Water policy and climate change in Australia
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Executive summary

About this report

Climate change and water management are two of the most important public policy issues facing Australia. Adding to existing water management challenges is the fact that climate change, and policies aimed at mitigating and adapting to climate change, can strongly affect water management outcomes.

The National Water Commission’s 2011 biennial assessment of progress under the National Water Initiative pointed to the interactions between water and climate change, suggesting that policies and investment decisions involving climate change, energy and water are intrinsically entwined (NWC 2011a). The Commission recommended that it would be prudent to analyse the interactions between climate change and water in one of 12 headline recommendations made in the assessment.

This report responds to that need. Its specific objectives are to:

+ better understand the interactions between water policy and climate change policy
+ assess the likely location, timing and materiality of climate change impacts on water resources, water infrastructure and services
+ assess whether Australia’s water policy settings are sufficiently robust to deal with the potential implications of climate change
  mitigation policies and adaptation responses
+ assess whether current water policy settings have implications for the implementation of climate change policy
+ inform further water policy development and implementation.

To meet those objectives, a comprehensive assessment of the interactions between climate change policy and water policy was undertaken across seven key sectors that supply water, use water or otherwise affect water policy (urban water, rural water, the environment, agriculture, electricity generation, forestry and mining). An overview of the approach and outcomes is illustrated in Figure 1 below.

This framework has been applied to identify and assess the potential impacts on water resources and service provision of:

+ climate change mitigation policies or actions designed to reduce greenhouse gas emissions
+ climate change adaptation policies or actions designed to better manage the impacts and/or risks associated with climate change that has already occurred and will continue regardless of short- to medium-term mitigation efforts.

The assessment has drawn mainly on existing studies and modelling, but also on consultations with key government and industry stakeholders.
Figure 1: Approach and overall conceptual framework
Findings

The key findings of this assessment are as follows.

Water-related impacts of climate change mitigation policies

Climate change mitigation measures include:

+ **Cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources to lower emissions sources

+ **Energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **Land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

These policies will have a number of impacts on water resources and services:

+ impacts on balancing the supply of and demand for water

+ impacts on the costs of water-related infrastructure and services

+ impacts on the environment and the broader community.

Cleaner energy policies

Changes in the level and mix of energy generation (from coal towards gas fired generation and renewable sources) will generally reduce the electricity generation sector’s demand for water. However there may be localised increases depending on the location and type of new investment.

Potential longer term changes in the energy generation mix towards geothermal, solar thermal and carbon capture and storage (CCS) would result in significant water-related impacts. Changes in policy, underlying economics, and technology may mean that some of these new/alternative sources may develop with relatively short notice.

Urban and rural water service providers will face some increase in costs but these are likely to be moderate and manageable. The urban water supply sector is likely to be more affected as it uses significant amounts of energy. Due to its extensive reliance on gravity fed water supply, the rural water sector is likely to be less affected by increased electricity prices.

By increasing the cost of energy-intensive sources (e.g. desalination, large scale recycling), the carbon price could encourage water utilities to shift investment and sourcing decisions back toward traditional sources and away from new/alternative sources.

Higher energy costs may also exacerbate the level of uncertainty about future water supply costs. In particular, desalination is increasingly being used as a fallback supply option at time when traditional sources are in short supply. This means that it may be difficult to predict in advance how much water will be required from a desalination plant as actual orders may vary depending on how much water turns out to be available from traditional sources.

Energy efficiency

While their water-related impacts are limited, to the extent that energy efficiency programs are effective, they will reduce the overall demand for electricity which in turn affects the demand for water as an input to energy generation. The multitude of existing energy efficiency programs imposes compliance and reporting costs for some water service providers, and may create uncertainty regarding obligations that extend beyond prudent commercial decisions.
Land-use measures

Current policy settings for encouraging changes in land use that capture or reduce greenhouse gas emissions are likely to have only a modest impact on the development of permanent ‘carbon forestry’ plantings. Nevertheless, this could result in additional interception of runoff and groundwater use, particularly in northern New South Wales and southern Queensland. Modelling indicates that most of this is expected to occur after 2030.

The water interception impacts associated with induced land-use changes in the agricultural sector appear to be limited, based on current carbon prices in Australia.

A summary of the location, timing, magnitude and sensitivity of the key potential water-related impacts of mitigation policy is shown in Table 1 at the end of this executive summary.

Water-related impacts of climate change adaptation responses

Although subject to considerable uncertainty, key climate change projections include increases in temperatures, increases in the number of extreme heat events, lower and more variable rainfall and runoff, increases in extreme daily rainfall, increases in the frequency and extent of areas experiencing exceptionally dry years, and sea level rises.

While climate change has the potential to affect almost every facet of Australia’s economy, society and environment, the key risks for the water sector relate to:

- the impacts of lower average and more variable water availability on the environment, urban water users and water-using industries such as agriculture, mining and electricity generation
- the risks to water, wastewater and stormwater infrastructure assets from damage during extreme weather events (such as floods and bushfires) and other climatic changes (such as sea level rise)
- the impacts of changed water availability and climatic events on water-dependent ecosystems.

Adaptation primarily aims to moderate the adverse effects of climate change through a wide range of actions targeted at specific vulnerabilities and risks. Climate change adaptation responses of governments, firms and individuals have the potential to affect the management and use of water resources and the provision of water-related services. In fact, adaptation responses are likely to have greater impacts on water policy than mitigation responses, and may be more challenging to address.

Adaptation responses to changed water availability

Together, reduced water availability and increasing demand will increase competition for water among urban, irrigated agricultural, mining, industrial and environmental users. The resultant impacts of those pressures on supply and demand depend on the adaptation responses available to users, many of which are influenced by water policy settings.

The recent prolonged drought provided an opportunity to observe which adaptation responses may emerge:

- In the urban water sector, adaptation to reduced water availability to date has been driven mainly by direct intervention by state governments, together with Australian Government funding. While no city has run out of water, the imposition of restrictions, and investments in urban water security, have come at a significant financial and economic cost.
- While water markets in the Murray–Darling Basin have made a major contribution to the efficient allocation of scarce water resources, there are still a number of constraints on the operation of those markets that inhibit the realisation of their full potential benefits.
- The environment has tended to lose out at times of critical shortage. Under current water planning arrangements, a reduction in long-run water availability may lead to considerably less environmental water from flooding and highflow events. This may reduce environmental flows more significantly than the reduction experienced by consumptive users.
- Governments are investing in major upgrades of some rural water supply networks to improve delivery efficiency as a response to water scarcity and to generate water savings for the environment. However, there is also some risk that government investments may become underutilised if the risk of future climate changes and the likely future demand for irrigation services are not effectively factored into decision-making.
- Outside major urban areas, large industrial customers (such as mines and electricity generators) implemented a range of supply- and demand-side measures during the drought. Many users depend on a secure water supply and have thus needed to take significant steps to ensure that their supplies are secured.
Adaptation responses to the impacts of climate change on water infrastructure assets and services

While the water sector has been adapting to lower and more variable water availability for some time, adaptation responses to changes in other climatic variables are in their formative stages:

+ Adaptation responses to some climate change effects (such as sea level rise, storms and floods) could have major impacts on water, wastewater and stormwater infrastructure and service provision in the urban water sector.

+ Changes in climate variables pose a number of risks to the condition of water-related assets and their performance. In general, those impacts could hamper the ability of urban and rural WSPs to provide reliable and safe services to customers, increase the costs of doing so, or both. They could also lead to major costs for other parties (for example, risks to human life and damage to property from flooding) and the environment (such as sewer spills to waterways).

The potential adaptation responses encompass a range of approaches to managing risk through:

+ reducing exposure to the risks (such as by relocating assets)
+ reducing vulnerability by increasing resilience to climate change impacts (for example, more stringent design standards for new infrastructure capable of withstanding climatic impacts)
+ tolerating some adverse impacts (such as allowing certain water-related infrastructure assets to fail under certain conditions and then repairing or replacing them, while ensuring that the system as a whole continues to operate)
+ clearly allocating responsibility for managing climate change risks to assets to those best able to manage them.

While climate change risks could result in significant economic, social and environmental losses, protecting against all possible risks is likely to be prohibitively costly.

Adaptation responses to the impacts of climate change on water-dependent ecosystems

Projected increases in average temperatures and in the incidence of extreme weather have the potential to cause deleterious and potentially irreversible impacts on environmental assets associated with surface water and groundwater systems.

In recent years there have been moves towards better meeting the needs of the environment through water planning, purchases of water entitlements from consumptive users and investments that reduce losses in irrigation systems. While such measures were primarily aimed at addressing the longstanding overallocation of water, they provide an insight into the types of adaptation responses that may occur.

The protection of environmental assets in the context of climate change is likely to require increasing reliance on adaptive management. Future adaptation responses may involve making difficult ‘triage’ decisions in managing water-dependent ecosystems. They may include decisions about whether to continue to water already degraded sites that are unlikely to survive due to climate change.

A summary of the location, timing, magnitude and sensitivity of the key potential water-related impacts of adaptation responses is shown in Table 2 at the end of this executive summary. Adaptation responses can be seen as having types of broad impacts similar to those of climate mitigation policies:

+ impacts on balancing the supply of and demand for of water
+ impacts on the costs of water-related infrastructure and services
+ impacts on the environment and the broader community.

Implications of climate change mitigation policies and adaptation responses for water policy

A key question for this study is whether existing water policy settings can address the impacts of climate change mitigation policies and adaptation responses without compromising water policy objectives.

The overarching objective of the National Water Initiative (NWI) is to establish ‘a nationally-compatible, market, regulatory and planning based system of managing surface water and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes’. This high-level objective includes several key elements:

+ the efficient and sustainable allocation and use of water resources
+ the efficient provision of, and investment in, water and wastewater services and assets
+ the protection of public health and safety and environmental outcomes.
The high-level objective of the NWI remains relevant in the context of climate change mitigation and adaptation. However, the optimal economic, social and environmental outcomes are likely to change over time as a result of climate change. For example, climate change mitigation and/or adaptation may lead to changes in the marginal value of water in different uses, so that an efficient allocation of water resources requires water to move between uses. Similarly, if the cost of some water sources (such as desalination) increases with a carbon price, that may imply that the optimal mix of supply sources and demand management options changes.

Overall, current water policy settings are well placed to address most of the potential impacts arising from climate change mitigation and adaptation. However, there are several areas where there is scope for changes in current arrangements to ensure that the underlying water policy objectives will continue to be achieved.

**Policies affecting the sustainable and efficient allocation and use of water resources**

Water resource planning in Australia has not adequately addressed climate change. A key problem is that water plans have not always catered for climatic conditions outside the bounds of those captured in the historical record. While governments have recently made progress towards better incorporating climate change into water resource planning, it will take some time for planning processes to extend this better practice across Australia.

Adapting to a changing environment may mean that some current environmental objectives cannot be met in the future. Perseverance in the pursuit of environmental objectives that are unachievable is likely to result in wasted effort, reduced or ineffective accountability, and forgone opportunities for environmental benefits from watering other sites.

Climate change further highlights the benefits of clear and secure water access entitlements developed in accordance with the NWI. Climate change interactions are likely to place further pressure on water access arrangements in situations where entitlement reform is incomplete.

As the impacts of climate change on water availability are likely to remain inherently difficult to quantify, the NWI risk assignment framework is difficult to apply in practice in a way that provides certainty and consistency.

Climate change mitigation policy and adaptation responses could increase interceptions of water resources that are not adequately accounted for or managed.

Water markets have proven to be effective in reallocating water to its highest valued use, particularly during severe droughts. Because climate change is likely to lead to both rapid and cumulative changes in the supply of and demand for water, water markets will be an important adaptation mechanism to ensure that maximum value is obtained from Australia’s scarce water resources.

The acquisition and use of water entitlements by environmental water managers is a flexible and useful climate change adaptation strategy. Climate change is likely to increase the need for environmental water managers to manage their water holdings adaptively in response to emerging impacts in different regions. This raises important questions—which the Commonwealth Environmental Water Holder and others are beginning to address—about acquiring the optimal portfolio of holdings, using water allocated to entitlements effectively for environmental purposes, water accounting, and the governance of environmental water managers’ water market activity.

**Policies affecting efficient investment and service provision**

Supply–demand planning and investment decisions are likely to be increasingly difficult due to the uncertainty associated with climate change. There are a number of inadequacies in past approaches to balancing urban water supply and demand efficiently in the context of climatic uncertainty.

Climate change adaptation poses a number of new challenges to planning and investment in rural water infrastructure, including in relation to asset maintenance strategies, asset renewals, and system or subsystem rationalisation and closure. There is a risk that large rural water infrastructure projects may be inefficient if responses to the impacts of climate change on water availability and irrigation water demand (and other factors) are not adequately considered.

While urban water planning tools are being developed to help address the impacts of climate change on rainfall and inflows, much less attention has been given to managing the risks to water assets and their performance from other impacts of climate change, such as extreme weather, sea level rise and higher temperatures. However, some useful foundation work is now being undertaken by the industry and the Australian Government.

The effectiveness and efficiency of adaptation responses in the water sector will be influenced by broader urban, regional, catchment and coastal adaptation strategies.

Where independent economic regulation exists, increases in the costs of providing water-related services—due to higher energy prices associated with climate mitigation policies—would normally be passed through, notwithstanding that they imply higher bills to users.
Policies for the protection of public health, safety and the environment

Climate change interactions create a number of challenges in defining appropriate service standards and regulatory obligations and balancing targets with the costs of achieving them.

Governance arrangements

There is a significant risk that climate change will make existing management objectives and service standards more difficult and costly to achieve. Revised management objectives and service standards may be required in the light of mitigation efforts and adaptation to the impacts of climate change.

Where roles and responsibilities are unclear, there is a risk of inefficient adaptation.

Climate change interactions create extra pressure on decision-making tools and processes. Developing effective adaptation responses will require new skills and capabilities.

Implications of current water policy settings for the implementation of climate change policy

This study has found that, in the main, current water policy settings will not impede cost-effective implementation of climate change policy. However, there are a small number of exceptions, including some that might affect the shift towards lower emissions energy sources. They include the following:

- Lack of clear and secure entitlements and access to water markets might inhibit investment in new, less emissions-intensive electricity generation facilities.
- The inability of water and related environmental regulations to keep pace with alternative and emerging energy sources may inhibit the development of less emissions-intensive energy sources.
- Uncertainty surrounding the water entitlements of some coal-fired generators may affect the willingness of some energy companies to enter into agreements for the early closure of some high-emissions generators.
- Recycled water targets and subsidies for some demand management measures may not be adequately considering increased greenhouse gas emissions.
- While well intentioned, some voluntary mitigation actions by WSPs are unlikely to be the most cost-effective means of achieving national mitigation objectives.

What are the priorities for water reform?

This study highlights a number of interactions between water and energy. For example:

- Many new investments in the urban water sector aimed at diversifying water supplies (such as desalination plants) require higher energy inputs.
- Energy generation (including some new or lower emissions sources) can have significant requirements for water as an input.

However, the relationship between energy and water does not imply, as some have suggested, that governments need to become more directly involved in attempting to integrate investment and resource use decisions across these sectors. Rather, what is needed is a framework that ensures that individuals and firms take into account the full water, energy and carbon costs and benefits of production, consumption and investment decisions. This highlights the importance of efficient and cost-reflective pricing of water-related services so that the new carbon price signal flows through into water use, investment and sourcing decisions.

Many elements of current water policy settings are well placed to manage potential impacts from climate change and related policies. Indeed, reforms to water pricing, entitlements and markets, particularly in the Murray-Darling Basin, provide a world-leading example of climate change adaptation policy. In some cases, however, there is a need for better and more complete implementation of the NWI.
The analysis in this report also reveals that dealing with profound climatic uncertainty and the transition to a carbon-constrained economy adds a number of new dimensions to the water reform agenda. Institutional, policy and governance reforms that encourage flexibility should be at the heart of the water policy response to climate change wherever possible. The water policy framework needs to be truly adaptive and able to effectively manage the uncertainties and risks associated with climate change.

Due to the uncertainty associated with climate change, decentralised approaches such as water markets that clearly assign risks to those best placed to manage them are likely to perform much better than attempts at centralised planning. In some remote areas where water markets are less feasible, other changes to water planning and regulation may be needed.

The analysis undertaken for this report has led to the development of five overarching recommendations:

1. Further water entitlement and market reforms should be implemented to provide security to water users and to flexibly manage changes in water supply and demand due to climate change.
2. Improvements to water planning and related decision-making processes should be implemented to better manage climate change risk and uncertainty.
3. Reforms to regulation and pricing should be made to provide greater flexibility to adapt to climate change, and better signal all the relevant costs of managing it.
4. Approaches to investment in urban supply augmentations and rural water infrastructure should be reviewed to ensure that they address water security but also to reduce the risk of poor investments.
5. The management of climate change risks to water infrastructure and services, particularly in urban areas, should be given higher priority.

The recommendations are supported by detailed proposed actions presented in Section 5 and Section 7 of the report.

**Implementation**

This study highlights the broad range of challenges to water policy posed by climate change mitigation policy and adaptation responses. However, further work in each jurisdiction is required to understand which issues are most important at a local level.

Jurisdictions should continue to drive water policy and take responsibility for addressing the issues that arise from this assessment. In particular, reforms affecting the urban water sector are primarily the responsibility of the states. The Commonwealth also has a number of existing roles, particularly in the Murray–Darling Basin, that are affected by climate change and related policy. With the recent easing of drought conditions, there is a risk of complacency about the water reform agenda at the state and national levels. Recent experience with floods and droughts, combined with the range of risks identified in this report, means there can be no excuses for lack of preparation in the future.

Climate change mitigation and adaptation are nationally important issues. To meet many adaptation challenges, water policymakers and service providers will need to participate in a coordinated whole-of-government approach to adaptation, particularly in coastal and urban areas. However, this does not mean that all actions and responsibilities should be centralised. On the contrary, water policy should aim to facilitate autonomous adaptation by individuals and firms, and planning should be undertaken by local institutions and informed by local conditions.
<table>
<thead>
<tr>
<th>Mitigation policies</th>
<th>Incentive/direct effect</th>
<th>Key water-related impacts</th>
<th>Location</th>
<th>Timing</th>
<th>Magnitude/sensitivity</th>
<th>Relative importance as driver of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaner energy</td>
<td>Carbon price and renewable targets lead to change in electricity generation mix (away from coal).</td>
<td>Reduced water demand in coal-fired generation locations.</td>
<td>Latrobe Valley (Vic.), south-east Queensland and Hunter Valley (NSW)</td>
<td>Potential early shutdown of coal generation, and long-term investment in non-coal generation.</td>
<td>Switching from coal to gas could have significant localised impacts on the availability of water.</td>
<td>Main driver of change in domestic electricity generation over next 20 years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased use of and demand for gas, including coal seam gas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased incentives for geothermal, solar thermal and carbon capture and storage technology.</td>
<td>Localised impacts depending on technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased costs in other emissions-intensive activities (e.g. fugitive emissions from wastewater treatment). Agriculture currently excluded.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased energy price for water-using industries and consumers.</td>
<td>Metropolitan cities. Cities/towns with multiple supply options.</td>
<td>Immediate (due to carbon costs and liabilities) and longer term (due to changed water supply augmentation investment).</td>
<td>Low–moderate (given that carbon liability is a small proportion of total costs).</td>
<td>Low–moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased costs of urban water supply (wastewater, desalination and recycling). Potential switch to relatively cheaper options (i.e. gravity-fed dam storage supply).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Increased investment to increase energy efficiency.</td>
<td>May increase or decrease water demand (likely to decrease, with energy-efficient appliances tending to be more water-efficient).</td>
<td>National</td>
<td>Immediate</td>
<td>Low</td>
<td>Commercial drivers provide incentive to reduce energy costs.</td>
</tr>
<tr>
<td>Land-use change</td>
<td>Payments for carbon farming (and biodiversity), leading to land-use change.</td>
<td>Water quality and quantity impacts (i.e. increased interception from tree planting).</td>
<td>Forestry—possibly north-east NSW and mid-coast Queensland. Agriculture—across Australia.</td>
<td>Immediate (and into future if new carbon farming activities are approved).</td>
<td>Low (given interception managed by carbon farming policy and low incentive for commercial forestry).</td>
<td>Low (at current carbon price).</td>
</tr>
<tr>
<td>Adaptation response impacts</td>
<td>Incentive/direct effect</td>
<td>Key water-related impacts</td>
<td>Location</td>
<td>Timing</td>
<td>Magnitude/sensitivity</td>
<td>Relative importance as driver of change</td>
</tr>
<tr>
<td>----------------------------</td>
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<td>----------------------------------------</td>
</tr>
<tr>
<td>Water supply–demand</td>
<td>More variability and reduced average water availability.</td>
<td>Increasing demand for and shortfalls in water available for electricity generation, urban demand, environmental requirements, perennial horticulture, mining, etc.</td>
<td>Potentially national; effects expected to be greatest in southern Australia.</td>
<td>Increased likelihood of extreme events in short and long term. Long-term impacts from reduced average water availability.</td>
<td>High (shared between consumptive users and the environment), but highly uncertain.</td>
<td>Very high</td>
</tr>
<tr>
<td></td>
<td>Pressure on water allocation and planning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes to locations of agricultural and forestry land use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assets and services</td>
<td>Risks to assets from sea level rise.</td>
<td>Costs of relocating or protecting assets (i.e. urban water assets at risk from sea level rise).</td>
<td>Coastal urban areas.</td>
<td>Long-term impacts from sea level rise.</td>
<td>High, but highly uncertain. High costs if risks eventuate and also significant costs from risk management (depending upon adaptation response).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased risks to assets from extreme events (e.g. floods and storms).</td>
<td>Risk to community assets and populations and environment. Costs of increasing standards to manage risks.</td>
<td>Urban and rural areas. Mining sites.</td>
<td>Increased likelihood of extreme events in short and long term.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Degradation of distribution and other network infrastructure.</td>
<td>Increased costs of operation and maintenance.</td>
<td>Urban and rural areas.</td>
<td>Long-term impacts from climate changes (e.g. higher temperatures).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced demand for assets/services.</td>
<td>Risks of underutilised infrastructure assets or water-intensive assets.</td>
<td>Some irrigation districts (rural infrastructure).</td>
<td>Long-term impacts from climatic changes, including reduced average water availability.</td>
<td>Low (given economic life of assets).</td>
<td>Low (market factors determine agricultural viability).</td>
<td></td>
</tr>
<tr>
<td>Water-dependent ecosystems</td>
<td>Risks to water-dependent ecosystems.</td>
<td>Risk of compromising environmental objectives.</td>
<td>Environmental water sites nationally.</td>
<td>Increased likelihood of extreme events in short and long term. Long-term impacts from reduced average water availability.</td>
<td>High, but highly uncertain. High</td>
<td></td>
</tr>
</tbody>
</table>
Mitigation policy, adaptation responses, and water policy
1 Introduction

1.1 About this report

This report provides the National Water Commission’s assessment of the national water policy implications of climate change mitigation policies and adaptation responses.

The project objectives are to:

+ better understand the interactions between water and climate change policy
+ assess the likely location, timing and materiality of impacts on water resources, water infrastructure and water services
+ assess whether Australia’s water policy settings are sufficiently robust to deal with the potential implications of climate change mitigation policies and adaptation responses
+ assess whether current water policy settings have implications for the implementation of climate change policy
+ inform further water policy development and implementation.

The report does not assess the effectiveness or appropriateness of current climate change policies; nor does it provide scientific analysis or modelling on the projected climatic impacts of climate change. Instead, the project considers a range of plausible mitigation policy scenarios and adaptation responses and draws upon the best available scientific information on the climatic impacts of climate change.

1.2 Project background

Dealing with climate variability has long been an integral element of Australia’s approach to water policy and management. The National Water Initiative (NWI) includes a range of policy measures to manage seasonal climatic variability. It also recognises the need to address the long-term impacts of human-induced climate change on water resources, which may go beyond those observed historically. Whether this is adequately reflected in policy settings is a key focus of this report.

