extreme scenarios has a lower probability of occurring. That is, each of these scenarios is has a probability of 1 in 10 000 chance of occurring.

- commencement of the emergency measures. In Run 28 the emergency measures are triggered when dam levels are between 10 to 15 per cent lower than assumed for Runs 15 and 20; and
- commencement of quantitative water restrictions. In Run 28, water restrictions are assumed to commence at slightly lower dam levels. Further, level 3 restriction also does not apply in Run 28.

F.9 Extreme security outcome 2010 to 2020



^a The graphs were based on simulation replicate 2643.

Data source: SCA Wathnet model.

In this simulation the drought is assumed to occur from December 2010 to August 2019. The inflows into the storages over this period was 1.9 GL or 18 341 ML per month.⁴⁴ As a comparison to this, the 2001 drought 27 460 ML per month over a five year period and the 1940s drought of 25 155 ML per month over a four year period. Therefore, the simulated drought results in a significantly lower average monthly inflow but also extends for a significantly longer time period.

The analysis does provide some comfort that over the next 10 years that the existing range of measures combined with the range of measures considered in this analysis does provide a good basis for greater security. However, if a similar drought occurred from today, when storage levels are at approximately 60 per cent then more drastic measures would be required.

Similarly, if a similar drought occurred at some point in the future when demand levels are expected to be higher then there would be a greater risk to the security of supply. In the chart above the demand over the period is assumed to be between 570 000 ML to 580 000 ML per annum.

⁴⁴ Consistent with the approach adopted in the main body of the report we have excluded inflows into Tallowa dam from these calculations.

If the ranking of the portfolios was based on the security outcome using the 10 000 inflows simulations, then only two of the portfolios (Runs 15 and 17) would come close to meeting the working criterion used of 10 per cent storage level. This would result in greater security, but at a higher cost compared with alternative portfolios.

Cost of restrictions

A key uncertainty in the analysis is the potential cost attached to different levels of water restrictions. As noted in the report, the cost of the restrictions is not readily observed. The cost to consumers, therefore, needs to be derived through other pieces of information such as information on the:

- price elasticity of demand for water;
- assumed level of reduction in consumption under each level of restrictions; and
- proportion of household consumption attributed to outdoor water use.

The cost of restrictions is a relatively large component of the costs. We would therefore, expect that changes to the underlying cost assumptions attributed to different levels of quantitative water restrictions would impact on the costs of restrictions.

For this analysis we have tested how the rankings of the project would change if there was no cost to consumers attached to the first level of restrictions. The reason for focusing on the level 1 restrictions is that in recent analysis conducted by Sydney Water, for example, some of savings from the first level of restrictions has occurred through reducing indoor usage even though the restrictions are only intended to impact on outdoor use. Therefore, it is possible that only some proportion of level 1 restriction results in a loss in utility to the consumer – hence we only consider the impact of applying a lower cost to restrictions.⁴⁵

The results of assuming that level 1 restrictions, has no cost on consumers are presented in the table below. As indicated, changing this assumption significantly changes the total costs associated with each portfolio.

The rankings of the portfolios using cost and security criteria are presented in chart F.11. If there is no cost to consumers of level 1 water restrictions, then we would expect a number of outcomes:

- Portfolios that spend relatively more time in level 1 restrictions are not ‘penalised’, if we assume a zero cost to consumers of level 1 restrictions.

⁴⁵ It is possible to test the potential impact of changing the costs related to each level of restrictions. Level 1 restriction, however, is the largest cost element given that there is a much higher percentage of time spent in Level 1 compared to other levels of restrictions. The expected cost associated with Level 1 restrictions is approximately double that of the water usage targets. Therefore, we have focused our testing on this cost element.

- It can change the ranking of the portfolios where there are different dam levels assumed for triggering water restrictions.

In this instance the difference between Runs 26 and Run 30 is lessened — in Run 30 the trigger point for level 1 restrictions is 5 per cent lower than that assumed in Run 26.

F.10 Net Present Value of Costs to 2050 — no costs to consumers associated with level 1 restrictions

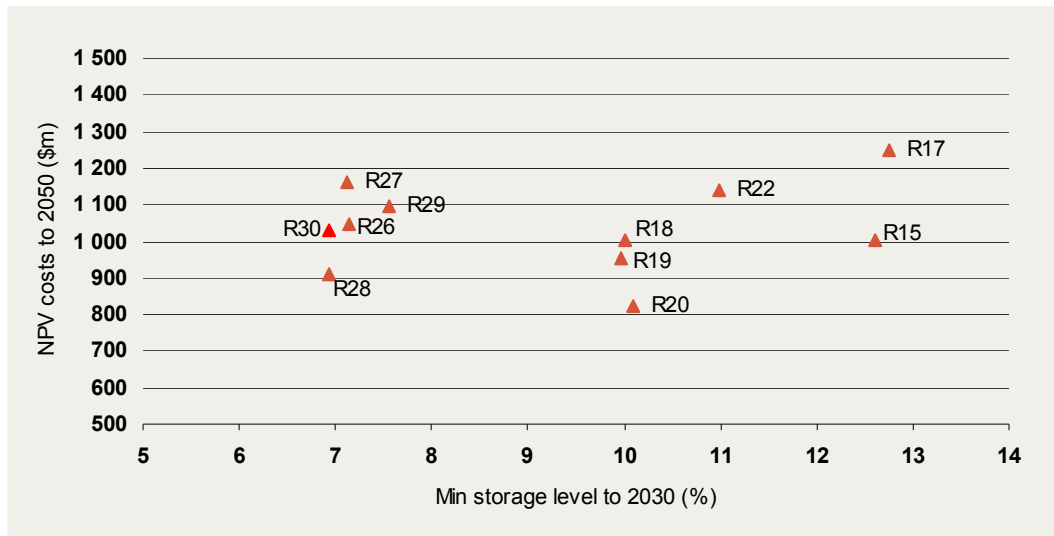
	<i>NPV Costs Baseline</i>	<i>NPV Costs Reducing CO2 costs</i>	<i>Difference</i>
	\$m	\$m	\$m
Base Case	786	652	-135
Base Case — with Eflows	920	758	-162
R13	1 854	1 723	-131
R15	1 165	1 002	-163
R17	1 403	1 248	-155
R18	1 160	1 001	-160
R19	1 114	954	-160
R20	987	824	-163
R21	1 074	915	-159
R22	1 278	1 138	-140
R26	1 204	1 046	-158
R27	1 314	1 159	-155
R28	1 018	913	-105
R29	1 347	1 097	-250
R30	1 130	1 028	-102

Source TheCIE calculations.

Run 29 is also now ranked higher than Run 27 — Run 29 has level 1 restrictions triggered 5 per cent higher than that assumed in Run 27.

Of more significance for this analysis, it does firm-up the ranking of Run 20 as being preferred to Run 28 (on cost and security grounds). It also highlights that Runs 20 and 15 remain the favoured portfolios.

F.11 Portfolio Ranking — no cost to consumers of level 1 restrictions



Data source: TheCIE calculations.

Shoalhaven pumping costs

Another sensitivity test that we have conducted is to consider the ranking changes if the energy costs of the pumping water from the Shoalhaven system and associated CO₂ emissions costs are changed. We test this by increasing and decreasing these costs by 20 per cent compared with the baseline costs reported in the analysis in the main body of the report.

The total costs, in net present value terms over the period 2010 to 2050, for the portfolios are presented in table F.12 below. For the status quo portfolio, the direct energy costs of pumping water from the Shoalhaven system is approximately \$25 million of the total costs, while the associated CO₂ emissions costs is approximately \$31 million. Given the relatively small share of these costs relative to total costs varying these costs is not expected to significantly change the total costs.

Table F.12 below illustrates this with respect to a 20 per cent reduction in the cost attributed to CO₂ emissions.⁴⁶ Given the small difference that this makes to total costs it does not change the ranking of the portfolios. The impact of changing the direct energy costs is smaller than that with respect to the price of carbon. Given this, varying the energy costs also does not change the ranking of the portfolios.

⁴⁶ A 20 per cent increase in CO₂ emissions costs has the same magnitude of impact resulting in an increase in the costs compared to the baseline.

F.12 Net Present Value of Costs to 2050 — 20 per reduction in the cost of CO2 emissions

	<i>NPV Costs Baseline</i>	<i>NPV Costs Reducing CO2 costs</i>	<i>Difference</i>
	\$m	\$m	\$m
Base Case	786	780	-6
Base Case — with Eflows	920	912	-8
R13	1 854	1 845	-9
R15	1 165	1 157	-8
R17	1 403	1 394	-9
R18	1 160	1 152	-9
R19	1 114	1 105	-9
R20	987	979	-8
R21	1 074	1 066	-9
R22	1 278	1 271	-7
R26	1 204	1 195	-8
R27	1 314	1 305	-9
R28	1 018	1 009	-9
R29	1 347	1 339	-8
R30	1 130	1 121	-9

Source: TheCIE calculations.