Knowledge about the range of climate change impacts is improving, and many lessons in dealing with climatic extremes of floods and droughts have been learned over the past decade. However, there is a multitude of interactions between climate change and water policy, beyond those related to the impacts of climate on water availability. For example, water sector assets and investments may be affected by sea level rise and rising temperatures associated with climate change. Water policy and management may also be affected by the implementation of mitigation policy, which is now being given effect through the Australian Government’s Clean Energy Future (CEF) package.

The Commission has undertaken a number of previous studies related to climate change, including work on:

+ water management in the energy and mining sectors
+ the interception of water resources by forestry plantations and land-use change
+ approaches to incorporating climate change in water planning
+ the impacts of climate change on groundwater resources
+ the future direction of urban water reform, including in response to climate change.
Jurisdictions, government agencies and researchers have also undertaken extensive research, particularly on the scientific and technical aspects of the interactions between water and climate change and the risks that they pose. An emerging theme of that research has been the ‘energy–carbon–water nexus’ and whether current policy adequately considers the interactions.

While much good work has been done, a comprehensive and integrated assessment of the materiality of the range of interactions between water policy and climate change policy is yet to be undertaken in the Australian context.

Addressing this gap was the subject of headline recommendation 9 in the Commission’s recently released The National Water Initiative—securing Australia’s water future: 2011 assessment:

> It would be prudent at this stage to analyse the nature and materiality of potential changes to water use as a result of climate change adaptation and mitigation initiatives. Water management policies may need to be elaborated to operate more effectively in the context of these new initiatives. (NWC 2011a:7).

This report addresses that recommendation.

### 1.3 Scope of the study

This report examines the water-related impacts and policy implications of both climate change mitigation and climate change adaptation. For the purposes of this report:

+ **climate change mitigation** refers to policies or actions designed to reduce the amount of greenhouse gas emissions; these tend to focus on energy and include carbon price signals (such as taxes or emissions trading schemes), energy efficiency programs, and various forms of carbon sequestration and offsets
+ **climate change adaptation** refers to policies or actions designed to better manage the impacts and/or risks associated with climate change that has already occurred and will continue regardless of short- to medium-term mitigation efforts.

The Commission has analysed the interactions between climate change mitigation and adaptation and water policy in seven sectors seen as being significant users of water or otherwise having significant water-related impacts:

+ mining
+ agriculture\(^1\)
+ forestry
+ electricity generation (including from renewable sources)
+ the environment (surface water and groundwater dependent ecosystems)
+ urban water service providers (WSPs) and their customers (households and commercial/industrial water users)
+ rural WSPs.\(^2\)

Together, these sectors cover most consumptive water use in Australia (Figure 2). However, the Commission also recognises that interactions do not arise just through consumptive water use. For example, the environment is both a consumptive and a non-consumptive user.

In addition, flooding and stormwater management are considered within the scope of the assessment, across each of the sectors.

\(^1\) The focus was primarily on the irrigated agricultural sector, although it is recognised that changing landuse practices in dryland agriculture can influence interception. Other types of agriculture, including aquaculture, may also be affected by climate change.

\(^2\) Rural WSPs’ customers are mainly irrigated agriculturalists. Irrigated agriculture is addressed in the agricultural sector assessment in Section 11.
Details on each sector’s water use and other interactions with water resources are provided in the sectoral assessments in Part B. An overview of energy use and greenhouse gas emissions is also provided for each sector, given their relevance to the mitigation policy interactions.

While the current level of water and energy use is documented as a starting point for the analysis, other factors affecting the future of the sector have also been considered when defining the baseline for the assessment. For example, because the mining sector is expanding rapidly, growth in water use in mining is expected as part of the baseline (that is, without considering climate change mitigation policies, the impacts of climate change, or adaptation responses to climate change). Table 3 summarises key sectoral characteristics relevant to this analysis.

Table 3: Summary of key characteristics of each sector relevant to this study

<table>
<thead>
<tr>
<th>Sector</th>
<th>Water interactions</th>
<th>Energy use and emissions</th>
<th>Factors affecting sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>Use of surface water and groundwater.</td>
<td>On-site electricity.</td>
<td>Major increase in investment due to global demand.</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Irrigation is largest water user. Return flows. Surface water and groundwater use.</td>
<td>Direct emissions (e.g. methane from livestock and crops). Some energy use in inputs, pumping and processing.</td>
<td>Commodity prices and input costs. Policies to increase environmental flows, especially in the Murray–Darling Basin.</td>
</tr>
<tr>
<td>Forestry</td>
<td>Use of groundwater and interception of surface water.</td>
<td>Potential for carbon sequestration.</td>
<td>Driven by economic conditions; recent decline due to collapse of managed investment schemes.</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>Water requirements for cooling and on-site use vary between generators.</td>
<td>Major source of emissions.</td>
<td>Mitigation policy is the major factor affecting future investment.</td>
</tr>
<tr>
<td>Environment</td>
<td>Consumptive and non-consumptive user.</td>
<td>Pumping requirements for some environmental watering.</td>
<td>Policies to increase environmental water.</td>
</tr>
<tr>
<td>Urban water</td>
<td>Full urban water cycle, including harvesting, distribution, use, treatment and disposal.</td>
<td>High energy use in treatment and pumping.</td>
<td>Population growth and climate variability and change.</td>
</tr>
<tr>
<td>Rural water</td>
<td>Storage, transfer and distribution.</td>
<td>Some pumped systems and increasing automation.</td>
<td>Nature and viability of irrigated agriculture.</td>
</tr>
</tbody>
</table>
1.4 The study process

The Commission carried out this project in a phased and inclusive manner (Figure 3):

- An initial scoping paper was tested with two reference panels (an Australian Government agency panel and an industry panel) in October 2011.
- Jurisdictions and other stakeholders were consulted bilaterally, and a major stakeholder workshop was held in November 2011.
- Reference panel members and jurisdictions were also given the opportunity to comment on a version of this report in February 2012.

These engagement activities helped the Commission identify interactions, assess their materiality and undertake the policy assessment.

Figure 3: Summary of project process and stakeholder engagement activities

The Commission engaged Frontier Economics, URS Australia, DG Consulting and Element Solutions to assist with project delivery and the preparation of this report.

Appendix A details stakeholder engagement in the project.
1.5 Report structure

The report has two parts:

+ Part A contains the main report, which identifies, describes and assesses the interactions between water policy and climate change policy and provides a cross-sectoral assessment of the implications for water policy.
+ Part B contains a detailed assessment of the interactions for each of the following sectors: agriculture; mining; electricity generation; forestry; the environment; urban water services; and rural water services.

The remainder of Part A is structured as follows (see also Figure 4):

+ Section 2 details the conceptual framework for the assessment of interactions between climate change and water policy.
+ Section 3 defines mitigation policy and identifies and assesses water-related interactions.
+ Section 4 defines adaptation responses and identifies and assesses water-related interactions.
+ Section 5 sets out the Commission's findings and recommendations on the ability of current water policy settings to accommodate the impacts and interactions identified in sections 3 and 4.
+ Section 6 examines whether current water policy settings may affect the implementation of climate change policy.
+ Section 7 distils the key policy messages and suggested reform priorities.

Figure 4: Report structure—Part A
2 Conceptual framework

Early in the project, the Commission identified the need for a strong conceptual or organising framework to guide the study and ensure that the project objectives were met. The conceptual framework helps to define the boundaries of assessment, the types of interactions under investigation, and the approach to assessing their materiality.

This section describes the overarching conceptual framework for understanding the interactions between water and climate change policies (Section 2.1) and the approach used to identify and assess those interactions (Section 2.1). The assessment is then applied in the following sections of Part A, and to the sectoral assessments in Part B.

2.1 Overview

The conceptual framework guiding the project and the structure of the main report is shown in Figure 5. The framework begins by separating mitigation policy interactions from those related to adaptation, and then identifies specific categories of mitigation policies and adaptation responses. The water-related impacts are then assessed in an integrated manner and water policy implications are considered.
Figure 5: Approach and overall conceptual framework

- Define and categorise climate change policies and impacts
- Sectoral analysis of incentives and interactions
- Identify plausible water-related impacts and assess location, timing and magnitude
- Assess water policy implications
- Identify reform priorities

Sectoral analysis

- Impacts on water supply and demand
- Adaptation actions and adaptation in response

Mitigation

- Cleaner energy
- Energy efficiency
- Land use change

Adaptation

- Impacts on water-dependent ecosystems
- Adaptation policies and actions in response
- Impacts on assets and service performance
- Impacts on community and environment

Mitigation policies

- Efficient and sustainable allocation and use of water resources
- Efficient investment and delivery of services
- Protection of environment and public health

Adaptation policies and actions in response

- Can current water policy settings manage impacts to achieve water policy objectives?
- Do current water policies compromise effective implementation of climate change policy?

Define and categorise climate change policies and impacts

- Changes in climate variables:
  - Temperature and rainfall
  - Extreme weather events
  - Changes in sea levels, bushfires, etc.

Impacts on water resources, services, and infrastructure:

- Balancing supply and demand
- Costs and availability of supply
- Impacts on community and environment

Impacts on the environment:

- Urban water service providers
- Rural water service providers

Impacts on water-dependent ecosystems:

- Forestry
- Agriculture
There are several important conceptual differences between interactions associated with mitigation and those associated with adaptation. For mitigation, it is possible to identify specific types of policies that operate at the national level and have water-related impacts. Those policies and impacts are the focus of the mitigation assessment.

Specific adaptation policies are not highly developed, including at the national level, so it is not possible to apply a similar approach to them. Adaptation responses to the potential impacts of climate change are subject to significant uncertainty and are likely to be both policy induced and the autonomous actions of individuals and firms. However, for most climatic impacts, the Commission has focused on identifying plausible adaptation responses. Where appropriate, we have drawn on observed responses by government agencies and private individuals and firms to climatic variability and extreme climatic events that have occurred in recent years.

### 2.2 Approach to assessing interactions and implications for water policy

The specific steps in the assessment are summarised in Figure 6.

**Figure 6: Approach to the project**

1. **Step 1:** Define and categorise climate change mitigation policy and adaptation responses
2. **Step 2:** Identify plausible impacts on each sector of interest, including changes in:
   - costs and revenue
   - the level, nature and location of activities
3. **Step 3:** Identify water-related impacts, including on:
   - water demand and use
   - water availability, hydrology
   - water quality
   - effluent disposal
   - water sector services and infrastructure
4. **Step 4:** Assess materiality of impacts, considering:
   - the nature, timing, location, likelihood and magnitude of impacts
   - uncertainty and sensitivity to change
   - whether climate change is the main driver of change
5. **Step 5:** Assess water policy implications
   - Are current water policy settings sufficient to enable:
     a) optimal economic, social, and environmental outcomes for water
     b) efficient implementation of climate change policy?
6. **Step 6:** Identify priorities and reform recommendations

Steps 1–4 are completed in Part B on a sector-by-sector basis and in a cross-sectoral fashion in sections 3 and 4 of Part A.
Step 1—Define and categorise climate change policies and interactions

The approach starts by separating climate change into interactions associated with:

+ mitigation policy
+ adaptation responses.

In Step 1, these policies are defined and interactions are identified in a structured and systematic manner. For example, for mitigation policy, the Australian Government’s Clean Energy Future package provides a tractable suite of mitigation policies to assess.

In order to recognise uncertainty, the sensitivity of our assessment of impacts has been tested for a range of plausible policy scenarios that might emerge over the next 20–30 years, such as changes in the level of a carbon price (see Section 3).

Similarly, the profound level of uncertainty about the impacts of climate change and the associated adaptation responses is important for our assessment of climate change adaptation (see Section 4).

Step 2—Identify impacts on sectors of interest

The plausible impacts of climate change mitigation policies and adaptation responses on activities in the sectors of interest are identified in Step 2. They include impacts on costs and revenues and ultimately on the level, nature and location of specific activities. For example, a carbon price is expected to change the mix of energy generation sources.

Step 3—Identify water-related impacts

Step 3 identifies what the impacts on sectoral activities might mean for water resource management and service delivery. Potential water-related impacts of interest could include impacts on the availability of water, demand for and use of water, water quality, and water sector service and infrastructure (for the urban and rural water sectors only). For example, if a carbon price were to lead to a change in the mix of energy generation, that may have impacts on the aggregate demand for water and demand for water in a particular location, given the different water requirements of different technologies.

Step 4—Assess the materiality of impacts

Step 4 involves assessing the materiality or significance of the impacts. In doing so, we have outlined evidence and analysis relating to:

+ the timing, location, likelihood and magnitude of the impacts
+ the sensitivity of the impacts to plausible changes in mitigation policy and adaptation responses
+ whether there are other drivers of change in the sector that have more important water-related implications (such as commodity prices).

A key issue here relates to distinguishing business as usual from a change induced by mitigation policy or adaptation responses. Australia’s economy is dynamic, and industries respond to a range of signals. In some cases, climate change policy is very important (for example, in relation to the electricity generation mix and its water use), whereas in others the impact of climate change is likely to be small compared to the impact of other factors (for example, growth in water use in mining is driven by global demand, particularly in Asia).

Step 5—Assess water policy implications

Step 5 assesses whether the individual and cumulative impacts identified in the previous steps have any implications for water policy. As noted above, water policy issues may not arise even though climate change might have an impact on water demand or supply or other aspects of water management. Therefore, the policy assessment considers whether current policy settings are sufficient to enable optimal economic, social and environmental outcomes for water—which is the agreed objective for water policy under the NWI.

As part of the policy assessment, the Commission has also considered whether current water policy settings will affect the efficient implementation of climate change mitigation policy and adaptation responses.
Step 6—Identify priorities and reform recommendations

From the impact assessment (Step 4) and policy assessment (Step 5), we have made recommendations that focus on those interactions that:
+ are most material
+ present a water policy issue (see Figure 7).

However, lower impact interactions are still considered to be important, particularly where:
+ the water-related impacts might be more severe in particular locations
+ the impacts of climate change are new or unique and not yet addressed in current water policy settings
+ cost-effective improvements in water policy settings could effectively address the problem.

The appropriate response to some interactions may simply be to implement known and agreed reforms (such as those already included under the NWI). In other cases, climate change interactions might require a new set of policies, or changes to existing policies.

Figure 7: Conceptual approach to the prioritisation of interactions
3 Mitigation policy impacts

This section:
+ defines and categorises mitigation policy (Section 3.1)
+ identifies and assesses the potential water-related impacts associated with three key categories of mitigation policy
  - cleaner energy measures (Section 3.2)
  - energy efficiency measures (Section 3.3)
  - land-use change measures (Section 3.4)
+ provides a summary of the key impacts (Section 3.5).

3.1 Definition and categorisation of mitigation policies

Mitigation policies are actions designed to reduce overall emissions of carbon dioxide and other greenhouse gases (such as methane and nitrous oxide). The direct combustion of fossil fuels produces greenhouse gas emissions. This occurs during the production of electricity but also in other industries, such as manufacturing and construction; in air, road, rail and shipping transportation; during the extraction and distribution of coal, oil and natural gas (which produce ‘fugitive emissions’); and in agriculture (livestock and crop cultivation) and agricultural burning (which emit methane and nitrous oxide). Changes in land use (such as adding to or removing forests) can also affect the removal of carbon dioxide. An indication of the relative contribution of greenhouse gases from these sectors is shown in Figure 8.
A range of mitigation policies and actions are currently being, or are proposed to be, undertaken in Australia. They operate at the national, state and local government level. Some are directly focused on mitigation, while others are broader environmental policies that include elements relating to mitigation.

A recent Productivity Commission (2011c) study on implied carbon prices identified some 233 Australian policies (national and state) that affect carbon emissions directly or indirectly. They include subsidies and taxes; direct government spending; research and development; public education and labelling programs; and other regulatory instruments. They are summarised by type/category in Figure 9.
Given the broad range of policies in existence and under development, it is not feasible to consider the impacts of them all. Many have a primary objective other than emissions reductions, a relatively small impact on emissions reductions, or both.

To make the analysis tractable, mitigation policies have been categorised into:

+ **cleaner energy measures** (see Section 3.2): policies that aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (such as coal-fired electricity generation) to lower emissions intensity sources (such as gas-fired or renewable electricity generation)

+ **energy efficiency measures** (see Section 3.3): policies that aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **land-use change measures** (see Section 3.4): policies that aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation and abate emissions in the agricultural, waste and other sectors.
Figure 10 shows the estimated abatement contribution of each type of mitigation policy in Australia.\(^3\)

**Figure 10: Department of Climate Change and Energy Efficiency/Treasury estimates of emissions reductions, by category (Mt CO\(_2\)-e)**

![Bar chart showing emissions reductions by category (Mt CO\(_2\)-e)](chart.png)

Emissions reductions Mt

- Kyoto
- 2015
- 2020

- Land-use change measures
- Energy efficiency measures
- Cleaner energy measures

Sources: Frontier Economics, based on DCCEE (2010b); carbon price and Carbon Farming Initiative impact based on Treasury (2011).

The discussion in the rest of this section considers each of these types of policies in more detail (particularly the Australian Government’s *Clean Energy Future* package) and identifies and assesses the potential water-related impacts of each (see Figure 11).

**Figure 11: Categorisation of the water-related impacts of mitigation policies**

![Diagram showing categorisation of water-related impacts](diagram.png)

This is based on converting the Department of Climate Change and Energy Efficiency (DCCEE) estimates of Australia’s emissions into these three categories.
3.2 Cleaner energy policy impacts

3.2.1 Definition and current policy settings

Cleaner energy policies are designed to reduce the emissions intensity of the energy generation sector, particularly by changing the mix of electricity generation. These policies also cover other sources of emissions to the extent that they are included in a carbon tax or an emissions trading scheme, or might be included in the future.

Current policy settings

Most clean energy policy measures are contained in the Clean Energy Future (CEF) package. Hence, those measures are the focus for the assessment of policy interactions.

The key elements of the CEF package include the following:

+ **A carbon price**: A carbon price operates by establishing property rights for greenhouse gas emissions and then charging emitters for the emissions for which they are liable (although a price can also be created through an emissions trading market). In the energy sector, this changes the relative cost of generation in favour of lower emitting sources. Under the CEF, the carbon price is initially fixed by legislation at $23 per tonne of carbon dioxide equivalent (t CO₂-e) from July 2012, to increase annually by 2.5% in real terms for the first three years of the scheme. Beyond that, the scheme will move to emissions trading (with a floating price), and it is expected that the Australian price will be set by the global market. Businesses operating facilities that emit over 25 000 t CO₂-e per year will be directly liable for their emissions. The Australian Government has estimated that about 500 businesses will be liable, including some urban WSPs.

+ **Targets and subsidies for renewable energy**: A renewable energy target operates as a targeted subsidy to encourage renewable generation. In the absence of a renewable target, electricity demand would be met through the lowest cost mix of generation, which in Australia is typically coal-fired generation (with some hydro and gas). Renewable options (typically wind power) are more expensive per unit of output and capacity. A renewable target requires electricity retailers to purchase a given percentage of electricity from renewable sources, thus increasing the contribution of low/no-emissions energy sources to Australia’s economy. The CEF includes:
  - the Large-scale Renewable Energy Target (LRET), which creates a financial incentive for the establishment and growth of renewable energy power stations, such as wind and solar farms
  - the Small-scale Renewable Energy Scheme, which creates a financial incentive for owners to install eligible small-scale installations such as solar water heaters, heat pumps, solar panel systems, small-scale wind systems and small-scale hydro systems.

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4 In principle, a carbon price can be applied to a range of emitters in various sectors, including transport, fugitive emissions from fuels and agriculture.
Also included in the CEF are:

+ the establishment of the $10 billion Clean Energy Finance Corporation to provide commercial loans to investments in renewable energy and technologies

+ a tender for the closure of 2000 MW of high-emissions generation capacity (such as Hazelwood, Victoria; Yallourn, Victoria; Energy Brix, Victoria; and Playford, South Australia); details of this are not yet clear, although if tenders are accepted (that is, if terms can be reached) it is expected that this would lead to the early closure of coal-fired generation at those sites by 2020.

The Australian Government proposes to provide industry assistance to emissions-intensive and trade-exposed industries, including aluminium, cement, steel, pulp and paper, liquefied natural gas, chemical production and some electricity generators. This will mitigate some of the impacts of the CEF on those sectors, although the rate of assistance reduces over time. Compensation will also be provided to households.

Under current policy, agricultural activities that produce emissions will not be subject to the carbon price. However, agricultural activities that abate emissions are encouraged under the Land Sector Package. Under that package, carbon offsets are available under the Carbon Farming Initiative, while the Biodiversity Fund provides funding to encourage sustainable land use and management practices and revegetation (see Section 3.4).

**Sensitivity to policy change**

It is recognised that cleaner energy policies are likely to evolve over time. This could be because of a change in government policy, improvements in information and knowledge, or the influence of other countries and their policies. For example, the following elements may change:

+ the level of the carbon price

+ specific regulations (such as the coverage of the scheme)

+ the type of mitigation policy measures adopted (for example, the carbon price is intended to transition to an emissions trading scheme)

+ the level and form of any direct investment in, and subsidies for, particular renewable energy sources.

In addition to such potential policy changes, there is also the prospect of technological changes to alter the investment mix. The sensitivity of water-related interactions to changes in these policy settings is explored below and in the Part B assessment for each sector. In most cases, policy changes will only influence the magnitude of the water-related impact, but in some cases they could change the nature of the interactions.

**3.2.2 Categorisation of water-related impacts of cleaner energy policies**

Cleaner energy policies have direct and indirect impacts on water use and the delivery of water services. Those impacts relate to:

+ the direct liability of urban WSPs for fugitive emissions from wastewater treatment processes under a carbon price (Section 3.2.3)

+ the direct impact of the carbon price and renewable energy targets on the level and mix of electricity generation and the resulting water demand, extraction, use and disposal (Section 3.2.4)

+ the indirect impact of higher energy prices (due to the change in electricity generation) on water-using energy consumers and the associated impact on water use in each sector (Section 3.2.5).

Through these paths, cleaner energy policies can affect the cost of different water supply options, affect the demand for water and create other water-related risks for the environment and third parties. Figure 12 illustrates these direct and indirect impacts.
Based on this categorisation, the following discussion identifies and describes the water-related impacts of the cleaner energy policies across all sectors.

### 3.2.3 Direct liability for emissions in the water sector

Arguably the most direct (but not necessarily the most significant) impact of cleaner energy measures is the liability they create for some urban WSPs that will need to pay a carbon price for fugitive emissions. As the direct (‘Scope 1’) emissions of rural WSPs are negligible, they are not directly liable under the CEF package and are unlikely to be affected directly in the future.

The urban water industry’s fugitive emissions are mainly from wastewater transport systems, treatment plants and treated effluent disposal (WSAA 2009). Under the proposed carbon pricing mechanism, the direct emissions of a number of water utilities appear likely to exceed the 25,000 t CO₂-e threshold, making them liable to pay the carbon price for those emissions. This would include Sydney Water, Hunter Water, Power and Water (NT), Water Corporation (WA), SA Water and Melbourne Water (AWA–Deloitte 2011).

The carbon price on fugitive emissions will increase the cost of those operating facilities deemed to be liable. However, the estimated liability of water businesses for direct emissions is relatively low compared to their overall operating costs. For example, Sydney Water (2011) may be required to spend around $0.9 million a year to purchase carbon permits for its direct greenhouse gas emissions from wastewater treatment. That amount is less than 1% of Sydney Water’s total annual operating costs.

In principle, urban water businesses may be able to reduce their liability by changing their processes to capture or alter their greenhouse gas emissions. For example, a wastewater treatment plant could reduce emissions by capturing and burning methane that would otherwise be released into the atmosphere. There are also opportunities to produce biochar from sludge as a form of biosequestration.

The cost of direct liability for fugitive emissions is unlikely on its own to drive investment in emissions-reducing technology. However, in combination with increases in the cost of electricity, the carbon price on emissions may make capturing biogas from wastewater treatment more financially attractive in the longer term. A Water Services Association of Australia report has previously noted that:

> the use of biogas as an energy source has a double benefit in that it reduces fugitive methane emissions from entering the atmosphere as well as reducing use of standard imported electricity. (Kenway et al. 2008)

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5 There is ongoing debate about whether individual sewage treatment plants (including in Sydney) should be treated jointly as a ‘facility’ for the purposes of the carbon tax or as separate facilities, each of which would fall below the threshold. The Australian Government and the water industry are still resolving the precise definition of ‘facility’.
3.2.4 Impacts of changes in the energy generation mix

Cleaner energy policies will have water-related impacts that result from expected changes to the mix of energy generation sources due to the carbon price, renewable energy targets and tenders for the closure of high-emissions electricity generation. A summary of those impacts is provided here; more detail is in Section 8 of Part B.

Impacts of a carbon price on the electricity generation sector

The CEF measures (including the carbon price signal) are designed to influence the carbon emissions of the electricity generation sector. Specifically, the objective of the carbon price on emissions is to encourage ‘fuel shifting’ from lower-cost/high-emitting sources (coal-fired generation) to higher-cost/lower-emitting sources (gas-fired generation and renewables).

The Commonwealth Treasury projects the carbon price to remain less than $40/t CO$_2$-e by 2020. Analysis undertaken for this study suggests that that price is not sufficient to encourage new wind or other renewables in their own right, and that a price greater than $80/t CO$_2$-e would be needed, based on current generation costs. Investment in renewable technologies is being driven through complementary assistance under the Large-scale Renewable Energy Target (LRET), which applies independently of the carbon price.

The projected carbon price is also too low to drive the early closure of most existing coal-fired plant before 2020 without additional measures, such as the tender for closure.

In the light of those factors, the expected direct effects of cleaner energy policies on the electricity sector are as follows:

+ There will be a slowing of projected electricity demand growth due to price increases.
+ There will be minimal requirements for new baseload capacity from large coal or gas plants. Most of the new capacity required to meet baseload demand over the next decade is expected to come from wind farms incentivised through the LRET. However, some expansion in new complementary gas plants will still be required to meet peak demand because wind remains an expensive source for peak demand, as it only generates when the wind blows.
+ The tender for closure may see the early closure of up to 2000 MW of emissions-intensive generation capacity, if the prices bid are acceptable to the government. That capacity will almost certainly be replaced with gas-fired generation because other generation types are more expensive.

It is important to emphasise that the analysis of the likely future generation mix (outlined in more detail in Section 8 of Part B) is based on carbon price projections consistent with the current policy settings in the CEF package. These energy generation mix predictions would be sensitive to significant changes in mitigation policy (such as a significant increase in the carbon price or targeted assistance to particular technologies) or major technological changes in energy generation.

Water-related impacts of the changes

In general, the introduction of the cleaner energy policies should slow the growth in water demand from electricity generation, mainly because the renewable energy sources and new gas-fired electricity generation are less water intensive than coal-based generation.

Reduction in water demand for coal-fired generation

In general, a shift away from coal would reduce aggregate water demand because coal-fired generation is typically an intensive water use (2–3 ML/GWh).

These impacts are expected to be highly significant at a localised level, as existing coal-fired generators have large water requirements, for example in the Latrobe Valley in Victoria, the Hunter region in New South Wales and southern Queensland (see Figure 13). There are important policy questions about the nature of entitlements to water for these generators and what might happen to those entitlements if the plants were shut down or if output were reduced.

The overall impact on water demand depends on which particular plants reduce generation or shut down, and whether such changes occur in plants that use fresh or saline water cooling. For example, Hazelwood in Victoria uses freshwater cooling, but Playford in South Australia uses saline cooling.

There could also be flow-on effects of these changes to localised urban water demand where a carbon price has significant local or regional economic effects (such as through the closure of an electricity generator that is a major local employer). However, adjustment measures and other policies could ameliorate any of those potential effects.
Reduction in water demand arising from increased gas-fired generation

Over time, gas-fired generation is expected to meet some of the demand that would otherwise have been met by coal. Gas-fired generation also complements investment in wind energy, as its flexibility helps manage the inherent variability of wind energy generation.

Some gas-fired technologies, such as open cycle gas turbine (OCGT) and closed cycle gas turbine (CCGT) with dry cooling, have negligible water requirements, resulting in limited water impacts. Other technologies have substantial water requirements (for example, CCGT with recirculated cooling uses up to 1 ML/GWh), which could create significant additional localised water demands (Smart and Aspinall 2009).

The location of gas-fired generation facilities is relatively flexible, so it may be that existing water demand from coal-fired power stations is replaced by demand from new gas-fired generators at the same or nearby locations. However, that is not guaranteed, and there may be significant demand from new gas-fired generators in one catchment and large reductions in demand from existing coal-fired power stations in another.

In its review of the impacts of climate change policies on energy market frameworks, the Australian Energy Market Commission (AEMC 2009) found that access to cooling water will have a major influence on the location of new generators, and that the cost of water can influence long-run operating costs.
Water-related issues associated with coal seam gas development

Although a large proportion of Australian gas output is expected to be exported via liquefied natural gas plants (including in response to international carbon price signals), some domestic gas-fired electricity generation, induced by a domestic carbon price, may come from gas extracted from coal seams in New South Wales and Queensland.

As discussed in Section 9, depending on its management, the water that is extracted with the coal seam gas (‘associated’ water) has the potential to adversely affect the environment and other consumptive users. Once treated, associated water could be used for beneficial purposes (irrigation, reinjection, discharge), but the extraction could potentially reduce the quality and quantity of local water resources used by others. For example, the increase in water extraction could lead to localised reductions in groundwater levels in the Great Artesian Basin, and could also affect shallower interconnected aquifers.

Figure 14 shows water resources and areas of potential coal seam gas development.

Figure 14: Water resources and areas of potential coal seam gas development

Renewable energy sources

Under current policy settings, most of the renewable energy target is likely to be supplied through wind energy development, at least in the short term. Wind energy generation does not have any material water requirements or interactions.

In the longer term, viable geothermal, solar thermal and carbon capture and storage technologies could emerge. Some solar thermal and geothermal technologies require significant amounts of water (for example, solar thermal technologies heat water to generate steam or require water to wash mirrors). This is a constraint to their development and deployment in Australia, where locations with the best solar and geothermal resources have very little water. Furthermore, adding carbon capture and storage to an existing coal-fired power plant could double the plant’s already significant water requirements. Therefore, the availability of water could be a significant barrier to that technology (see Section 8).
3.2.5 Indirect impacts of increased energy prices

The cleaner energy policies will lead to an increase in the price of electricity as a result of the fuel switching outlined above. Government modelling of the electricity price impacts is presented in Section 8 in Part B (the electricity sector assessment). Electricity price increases may:

+ affect the costs of water service provision
+ affect water demand, use and disposal by firms and individuals who use water as an input to production.

Cost impacts on the water sector

The following discussion:

+ identifies the nature and possible magnitude of these cost impacts
+ examines the potential implications for customers’ bills
+ identifies potential means to manage the cost impacts
+ identifies other potential impacts on the urban water sector.

Nature and possible magnitude of the cost impacts

Increases in energy costs will affect urban and rural water businesses to differing degrees.

The urban water supply sector is likely to be affected more because it uses significant amounts of energy. For example, Sydney Water is one of the largest energy users in New South Wales, consuming almost 1% of the state’s electricity (Sydney Water 2009). Some aspects of urban water service provision are particularly energy intensive, including water treatment, wastewater treatment, water supply pumping and wastewater pumping. The carbon price will therefore lead to increases in energy costs for urban water businesses. For example:

+ Sydney Water (2011) estimates that it will face increased energy costs of $8.6 million a year due to carbon cost pass-through on electricity prices and some fuel prices.
+ Preliminary modelling by the Western Australian Water Corporation suggests that the carbon tax will increase the corporation’s annual operating costs by around $14 million, due to the combined effect of increased energy costs and the carbon price on its wastewater treatment plants’ direct emissions (WA Treasury 2011).

It is important to note that baseline energy use in the water sector is typically increasing (for example, because of investment in desalination and increasingly stringent discharge requirements). This may have a greater effect on future water supply costs and investment decisions than the introduction of the carbon price. For example, Sydney Water estimates that its total electricity costs will increase from $40 million in 2009–10 to almost $60 million over the next five years, excluding the impact of any carbon price (Sydney Water 2011a).

Due to its extensive reliance on gravity-fed water supply, the rural water sector is likely to be affected less by increased electricity prices. However, those individual businesses that operate pumped and pipelined supply systems are significantly more energy intensive per megalitre of water delivered than the general industry average, and may face greater cost impacts as a result.

SunWater is by far the largest electricity user among the rural WSPs. Electricity costs make up around 15% of the operating costs for its bulk water and irrigation distribution schemes (SunWater 2011). SunWater expects that the introduction of a carbon price will result in a one-off increase in electricity costs of about 10%. The two largest schemes (by volume) have current electricity costs of $14.80/ML and $30.99/ML (SunWater 2011), which implies a price impact due to the introduction of a carbon price of between $1.48/ML and $3.10/ML (see Section 13 in Part B).
Scope to manage the cost impacts

Some factors will ameliorate the potential effect of the carbon price on energy costs in the urban water sector. In particular, the Water Services Association of Australia notes that the carbon tax will not increase electricity costs for urban water desalination plants for at least 20 years (WSAA 2011). This is because the contract conditions for those plants include long-term energy supply agreements that typically exclude the pass-through of carbon costs, which are instead offset with green power and wind power.

There may also be scope for water businesses to manage the potential cost increases from higher energy charges by changing their patterns of energy consumption or source of energy supply. For example, investment in renewable energy and energy capture has already occurred in the urban water sector. It appears that voluntary and regulatory targets for emissions reduction and renewable energy have at least partly driven that investment (see Section 12). Increasing energy costs for traditional sources (such as fossil fuels) will provide an incentive for further investment in onsite renewable or alternative energy generation (involving waste heat and energy capture) (Woods et al. 2011). The cost-effectiveness of these options will vary by city.

Impacts on total costs and customer bills

Although the carbon price on direct emissions and energy inputs will increase the cost of water and wastewater services, the impact on end users is likely to be moderate. This is because energy costs are only a relatively small percentage of water businesses’ total costs. For example, Sydney Water (2011a) estimates suggest that the initial increase in the typical water and wastewater bill due to the carbon price will be less than $10 over the 2011–12 to 2015–16 period. That increase would be less than 1% of the typical Sydney water and wastewater bill for 2011–12.

This finding is likely to extend to other Australian cities. The Western Australian Treasury, for example, estimates that the carbon price will increase the ‘representative’ household’s yearly expenditure on water tariffs, fees and charges by $13.25 or 1.0% per year (WA Treasury 2011).

In the longer term, however, the carbon price may increase and have a greater effect on water and wastewater bills and the demand for services.

Other potential impacts on operations and investment in the urban water sector

In addition to simply increasing the costs of urban water-related services, higher energy prices stemming from cleaner energy policies may have implications for operations and investment in the sector.

Most importantly, higher energy prices will change the relative costs of alternative water supply options. By increasing the cost of energy-intensive services (such as desalination or large-scale recycling), the carbon price could encourage water utilities to switch to less energy intensive supply options, such as drawing more water from their own catchment dams or seeking to import water from other catchments via water trading. This may shift investment and sourcing decisions back towards traditional sources and away from new or alternative sources. This would include decentralised solutions and desalination, both of which are currently being pursued as a climate change adaptation response in the water sector.

This is most likely to be an issue in major coastal cities (such as Adelaide, Sydney, Melbourne, south-east Queensland and Perth) that have access to a range of bulk supply sources (local dams, large-scale recycling, desalination, groundwater or water trading). However, it is still relevant for inland areas where there are opportunities to use recycling or water trading to supplement existing surface water or groundwater sources.

Higher energy costs may also exacerbate uncertainty about future supply costs. In particular, desalination is increasingly being used as a fallback supply option at times when water from traditional sources is in short supply. This means that it may be difficult to predict how much water will be required from a desalination plant, as orders may vary depending on how much water turns out to be available from traditional sources (orders from desalination plants are often triggered by levels of water in storages). While this is already an issue, increases in the price of electricity will further increase the uncertainty about costs faced by urban water suppliers. Similar considerations apply to other energy-intensive supply sources that are used opportunistically or vary from year to year (such as pumping from the River Murray to Adelaide).

Higher energy prices will also increase the costs of meeting environmental standards for wastewater discharge. They will particularly increase the cost of meeting higher standards (such as requirements for tertiary treatment) and so reduce the value of making those investments.
Indirect impacts arising from effects on other water-using sectors

Higher electricity prices will have a range of impacts on the activities of individuals and firms that use electricity. Some of those impacts will have implications for water demand.

Most significantly, the introduction of a carbon price may affect the viability of irrigated agricultural producers (the largest water-using sector in Australia), who may face increased input costs (see Section 11). However, the overall impact of increased electricity prices on farm viability is extremely difficult to determine, particularly in the long term. Many producers are price takers in global commodity markets, and their profitability has already been affected by the recent drought and adverse commodity price conditions in some markets (such as for wine grapes). Therefore, even small changes in the cost base of some producers may have a significant impact on their viability. Ultimately, this might decrease water use in irrigated agriculture.

Higher electricity prices could also affect other water-using industries, leading to reductions in water demand from those industries. For example:

+ Some minerals processing sectors (such as steel and aluminium) could be affected, but their water use is small and localised. These emissions-intensive trade-exposed industries will also receive some transitional adjustment assistance to at least partly shield them from the impacts of the carbon price.

+ Higher energy prices could affect the costs of pumping environmental water. However, most pumps are diesel fuelled, and diesel is not subject to the carbon price under current policy.

+ Higher energy and other input prices are not likely to have a major impact on the forestry sector.

At the household level, higher energy prices will increase the costs of heating water, which may in turn lead to some reductions in water use (such as shorter showers). There could also be flow-on effects of these changes to localised urban water demand where a carbon price has significant local or regional economic effects (for example, through the closure of a coal mine that is a major local employer). However, adjustment measures such as those under the CEF package and other policies could ameliorate any such potential effects.

3.2.6 Summary of key findings

Key findings

The cleaner energy policies and in particular the imposition of a carbon price will have a number of water-related impacts. The most significant are as follows:

+ Changes in the level and mix of energy generation (from coal towards gas-fired generation and renewables) will generally reduce the electricity generation sector’s demand for water, but there may be localised increases depending on the location and type of new investment.

+ Potential longer term changes in the energy generation mix towards geothermal, solar thermal and carbon capture and storage (CCS) would result in significant water-related impacts.

+ Urban and rural WSPs will face some increase in costs, but those increases are likely to be moderate and manageable.
3.3 Energy efficiency policy impacts

3.3.1 Definition and current policy settings

Energy efficiency measures are those aimed at reducing energy use and as a consequence reducing carbon emissions. They include:

- measures to encourage energy efficiency in homes, such as a household advice line and website, standards and energy rating labelling of household appliances, and a renewable energy bonus to help households replace household electric storage hot water systems with clean energy alternatives

- measures to encourage energy efficiency in businesses, such as the Clean Technology Program (providing grants to manufacturers to invest in energy-efficient capital equipment and low-pollution technologies, processes and products) and the Energy Efficiency Opportunities program, which requires Australia’s biggest energy-using companies to identify efficiency opportunities and report on their implementation.

Current policy settings

Based on the estimates of the Department of Climate Change and Energy Efficiency (DCCEE), there are a range of energy efficiency schemes that could make a significant contribution to overall emissions abatement in Australia. Those measures are summarised in Table 4.

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<td>Energy Efficient Homes package: Homeowner Insulation Program</td>
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<tr>
<td>Greenhouse Challenge</td>
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<td>Greenhouse Friendly™</td>
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<td>Greenhouse Gas Abatement Program</td>
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<tr>
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<td>Victorian Energy Efficiency Target</td>
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Source: DCCEE (2010).
Sensitivity to policy change

The large number of energy efficiency programs operating at the state and national level (see Productivity Commission 2011c) has led to discussions about whether there is potential for those programs to be rationalised. In any case, some may be removed as the carbon tax and emissions trading scheme are implemented. Therefore, this study has adopted a broad approach in considering the effect of typical types of energy efficiency programs and actions. Specific energy efficiency policies have been considered where they have a particular impact on the water sector.

3.3.2 Categorisation of potential impacts of energy efficiency policies on water use and water services

While energy efficiency measures are an important component of climate change mitigation policy, the interactions with water resources are much more limited. Nevertheless, energy efficiency policies may affect water use and water services where:

+ WSPs are subject to energy efficiency programs or regulations
+ the specific activities or behaviours that are the subject of energy efficiency measures lead to consequent changes in water use because water is a complement to or substitute for energy (for example, in water heaters and washing machines)
+ energy efficiency initiatives reduce overall demand for electricity, which in turn affects the demand for water as an input to energy generation.6

Figure 15: Impacts of energy efficiency policy on water policy

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6 This impact has been taken into consideration in the Commonwealth Treasury’s modelling reported above and assessment of the impact of the carbon price, and so is not repeated here.
3.3.3 Impacts where water service providers are subject to energy efficiency programs or measures

Energy efficiency programs targeted at WSPs often only require businesses to identify and invest in cost-effective energy efficiency opportunities. For example:

+ Under the Australian Government’s Energy Efficiency Opportunities program, businesses must identify, evaluate and report publicly on cost-effective energy savings opportunities (DRET 2011). Melbourne Water has completed reports for both the Western and Eastern treatment plants (Melbourne Water 2011b).

+ Under EPA Victoria’s environment and resource efficiency plans, Melbourne Water is required to invest in energy efficiency projects that have a three-year or less payback period at sites exceeding energy- and water-use thresholds (Melbourne Water 2008: 119).

In practice, it is difficult to see why businesses would not exploit many of these opportunities in response to commercial drivers, such as rising energy costs, regardless of the existence of these energy efficiency programs. For example, in the rural water sector, there is limited scope for major energy efficiency activities to reduce carbon emissions, given that much of the water in that sector is delivered via gravity systems. Nevertheless, most rural WSPs have been pursuing cost-saving and efficiency measures over a number of years, and some have already implemented a range of cost-effective energy efficiency measures (such as more efficient pumping systems).

The introduction of a carbon price will reinforce the financial incentives for energy efficiency, particularly if the price increases in the longer term. For example, Sydney Water (2011:184) notes that:

> Beyond the potential regulation and pricing of carbon emissions, increasing and volatile electricity prices create a significant financial incentive for Sydney Water to reduce energy consumption.

In other cases, existing obligations are very general and WSPs must interpret how to apply them in practice. For example, Melbourne Water’s Statement of Obligations requires it to develop and implement programs for assessing, monitoring and continuously improving its sustainability performance, including ‘responding to climate change’, ‘using resources more efficiently’ and ‘managing everyday environmental impacts’. Melbourne Water attributed $1.3 million in operating costs to meeting this obligation in the 2005 regulatory period.

The large number of existing energy efficiency programs operating at multiple levels of government may increase compliance and reporting costs for some WSPs, or increase uncertainty about obligations that extend beyond prudent commercial decisions.

3.3.4 Impacts arising from specific changes in water and energy use

Some energy efficiency measures target specific uses of electricity that may also have water-use implications. In most cases, more energy-efficient appliances tend to also be more water-efficient. For example, at the household level, analysis has shown that installing a Water Efficiency and Labelling Standard (WELS) 3-star shower rose would cut both water and hot-water system energy consumption in a household with high water use by 45%. Similarly, in the industrial sector, energy efficiency measures (such as replacing electrical water heating) will typically result in water savings.

In mining, studies suggest that the largest opportunities for energy efficiency relate to processing (particularly grinding) and transportation (Sterling 2009). However, improvements in energy efficiency in these areas are likely to have very little impact on water use.

In general, the impact on water use in activities targeted by energy efficiency programs is expected to be minimal.

3.3.5 Impacts on water use arising from reduction in demand for energy

To the extent that energy efficiency programs are effective, they will reduce the overall demand for electricity, which in turn affects the demand for and disposal of water as an input to energy generation. This effect is analogous to the impact of a carbon price on aggregate demand for energy, as discussed in Section 3.2.4.

The modelling undertaken by the Treasury (2011) to inform the assessment of the impacts of the carbon price includes the effects of energy efficiency programs. Thus, the combined impacts of reduced demand for energy are already included in the analysis above.
3.3.6 Summary of key findings

Findings
While their water-related impacts are limited, to the extent that energy efficiency programs are effective, they will reduce the overall demand for electricity, which in turn affects the demand for water as an input to energy generation. The multitude of existing energy efficiency programs imposes compliance and reporting costs on some WSPs, and may create uncertainty about obligations that extend beyond prudent commercial decisions.

3.4 Land-use policy impacts

3.4.1 Definition and current policy settings
Land-use change measures seek to reduce emissions by changing land use, including by reducing deforestation or encouraging afforestation and reforestation. These measures capture or maintain carbon in soil and vegetation (also known as carbon sequestration), which can potentially contribute to meeting emissions reductions targets. Land-use change policies originally targeted reforestation, afforestation and the cessation of land clearing. Large-scale land clearing has been, or is being, phased out in all states and territories. Hence, the recent focus has been on reforestation and afforestation in the forestry sector. In this regard, it is important to distinguish between:
+ forestry for wood production
+ forestry for carbon sequestration (‘carbon plantings’).
Both types take up carbon during growth and store it in roots, stems, branches and leaves.
Outside forestry, for the purposes of this assessment, this category of mitigation measures also includes abatement (emissions reduction) options associated with land management and agriculture, where they have water-related impacts. The main current Australian policies include the Carbon Farming Initiative and the Biodiversity Fund, both of which are part of the CEF package. Carbon credits generated through sequestration can also be sold internationally if they comply with the Kyoto Protocol.
The treatment of forestry in the Kyoto Protocol

The Kyoto Protocol provides the overarching policy framework for addressing climate change by encouraging reductions in global emissions. The protocol incorporates recognition of land use, land use change and forestry. Importantly, it recognises the role that forest carbon offsets (specifically, eligible activities relating to afforestation, reforestation and/or deforestation activities) can play in addressing climate change.7

This international policy position has informed the development of approaches in Australia. However, the interpretation of the rules for forest-based carbon sequestration has been the subject of extensive international debate, so specific accounting treatments vary.

Among Kyoto signatory countries that have established emissions trading schemes, New Zealand is the only country to have included the commercial forestry sector as a potential source of carbon credits.

In relation to the international policy settings, the Australian National Climate Change and Commercial Forestry Action Plan (DAFF 2009) argues that widespread inclusion of forestry would require a set of more rigorous, cost-effective and holistic international greenhouse gas emissions accounting rules for forests.

The Carbon Farming Initiative

The Carbon Farming Initiative (CFI) is a voluntary carbon offsets scheme established by the Australian Government to provide opportunities for farmers, forest growers and landholders to contribute to activities that reduce carbon pollution (DCCEE 2011). The CFI recognises the contribution that forestry, agricultural and other activities can make to managing atmospheric carbon concentrations through:

+ sequestering atmospheric carbon into biomass and soil
+ reducing/avoiding emissions that would have otherwise occurred from agricultural, waste management and other activities.

Once activities are approved and underway, any carbon credits generated through them can be used by the party that undertook the activity, or sold to another party to offset its carbon liabilities. The type of carbon credit created depends on the characteristics of the project:

+ Kyoto credits can be used for carbon compliance to meet regulatory requirements (that is, offsetting liabilities to pay the carbon tax). These credits are created if a project undertakes an abatement activity that is recognised as contributing towards Australia’s Kyoto Protocol target. They can also be sold in compliance markets overseas.
+ Non-Kyoto credits can only be used for voluntary carbon management (where buyers choose to reduce their emissions out of social responsibility or for product marketing purposes8). These credits are created if a project undertakes an abatement activity that is not recognised as contributing towards Australia’s Kyoto Protocol target (for example, soil carbon sequestration).

For a project to meet the CFI requirements and generate a carbon credit, it must be in line with an approved ‘methodology’. At March 2012, four such methodologies had been approved (DCCEE 2012):

+ capture and combustion of landfill gas
+ destruction of methane generated from manure in piggeries
+ environmental plantings (reforestation)
+ savannah burning.

It is expected that further methodologies will be developed over time.

More generally, for a given project to be considered eligible under the CFI it must demonstrate that it will operate within the scope of the CFI and will conform with an approved methodology. In addition, it must be on the ‘positive list’ of activities recognised under the CFI, and not be on the ‘negative list’ of activities. Activities on the negative list are not eligible to generate carbon credits.