Changing the demand profile

The assumptions regarding the underlying demand for water has a significant impact on the underlying costs of alternative portfolios. For example, lower demand will allow dam levels to be maintained at higher levels, thereby, reducing the chance of triggering the operation of the desalination plant or triggering the implementation of water restrictions. Similarly, if demand is higher than expected this is likely to raise the cost of operating the existing assets and bringing forward the need for new assets.

The modelling presented in the main body of this report assumes a demand level that is based on a median level of population growth and low savings assumed from demand management programs. Alternative scenarios that we have considered for the sensitivity testing include:

- a higher population assumption, while maintaining the assumed low savings from demand management programs; and
- changes to the level of savings assumed. We have tested the impacts of a median savings and high savings options.

It should be noted that there has been limited data available to understand the potential cost implications of adopting the median and high savings options. These options will include additional costs such as due to an increase in the uptake of existing programs such as the rainwater tank rebates or installation of low flow showerheads. Given this, the sensitivity testing of alternative demand assumptions has been conducted for a limited range of portfolios. We are, therefore, not able to

consider the potential impact of the ranking of the portfolios of adopting the different demand assumptions. However, we can illustrate the potential impacts on a select group of portfolios.

Base case

Table F.13 presents the security and reliability outcomes under the current portfolio (*without* the introduction of a revised environmental flow regime for Warragamba Dam). It illustrates that the alternative demand scenarios do not result in much difference in the security outcomes in the period from 2010 to 2020.

However, in the medium term period, 2020 to 2030, being able to achieve a median level of savings from demand management programs can offer some security benefits in these extreme drought events (providing a buffer of approximately 4 per cent). In the long term additional measures will be required to provide security in extreme drought events and being able to achieve a higher level of savings from demand management programs is not sufficient to counter the increase in demand generated through higher long term population growth.

F.13 Security outcomes — Pr<10% and minimum storage levels

	Up to 2020		2020-30		2030-50	
	Probability <10%	Minimum storage	Probability <10%	Minimum storage	Probability <10%	Minimum storage
	%	%	%	%	%	%
Base case – MidPop/Low Savings	0.1	5.5	0.3	2.2	3.3	0.0
Base case – HighPop/Low Savings	0.1	5.5	0.4	1.3	4.7	0.0
Base case – MidPop/Mid Savings	0.1	7.8	0.2	6.4	0.8	0.0

Source: SCA Wathnet model.

Table F.14 below illustrates how each of the alternative demand scenarios impacts on the average time in restrictions. In the period up to 2030 there is not much difference in the average time in restrictions between the median and high population assumptions. However, in the longer term there is a more significant divergence between median and high population assumptions resulting in significantly different demand outcomes.

The difference between the median population and alternative savings assumptions does result in significantly alter the time in restrictions from the start of the planning period. Even in the final planning period, achieving a median level of savings from demand management programs reduces the average time in restrictions to around 5 per cent of the time.

F.14 Average time in restrictions

	2010-20	2020-30	2030-50
	%	%	%
Base case — MidPop/Low Savings	5.0	3.6	6.9
Base case — HighPop/Low Savings	5.0	3.8	8.3
Base case — MidPop/Mid Savings	4.5	2.8	5.3

Source: SCA Wathnet model.

The differences in the costs of each of these outcomes are presented in the following table below. As noted earlier the assumption regarding higher levels of savings from demand management initiatives is also likely to result in higher costs. However, we do not have information on these specific costs at this stage. Therefore, the costs presented in table F.15 below for the Mid-Population and Mid-Savings scenario is likely to underestimate the cost outcomes of the portfolio.

F.15 Costs, net present value up to 2050

	Up to 2050
	\$m
Base case — MidPop/Low Savings	786
Base case — HighPop/Low Savings	841
Base case — MidPop/Mid Savings	646

Source: TheCIE calculations.

The results indicate that the different assumptions on demand can impact on the results of the analysis. Therefore, it is important for agencies to keep monitoring the underlying trends in demand into the future. This will be particularly important as the trigger points for the range of measures is dependent on the rates of depletion of storages. So if demand is expected to be higher than projected over the next 10 years then this may imply raising the trigger level for, for example, the construction of the second stage of the desalination plant.

It would also be useful to continue to monitor the savings generated by the demand management programs and the costs associated with these programs. There may be scope into the future of changing the current mix of demand management programs if it proves cost effective to do so.

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