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7 For the purposes of Article 3, paragraph 3, eligible activities are ‘those direct human induced afforestation, reforestation and/or deforestation activities that meet the requirements set forth in this annex and that started on or after 1 January 1990 and before 31 December of the last year of the commitment period’ (UNFCCC 2001).

8 For example, an individual who books an airline ticket and then buys offsets to abate the emissions produced by the flight is participating in a voluntary market.
Details of the positive and negative lists as they affect forestry are outlined in Section 10. In summary:

+ The positive list for the CFI includes most types of permanent carbon plantings, but does not include commercial plantations for harvesting. In addition, all projects need to comply with all local, state and national government water planning and environmental requirements and must take account of regional and natural resource management plans.

+ The negative list guidelines encompass the government’s approach to managing adverse environmental, social or economic impacts from CFI activities. This includes where there is a material risk that the activity will have an adverse impact on one or more of the availability of water; the conservation of biodiversity; employment; the local community; and access for agricultural production.

On the basis of the requirements of the positive list, there is currently no opportunity for plantation forestry incorporating wood production to participate in the CFI. Commercial forestry projects, in the traditional sense of wood production, would not be considered ‘additional’ under the CFI methodology guidelines for assessing eligibility. However, as methodologies continue to evolve and develop, wood production plantation forestry activities that can be demonstrated to increase carbon sequestration could be considered as potentially eligible activities under the CFI. The Commission understands that the potential for certain commercial wood production forestry activities to be considered eligible under the CFI is currently being investigated.

The negative list provides the framework by which activities are assessed as ineligible under the CFI. Reflecting concerns about potential adverse impacts on interception, the planting of trees in areas of high mean rainfall (above 600 mm/year) is generally deemed to be ineligible, unless at least one of five specific conditions that may ameliorate those concerns have been met. Some conditions relate to the treatment of water interception (for example, where the project occurs in an approved water plan area that addresses interception or the proponent holds a suitable water access entitlement).

However, permanent plantings that are also ‘environmental’ plantings do not need to meet these requirements because an activity is not rendered ineligible under the negative list if any of the specified conditions applies. In effect, therefore, the impacts on interception of any new permanent plantings that are deemed to be environmental plantings will depend on the effectiveness of the positive list requirements for activities to comply with local, state and national government water, planning and environment requirements. Permanent plantings that are not environmental plantings would be required to meet at least one of the other requirements.

The Biodiversity Fund

The Biodiversity Fund, a component of the Clean Energy Future package, will be used to support landholders to establish new native vegetation and to restore habitats in targeted areas of the landscape. A total of $946 million is to be made available over six years (Australian Government 2011). The focus of this commitment is on environmental plantings, which may include mixed-species carbon plantings, but not plantations that are established for wood production. It also includes a range of other improved natural resource management practices, including revegetation (DSEWPaC 2011).

Sensitivity to policy change

While the CFI provides direction for the current assessment of land-use change measures in Australia, it is likely to evolve over time. Developing robust methods for estimating and verifying emissions abatement and sequestration is a major challenge for climate change mitigation policy around the world. As these methods are developed and gain acceptance, there is potential for a broader range of options to be able to generate carbon credits. One important example relates to the potential for harvested plantations to be able to generate credits. If that were to occur, the potential land-use change and water-related interception impacts associated with mitigation policy could increase significantly.

9 Environmental plantings are ‘plantings that consist of Australian native species that are native to the local area of the plantings and may be: a mix of tree and understory species; or a single species if monocultures occur naturally in the area’ (DCCEE, 2012:3).
3.4.2 Categorisation of potential water-related impacts

Land-use change measures have direct impacts on the financial incentives facing landholders (across industries). In particular, policies that impose liabilities (or provide credits) for landholders based on how their actions affect greenhouse gas emissions will encourage them to increase or maintain carbon, either in soil or in vegetation.

Changes in land use and land management practices can have a direct impact on water resources. In particular, increasing vegetation cover, including through plantation establishment, can have both positive and negative effects on water quantity and quality.

Large-scale afforestation may intercept significant volumes of surface water and groundwater, reducing water available for other users. However, if the location of plantations is carefully managed, they could help control erosion, reduce salinity and improve water quality.

Resulting land-use change could also have an impact on WSPs in rural areas (for example, if irrigation demand is affected by the change). WSPs may also be interested in exploring opportunities for reforestation and land-use change on their own land.

The impacts of land-use change measures on the water sector are illustrated in Figure 16.

Figure 16: Impacts of land-use change policy measures on water policy

3.4.3 Land-use change measures

Potential for land-use change under the Carbon Farming Initiative

Land-use change measures such as the CFI alter the relative profitability of different land uses and land management practices to promote activities that sequester carbon or reduce emissions. Such measures may lead to:

+ expansion of permanent (carbon) plantings
+ changes in agricultural practices and crop types (such as greater use of perennial pastures and increasing soil carbon)
+ changes in land use in water-dependent environmental assets (such as wetlands).
Expansion of permanent (carbon) plantings

Limited analysis has been undertaken to date on the likely expansion of permanent (carbon) plantings under the CFI. In 2011, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) estimated the abatement potential from reforestation under the CFI (Burns et al. 2011). ABARES defined reforestation activity as comprising long-rotation hardwood plantations and carbon plantings, which were assumed at the time of the study to create eligible carbon sequestration credits under the CFI.

ABARES estimated the total area of agricultural land that may be economically feasible for reforestation, under a medium global action scenario, to be around 350 000 ha between 2012–13 and 2049–50 (Burns et al. 2011). This comprised long-rotation hardwood plantations of 190 000 ha and CFI-compliant permanent carbon plantings (that is, not harvested) of around 160 000 ha, with relatively minimal land-use change until 2032–2042 (see Section 10).

The ABARES research stands as the only known published modelling at a national level of the potential impacts of current climate change policy on reforestation levels. It provides the best available guidance on the magnitude and location of reforestation associated with climate mitigation policy.

Changes in dryland and irrigated agricultural land use and practices

For management practice and crop type changes in agriculture (particularly irrigated agriculture), the underlying economics suggests that there may be limited take-up of initiatives based solely on returns for carbon. The cost of undertaking the activities that would be eligible for carbon credits suggests that the carbon price may need to increase substantially to encourage major changes to irrigated agricultural practices (see CSIRO 2009).

CSIRO (2009) and the Garnaut Review (2008) both indicate that the land-use changes likely to produce the highest level of abatement relate to the rehabilitation of overgrazed rangelands to build carbon stores. Such options have very limited interactions with water resources.

However, carbon sequestration on irrigated farmland could be used to assist and expand onfarm tree-growing activities that have other benefits, such as biodiversity enhancement, that are funded through the Biodiversity Fund.

Changes in land use in water-dependent environmental assets

There may also be potential for elements of the Biodiversity Fund to help fund land-use change on environmental watering sites, particularly where the achievement of environmental outcomes depends on both environmental watering and revegetation. In a strict sense, environmental water managers are not generally responsible for making non-water-related changes in land use and land management practices. For example, the Commonwealth Environmental Water Holder is responsible for managing the Commonwealth portfolio of environmental water entitlements and for delivering that water in accordance with environmental watering plans. It does not own or manage land, and cannot purchase land or make payments for land-use change under the provisions of the Water Act 2007 (Cwth). Other parties responsible for land management (for example, state government agencies and catchment management authorities) could undertake such revegetation works and control access to environmental assets. However, as discussed in Section 14, there is a potentially important coordination issue to be addressed.

Potential water interception impacts

As described above, ABARES modelling of abatement potential from reforestation under the CFI suggests that by 2050, the area of permanent carbon plantings could be around 160 000 ha Australia-wide under a medium global action scenario (see Section 10 in Part B). Most of those plantings are likely to be in north-eastern New South Wales (100 000 ha) and along the mid-coast region of Queensland (60 000 ha) (see Figure 17).

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10 The ABARES medium global action scenario assumes atmospheric greenhouse gas concentrations of 550 parts per million CO₂-e by around 2100 and a world carbon price of $23/t CO₂-e.
Vertessey et al. (2003) estimated that, for catchments that receive mean annual rainfall of approximately 800 mm, each hectare of eucalypt afforestation can result in a reduction in catchment runoff of about 1.7 ML in a given year. If the mean annual rainfall is 600 mm, the reduction could be 1 ML per hectare. Using this figure and ABARES (2011a) estimates of new permanent carbon plantings (under the medium global scenario), the total reduction in mean annual runoff could therefore be around 160–272 GL by 2050.

To date, a large proportion of permanent carbon plantings have been planted in areas of low to medium annual rainfall (350–800 mm) (Benyon et al. 2007). If this trend continues, the reduction in runoff would be at the low end of this range. SKM et al. (2010) have estimated this to be equivalent to a reduction in total runoff due to interception from plantations by 8% from current levels of 2000 GL/year.

It is important to note, however, that ABARES’ modelling suggests that much of the carbon plantings will occur in the period from 2032 to 2050. Therefore, significant additional impacts on runoff would not occur in the short to medium term.

In relation to groundwater impacts, SKM et al. (2010) estimated that plantations could extract groundwater at the rate of just over 1 ML/ha/year in areas of shallow watertables (under long-term climatic conditions) or up to just over 2 ML/ha/year (under the climatic conditions of the past decade). While those results are highly dependent on the climatic assumptions and site geology and soils, this indicates that total groundwater extraction associated with ABARES’ (2011b) estimates of new areas of permanent carbon plantings could be about 160–320 GL per year by 2050.

Understanding the potential water-related impacts of increased interception from plantations associated with the CFI also requires looking not just at the aggregate volumes but at the geographical distribution of the impacts. Increased interception will be of more concern in water systems that are fully allocated, overallocated or approaching full allocation.
Significantly, ABARES’ modelling forecasts few carbon plantings linked to the CFI in the Murray–Darling Basin (MDB), suggesting that the CFI in its current form may not significantly add to water resource management pressures in the basin. However, that may change if the CFI regulations change (for example, to enable some plantations involving wood production to be eligible). Also, it is important to note that the ABARES study of where investment in permanent plantings is likely to occur should be treated as indicative only—actual investment may occur in other areas.

In any case, the impact of any interception on other users and the environment will depend on the regulatory arrangements in place to adequately address those issues. Current CFI regulations should ensure that any water interception impacts are appropriately managed. However, permanent plantings that are also considered to be environmental plantings face potentially less stringent conditions in government water planning and environmental requirements.

### 3.4.4 Summary of key findings

<table>
<thead>
<tr>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current policy settings for encouraging changes in land use that capture or reduce greenhouse gas emissions are likely to have only a modest impact on the development of permanent carbon forestry plantings. Nevertheless, that modest change could result in additional interception of runoff and groundwater use, particularly in northern New South Wales and southern Queensland. Modelling indicates that most of this is expected to occur after 2030.</td>
</tr>
<tr>
<td>Current CFI regulations require permanent plantings to meet at least one of several specified conditions, which should ensure that any water interception impacts are appropriately managed. However, permanent plantings that are also considered to be environmental plantings face potentially less stringent conditions in government water planning and environmental requirements.</td>
</tr>
<tr>
<td>The water interception impacts associated with induced land-use changes in the agricultural sector appear to be limited, based on current carbon prices. The Biodiversity Fund might lead to more immediate land-use change and revegetation in the agricultural sector.</td>
</tr>
</tbody>
</table>

### 3.5 Summary of mitigation impacts

Table 5 summarises the location, timing, magnitude and sensitivity of the key potential water-related impacts of mitigation policy. While subject to the range of sensitivities and complexities outlined above and in the sector assessments in Part B, in broad terms, those impacts include:

+ **potential impacts on balancing water supply and demand**, most notably the potential for localised impacts associated with changes in the mix of energy generation over time
+ **potential impacts on the costs of water-related infrastructure and services**, particularly in the urban water sector, although those impacts are generally likely to be moderate and manageable
+ **potential impacts on the environment and the broader community**, particularly water-related environmental impacts arising from new energy sources, and limited potential impacts on water interception in the longer term.
<table>
<thead>
<tr>
<th>Mitigation policies</th>
<th>Incentive/direct effect</th>
<th>Key water-related impacts</th>
<th>Location</th>
<th>Timing</th>
<th>Magnitude/sensitivity</th>
<th>Relative importance as driver of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaner energy</td>
<td>Carbon price and renewable targets lead to change in electricity generation mix (away from coal).</td>
<td>Reduced water demand in coal-fired generation locations.</td>
<td>Latrobe Valley (Vic.), south-east Queensland and Hunter Valley (NSW).</td>
<td>Potential early shutdown of coal, and long-term investment in non-coal generation.</td>
<td>Switching from coal to gas could have significant localised impacts on the availability of water.</td>
<td>Main driver of change in domestic electricity generation over next 20 years.</td>
</tr>
<tr>
<td></td>
<td>Increased use/demand for gas, including coal seam gas. Increased incentive for geothermal, solar thermal and carbon capture and storage technology.</td>
<td>Increased use/demand for gas, including coal seam gas. Localised impacts, depending on technology.</td>
<td>Latrobe Valley (Vic.), south-east Queensland and Hunter Valley (NSW).</td>
<td>Immediate (due to carbon costs and liabilities) and longer term (due to changed water supply augmentation investment).</td>
<td>Low–moderate (given that carbon liability is a small proportion of total costs).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased costs in other emissions-intensive activities (e.g. fugitive emissions from wastewater treatment). Agriculture currently excluded. Increased energy price for water-using industries and consumers.</td>
<td>Increased costs of urban water supply (wastewater, desalination and recycling). Potential switch to relatively cheaper options (i.e. gravity-fed dam storage supply).</td>
<td>Metropolitan cities. Cities/towns with multiple supply options.</td>
<td>Immediate (due to carbon costs and liabilities) and longer term (due to changed water supply augmentation investment).</td>
<td>Low–moderate (given that carbon liability is a small proportion of total costs).</td>
<td>Low–moderate</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Increased investment to increase energy efficiency.</td>
<td>May increase or decrease water demand (likely to decrease with energy-efficient appliances tending to be more water-efficient).</td>
<td>National</td>
<td>Immediate</td>
<td>Low</td>
<td>Commercial drivers provide incentive to reduce energy costs.</td>
</tr>
<tr>
<td>Land-use change</td>
<td>Payments for carbon farming (and biodiversity) leading to land-use change.</td>
<td>Water quality and quantity impacts (i.e. increased interception from tree planting). For forestry—possibly north-east NSW and mid-coast Queensland. Agriculture—across Australia.</td>
<td>Forestry—possibly north-east NSW and mid-coast Queensland. Agriculture—across Australia.</td>
<td>Immediate (and into future if new carbon farming activities are approved).</td>
<td>Low (given interception managed by carbon farming policy and low incentive for commercial forestry).</td>
<td>Low (at current carbon price).</td>
</tr>
</tbody>
</table>

Source: Frontier Economics assessment and sectoral summaries.
4 Climate change adaptation impacts

This section:
- defines and categorises adaptation responses (Section 4.1)
- identifies and assesses the potential water-related impacts related to those adaptation responses (section 4.2, 4.3 and 4.4)
- provides a summary of the key potential water-related impacts (Section 4.4).

4.1 Definition and overview of climate change adaptation

4.1.1 What is climate change adaptation?

According to the Intergovernmental Panel on Climate Change, adaptation is ‘adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities’ (IPCC 2001:982)

Adaptation primarily aims to moderate the adverse effects of climate change through a wide range of actions targeted at specific vulnerabilities and risks. It may also include taking action to take advantage of new opportunities presented by climate change. Adaptation is complex and is an evolving area of research and policy development.
The need for adaptation

The need for climate change adaptation is based on the notion that, given the volume of past greenhouse gas emissions and the inertia of the climate system, some level of climate change cannot be prevented. Therefore, there is a need to manage the impacts and/or risks associated with climate change that has already occurred and will continue to occur regardless of short-term mitigation efforts.

Climate change projections

As a starting point, it is important to identify which unavoidable climate changes are expected. There is now broad acceptance among scientists and policymakers in Australia that climate change is occurring and that further climate change is inevitable. While there is considerable uncertainty about future climatic trends, key climatic projections include:

- increases in temperature (mean and variance)
- increases in the number of heatwaves
- decreases in rainfall and runoff
- increases in extreme daily rainfall events
- increases in areas experiencing exceptionally dry years and the frequency of exceptionally dry years
- sea level rises and more frequent tidal and storm surges.

Table 6 provides more detail on the changes in climatic variables expected in Australia as a result of climate change.

In broad terms, the projected changes can be seen as including both:

- *incremental changes* (for example, sea level rises and increases in temperature)
- *extreme weather* (such as floods and heatwaves).

As discussed in more detail below, these different types of climatic changes can lead to different types of risks and may require different types of adaptation measures.
Table 6: Summary of findings for trends in key climatic variables and issues of interest

<table>
<thead>
<tr>
<th>Variables</th>
<th>Central projections for Australia</th>
<th>Sources of uncertainty relevant to adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Median estimate of 1°C warming by 2030; 0.7–0.9°C in coastal areas and 1–1.2°C in inland areas. Projected warming between 0.8°C and 1.8°C by 2050. Projected warming of 1.8°C (low-emissions future) to 5°C (high-emissions future) by 2070. Increase in number of extreme heat events (days above 35°C). Number of such days to more than double by 2070 under high emissions for most capital cities, except Brisbane (sevenfold increase) and Darwin (20fold). Greater likelihood of longer heatwaves.</td>
<td>Widening range of projected temperatures, with time depending on emissions scenarios. Intergovernmental Panel on Climate Change projections for Australia are for sea level increases of 0.18 metres to 0.79 metres by 2100. The forecast midrange value for Australia is 0.5 metres. The Victorian Government’s Future Coasts strategy is based on a projection of 0.8 metres. Under the mid-range projection, tidal/storm-surge events with a 100-year recurrence interval would happen several times a year.</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Projected decreases of –5% by 2030 compared to 1990 in southern and eastern regions during winter and spring. Projections for northern summer rainfall uncertain, with possibility of increase or decrease and low convergence of forecast models. Modelling for 2055 and 2090 projects increases in extreme rainfall events for all regions, with larger increases in the north.</td>
<td>Greater level of confidence for projections for southern Australia than for northern Australia. Historical association between La Niña – Southern Oscillation events and heavy rainfall in southern and eastern Australia. Uncertainty as to effects of warming trend on Southern Oscillation Index. Uncertain interaction between long-term trends and interannual/decadal processes.</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Runoff affected by rainfall declines in autumn and winter, and higher temperatures. With 1°C warming by 2030, river flows in southern, western and south-eastern Australia may decline by 5%–30%, or 30%–50% under driest projections. Median runoff similar to extreme dry conditions of 1997–2009 under median rainfall projections to 2070 or dry extreme projections to 2050. Rainfall and runoff changes affect aquifer recharge. Fourteen priority aquifers have been identified, based on their sensitivity to climate and regional importance: Daly Basin (NT); Coastal River Alluvium, Upper Condamine and Border Rivers Alluvium, Atherton Tablelands and Toowoomba Basalts (Qld); Coastal River Alluvium and Coastal Sands (NSW and Qld); Gunnedah and Lachlan (NSW); Adelaide Geosyncline (SA); Pillara (WA) and Newer Volcanics (Vic.) (Barron et al. 2011).</td>
<td>Projections sensitive to projected rainfall trends, which have a high degree of uncertainty (see above). Warmer and wetter conditions could see runoff increase by between 10% and 30%. Recharge scenarios depend on rainfall projections. Under median scenario, half of the priority aquifers would be affected.</td>
</tr>
<tr>
<td>Drought and extreme weather</td>
<td>Areas experiencing exceptionally hot years likely to increase by 60%–80% by 2030. Exceptionally dry years likely to occur more often and over larger areas in south-west of Western Australia, Victoria and Tasmania, with little detectable change in other regions. Increase in number of days with very high fire danger, but projected ranges are broad (e.g. 25%–30% by 2030 and 5%–100% by 2050).</td>
<td>Considerable uncertainty about drought projections, largely reflecting uncertainty in the relationship between warming trends and interannual/decadal processes.</td>
</tr>
<tr>
<td>Tropical cyclones</td>
<td>Simulations suggest a decrease in tropical cyclone activity in the Australian region (some simulations project a decrease of 50% for 2051–2090 compared to 1971–2000).</td>
<td>Significant difficulties in estimating trends in cyclonic activity because of interannual and interdecadal fluctuations. One study suggests that, on the basis of such fluctuations, record low levels of tropical cyclones in the first part of the past decade may set the stage for a short-term increase in such phenomena.</td>
</tr>
<tr>
<td>Sea level rises</td>
<td>Intergovernmental Panel on Climate Change projections are for sea level increases of 0.18 metres to 0.79 metres by 2100. The forecast midrange value for Australia is 0.5 metres. The Victorian Government’s Future Coasts strategy is based on a projection of 0.8 metres. Under the mid-range projection, tidal/storm-surge events with a 100-year recurrence interval would happen several times a year.</td>
<td>There is uncertainty about the upper bound because of incomplete understanding of the contribution of melting polar ice to sea level rises. Uncertainties about the relationship between cyclones and warming trends (see above on cyclones) can affect the forecast probability of coastal surge events.</td>
</tr>
</tbody>
</table>

Factors affecting exposure to climate change

As shown in Table 6, exposure to changes in climate variables varies across Australia. In addition, distinguishing between the effects of underlying climate variability and climate change is exceedingly difficult for many variables, particularly rainfall and extreme weather events. This is particularly so in Australia, where rainfall is naturally highly variable. Thus, the following factors must be taken into account in considering the potential changes in climate that may need to be managed:

+ **Timeframes**: Given that anthropogenic climate changes are determined by the atmospheric stock of greenhouse gases, climate change for the next two decades is largely ‘locked in’, in the sense that it is not a function of emissions reduction efforts. For example, the Intergovernmental Panel on Climate Change’s best estimates of how much global average temperature will increase by 2030 vary by only 0.12°C between the lowest and highest modelled emissions scenarios (DCCEE 2010a). The median estimate for projected annual average warming for Australia by 2030 is 1°C, relative to 1990 values. Projected warming by 2050 ranges from 0.8°C to 1.8°C, and by 2070 the range extends from 1.8 to 5°C under low- and high-emissions scenarios (Whetton et al. 2010). Timeframes are important because adaptation efforts will need to take into account the lifespan of the assets affected. The longer-lived the assets, the greater the range of possible outcomes that need to be considered.

+ **Risk and uncertainty**: The outcomes envisaged due to climate change can be described as increased climate risk. Arguably, however, the adaptation challenge stems not only from the climatic risk, but from the uncertainty associated with that risk. Not only do key variables fall within wider ranges, but the probability distributions associated with those ranges are uncertain or unknown. In particular, over any given period, key variables of interest (such as rainfall) are likely to display significant volatility, which can be hard to predict.

+ **Underlying climatic variability**: Variability has, historically, been a critical issue in Australia’s climate. For example, the climatic system of the south-west Pacific is marked by substantial fluctuations across years and between decades. Decadal modes of variability, which last 20 to 50 years, are linked to ocean–atmospheric phenomena, such as the Interdecadal Pacific Oscillation, which are significant for water resources (see, for example, Salinger 2007). Interannual fluctuations include those associated with the Southern Oscillation Index, the Indian Ocean Dipole, the Southern Annular Mode and the subtropical ridge (DPI 2011a). The interannual phenomena occur against a backdrop of multidecadal fluctuations in the incidence of severe weather events, such as tropical cyclones (see, for example, Callaghan and Power 2010). The process of climate change involves superimposing a long-run warming trend on these periodic processes, and the interaction between the two is not well understood. For example, there is little consensus on whether the El Niño – Southern Oscillation phenomenon will strengthen, decline or remain constant as a consequence of climate change (Collins et al. 2010).

Vulnerability and sensitivity to change

The need for adaptation stems from concerns that unavoidable climate change may impose significant costs on the economy, the environment and the community. While climate change has the potential to affect almost every facet of Australia’s economy, society and environment (DCCEE 2010a:5), this report focuses on those impacts most closely related to the management of water resources and the provision of water-related services. In this context, some of the key risks and potential impacts include:

+ the impacts of lower average and more variable water availability on the environment, urban water users and water-using industries, such as agriculture, mining and electricity generation

+ the risks to water, wastewater and stormwater infrastructure assets from damage resulting from extreme weather events, such as floods and bushfires, and other climatic changes (such as sea level rise)

+ the impacts of changed water availability and other climatic events on water-dependent ecosystems.

The impact of climate change across the Australian economy and natural environment will depend on the vulnerability of the affected regions, communities, industries and assets. Vulnerability is a function of the degree of exposure to climate change and the sensitivity to that exposure of populations, economic assets, human activities, and natural and physical systems. In turn, sensitivity is a function of many factors, including demographics, physical geography, production characteristics, wealth and income distribution, and government policy choices (often unconnected with climate policy). For example, the potential impact of climate change on an irrigation community will depend on the extent of the reduction in water availability (exposure) and the extent to which the community relies on irrigated agriculture (sensitivity).

Vulnerability is also related to a community’s or industry’s adaptive capacity, which is defined by the Intergovernmental Panel on Climate Change (IPCC 2001:894) as ‘the potential, capability, or ability of a system to adapt to climatic stimuli or their effects or impacts’ or, in other words, the system’s capacity to deal with the effects or risks associated with the exposure. For example, people in an irrigation community may have the capacity to adapt their water use and crop types, or move into other industries, in response to a reduction in water availability.
Broad types of adaptation responses

The need to manage risks and their consequences creates a need for appropriate adaptation responses. Adaptation can take a variety of forms, including:

+ **avoiding exposure**: avoiding adverse impacts (or securing benefits) by avoiding or exploiting changes in exposure to climate change (for example, by moving activities to other locations)

+ **reducing sensitivity**: preventing or reducing adverse impacts by reducing sensitivity to climate change impacts (for example, through regulation or direct investment in structural or engineering options)

+ **tolerating some adverse impacts**: accepting losses where it is not possible or cost-effective to avoid them (for example, allowing infrastructure assets to fail and then repairing or replacing them)

+ **sharing losses/risks**: allocating and/or distributing the risk and burden of impacts (such as through insurance)

+ **improving adaptive capacity**: increasing the ability to adapt to climate change through knowledge and information (for example, through research).

Based on their timing, adaptations can also be **anticipatory or reactive**, and depending on their degree of spontaneity they can be **autonomous or planned** (Fankhauser et al. 1999, Smit et al. 2000). While most literature on adaptation focuses on the role of governments in planned adaptation (primarily through direct public investment and regulation), it is reasonable to expect that individuals and firms will also plan and take proactive action where they face significant climate risks.

The Australian Government's position paper on adaptation, *Adapting to climate change in Australia* recognises the interaction between autonomous adaptation initiatives and policy measures. A central plank of the outlined approach to adaptation is ensuring that risks are allocated to the parties that are best placed to manage them, coupled with a recognition of the ability of the market economy to do the allocating (DCCEE 2010a).

There are a number of instruments by which governments may implement adaptation policies. They include direct public investment to manage risks or improve adaptive capacity; regulation; research and information provision to facilitate autonomous adaptation; support for or creation of markets to facilitate autonomous adaptation; clarifying risk assignment between public and private agents; and promoting community awareness and education. Alternatively, government may choose to do nothing and rely on autonomous adaptation by individuals and firms.

A key finding of the sector assessments in Part B is that many existing water policy tools also constitute, or influence, adaptation responses.

It is not possible to simply identify specific current national policies for adaptation and assess their water-related impacts, as it is for mitigation policies. This is because there is a diverse range of responses, by both governments and individuals, operating at various levels, and because adaptation policy is in its formative stages (see Box 1).
Box 1: Current adaptation policy in Australia

The Australian Government’s position paper on adaptation (DCCEE 2010a) proposes work through the Council of Australian Governments to develop a national adaptation agenda. It has as priorities for adaptation policy:

- agriculture
- coastal management
- water
- infrastructure
- natural systems of significance
- preparation for and management of natural disasters.

The government has also recently released a report on the role of regulation in facilitating or constraining adaptation to climate change for infrastructure in Australia (Maddocks 2011).

State and local governments are also developing climate change adaptation policies in a number of areas (see, for example, Queensland Government 2011 and South Australian Government 2010). Those policies also tend to focus on urban and coastal settlements, infrastructure, the environment, water, agriculture, emergency management and human health.

Recently, the Australian Government has given the Productivity Commission terms of reference for an inquiry into the regulatory and policy barriers to effective climate change adaptation. The Productivity Commission has been asked to identify any specific barriers that inhibit effective adaptation to unavoidable climate change, and high-priority options for addressing those barriers.

4.1.2 Categorisation of water-related adaptation responses

Many existing water policies already deal with climatic variability. In particular, it could be argued that adaptation policy for the water sector itself is relatively well advanced. Much of the focus in the past decade in the rural and urban water sectors has been on how to deal with declining and more variable water availability. However, in the water and other sectors less progress has been made in developing adaptation policies to deal with other aspects of climate change.

For the purposes of this report, three categories of adaptation response affecting water policy and management have been identified (Figure 18). Each category of response affects a different area:

- the supply of and demand for water (Section 4.2).
- water infrastructure and service performance (Section 4.3)
- water-dependent ecosystems (Section 4.4).

These categories have been selected based on significant differences between them in the key driver of the climatic impacts, the nature of impacts, and the types of water policy issues that arise. However, there is some overlap between the three categories.

For each of these categories, the remainder of this section identifies:

- the potential water-related impacts arising from climate change
- current and emerging adaptation strategies to manage the potential impacts
- the water policy issues that may arise as a result of adaptation policies and responses.
4.2 Adaptation responses to changes in water availability

4.2.1 Potential impacts of climate change on water availability

Climate change may affect both the supply of and demand for water.

Potential impacts of climate change on water supply

Perhaps the most important impacts of climate change on surface water and groundwater resources come from the projected reduction in rainfall and increase in the variability of rainfall (see Table 6).

Groundwater is generally considered less exposed to the impacts of climate change. However, rainfall and runoff changes can affect aquifer recharge. A recent study for the Commission identified 14 priority aquifers, based on their sensitivity to climate changes and their regional importance: Daly Basin (NT); Coastal River Alluvium, Upper Condamine and Border Rivers Alluvium, Atherton Tablelands, Toowoomba Basalts (Qld); Coastal River Alluvium and Coastal Sands (NSW and Qld); Gunnedah and Lachlan (NSW); Adelaide Geosyncline (SA); Pilbara (WA); and Newer Volcanics (Victoria) (Barron et al. 2011).
There is an extremely high level of uncertainty in the climate modelling underpinning all of these forecasts, particularly at the regional and local scales, and there is greater certainty about predictions for southern Australia compared to northern Australia. However, the main challenge relates to uncertainty about the interactions between global warming trends and interannual, decadal and interdecadal climatic processes.11

Impacts of water availability on water users

Overall, the likely impacts of climate change on surface water and groundwater availability could be severe, affecting all current and future water users and the environment. Increasing water scarcity at particular times and locations and greater uncertainty about availability can become manifest as one or more of the following.

Difficulties in meeting the water demands of major cities and towns

Reduced rainfall is already contributing to water security problems in many urban centres, particularly in southern and eastern Australia. Extremely low rainfall contributed to acute urban water shortages across most of the country during the 2000s (NWC 2011b). For example, annual inflows to urban catchments in Perth and Melbourne have been well below historical averages in recent years. There is high confidence that reduced precipitation and increased evaporation will further intensify water security problems in southern and eastern Australia in the coming decades (PMSEIC Independent Working Group 2007). Those factors are widely seen as being at least partly attributable to climate change.

Low allocations to irrigators, affecting production and demand for rural water services

Reduced runoff would lead to reduced water entitlement reliability for irrigators, which could change the size of the irrigation sector and the mixture of permanent and annual crops that is grown. Climate change (in combination with other factors) might result in existing rural water supply networks becoming underutilised, which would make it harder for rural WSPs to recover the ongoing costs of service provision and asset maintenance from a shrinking customer base.

Challenges for large industrial water users, including electricity generators and mining operations

The National Energy Security Assessment (DRET 2011) identified water security as a critical determinant of electricity security. If water scarcity led to the outage of a major baseload power station, that could result in significant spikes in spot electricity prices and the requirement for more expensive generation to meet demand, particularly on days with high demand. Similarly, if water were to become a limiting factor, that could result in a cutback in production in a number of mines throughout Australia (McInnes et al. 2008).

Potential changes in water interception by plantations and farm dams

With lower annual rainfall and an increase in temperatures, rainfall interception by plant canopies will probably be lower, evaporation from soil and surface water bodies will probably be higher, and groundwater recharge may be reduced (ABARES 2011b). Transpiration from vegetation is also expected to be generally higher in the future. The extent to which these trends would result in a net increase or decrease in runoff is not yet clear because of the interplay between reduced rainfall and increased temperatures.

Farm dams are a significant interception activity affecting runoff and the reliability of water entitlements. Climate change adaptation by landholders might lead to further growth in the number of farm dams. In addition, if runoff decreases as a result of climate change, existing farm dams may capture a larger proportion of available runoff, given their location within catchments.

Potential impact of climate change on water demand

In addition to reductions in supply, climate changes could lead to changes in the aggregate demand for water (from surface water and groundwater sources) and the distribution of demand across Australia. In particular, changes in temperature and rainfall are also likely to prompt changes in demand.

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11 One of the other key issues in relation to climate forecasts associated with rainfall is the baseline selected. For example, south-western Australia and south-eastern Australia have experienced significant reductions in average rainfall and catchment inflows over the last 10 to 30 years (in many cases equivalent to the upper estimates of the impacts of climate change), so it is unclear whether forecasts should be based on long-term historical records or on recent history.
The most significant changes are likely to be associated with irrigated agriculture, which is the largest water user in Australia. Nearly all irrigated agricultural activities are in areas where the expected change to rainfall is between -5% and -10% (Figure 19).

Climate change may result in certain types of agricultural production moving to, or expanding in, less traditional growing areas, leading to increased water demand in those areas:

+ Viticulture may become suitable in some areas in southern Victoria and Tasmania that were previously too cool.
+ Dairy production in Tasmania and southern Victoria may increase compared to dairy production in the MDB.
+ Cotton production may expand in southern New South Wales and the Ord (Northern Territory) compared to production in northern New South Wales.
+ Cereal crops may be grown in areas previously deemed too wet or too cool.

**Figure 19: Locations of irrigated agriculture and potential changes in water availability**

![Map showing projected changes in water availability](image)

Conversely, projected increases in average temperatures and the incidence of extreme weather events will have implications for the cost, quality and quantity of irrigated agricultural production. This could lead to a reduction in water demand in other areas:

+ Higher temperatures and extreme weather (frosts, heatwaves etc.) may affect the suitability of wine-grape varieties originally selected to suit historical climatic conditions.
+ The combination of higher summer maximum temperatures and reduced winter chill and frost may mean that some areas that currently produce stone fruit will be unsuitable in the longer term.
+ Higher temperatures and greater evaporative demand by crops may reduce the yield and fibre quality of cotton in northern New South Wales and southern Queensland.
+ Higher temperatures in dairying regions of the MDB (for example, the Murray Valley) are likely to create heat stress problems for stock and higher energy demand for cooling production sheds.
Such changes in irrigated agricultural demands have important flow-on impacts for rural WSPs (see Section 13). The potential for a contraction of irrigated agriculture in conjunction with a movement of remaining water to new areas and crops poses challenges for operators of existing fixed supply networks and for those responsible for planning infrastructure investments based on future water demand and service requirements.

Changes in climatic variables (mainly higher temperatures) could also result in increases in water demand in other sectors:

- **Urban water**: Higher temperatures and less rainfall could result in increased demand by urban residential, commercial and industrial customers and local governments.
- **Electricity generation**: Higher temperatures might drive increases in peak electricity demand, increasing generation and water use by gas-fired peaking plants and increasing demand for hydro-electric power.
- **Mining**: Higher temperatures and less rainfall might drive increased water use for dust suppression.
- **Environmental water**: Hotter, drier conditions are likely to mean that environmental assets, such as wetlands connected to river systems, require additional surface water to maintain their ecological integrity.

Further detail on these effects is included in the sector assessments in Part B.

### 4.2.2 Adaptation responses to impacts of climate change on water availability

Climate change can simultaneously reduce water supply and increase demand. Together, reduced water availability and increasing demand will increase competition for water among urban, irrigated agricultural, mining, industrial and environmental users. The resulting impacts on supply and demand depend on the adaptation responses available to users, many of which are influenced by water policy settings.

Adaptation responses can come from water users, WSPs, and governments acting on behalf of water users and the environment. The recent drought created an opportunity to observe which adaptation responses may emerge. As shown in Table 7, most responses seek to reduce sensitivity to generally lower and more variable water availability. However, there are significant differences in the types of adaptation responses adopted by different users, because water rights and pricing mechanisms enable autonomous adaptation.

In the urban water sector, adaptation to reduced water availability to date has been driven mainly by direct intervention by state governments, together with Australian Government funding. For example, adaptation responses in recent years have involved both supply- and demand-side measures, including:

- diversifying towards new and alternative sources that are less climate dependent
- constraining demand through demand management, restrictions and water efficiency programs and pricing
- changing the way that water is priced, particularly through inclining block tariffs
- creating networks to move water between locations
- applying direct government subsidies to alternative sources (such as recycling, stormwater reuse and rainwater tanks)
- using financial incentives to encourage the uptake of alternative water supplies that reduce pressure on potable supplies
- using water planning policies (such as water security targets and targets for water reuse) to influence the mix of supply- and demand-side options, and the level of water security, provided by water businesses
- promoting integrated water management and water-sensitive urban design to reduce demand for potable water.

Individual water users have also played a significant role in adapting to changed water availability. Households have changed their water-use behaviour to reduce per capita consumption, and installed more water-efficient appliances. Commercial and industrial users have invested in more efficient water-use technologies and processes. Those responses have often been responses to regulatory requirements.
Table 7: Potential adaptation responses to impacts of climate change on water availability

<table>
<thead>
<tr>
<th>Type of response</th>
<th>Types of measures</th>
<th>Sectoral examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoiding exposure</td>
<td>Relocation of activities</td>
<td>Some types of agricultural production may move to or expand in less traditional growing areas (e.g. some areas in southern Victoria and Tasmania that were previously too cool for viticulture may become suitable for that activity).</td>
</tr>
<tr>
<td>Reducing sensitivity</td>
<td>Using available water more efficiently</td>
<td>Urban water demand management programs. Water-use efficiency investments (agriculture or other industries). The development of tools to promote tree survival and improved water efficiency under the National Climate Change and Commercial Forestry Action Plan 2009–2012 (DAFF 2009).</td>
</tr>
<tr>
<td>Recourse to alternative supplies</td>
<td></td>
<td>Investment in diversified and non-climate-dependent water sources (e.g. desalination plants). Water recycling or reuse (e.g. urban sewer mining, on-site industrial reuse).</td>
</tr>
<tr>
<td>Tolerating some adverse impacts</td>
<td>Continuation of activities at reduced levels</td>
<td>Urban water restrictions. Continued production with lower expected yields/returns.</td>
</tr>
<tr>
<td>Sharing losses/risks</td>
<td>Market reallocation of resource or risk</td>
<td>Water trading between competing users (e.g. irrigation, urban, environment, industry).</td>
</tr>
<tr>
<td>Improving adaptive capacity</td>
<td>Research and development</td>
<td>Water-sensitive cities. Breeding new agricultural crops tolerant of dry or extreme conditions.</td>
</tr>
</tbody>
</table>

In the rural (irrigation) sector, there are fewer economically viable options to invest in new or alternative sources of supply. However, there has been some direct government investment, including major capital contributions to large-scale irrigation infrastructure modernisation projects aimed at reducing conveyance and other losses in water systems.

While there is some scope for on-farm and off-farm works to secure water savings, adaptation responses in the irrigation sector are in large part about how to best manage a finite resource. Rights to surface water and groundwater systems have been defined as shares of the available consumptive pool and assigned as water access entitlements to end users. Irrigators therefore bear the risk of climate variability and develop their own strategies to deal with that risk.

The ability to trade water entitlements and allocations was particularly important during the recent drought (NWC 2010b). It enabled some irrigators with flexible production systems to reduce their water use, and those with inflexible demands (such as horticulturalists) to keep their trees and vines alive. In those systems where water trading is possible, the market determines the scarcity value of water and allocates limited resources to those who value it most highly. The market price of water also provides a signal to irrigators to invest in improved water efficiency on their farms.

While much of the adaptation task has been devolved to individual irrigators who are best placed to manage water-related risks, further work is required to improve water markets and to implement NWI-compliant water planning and entitlements regimes across Australia (NWC 2011c).

Outside major urban areas, large industrial customers (such as mines and electricity generators) implemented a range of supply- and demand-side measures during the drought. Low-cost adaptation responses by generators included using water markets to secure water requirements within the existing water system, and applying for increases in licensed volumes or entitlements (in uncapped surface water and groundwater systems). If those options are not available or are insufficient, higher cost adaptation responses might include increasing connectivity to other water systems (for example, by constructing a pipeline), switching to dry-cooled generation, investing in desalination, or any combination of them.

Obtaining secure access to water is an essential prerequisite for most mining and processing operations and for many electricity generators. If water availability were to decline (or even if there were a risk a decline), it is likely that miners would invest in options to secure their supplies, or alter their investment decisions (such as the location of processing facilities). The lack of integration of the mining and power generation sectors in Australia’s entitlement frameworks and water markets may increase water security risks and increase the cost of adaptation responses.
The various adaptation responses to water scarcity over the past decade have undoubtedly helped to ameliorate the impacts of the shortfall in supply. However, that does not necessarily mean that those responses have balanced supply and demand at the least cost. For example:

+ While no city ran out of water, water restrictions and investments in urban water security came at a significant financial and economic cost. The combined capital expenditure programs of 30 of Australia’s largest water utilities totalled around $30 billion over the 2005–06 to 2011–12 period (Productivity Commission 2011b). Much of that investment has been in rainfall-independent supplies, such as desalination and recycling, in major cities.

+ While water markets in the MDB have made a major contribution to the efficient allocation of scarce water resources, there are still a number of constraints to the operation of water markets that hinder the realisation of their full potential benefits.

+ The environment has tended to lose out at times of critical shortage. Under current water planning arrangements, a reduction in long-run water availability may lead to considerably less environmental water from flooding and highflow events. This may reduce environmental flows more significantly than the reduction experienced by consumptive users. Consumptive users’ recourse to alternatives such as groundwater may also damage ecosystems, particularly where total extraction limits have not been well regulated.

+ Governments are investing in major upgrades of some rural water supply networks to improve delivery efficiency as a response to water scarcity and to generate water savings for the environment. However, there is also some risk that those networks may become underused if the risk of future climate changes and probable future demands for irrigation services are not effectively factored into decision-making.

Clearly, the economic, social and environmental impacts of potential changes in water availability due to climate change will depend on the effectiveness of the adaptation responses of individuals and governments. The key question for water policy is whether or not existing policy settings will facilitate efficient and effective responses to climate change. Water policy and management regimes need to be able to deal with the full spectrum of inflow conditions, including conditions more extreme than those noted in historical records.

Section 5 assesses whether current water policy settings are flexible and robust enough to provide for efficient adaptation to climate change (including the water supply–demand balance).

### 4.2.3 Summary of key findings

**Finding**

Together, reduced water availability and increasing demand will increase competition for water among urban, irrigated agricultural, mining, industrial and environmental users. The resulting impacts on supply and demand will depend on the adaptation responses available to users, many of which are influenced by water policy settings.
4.3 Adaptation responses to impacts on water infrastructure and service performance

4.3.1 Potential impacts of climate change on water sector assets

Climate changes could affect public and private water-related assets and their performance. In particular, impacts may be driven by more frequent and intense storms, increased heatwaves, increased risks of bushfires in catchment areas and gradual increases in average temperatures and sea level.

Such changes in climate variables pose a number of risks to the condition of water-related assets and their performance. In general, their impacts could hamper the ability of urban and rural WSPs to provide reliable and safe services to customers, increase the costs of providing services, or both. They could also lead to major costs for other parties (for example, risks to human life and damage to property from flooding) and the environment (such as sewer spills to waterways).

The risks and costs are likely to be most significant in the urban water sector (given the value of the assets and their proximity to large populations) but are also relevant to rural water supply. For the purposes of this report, the risks have been categorised as:

+ impacts from high-rainfall events
+ inundation of low-lying water-related assets due to sea level rise
+ degradation of distribution and other network infrastructure
+ interruptions to supply from extreme weather
+ combinations of the above.

Changes in climate variables:
+ Temperature and rainfall
+ Extreme weather
+ Sea level, bushfires etc.

Impacts on water supply demand

Adaptation responses

Impacts on assets and service performance

Adaptation responses

Impacts on individual sectors

Adaptation responses

Impacts on water-dependent ecosystems

Impacts on water demand, use, wastewater disposal, water quality

Water policy implications
Risks associated with high-rainfall events

One potential impact of climate change is an increase in the frequency and severity of severe rainfall and storm events. This poses a number of risks for both the condition of water sector assets and for how those assets are managed to mitigate flood damage to the broader community and to protect the environment, including the following:

+ **Storage management**: Rainfall intensity and peak flows will increase the risks of uncontrolled spills from storages. While the main role of storages is to provide for secure water supplies where rainfall is inherently variable, they also play a key role in flood mitigation. Because WSPs face these risks, they are subject to regulation and guidelines for maintaining dam safety. They have also typically managed storages to avoid the risks of excessive spills. While some spills do not have major negative impacts (indeed, spills can provide positive benefits to the environment), large-scale and/or unplanned spills have the potential to cause major damage to downstream infrastructure and communities.

+ **Stormwater management**: Increased rainfall intensity and peak flows will also increase the risk of stormwater flooding and damage to stormwater infrastructure and facilities (underground drains, levee banks, pumpstations etc.).

+ **Sewer overflows**: Higher rainfall intensity and peak flows will increase the risk of sewer overflows, which may pose dangers to public health and the environment and the ability of service providers to meet prescribed standards for discharges from wastewater treatment plants to the environment.

+ **Other water infrastructure**: Surface water treatment and abstraction facilities are likely to be near rivers and so could be affected by flooding. Severe flooding could cause contamination of water supplies and damage to treatment infrastructure. Floods could also have impacts on water supply distribution infrastructure. There is some risk that increased flooding could result in cross-connection or water supply cross-contamination from sewerage and stormwater systems.

**Inundation of low-lying water-related assets due to sea level rise**

Sea level rises and increased storms will mean that low-lying water assets, such as drainage infrastructure and wastewater treatment plants, may be increasingly affected by inundation. Most urban wastewater infrastructure is on the coast and is highly vulnerable to sea level rise. Several studies (for example, ATSE 2008 and Loftus et al. 2011) suggest that the level of vulnerability is significant. However, quantitative climate change risk analysis by urban water utilities is in its very early stages, and currently only being considered by a few large capital city utilities.

**Degradation of distribution and other network infrastructure**

Changes in climatic variables could progressively undermine the condition of existing infrastructure, create difficulties in operating it, or both. For example, increased variation in wet and dry spells and decreases in soil moisture will increase the risk of asset failures (including pipe cracking and leaks, building cracking, sewer chokes and overflows) due to increased movement and tree root incursion. Similarly, higher temperatures and longer hot periods promote hydrogen sulfide generation, increasing the risk of corrosion and odours. Another consideration is that a greater number of extremely hot days could pose a threat to worker safety.

**Interruptions to supply from extreme weather**

As the incidence of extreme weather events increases due to climate change, so too does the risk of interruptions to the continuity of supply of water and wastewater services. Such interruptions may also cause cascading risks of outages in other services and infrastructure (such as disruption to electricity supplies) that have consequences for water service provision. An increased incidence of extreme weather and floods also brings with it the likelihood that the automated monitoring and control equipment that is increasingly being adopted by rural WSPs may be damaged and become inoperable.
Combinations of risks

Two or more of these risks can occur simultaneously. For example:

+ the impacts of sea level rise are likely to become apparent and be most significant during times of severe weather (for example, during storm surges)
+ where assets are already degraded, severe weather might be the catalyst for major asset failure.

Combinations of risks are likely to be more difficult to manage than single risks, and could be expected to result in more significant economic, social and environmental costs.

4.3.2 Adaptation responses to impacts of climate change on water sector assets

While the water sector has been adapting to lower and more variable water availability for some time, adaptation responses to changes in climatic variables are in their formative stages. Governments, WSPs and industry bodies are beginning to identify and assess the risks and adaptation options, but there is less evidence of specific adaptation strategies being implemented to date.

Urban water utilities have begun analysing the risks that climate change impacts pose to their businesses and to implement climate change adaptation planning. The analysis has been developing around the key elements of the business cycle (planning needs; design and installation; operations and maintenance; customer service; business continuity), and until recently has been focused on qualitative assessments of impacts (WSAA 2011b). Utilities have developed approaches to the immediate challenges posed by climate change and are continuing to develop strategies for handling its long-term impacts. Approaches implemented to date include responding to water scarcity with infrastructure investment programs, water conservation and efficiency measures and strategic responses; asset management strategies; planning for urban development; monitoring for health impacts; and climate vulnerability research (WSAA 2011b).

The Water Services Association of Australia (WSAA) has acknowledged that urban water utilities, as regulated authorities, must select climate change adaptation responses that are cost-effective, defensible and representative of sound investment (2011b). To facilitate robust decision-making and to make a quantitative assessment of climate change risks, the WSAA and its members are undertaking the AdaptWater project (co-funded by the Department of Climate Change and Energy Efficiency), which will develop a pilot climate change adaptation tool for the Australian water industry. The objective of AdaptWater is to capture and quantify the complexity of modern water utilities’ economic, social and environmental performance requirements and integrate the effects of evolving direct and indirect climate change hazards.

Further work to quantify the impacts of climate change on the urban water sector will be required in determining costs and other operational impacts resulting from climate change (such as impacts on service standards and environmental outcomes).

The potential adaptation responses encompass a range of approaches, from reducing exposure to the risks or reducing vulnerability by increasing resilience, to increasing the ability to recover from impacts (see Table 8).
Table 8: Potential adaptation responses to impacts of climate change on water sector assets and their performance

<table>
<thead>
<tr>
<th>Types of response</th>
<th>Types of measures</th>
<th>Sectoral examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoiding exposure</td>
<td>Relocation of assets.</td>
<td>Decommissioning treatment plant at risk and investment in new location. Relocating sewers to avoid storm surges and sea level rise.</td>
</tr>
<tr>
<td>Reducing sensitivity</td>
<td>Management of existing assets (e.g. investment in refurbishment of existing infrastructure) investments in new assets, changes to strategies for operating assets.</td>
<td>Relining pipelines; increasing the capacity of water storages or tailings dams. Strategies for managing storages that reflect the changing trade-offs between supply security and flood mitigation benefits. Maintenance of assets (e.g. adequate ventilation, chemical dosing or silt removal) to reduce odour and corrosion. Changing work practices to limit staff exposure to high temperatures.</td>
</tr>
<tr>
<td></td>
<td>Investments in new infrastructure (e.g. higher design standards for new infrastructure capable of withstanding climate impacts, and encouraging integrated water cycle management to minimise overall infrastructure risks).</td>
<td>Harvesting stormwater for productive use to reduce the risk of floods in urban areas. Sizing drainage and sewers for peak flow. Providing for cross-drainage for channels in rural water systems.</td>
</tr>
<tr>
<td>Tolerating some adverse impacts</td>
<td>Developing strategies for managing asset failures or other adverse impacts.</td>
<td>Allowing certain water-related infrastructure assets to fail under certain conditions (and then repairing or replacing them), while ensuring that the system as a whole continues to operate. Developing emergency response protocols to minimise the costs of periodic disruptions. Consulting customers and regulators on the trade-offs between the benefits of meeting particular standards and the costs of doing so.</td>
</tr>
<tr>
<td>Sharing losses/risks</td>
<td>Clearly allocating responsibility for managing risks associated with climate change to those best able to manage them.</td>
<td>Clear standards for asset performance in the context of climate change. Facilitating insurance markets.</td>
</tr>
<tr>
<td>Improving adaptive capacity</td>
<td>Investing in understanding the nature and likelihood of risks. Developing options to reduce the impact of risk events on the continuity of supply.</td>
<td>Developing a climate change adaptation tool for the water industry (AdaptWater).</td>
</tr>
</tbody>
</table>

Clearly, the economic, social and environmental impacts of potential changes in extreme weather and other climatic changes will be significantly affected by the efficiency and effectiveness of the adaptation responses employed to manage those risks. While climate change risks could result in significant economic, social and environmental losses, protecting against all possible risks is likely to be prohibitively costly. Finding the right balance is therefore a key adaptation challenge for water policymakers.

In addition, while urban and rural WSPs are best placed to deal with the technical, operational and asset management challenges posed by the impact of climate change on assets and service performance, and to ensure that adaptation responses are effective and efficient, it is unlikely that they are well placed to make all of those decisions in the absence of clear and effective institutional, policy and regulatory settings.

The extent to which current water policy settings can address these issues is examined in Section 5.

4.3.3 Summary of key findings

Findings

Adaptation responses to some climate change effects (for example, sea level rise, storms and floods) could have major impacts on water, wastewater and stormwater infrastructure and service provision in the urban and rural water sectors.

While climate change risks could result in significant economic, social and environmental losses, protecting against all possible risks is likely to be prohibitively costly.
4.4 Adaptation responses to impacts on water-dependent ecosystems

4.4.1 Potential impacts of climate change on water-dependent ecosystems

Projected increases in average temperatures and in the incidence of extreme weather have the potential to cause damaging and potentially irreversible impacts on environmental assets associated with surface water and groundwater systems:

+ Prolonged droughts may reduce flows and connectivity for long periods when many ecosystem processes require a return to wetter conditions within a given period of time. For example, the resilience and productivity of wetlands will be lost if the seed viability thresholds of aquatic plants are exceeded. As another example, the length of time between waterings of river red gum communities along the River Murray and other MDB rivers during the recent drought was seen as a major contributing factor to the decline of those communities.

+ While flooding is critical to maintain many ecosystem functions, more frequent or higher floods may also cause damage to elements of the ecosystems and result in declines in environmental outcomes (for example, erosion and changes to river geomorphology).

+ Higher temperatures, reduced rainfall and more hot days could have a significant impact on the health and integrity of some environmental assets regardless of what happens to their watering regimes.

+ Bushfires can damage or destroy the flora and fauna in affected areas, and can degrade catchment water quality.

+ ‘Black water’ events may become more likely if climate change leads to increased variability in seasonal conditions. Such events occur when large amounts of accumulated leaf litter are washed from floodplains into water bodies or rivers. The decay of the leaf litter increases the concentration of dissolved organic carbon in the water, which gives the water a dark colour. Often, it also produces low dissolved oxygen levels, which can cause fish kills (DPI 2011b).

+ Sea level rise will affect estuarine ecosystems, such as the Coorong and the Gippsland Lakes. It could also lead to greater saline intrusion into groundwater aquifers near the coast.

The effects of climate change on water-dependent environmental outcomes are likely to be greatest where climate changes are greatest, where ecosystems are most sensitive to those changes, and where current levels of water extraction and water planning and management arrangements expose the environment to the greatest climate risk.
4.4.2 Potential adaptation responses to impacts of climate change on water-dependent ecosystems

In recent years, there have been moves to better meet the needs of the environment through water planning, purchases of water entitlements from consumptive users, and investments that reduce losses in irrigation systems. While those measures have been mainly aimed at addressing the longstanding overallocation of water, they provide an insight into the types of adaptation responses that may occur in response to climate change.

As shown in Table 9 and discussed further in Section 14, the broad types of adaptation responses include:

+ securing more water for the environment
+ improving environmental outcomes from a given volume of environmental water
+ changing the underlying environmental objectives.

Table 9: Potential adaptation responses to impacts of climate change on water-dependent ecosystems

<table>
<thead>
<tr>
<th>Type of response</th>
<th>Types of measures</th>
<th>Sectoral examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoiding exposure</td>
<td>No feasible measures.</td>
<td>Focusing conservation efforts on environmental systems that are less exposed.</td>
</tr>
<tr>
<td>Reducing sensitivity</td>
<td>Building robustness and resilience.</td>
<td>Reducing damage and facilitating recovery (e.g., maintaining refugia and promoting connectivity).</td>
</tr>
<tr>
<td>Tolerating some adverse impacts</td>
<td>Prioritising assets.</td>
<td>Triaging sites according to likelihood of future benefits.</td>
</tr>
<tr>
<td>Sharing losses/risks</td>
<td>Regulating for resource sharing.</td>
<td>Sharing water resource variability between environmental and consumptive uses in water planning.</td>
</tr>
<tr>
<td>Improving adaptive capacity</td>
<td>Building robustness and resilience.</td>
<td>Reducing damage and facilitating recovery (e.g., through research to better understand ecosystem characteristics).</td>
</tr>
</tbody>
</table>

Securing more water for the environment could be achieved though:

+ increases in ‘planned’ water through changes to water planning regimes
+ increases in ‘held’ water though market purchases (such as buybacks or seasonal trading) or other means (such as infrastructure upgrades that reduce system losses).

An extreme approach to safeguarding environmental outcomes would be to revise water planning arrangements to provide sufficient volumes and suitable patterns of water for all environmental outcomes to be met under the full range of possible climate change conditions. However, such a revision would have impacts on other water users. It could undermine water planning and other water resource management arrangements and reduce the incentive for environmental water managers to pursue lowcost adaptation opportunities.

The alternative—securing environmental water in the market—would enable environmental water managers to increase the frequency of environmental watering without adversely affecting the reliability of the entitlements held by consumptive users. However, as discussed in sections 5 and 14, the emergence of environmental water holdings raises important questions about acquiring the optimal portfolio of holdings, using water allocated to entitlements effectively for environmental purposes, water accounting and the governance of water market activity.

Future adaptation responses may involve making difficult ‘triage’ decisions in managing water-dependent ecosystems, possibly including decisions about to whether to continue to water already degraded sites that are unlikely to survive due to climate change.
4.4.3 Summary of key findings

Findings

Projected increases in average temperatures and in the incidence of extreme weather have the potential to cause damaging and possibly irreversible impacts on environmental assets associated with surface water and groundwater systems.

Protecting environmental assets in the context of climate change is likely to require increasing reliance on adaptive management.

4.5 Summary of adaptation impacts

Table 10 summarises the key findings on the water-related impacts of adaptation responses to climate change. Subject to uncertainty about climatic projections (and other complexities outlined above and in the sector assessments in Part B), the potential impacts include the following:

+ **Impacts on balancing the supply of and demand for water:** Reduced water availability and increasing demand will increase competition for water among urban, irrigated agricultural, mining, industrial and environmental users. The impacts of pressures on supply and demand depend on the adaptation responses available to water users, many of which are influenced by water policy settings.

+ **Impacts on the costs of water-related infrastructure and services:** Adaptation responses to some climate change effects (for example, sea level rise and stronger or more frequent storms and floods) could have major impacts on the costs of water, wastewater and stormwater infrastructure and service provision in the urban water sector.

+ **Impacts on the environment and the broader community:** Climatic changes could result in major impacts on water-dependent ecosystems and on the broader community, depending on the adaptation responses adopted.
<table>
<thead>
<tr>
<th>Adaptation response impacts</th>
<th>Incentive/direct effect</th>
<th>Key water-related impacts</th>
<th>Location</th>
<th>Timing</th>
<th>Magnitude/sensitivity</th>
<th>Relative importance as driver of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply and demand</td>
<td>More variability and reduced average water availability.</td>
<td>Increasing demands and shortfalls in water available for electricity generation, urban demand, environmental requirements, perennial horticulture, mining etc.</td>
<td>Potentially national; effects expected to be greatest in southern Australia.</td>
<td>Increased likelihood of extreme events in short and long term. Long-term impacts from reduced average water availability.</td>
<td>High (shared between consumptive users and the environment), but highly uncertain.</td>
<td>Very high</td>
</tr>
<tr>
<td></td>
<td>Increased competition for available water resources.</td>
<td>Pressure on water allocation and planning. Changes to locations of agricultural and forestry land use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assets and services</td>
<td>Risks to assets from sea level rise.</td>
<td>Costs of relocating or protecting urban water assets.</td>
<td>Coastal urban areas.</td>
<td>Long-term impacts from sea level rise.</td>
<td>High, but highly uncertain.</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Increased risks to assets from extreme events (e.g., floods and storms).</td>
<td>Risk to community assets, populations and the environment. Costs of increasing standards to manage risks.</td>
<td>Urban and rural areas. Mining sites.</td>
<td>Increased likelihood of extreme events in short and long term.</td>
<td>High costs if risks eventuate, and also significant costs from risk management (depending upon adaptation response).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Degradation of distribution and other network infrastructure.</td>
<td>Increased costs from operation and maintenance.</td>
<td>Urban and rural areas.</td>
<td>Long-term impacts from climate changes (e.g., higher temperatures)</td>
<td>Low (given economic life of assets).</td>
<td>Low (market factors determine agricultural viability).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduced demand for assets/services.</td>
<td>Risk of underutilisation of infrastructure assets or water-intensive assets.</td>
<td>Some irrigation districts (rural infrastructure).</td>
<td>Long-term impacts from climatic changes, including reduced average water availability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-dependent ecosystems</td>
<td>Risks to water-dependent ecosystems.</td>
<td>Risk of compromising environmental objectives.</td>
<td>Environmental water sites nationally.</td>
<td>Increased likelihood of extreme events in short and long term. Long-term impacts from reduced average water availability.</td>
<td>High, but highly uncertain.</td>
<td>High</td>
</tr>
</tbody>
</table>

Source: Frontier Economics assessment and sectoral summaries.
5 Implications of climate change mitigation policy and adaptation responses for water policy

The two previous sections identify a range of potential impacts on the water sector arising from climate change mitigation policy and adaptation responses. This section explores the potential implications for water policy. In particular, it seeks to assess whether Australia’s water policy settings are robust enough to deal with the potential implications of climate change mitigation policies and adaptation responses. This assessment:

+ outlines Australia’s overarching water policy objectives and existing policy tools (Section 5.2)
+ examines whether those policy tools can continue to deliver water policy objectives in the face of climate change mitigation and adaptation, or whether changes are required (sections 5.3 and 5.4)
+ considers whether governance and institutional arrangements in the water sector are adequate (Section 5.5).

This approach is illustrated in Figure 20.

**Figure 20: Approach to assessing the ability of water policy to address impacts of climate change policy**

- **Current water management/policy tools**
- **Climate change policies**
- **Expected climate change impacts**
  - Supply and demand
  - Cost and reliability of service
  - Community and environment
- **Policy outcomes – achieved?**
  - Efficient and sustainable water allocation and use
  - Efficient provision of water-related services
  - Health of community and environment
- **Recommended actions and changes**

- **Climate change**
- **Mitigation policy impacts & interactions (Section 3)**
- **Adaptation responses impacts & interactions (Section 4)**
- **Water policy implications from climate change policy (Section 5)**
- **Implications for implementing climate change policy (Section 6)**
- **Reform priorities (Section 7)**
5.1 Water policy objectives and tools

5.1.1 National water policy objectives

To assess whether existing water policy tools can accommodate the impacts arising from climate change mitigation and adaptation, it is helpful to clearly define the outcomes sought from water policy.

For the purposes of this analysis, the Commission has adopted the overarching objective of the NWI, which is to establish ‘a nationally-compatible, market, regulatory and planning based system of managing surface water and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes’.

The high-level objective of the NWI remains relevant in the context of climate change mitigation and adaptation. However, the optimal economic, social and environmental outcomes are likely to change over time as a result of climate change. For example, climate change mitigation and adaptation may lead to changes in the marginal value of water in different uses. This may require water to move between uses so that it continues to be allocated efficiently. Similarly, if the costs of some water sources (such as desalination) increase with a carbon price, the optimal mix of supply sources and demand management options may change. As a result, how the high-level objectives translate into specific objectives and standards may need to be reconsidered in the context of climate change.

Finding

The national water policy objective of optimising the economic, social and environmental outcomes associated with water remains appropriate in the context of climate change.

To make the analysis tractable, the overarching NWI objective can be seen as including several key elements:

- the efficient and sustainable allocation and use of water resources: ensuring that scarce water resources are allocated to consumptive and non-consumptive uses (including the environment) in a way that maximises the value of water to society
- the efficient provision of, and investment in, water and wastewater services and assets: ensuring that WSPs provide the desired level and quality of services to customers at the lowest possible cost
- the protection of public health and safety and environmental outcomes: ensuring that water resources are used and managed and water-related services are provided in a way that protects human health, manages potential third-party impacts (such as flooding or sewage spills) and ensures an appropriate level of protection for water-dependent ecosystems.

This categorisation makes it easier to assess how well existing policy tools are able to address the potential impacts of climate change mitigation and adaptation to achieve the underlying policy objectives.

5.1.2 Current policy tools

The NWI includes a number of elements of water policy and management that are currently applied and are considered in this assessment in the context of climate change policy. For this study, the following categories of water policy have been considered:

- water planning
- water entitlements
- water trading and markets
- environmental water planning, entitlements and trading
- pricing of water-related services and demand management
- regulation—environmental, public health and economic
- governance arrangements.
As shown in Table 11, there is a close relationship between the water policy objectives, the specific policy tools designed to deliver those objectives, and the broad nature of the potential impacts of climate change mitigation and adaptation policies identified in sections 3 and 4 of this report:

+ impacts on balancing the supply of and demand for water
+ impacts on the costs of water-related infrastructure and services
+ impacts on the environment and the broader community.

<table>
<thead>
<tr>
<th>NWI objective</th>
<th>Potential impact of climate change mitigation and adaptation policies (from sections 3 and 4)</th>
<th>Key water policy tools applied to achieve policy objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection of public health, safety and environmental outcomes.</td>
<td>Impacts on the environment and the broader public.</td>
<td>Regulation—public health and environmental.</td>
</tr>
</tbody>
</table>

Source: Frontier Economics analysis.

5.2 Policies for the sustainable and efficient allocation and use of water resources

Two fundamental objectives of water policy are to ensure that water is extracted at environmentally sustainable levels and to ensure that the water available for consumptive use is allocated efficiently.

The analysis in sections 3 and 4 and Part B of this report note a range of interactions between water and climate change that could result in greater competition for water resources, both between consumptive uses (for example, agriculture, mining, urban water and electricity generation) and between the environment and consumptive uses.

The analysis found that water supply and demand could be affected in the following ways:

+ Climate change may reduce supply and increase its variability while increasing demand in some areas. This will result in greater competition for water and in water security becoming more important in the future.
+ Adaptation responses in the agricultural and other sectors could lead to major changes in the nature and location of demand for surface water and groundwater.
+ Mitigation policies may result in a reduction in water demand by some coal-fired generators and potential increases in demand from other generation sources.

A number of existing water policy tools are designed to achieve the sustainable and efficient allocation and use of water resources. They include:

+ water resource planning processes that seek to establish sustainable limits on consumptive water use to protect the environment
+ approaches to recovering and using water for the environment
+ water access entitlements and markets that define rights to take and use water and provide for its reallocation.

12 While there will be examples where a particular objective is influenced by a number of policy tools, the categorisation Table 11 is considered to best reflect those relationships and provides a useful basis for the assessment of current water policy settings.
The following discussion examines the extent to which each of these existing policy tools addresses the potential impacts associated with climate change without compromising underlying policy objectives.

5.2.1 Water resource planning

Water resource planning processes seek to establish sustainable limits on consumptive water use in order to provide sufficient water for the environment and certainty for water users. Water plans can be defined as:

- statutory plans for surface and/or groundwater systems, developed in consultation with all relevant stakeholders on the basis of best scientific and socioeconomic assessment, to provide secure ecological outcomes and resource security for users. (NWC 2011a)

Ideally, water plans should provide clarity to water users about how they can access water under a range of conditions. Plans typically provide the framework within which entitlements are provided to water users and are able to be traded.

Comprehensive water planning is particularly important in catchments where the sustainability of the resource may be threatened or where there are competing demands on the resource that cannot all be met. For that reason, water plans have generally been rolled out progressively across jurisdictions, giving priority given to regions under water stress.

Water planning in Australia has had to deal with the inherent variability of rainfall and hence of water availability. Climate change and related adaptation and mitigation policies create additional challenges for planners:

+ **Specifying and allocating risks**: Climate change exacerbates uncertainty about water availability and could lead to patterns of availability beyond those experienced historically. Therefore, water planning frameworks will need to explicitly identify and allocate the risks associated with any decline in availability.

+ **Coverage and priorities**: Climate change as well as mitigation policies and adaptation responses could lead to large changes in demand for water in specific locations, potentially in a very rapid and unpredictable way. For example, the introduction of a carbon price could lead to changes in water demand in mining, coal seam gas extraction, agriculture, forestry and electricity generation. Similarly, adaptation responses in the agricultural sector may lead to increased water demand outside the MDB, in areas such as Tasmania, southern Victoria and northern Australia. Therefore, water planning frameworks should cover all water users and all catchments that may come under stress, and provide clarity and transparency about the prioritisation of plan development and review.

The need to account for climate change in water planning has been recognised for some time. As discussed below, however, there is evidence that current water planning frameworks do not yet deal sufficiently with climate change challenges.

### Specifying and allocating climatic risks

Water plans do not always cater explicitly for climatic conditions outside the ranges in historical records. In some cases, this has necessitated the suspension of water plans or the use of ad hoc rules to deal with unanticipated water shortages in recent years. This was highlighted in a Waterlines report (Bates et al. 2010), which found that, while technical assessments of climate change scenarios are being undertaken, they are not being used adequately to develop specific actions or strategies to deal with the potential impacts of climate change.

One of the main reasons for this is the uncertainty associated with climate change and its impacts on future water availability. This highlights the need for water plans to confront uncertainty by considering a wider range of climatic conditions than those captured in the historical records.

Water plans also need to address changes in water demand arising from the implementation of climate change policy. For example, plans may need to anticipate the potential for significant increases or decreases in demand by some users (such as electricity generators).

Some jurisdictions have made progress towards incorporating climate change into water resource planning. For example, the Victorian Government has developed detailed guidelines for doing so. The Northern Region Sustainable Water Strategy (DSE 2009) includes good examples of how various climate change scenarios would affect water provision to the environment and to consumptive users.

The Commission’s 2011 biennial assessment of progress under the NWI called for further work in this area across Australia. It found that ‘plans should be stress tested for extreme conditions to ensure that they can operate in all foreseeable circumstances’ (NWC 2011a).

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13 For example, Schedule E of the NWI acknowledges the need to manage the risk of climate change on water resource availability. Climate change is also addressed under NWI clauses 46–51, which provide a risk assignment framework to apply to any future reductions in water available for consumptive use.
Bates et al. (2010) suggest that there is merit in viewing water allocation plans as a series of options that could be triggered over time in response to particular events or seasonal conditions. They recommend that ‘water planners adopt a preparedness stance, rather than follow the traditional prediction paradigm’. This approach would make allocation plans more flexible and adaptive.

However, adopting such a preparedness approach requires a greater level of clarity, transparency and accountability in water allocation plans so that water users and other members of the community understand what changes will be implemented under specific conditions.

Finding

Water resource planning in Australia has not adequately addressed climate change. A key problem is that water plans have not always catered for climatic conditions outside the ranges captured in the historical record. While more recently governments have made progress towards better incorporating climate change into water resource planning, it will take some time for planning processes to extend this better practice across Australia.

Actions

Water planning should consider the full range of inflow sequences based on the latest climate change modelling. The flexibility to adapt in response to prevailing climatic conditions should be built into water plans in a manner that provides transparency and predictability to all water users and the public. This will provide greater clarity about the allocation of climatic risks between consumptive users and the environment.

The prioritisation of water planning should take into account potential changes in water supply and demand associated with climate change policies and adaptation responses.

Coverage of water plans

Climate mitigation and adaptation may affect the need for water planning in particular locations. For example, if water resources were to be developed in northern Australia or Tasmania as part of a broader adaptation response, there would be a greater urgency for water planning in regions where previously there was little competition for the resource and less concern about the sustainability of water use.

5.2.2 Water entitlements

Water access entitlements and other rights to manage consumptive users’ access to surface water and groundwater are already in place around Australia. Clear and secure water entitlements underpin confidence to invest in new capital equipment, better management and infrastructure, including that required to adapt to climate change. As the Commission has stated:

The NWI establishes a framework and set of characteristics that enable the development of clear, nationally compatible and secure water access entitlements. Under the NWI, a ‘water access entitlement’ is to be defined in statute as a perpetual or ongoing and exclusive entitlement to a share of water. Typically, volumetric allocations are made against these entitlements each year or irrigation season depending on the amount of water available, as defined in the relevant water plan. In the majority of cases, these water access entitlements are valuable business assets that underpin confidence for lending and investment. (NWC 2009)

Clearly specified water entitlements are also a prerequisite for water trading, which is an important adaptation response.

In considering whether current water entitlements arrangements are able to address potential impacts of climate change mitigation and adaptation, the same two challenges explored in relation to water planning must be considered:

+ whether the climatic risks have been clearly allocated, which will depend on the nature and specification of the entitlements
+ whether the entitlement regime provides appropriate coverage across all relevant industries, regions and sources, given that the nature and location of water demands may change.
Allocating risks through the specification of entitlements

Where entitlements are specified as shares of the available consumptive pool, this essentially allocates most of the climatic risk to entitlement holders who are best placed to manage any water availability uncertainty.

Entitlements provide a clear risk allocation framework for users, provided that:

+ the process for defining the water allocations associated with the entitlements is transparent and robust and has effective governance arrangements (NWC 2009, 2011a)
+ clear and transparent arrangements are in place for defining how extremely low and extremely high inflow conditions are to be managed, in order to provide users with confidence in their entitlements under all inflow conditions
+ clear and transparent arrangements are in place for defining how the risks of changes in longterm water availability are allocated.

The NWI risk assignment framework specifies how the risks of reduced or less reliable water allocations are to be shared between water access entitlement holders and governments. It is intended to give entitlement holders more planning and investment certainty about how changes in water availability will be dealt with, and so contribute to a robust, transparent and sustainable water planning and entitlement framework in the long term.

However, the Commission has previously found that implementation has been lacking and that some stakeholders are unclear about some practical elements of risk assignment. Risk assignment is extremely important in the context of climate change. The NWI risk assignment framework clearly states that entitlement holders are to bear the risks of any reduction in their entitlements arising from reductions to the consumptive pool as a result of:

+ seasonal or long-term changes in climate
+ periodic natural events, such as bushfires and droughts.

On the presumption that water users are best placed to manage the risks associated with climate change, this provision is appropriate.

However, the NWI risk assignment framework provides that, in some cases, governments will be wholly or partly responsible for any changes to the underlying reliability of the entitlement (that is, where there is a change in government policy or where changes are made due to improved knowledge of water systems’ capacity to sustain particular levels of extraction).

The key challenges in using the NWI risk assignment framework lie in determining what total changes in extraction limits are required and what portions of them are attributable to particular types of risk. In practice, it will be difficult to assess and make decisions about the percentage impact of climate change on water availability in the context of underlying climatic variability, compared with reductions required due to policy change and new knowledge.

In the context of this uncertainty, the Australian Government effectively decided to bear the risk associated with the transition to sustainable diversion limits under the Murray–Darling Basin Plan by seeking to buy entitlements from willing sellers, rather than by reducing the underlying reliability of existing entitlements. However, previous work undertaken by the Commission (2011c) suggested that uncertainty exists about how the risk assignment provisions will apply after the implementation of sustainable diversions limits.

Finding

Because the impacts of climate change on water availability are likely to remain inherently difficult to quantify, the NWI risk assignment framework is difficult to apply in practice in a way that provides certainty and consistency.

Action

The NWI parties should review the risk assignment provisions in the NWI with a view to ensuring that the provisions provide greater certainty and consistency in practice.
Coverage of the entitlements regime

Another potential policy issue relates to the coverage of NWI-compliant entitlements. Here two issues emerge. First, the entitlement regime needs to cover the full range of critical water users and catchments. Second, it needs to cover the full range of water uses. This includes adequately accounting for and managing water interception.

Because climate change could result in increased agricultural demand in some areas, including northern Australia and Tasmania, incomplete entitlement reforms in such regions may increasingly compromise the efficient and sustainable management of water in those areas (see NWC 2011a).

The potential changes in supply and demand outlined in sections 3 and 4 reinforce the need to better incorporate the mining industry, plantation forests and a range of other large industrial water users (including electricity generators) into the water access entitlements framework. This would enable those industries to reap the benefits of more secure water access and water trading, and further contribute to national productivity gains and long-term economic performance (NWC 2011a).

There is also a need to understand and clarify the status of water access entitlements held by coal-fired electricity generators, which may be the subject of the Australian Government’s policy for the early closure of some high emissions intensity generation by 2020. It will therefore be important to clarify the legal status of entitlements held by existing generators (for example, whether water access licences would simply be cancelled upon closure of the plant or could be sold in the water market).

Increasing competition for water may also increase demand for groundwater and unregulated surface water. This will reinforce the need to have secure water access entitlements in those systems to appropriately manage risks to the resources.

Finding

Climate change further highlights the benefits of clear and secure water access entitlements developed in accordance with the NWI. Climate change interactions are likely to place further pressure on water access arrangements in situations where entitlement reform is incomplete.

Action

Jurisdictions should extend NWI-consistent entitlements to all users where practicable, broaden the coverage to groundwater and unregulated surface water systems, and ensure that allocations to entitlements are robust and transparent under all inflow conditions.

The entitlement regime also needs to cover water interception. Water interceptions are water flows that are captured before they enter surface water or groundwater systems (for example, rainfall that does not reach the soil, but is instead intercepted by the leaves and branches of plants and the forest floor, water captured in farm dams etc.). Unless water interception is adequately accounted for and managed, it has the potential to reduce water available for other users. While interception is already an issue for water management, climate change policies have the potential to exacerbate it due to:

+ land-use changes arising from climate change mitigation policy incentives (for example, permanent plantation development) (see Section 3.4)\(^{14}\)

+ climate change adaptation responses affecting water resources (such as investments in farm dams to improve water security).

The expansion of plantation forestry has been identified as an activity that has the potential to intercept water that may otherwise have found its way into surface water and groundwater systems (see Section 3.4 and the forestry assessment in Section 10 of Part B). With the exception of some areas of South Australia and Victoria (where plantations for wood production are common), most water planning and entitlement regimes do not effectively address water interception and use by plantations (see NWC 2011e).

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\(^{14}\) While mitigation policies such as the CFI might add to the level of plantation investment, they are not the only driver of plantation investments, so there is already a case for developing arrangements to account for the interception impacts of additional plantation investment. In principle, changes in interception could also occur due to changes in agricultural land uses (for example, shifting from annual to perennial crops).
Farm dam developments and other interception activities in catchments create water availability risks for water entitlement holders. Those activities may potentially increase in response to climate change (and other factors, such as rural residential growth pressures in some regional areas). More frequent droughts and lower water availability may prompt landholders to invest in farm dams to secure their supplies. In addition, climate change has the potential to increase the proportional impact of interception by farm dams.\(^5\) These arguments may also apply to domestic and stock water use, which is also a major contributor to interception (SKM et al. 2010).

In 2010, the Commission released a position statement on interception activities. The problems outlined above highlight the need for further effort in quantifying and accounting for interception (NWC 2010a).

In addition to the benefits of improved water management, effective and consistent approaches to the management of significant interception impacts would simplify the assessment of the water impacts of plantation developments proposed under the CFI.

**Finding**

Climate change mitigation policy and adaptation responses could increase interceptions of water resources that are not adequately accounted for or managed.

**Action**

Jurisdictions should improve arrangements for the quantification, reporting and management of interception activities.

### 5.2.3 Water markets and trading

Part of the NWI water access entitlement reforms has been the development of systems and processes to enable users to trade water entitlements and allocations. These reforms, put in place over the past 20–30 years, mean that individual irrigators are able to adapt to seasonal changes in water availability and commodity market conditions. Water markets are seen as a key policy tool in ensuring that water is allocated in a way that enhances economic efficiency.

Climate change will potentially see demand for water increase and move to new areas, which will test the robustness of water markets. Given the potentially significant changes in water supply and demand outlined in sections 3 and 4, there is a growing imperative to increase the geographical coverage of water markets and the types of users that are able to participate.

The Commission has previously called for the incorporation of mining and electricity generation into the NWI water entitlements and markets framework, wherever possible (NWC 2011a). Water trading will also provide benefits to mining enterprises and some agricultural enterprises that are not yet able to trade entitlements. In addition, the ability to trade water between catchments to meet urban water needs is likely to be an important means of adaptation to reduced water availability in the urban sector. Rural–urban trading offers risk management benefits and flexibility, often without the high capital costs of other options such as desalination, which will also become more expensive with higher energy prices. In this context, existing barriers to rural–urban water trading will become more costly.

A number of other aspects of water markets could be improved. For example, improving the depth and performance of delivery capacity markets could help to manage the potential for changes in irrigation water demand that reduce deliverability for other users. Even though total demand may fall with climate change, peak demands (such as in spring and autumn) may not decrease and may even increase in absolute terms.

Other options for further enhancing and expanding water markets are addressed in detail in the Commission’s *Strengthening Australia’s water markets* report (NWC 2011c).

In general, because of the uncertainty associated with climate change, decentralised approaches (such as water markets that clearly assign risks to those best placed to manage them) are likely to perform much better than attempts at centralised planning (such as those used in addressing the recent water security crisis in the urban water sector). Without water markets, it is unlikely that centralised planning will be able to deal effectively with the competing demands for scarce resources that are likely to emerge.

However, some of the developments likely to occur will be in remote areas where water markets are less feasible. In those cases, other changes to water planning, entitlements and regulation may be needed. The underlying objective of such reforms should be to provide confidence for investment, clarity about rights and obligations, predictability and flexibility.

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\(^5\) For example, recent investigations into the impact of small farm dams in the Campaspe River catchment showed that under the average historical climate they intercept 11% of surface water. In the recent drought, this rose to 29% of the available surface water.
Finding

Water markets have proven to be effective in reallocating water to its highest valued uses, particularly during severe droughts. Because climate change is likely to lead to both rapid and cumulative changes in water supply and demand, water markets will be an important adaptation mechanism to ensure that maximum value is obtained from Australia’s scarce water resources.

Actions

The NWI parties should improve the functioning of water markets and further expand market coverage to a wider range of users, where practicable. In particular, facilitating the participation of the mining and electricity generation industries in water markets is likely to improve water management outcomes in the context of climate change. Eliminating artificial barriers to rural–urban water trading is also likely to enable urban WSPs to adopt more flexible and low-cost risk management and adaptation strategies.

Governments and rural WSPs should further clarify water delivery rights and enable trade in those rights as a means of managing potential changes in the location and timing of irrigation water demand.

5.2.4 Environmental water planning, entitlements and trading

Experience during the recent prolonged drought has shown that environmental water management can be more sophisticated than simply predetermining a planned flow regime. Most environmental water is still provided through the water planning regime, which caps consumptive use. However, the establishment of environmental water holders with portfolios of water access entitlements (particularly in the MDB) has emerged as one means of improving environmental outcomes. Such ‘held’ environmental water increases flexibility in achieving environmental outcomes, and is essentially an adaptation response by water policymakers. It enables environmental water managers to increase environmental watering without adversely affecting the property rights of consumptive users (that is, the reliability of their water entitlements).

Due to the uncertainty it creates, climate change will add to the underlying complexity of environmental water planning, management and trading decisions, such as those involving:

+ the establishment of environmental objectives
+ how much water is to be set aside as planned environmental water—and how planned environmental water is defined under various conditions
+ the portfolio of water entitlements held by environmental water managers
+ which environmental outcomes are provided for in a given season using the available mix of planned and held water
+ how much water is bought, sold and carried over by environmental water holders.

Key issues in this area are determining the best portfolio of water products to achieve the desired environmental objectives, and determining whether existing entitlements provide the right reliability of water to meet environmental requirements under extreme climatic events. This is not solely about managing climate change, but is a challenge in managing environmental water under the significant climate variability that occurs in Australia. This issue is further complicated by expected reductions to entitlement reliability due to climate change.

Climate change uncertainty adds to the complexity of environmental trading decisions, such as how much water should be bought, sold or carried over. The Commission’s assessment of the impacts of water trading in the southern MDB (NWC 2012) found that environmental trading is likely to have contributed to positive environmental outcomes. However, we also found that environmental watering plans and monitoring and evaluation will be required in order to assess the environmental benefits of water purchases in the future. This process of re-evaluation will become even more important in the face of climate change. More work is required to develop the tools and governance arrangements that will enable environmental water holders to adapt and prioritise effectively to meet climatic changes.
The possibility of environmental managers increasingly using the water market as an adaptation tool to manage climate variability and climate change has raised some concerns about how the large volumes of entitlement now held by a small number of environmental water managers affect water market dynamics. This raises questions about how and when environmental managers should enter the market, and what type of public disclosure of activity or intent may be appropriate. This is also a challenge for water market regulatory arrangements and accounting methodologies for dealing with trading between consumptive and environmental users.

Adaptation opportunities may also be limited by the broader water management structures within which the environmental water sector is operating. That is, the entitlements being acquired for the environment have characteristics and attributes that were designed specifically to meet the needs of consumptive water users. The environment has different needs and demand characteristics that sometimes cannot be efficiently met by standard consumptive entitlements. Factors that may constrain environmental water managers (noted in Section 14) include delays in obtaining approvals for watering to occur, limitations imposed by existing carryover arrangements, and liabilities for storage fees and charges.

Taking steps to address those constraints could improve the effectiveness of environmental water delivery without changing the fundamental reliability of the entitlements acquired for the environment or creating other third-party impacts. In turn, that could reduce the economic and social impacts associated with returning overallocated systems to sustainable levels of take and adapting to climate change.

Finding

The acquisition and use of water entitlements by environmental water managers is a flexible and useful climate change adaptation strategy. Climate change is likely to increase the need for environmental water managers to manage their water holdings adaptively in response to emerging impacts in different regions. This raises important questions—which the Commonwealth Environmental Water Holder and others are beginning to address—about acquiring the optimal portfolio of holdings, using water allocated to entitlements effectively for environmental purposes, water accounting, and the governance of water market activity by environmental water managers.

Action

Policymakers and environmental water managers should further develop the tools and governance arrangements that will enable environmental water holders to adapt and prioritise effectively in the face of climatic changes without significantly affecting the rights of other water users.

It is important to note that adapting to a changing environment may mean that some current environmental objectives cannot be met in the future. Perseverance with environmental objectives that are unachievable is likely to result in wasted effort, reduced or ineffective accountability, and forgone opportunities for environmental benefits from watering other sites. However, any decisions to change environmental objectives require sufficient transparency and community involvement so that all stakeholders can be confident that the revised objectives are appropriate to the changed climate situation that applies.

Finding

Adapting to a changing environment may mean that some current environmental objectives cannot be met in the future.

Action

Environmental managers should incorporate transparent public reviews of environmental objectives into their adaptive planning.

5.3 Policies for efficient investment and service provision

A second key water policy objective is to ensure that WSPs provide the desired level and quality of services to customers at the lowest possible cost.

Important potential impacts of climate change mitigation and adaptation that might impinge on that objective include:

- increased direct and indirect costs from higher energy costs
- investments to balance supply and demand in the light of changes in water availability due to climate change
- cost implications associated with managing risks to water, wastewater and stormwater infrastructure as a result of sea level rise and extreme events, including floods, which are expected to be more frequent because of climate change.

A number of existing water policy tools are designed to facilitate the efficient provision of and investment in water and wastewater services. They include various aspects of planning and price setting:

- urban supply–demand planning and investment
- planning for investments in rural water infrastructure
- planning and investment to manage climatic risks to water infrastructure
- the role of the water sector in broader urban, coastal and rural planning
- economic regulation and price setting

The following discussion examines the extent to which each of those tools is able to address impacts associated with climate change mitigation and adaptation.

5.4.1 Urban supply–demand planning and investment

Urban–supply demand planning refers to the processes, methodologies and institutional arrangements for determining the mix of investments and other options for balancing urban water supply and demand over the medium to longer term.

Experience during the recent drought illustrates how urban supply–demand planning operated at a time of unanticipated climate variability, arguably reflecting underlying climate change. During the drought, the uncertainty associated with climate change made it difficult to balance urban supply and demand efficiently. In particular, uncertainty about climatic projections, and the reduced reliability of historical inflow sequences as an indicator of future supply, meant that there was a greater likelihood of over- or underinvestment (see NWC 2011b for a detailed discussion). While no city ran out of water, the drought responses imposed significant costs on water users through the imposition of prolonged water restrictions and significant expenditures on major supply augmentations. Policy bans on certain supply options (for example, rural–urban trading and indirect potable reuse) are likely to have increased those costs.

There is evidence of deficiencies in the tools and institutional arrangements for urban water planning and investment and the other policies and regulatory settings influencing the supply–demand balance (NWC 2011b). The Commission found in its recent assessment of the reform needs of the urban water sector (NWC 2011a) that many policy, planning and investment decisions were made centrally under conditions of crisis and that the processes used suffered from a number of inadequacies, leading to inefficient outcomes. In many cases, the roles and responsibilities for providing water supply security became obscured, and it became evident that supply security standards were not adequately specified due to their reliance on historical inflow data. Moreover, urban water users have very limited choice in their level of water supply security (NWC 2011b).

Adapting to climate change reinforces the arguments for enabling an efficient portfolio of supply- and demand-side measures to emerge and evolve over time, including in response to climatic risk and uncertainty. In particular, supply–demand plans should demonstrate how security standards can be met under the full range of inflows, including by outlining pathways for new investment in response to changing conditions (NWC 2011b).

The implementation of a carbon constraint in the Australian economy adds to the relative cost of new supply augmentations, particularly those that rely on energy use for water treatment. This should be included in the evaluation of investment options. It could be facilitated by a greater devolution of such decisions to commercially oriented WSPs.

Compared to policy settings in the rural (irrigation) sector, those in the urban water sector are far more reliant on centralised approaches to managing supply and demand. While implementing the rural water model of end-user entitlements for all urban water users is unlikely to be the best approach, more attention should be given to increasing levels of customer choice and competition (NWC 2011b). If carefully designed, such mechanisms could facilitate adaptation to climate change by water supply businesses, individuals and firms.
Finding
Supply–demand planning and investment decisions are likely to be increasingly difficult due to the uncertainty associated with climate change. There are a number of inadequacies in past approaches to balancing urban water supply and demand efficiently in the context of climatic uncertainty.

Actions
Governments and WSPs should clarify roles and responsibilities for urban water supply security and develop plans that identify options for investment in new supply- and demand-side measures to be implemented depending on how conditions affecting the supply–demand balance develop.

Governments should remove policy bans on certain supply options (such as potable reuse and rural–urban water trading) and indirect limitations (such as treating mine water as wastewater). More attention should be given to greater levels of customer choice and the benefits of competition.

5.4.2 Planning for investments in rural water infrastructure

Several infrastructure planning and investment issues are associated with mitigation policy interactions and adaptation responses in the rural water sector.

Implications of a carbon price
The need to recover water for the environment and improve water delivery efficiency is driving significant government investment in on- and off-farm irrigation systems, particularly in the MDB. Off-farm options that are being implemented include replacing open channel systems with pumped, pipelined systems that require higher energy inputs. Government funding is usually provided for capital costs in return for a share of the water savings generated, whereas the ongoing operating costs for such schemes are the responsibility of the WSPs and their customers.

The disconnection between responsibilities for the capital and operational expenditure components of irrigation infrastructure upgrades has the potential to create incentives that may be contrary to climate change policy objectives. An agency offering capital grants for water savings may seek to minimise the capital cost to achieve an agreed level of water savings. However, that may tend to favour more energy-intensive solutions (involving pumping) over gravityfed options, which generally have higher capital costs.

One way to address this disconnection would be to devolve responsibility for such investments to commercially oriented WSPs. There may also be a need to review investment guidelines to take more account of the entire life cycle of modernised irrigation systems, including future real increases in energy costs that would be likely under a carbon pricing regime.

Implications of adaptation responses by irrigators
Expected reductions in future water availability in key irrigation areas due to climate change may mean that existing rural water supply networks become underutilised. In some areas, there may be a need to rationalise water supply systems.

At the same time, governments are investing in major upgrades of some rural water supply networks to improve delivery efficiency in response to water scarcity and to generate water savings for the environment. Unless carefully managed, this may give rise to inefficient adaptation (associated with infrastructure investments) by governments and rural WSPs.
Finding
Climate change adaptation poses a number of new challenges to planning and investment in rural water infrastructure, including in relation to asset maintenance strategies, asset renewals and system or subsystem rationalisation and closure. There is a risk that large rural water infrastructure projects may be inefficient if responses to the impacts of climate change on water availability and irrigation water demand (and other factors) are not adequately considered.

Action
Those making rural water infrastructure investments should carefully consider the potential impacts of climate change on the efficiency of those projects. In addition to full cost–benefit analysis, best practice approaches to investment under climatic uncertainty suggest potential benefits in ‘real options’ approaches. Governments and rural WSPs should develop clear planning and policy guidelines to deal with the range of issues that could emerge when making decisions about how to adapt irrigation infrastructure and service provision to the impacts of climate change on their customers’ water demands.

5.4.3 Planning and investment to manage climatic risks to water infrastructure
One of the most important national water policy implications of this study is the need to develop adaptation strategies that better address the risks of climate change for water, wastewater and stormwater infrastructure and service provision. Those risks raise the following water policy issues:

+ the appropriateness of technical design standards set on the basis of assumptions reflecting historical conditions
+ the capacity of smaller regional water authorities to undertake robust risk assessments and implement appropriate risk management strategies
+ clarifying regulatory obligations (such as for flood mitigation)
+ clarifying roles and responsibilities for emergency management
+ the role of government in setting clear service and performance expectations (particularly where there are impacts on the community as a whole)
+ the role of governments in ensuring a consistent approach to adaptation across all elements of public services and infrastructure, particularly in urban areas.

Existing infrastructure was often designed to standards based on historical climatic trends. Changes in climatic variables (such as more frequent or stronger storm and droughts and incremental increases in temperature and sea level) may mean that the adequacy of infrastructure designed to current standards may be eroded over time. Current levels of service (such as the maximum number of sewage spills) may become costly to maintain, and trade-offs will need to be made in consultation with customers and the community.

While the water sector has been adapting to lower and more variable water availability for some time, adaptation responses to the impacts of changes in other climatic variables on water infrastructure and service performance are in their formative stages. Some individual WSPs are beginning to undertake planning to identify, assess and then manage or reduce those risks (see Section 12 in Part B for examples). However, this is not standard practice, and even where risk assessments are being done many WSPs are struggling to develop robust strategies to be implemented when necessary. At the industry level, the WSAA and its members are undertaking foundation work, including the development of AdaptWater as a pilot climate change adaptation tool.
Finding

While urban water planning tools are being developed to help address the impacts of climate change on rainfall and inflows, much less attention has been given to managing the risks to water assets and their performance from other impacts of climate change, such as extreme weather, sea level rise and higher temperatures. However, some useful foundation work is now being undertaken by the industry and the Australian Government.

Action

Governments and WSPs should give high priority to identifying and developing risk-based strategies to address the impacts of climate change on water, wastewater and stormwater networks, and storage and treatment infrastructure. Such assessments should be coordinated with supply–demand planning to ensure that opportunities for integrated water management are identified and adequately considered.

5.4.4 The role of the water sector in broader planning

This report highlights risks from rising sea levels for water sector infrastructure, particularly wastewater treatment plants, pipelines, pumping stations and discharge outfalls. To be effective and efficient, any actions taken by WSPs to manage those risks need to be coordinated with broader approaches to adaptation in coastal areas.

The corollary is that federal, state or local planning requirements for coastal infrastructure relating to sea level rise will also influence decisions about new wastewater infrastructure. The planning requirements will also influence the pattern of urban development and demand for water-related services more generally.

It would make little sense for WSPs to invest heavily in protecting their assets from future climate change impacts before there is clarity in broader coastal planning. In fact, all adaptation planning within the water sector needs to be coordinated with broader adaptation planning. Conversely, any broader catchment, regional, urban or coastal adaptation planning should closely involve the water sector. While adaptation to sea level rise is a prime example, this need for coordination applies to a range of other climate change risks, including those associated with floods, bushfires and the potential for extreme weather to affect other critical infrastructure (such as transport and electricity systems), that have implications for water service provision.

Finding

The effectiveness and efficiency of adaptation responses in the water sector will be influenced by broader urban, regional, catchment and coastal adaptation strategies.

Action

Governments and responsible authorities should involve the water sector in broader climate change adaptation planning and policy setting. WSPs should seek clarification of broader adaptation policies before undertaking any major investments to manage the risks of climate change.

5.4.5 Economic regulation and price setting

Current approaches to economic regulation typically involve the setting of prices for services provided by natural monopoly water businesses for a defined regulatory period (such as five years). The regulated prices allow for the business to recover the estimated efficient costs of providing services to specified standards over the period (as determined by an economic regulator), but prevent it from using its market power to overcharge customers.

It is helpful to consider two aspects of economic regulation and whether they are able to deal with potential impacts from climate change and related policy:

- the overall level of prices and costs
- the structure of prices to recover those costs.
The overall level of prices and costs

Climate mitigation and adaptation policies could lead to an increase in the costs of supplying water-related services, mainly because of higher energy prices under mitigation policies (such as the carbon price). Under existing regulatory arrangements, those cost increases can be passed through to consumers. This will increase the costs of water and wastewater services, but that is appropriate to the extent that it is simply pricing in a cost (the cost of greenhouse gas emissions) that was previously unpriced. This is important in ensuring that the carbon price signal flows through to end users and influences their consumption decisions.

An important caveat is that regulators should only allow the pass-through of such costs where they represent efficient costs. The Essential Services Commission of Victoria has suggested that a price on carbon means that any carbon mitigation programs proposed by water businesses will now need to be justified through a commercial cost–benefit analysis.

However, one consequence of higher energy prices may have implications for current economic regulatory approaches. It may be difficult to predict, at the start of a regulatory period, the energy costs that are likely to be incurred during the period. This is because energy-intensive water sources, particularly desalination, are increasingly being used as opportunistic fallback supply options at times when water from traditional sources is in short supply. This makes it difficult to predict how much water will be required from energy-intensive sources (and hence the costs that will be incurred).

While this is already an issue, increases in the price of electricity due to mitigation policy will further increase the potential variation in costs faced by urban water suppliers. This could increasingly compromise the ability of water businesses to recover their costs in a timely fashion. There appears to be a strong case for more flexible economic regulatory approaches that incorporate appropriate mechanisms to address this issue. For example, the NSW Independent Pricing and Regulatory Tribunal’s December 2011 decision on the Sydney desalination plant includes two sets of prices—one if the carbon price proceeds and one if it does not (IPART 2011).

Findings

Where independent economic regulation exists, increases in the costs of providing water-related services—due to higher energy prices associated with climate mitigation policies—would normally be passed through, notwithstanding that they imply higher bills to users.

Higher energy costs may also exacerbate uncertainty about future water supply costs. In particular, desalination is increasingly being used as a fallback supply option at times when water from traditional sources is in short supply. This means that it may be difficult to predict how much water will be required from a desalination plant, as actual orders may vary depending on how much water turns out to be available from traditional sources.

Action

Appropriate mechanisms should be incorporated into economic regulatory processes to address the risks associated with forecasting energy costs at the start of a regulatory period.

Another challenge for economic regulation arising from climate change adaptation is in recognising efficient and prudent expenditure for managing potential climate change risks, and distinguishing it from ‘gold-plating’. That expenditure includes the costs of refurbishing existing assets or building new assets to standards capable of withstanding greater climatic shocks. Businesses and regulators should recognise climate change adaptation as one of the aims of ‘prudent’ investment.

Finding

The need for investments to manage the risks of climate change presents a new challenge for economic regulation.

Action

Water businesses should adopt transparent investment planning that explicitly builds in cost–benefit analyses of alternative climate risk management strategies. Regulators should adopt approaches that enable the recovery of responsive expenditure where that expenditure is deemed efficient.
The structure of prices to recover costs

The pricing of water services, together with other demand management measures, provides signals to water users about their consumption and to water businesses about where and when to invest in infrastructure. Economic regulation typically has a major influence on the structure of prices for water-related services.

In the urban water sector, key features of the current regulatory arrangements include:

+ increasing emphasis on user-pays pricing to promote efficient water consumption practices
+ government subsidisation of some sources, particularly new and alternative sources
+ a range of demand management programs designed to reduce water use.

The Commission’s analysis has identified a number of aspects of the current pricing arrangements that may lead to suboptimal water policy in the context of climate change mitigation and adaptation.

In the urban water sector, a key issue is the absence of an appropriate scarcity signal in urban water prices. The introduction of a carbon price will tend to make sources that use electricity (desalination, recycling etc.) more expensive and traditional sources (such as gravity-fed supplies from dams) relatively more financially attractive. Unless water is priced appropriately, this could lead to excessive recourse to traditional sources. This underlines the importance of pricing gravity-fed water efficiently (for example, to reflect its scarcity value or opportunity cost), rather than providing even higher subsidies for new sources.

Finding
By increasing the cost of energy-intensive sources (such as desalination and large-scale recycling), the carbon price could encourage water utilities to shift investment and sourcing decisions back towards traditional sources and away from new or alternative sources.

Action
Regulators and water businesses should consider reforms to the pricing of water to better reflect the scarcity value or opportunity cost of the resource.

In the rural water sector, termination fees are an important pricing issue in the context of climate change. Termination fees have been designed to ensure that remaining users do not face an excessive cost burden as a consequence of decisions by some irrigators to cease participation in irrigation schemes. They have been set to balance competing objectives: to encourage efficient investment and to encourage efficient structural adjustment.

Climate change may lead to greater pressures for the rationalisation of irrigation networks. Given that the determined level of the termination fee represents a trade-off between the objectives, there would be value in reviewing the role and level of termination fees in the future with the aim of ensuring that the balance between encouraging efficient investment and efficient rationalisation remains appropriate in the face of climate change. Rural WSPs currently have little guidance on whether and how decisions relating to non-voluntary terminations of service should be made.

Finding
Climate change may lead to greater pressures for the rationalisation of irrigation networks.

Action
Governments and WSPs should review the role and level of termination fees in the future to ensure that the balance between encouraging efficient investment and encouraging efficient rationalisation remains appropriate in the face of climate change. Rural WSPs also require guidance on whether and how decisions about non-voluntary terminations of service should be made.
5.4 Policies for the protection of public health, safety and the environment

A third key water policy objective is to ensure that the use and management of water resources and the provision of water-related services are undertaken in a manner that appropriately protects human health, manages potential third-party impacts (flooding, sewage spills etc.) and ensures an appropriate level of protection for water-dependent ecosystems.

Climate change mitigation and adaptation policies might impinge on that objective if they result, for example, in more frequent sewer spills or higher floods.

A number of existing water policy tools are designed to protect public health, safety and the environment, including:

+ **Environmental regulation** to ensure the protection of the environment, particularly in relation to discharges of wastewater to the environment, but also in the way that water is abstracted and used.

+ **Public health regulation** to ensure that water and wastewater services are supplied in a way that protects the health of users and the broader public.

This section examines the extent to which each of these existing policy tools is able to address the impacts of climate change mitigation and adaptation policies.

Key features of relevant current regulation include:

+ the setting of discharge standards for releases of treated wastewater into the environment

+ standards for managing sewer overflows

+ the specification and enforcement of drinking water quality standards

+ guidelines and standards for the use and management of recycled water for non-potable uses

+ standards for dam safety and the management of floods

+ regulations covering the management of water and wastewater by mines, electricity generators and other large industries.

One important policy question is whether current regulatory arrangements can ensure ongoing cost-effective protection of the environment and public health in the context of climate change mitigation policy and adaptation responses.

One effect is that higher energy prices (associated with a carbon price) will increase the costs of meeting environmental standards for wastewater discharge, particularly if the standards require tertiary treatment, which requires considerable energy. This reinforces the need to carefully consider the full costs and benefits when setting standards. In addition, discharges from wastewater treatment plants may become important options for environmental flows under climate change. This suggests that overall environmental outcomes may be improved if the level of treatment required is set more flexibly, taking into account the quality of the receiving waters.

Climate change adaptation and mitigation policies also have the potential to affect the use and management of water in ways that, if not managed appropriately, may have impacts on the environment and other parties.

The risks include more frequent sewer spills and more frequent and severe flooding. In some cases, the management of these risks is factored into current regulations and infrastructure design standards. However, in other cases, existing design standards will lead to service levels being eroded in the face of these risks. In any case, a key question is whether climate change will mean that current levels of service (such as the minimum number of expected sewage spills) will become too costly to maintain. This suggests that trade-offs between service standards and costs need to be subject to rigorous cost-benefit analysis and public consultation and review, taking into account the effects of climate change mitigation and adaptation.

Importantly, managing risks to the environment and public health also applies to privately owned water-related infrastructure. Climate change adaptation and mitigation affects the regulation of:

+ risks associated with mine tailings dams during floods

+ coal mine pit water, which could be subject to acidification in the event of early mine closure

+ a range of water interactions in the extraction of coal seam gas.
While management of the disposal of mine water is subject to existing regulation, climate change may mean that current standards provide a lower level of protection than they have in the past. For example, increased flooding may mean that mine tailings dams overflow once every 10 years rather than once every 100 years. Developing cost-effective regulatory arrangements that deal with these uncertainties is a challenge both for water policy and for environmental policy more generally.

Changes in policy, the underlying economics and technology may mean that new or alternative energy sources develop with relatively short notice. There is also a need to ensure that appropriate and timely regulatory arrangements are developed to manage the potential environmental and other impacts of newly emerging technologies driven, in part, by climate change mitigation and adaptation (for example, coal seam gas, geothermal energy, carbon capture and storage, and solar thermal generation).

**Finding**

Climate change interactions create a number of challenges in defining appropriate service standards and regulatory obligations and balancing them with the costs of meeting them.

**Actions**

Those setting standards for the protection of public health and the environment should subject the standards to cost–benefit analyses, consult about the trade-offs between standards and costs, and review the standards in the light of climate change.

Given that new or alternative sources of energy generation may develop with relatively short notice, appropriate arrangements to manage their water-related impacts should be put in place in good time. This will require monitoring the types of developments that may occur, rather than developing detailed regulatory arrangements for every possible emerging energy technology.

### 5.5 Governance and institutional arrangements

The water sector’s governance and institutional arrangements are another overarching feature of current policy settings with the potential to affect policy outcomes.

A number of government agencies are involved in water policy and management. Most importantly, in the context of this study:

+ the states have primary responsibility for water policy and the implementation of nationally agreed reforms
+ the Commonwealth has specific responsibilities, particularly in the MDB under the *Water Act 2007*
+ the Commission has a role in advancing the objectives of the NWI and advising the Council of Australian Governments on progress
+ local governments play a role in water service provision in New South Wales and Queensland and have significant roles in stormwater, drainage and flood management across much of Australia
+ large monopoly businesses, usually owned by state governments, are mostly responsible for providing water and wastewater services
+ in most states, separate bodies are responsible for economic, environmental and public health regulation.

Analysis for this project identified a number of aspects of the current arrangements that may not address either climate change or adaptation in a way that optimises water policy outcomes.

#### 5.5.1 Transparent decision-making and accountability

Governments, environmental water managers and WSPs will be required to make a range of decisions about managing the risks associated with climate change impacts and policy, such as decisions about flood protection, environmental watering, urban water supply security, public health protection, environmental protection and infrastructure management.

Climate change may mean that decisions not previously contemplated, such as about whether and when to relocate wastewater treatment plants, will need to be made. In addition, acting under climatic and policy uncertainty means there is a chance of getting things wrong, at least when those choices are viewed with the benefit of hindsight. For example, a decision to invest in climate-independent water supply sources such as desalination may be criticised if subsequent rainfall appears to render the investment unnecessary. To avoid unwarranted criticism after the event, planners need to base major decisions on a transparent risk management approach, and the principles driving decisions need to be clearly communicated in advance.
The ingredients of an adaptive approach to water policy and management include:

+ developing clear and specific objectives
+ ensuring that options are available to respond to a broad range of climate change impacts and defining implementation triggers clearly
+ monitoring climatic conditions and evaluating performance against objectives
+ periodically reviewing the appropriateness of objectives and strategies
+ ensuring that trade-offs are assessed and that affected stakeholders are engaged in the process.

### 5.5.2 Specific objectives and service standards

Governments and their agencies are responsible for setting a range of specific objectives for water policy and management to translate the high-level NWI objectives into action. For example, specific objectives may be set for the desired level of urban water supply security, the number of acceptable sewage spills, or the desired area of healthy wetlands.

An important finding of this assessment is that such specific objectives and levels of service may need to be reconsidered in the light of climate change impacts and policies. For example, more frequent or higher floods due to climate change may mean that the cost of meeting particular standards becomes prohibitive. In the context of environmental flows, objectives for specific environmental assets may need to change if climate change makes it impossible or too costly to continue to protect the asset at a particular level.

The Commission has previously identified examples of governments, WSPs and environmental water managers that are beginning to consider the achievability of specific existing objectives and service standards and the costs of meeting them in the light of climate change. However, given the profound changes expected, there is a strong case for all relevant parties (for example, governments, WSPs, environmental water managers and regulators) to review the achievability and appropriateness of their objectives and standards, including those that:

+ entail significant energy use and greenhouse gas emissions (such as water quality regulations for wastewater treatment plants)
+ might be influenced by climate change (for example, urban water security, floods, objectives for the performance of water, wastewater and stormwater systems, and objectives for water-dependent environmental assets).

Many existing objectives and service standards have been in place for a long time, so this process is likely to be difficult. Climate change adds to the need for transparency in the development and periodic revision of specific objectives. In addition, processes need to be developed so that objectives can be reviewed as events occur. For example, if a prolonged drought (exacerbated by climate change) leads to the irreversible degradation of parts of a wetland, then there may be limited benefit in continuing with environmental watering of those areas, and management objectives may need to be revised. Perseverance with management objectives and standards that are unachievable is likely to result in wasted effort, reduced or ineffective accountability, and less resources available to contribute to other, achievable, environmental outcomes.

### Finding

There is a significant risk that climate change will make existing management objectives and service standards more difficult and costly to achieve. Revised management objectives and service standards may be required in the light of mitigation and adaptation efforts.

### Action

Governments, water supply businesses, environmental water managers and regulators should review the achievability of existing objectives and service standards and the costs of meeting them to ensure that they remain appropriate in the context of rising energy costs and the potential impacts of and responses to climate change. The community and water users should be engaged to determine appropriate objectives and standards in the light of climate change interactions.
5.5.3 Roles and responsibilities

This assessment highlights climate change risks to water sector infrastructure and services. While service providers are generally best placed to take responsibility for those risks from a technical and operational perspective, governments may need to clarify regulatory obligations and service standards.

Climate change risks may also require the clarification of roles and responsibilities. For example, stormwater management may become more difficult because multiple stakeholders and organisations are involved, some with responsibility for avoiding urban flooding and others with an interest in stormwater as a potential resource.

In general, the localised differences and complexities associated with climate change impacts and adaptation responses might favour following the principle of subsidiarity, whereby functions and responsibilities are delegated to the lowest possible level. However, for some issues, the impacts may be widespread and state and national responses might be required. Getting the balance right and determining the appropriate role of the water sector, particularly in relation to broader adaptation responses, is a key issue.

Recent floods and droughts have highlighted uncertainties about who ultimately bears the risk of extreme climatic events and the circumstances in which governments or water providers might be liable for damages. Clarifying the assignment of various risks, including from the legal and financial perspectives, will be important in providing signals for efficient autonomous adaptation.

**Finding**

Where roles and responsibilities are unclear, there is a risk of inefficient adaptation.

**Action**

Governments should carefully consider and clearly communicate their expectations and the roles and responsibilities of various agencies, particularly in relation to water-related risks associated with climate change.

5.5.4 Knowledge and capacity for change

This assessment has found that some difficult decisions are required to develop and implement effective adaptation responses that manage climate change risks appropriately. Additional effort, and new skills and capabilities, will be required in some areas. While there is evidence of some sophisticated approaches to climate change adaptation in the urban water sector, those approaches are not yet widespread. Many smaller jurisdictions and smaller regional and rural WSPs may struggle to implement the necessary changes. There may be benefits in enhancing collaboration on various issues across states and at the national level.

**Finding**

Climate change interactions create extra pressure on decision-making tools and processes. Developing effective adaptation responses will require new skills and capabilities.

**Action**

Further investment in skills and capacity may be needed to address the complex challenges arising from the water policy implications of climate change interactions.
6 Implications of current water policy settings for the implementation of climate change policy

While the focus of this report is on the implications of climate change mitigation policy and adaptation responses for water policy, the Commission also sought to determine the implications of current water policy for the implementation of climate change policy.

The report does not seek to assess the efficacy of climate change policy itself, but to focus on whether there are any aspects of current water policy settings that might impede the effective implementation of climate change policy and thereby undermine the achievement of climate change policy objectives. Identifying and, where appropriate, removing any such impediments could therefore enhance the effectiveness of climate change policy.

The objectives underlying climate change policy and the behavioural changes that the various elements of the policy try to encourage are described in sections 3.1 and 4.1. In broad terms, they are as follows:

+ **Climate change mitigation** seeks to reduce the amount of greenhouse gas emissions. As described in detail in Section 3, emerging mitigation policy seeks to do this by:
  - encouraging a shift to cleaner energy sources through putting a price on carbon and subsidising lower emissions technologies (for example, renewable energy sources)
  - encouraging a reduction in energy use through the passing on of energy prices to users and through energy efficiency programs
  - encouraging changes in land use and other activities that could help to capture and store carbon.

+ **Climate change adaptation** seeks to better manage the impacts and risks associated with climate change that has already occurred and will continue regardless of short- to medium-term mitigation efforts. As discussed in Section 4, adaptation policies are less well defined and developed than mitigation policies but encompass a range of responses by governments, businesses and individuals to manage climate change risks.
6.1 Water policy settings that may impede the implementation of mitigation policy

The ability to adopt some of the behavioural responses sought under climate change policy may depend, at least in part, on water policy settings. This report identifies a number of such dependencies. They have been categorised into aspects of water policy settings that might impede:

+ a shift to less emissions-intensive energy sources
+ a reduction in demand for and use of energy
+ changes in land use and other activities that could help to capture and store carbon
+ cost-effective climate adaptation.

6.1.1 A shift to less emissions-intensive energy sources

A fundamental objective of climate mitigation policy is to encourage a shift towards less emissions-intensive energy sources.

Where new and less emissions-intensive electricity generators require water as a key input, lack of clear and secure entitlements and access to water markets could be a barrier to investment in such facilities. For example, some renewable energy sources may have high localised water requirements, including in areas where water availability is at risk from climate change.

New energy projects will also need to secure appropriate environmental and other regulatory approvals, some of which relate to the management of water resources, environmental impacts on water-dependent ecosystems, or both. In this regard, lack of effective water and related environmental regulation may cause governments to suspend the development of projects (such as coal seam gas ventures) that are less emissions-intensive energy sources.

Another mechanism that may be used to facilitate a shift to less emissions-intensive energy sources is contracts for the closure of high-emitting coal-fired generators. Uncertainty about the water entitlements of some coal-fired generators may affect the willingness of some energy companies to enter into agreements for early closure.

6.1.2 A reduction in demand for and use of energy

Another objective of climate change policy is to reduce the demand for and use of energy. While the primary instrument for achieving reductions in use to date has been the implementation of various energy efficiency programs, there appears to be a shift towards approaches that would secure reductions in the most economically efficient manner. In principle, a price on carbon should promote the least-cost ways of reducing energy usage. This is because users will only consume energy to the point where the benefits they receive are at least as high as the costs they face in doing so. In the context of a price being placed on carbon, there has also been increasing recognition of the possible need to rationalise existing energy efficiency schemes. Some schemes may be relatively high-cost means of reducing energy use.

A number of aspects of current water policy potentially run counter to reducing energy use. For example:

+ many new investments and regulatory interventions in the urban water sector aimed at diversifying water supplies require higher energy inputs
+ some voluntary mitigation actions by WSPs may not be the most efficient or cost-effective form of mitigation from a national perspective
+ pricing of water and wastewater services might not pass carbon price signals through to users
+ environmental and public health regulation requires very high wastewater effluent treatment levels, which involve high energy use and emissions
+ some public investments in rural water infrastructure might not be adequately factoring in increasing energy and carbon costs.
Investments in energy-intensive sources

A major thrust of urban water policy in recent years has been to diversify water sources into non-traditional sources. However, many non-traditional sources, such as desalination and recycled water, are energy intensive.

This has given rise to concerns that this ‘energy–water nexus’ could be seen as implying that water policy is working at cross-purposes to climate change mitigation policy (that is, while climate change policy seeks to reduce energy use, some aspects of water policy may be working to increase demand for energy).

The fact that some water sources use high volumes of energy does not in itself indicate a policy disconnection, provided that decisions to invest in energy-intensive water sources reflect the full economic and environmental costs. From an economic efficiency perspective, the objective should be to optimise the value of all resources (including energy and water) rather than to minimise the use of any particular resource. However, to the extent that some investments in energy-intensive water sources have been subsidised or are the results of artificial targets, then it could be argued that these policies run counter to climate change policy objectives.

The imposition of a carbon price should, in principle, provide a better signal of the social cost of energy use and thus encourage users to consume energy only where the benefits justify the costs. Water sector policies that subsidise or artificially promote energy-intensive water sources of supply in effect undermine the signals meant to be sent through the carbon price.

Voluntary mitigation actions by water service providers

Many water businesses are subject to specific voluntary and regulatory targets for emissions reductions and renewable energy at the state level. Those targets are likely to interact with the carbon price. For example, if the level of investment prescribed by existing targets exceeds the level that would occur as a result of commercial investment decisions (incorporating the carbon price), the carbon price may have limited effect on investment in renewable energy. On the other hand, as the carbon price increases, businesses may choose to invest in renewable energy and other forms of abatement at levels that make targets redundant.

The relationship between the carbon price and clean energy targets raises policy questions about efficient investment in the urban water sector and impacts on service costs. To the extent that the carbon price provides an efficient signal about the cost of emissions, investments that are not commercially viable to meet emissions reduction targets (even after factoring in the carbon price) will be inefficient and increase service costs unnecessarily.

The economic regulator of the Victorian water industry (the Essential Services Commission) has suggested that a price on carbon means that any carbon mitigation programs proposed by businesses will now need to be justified through a commercial cost–benefit analysis. The Essential Services Commission will ‘exclude from approved revenue requirements the costs associated with alleged but unclear Government obligations’ (ESC 2011:4).

Pricing of water and wastewater services

A carbon price signal will only be effective in influencing energy use if urban water businesses pass that cost through to customers in full. This would be generally be expected to occur under an effective regime of independent economic regulation. However, there are a number of previously identified inadequacies in water pricing in some cases, particularly in regional areas (NWC 2011b), which may mean that such costs are not passed through to customers, or are only partially passed through.

Standards for wastewater treatment

The treatment of wastewater involves the use of increasing amounts of energy as it moves from primary through secondary and tertiary treatment. Higher standards for discharges to protect receiving environments therefore also involve higher energy consumption and greenhouse gas emissions.

Again, this would be a policy disconnection only if the benefits of the environmental standards do not justify the costs of meeting them (including the costs associated with the use of energy and resulting emissions). For example, if standards were set without a cost–benefit assessment, there would be potential for them to be set at a level that resulted in costs (including emissions) greater than their benefits.
6.1.3 Changes in land use and other activities that could help to capture and store carbon

Climate change policy encourages changes in land use and other activities that could help to capture and store carbon. Some aspects of current water policy could potentially frustrate such changes. In particular, inadequate policies for addressing water interception might be a barrier to plantation investment and cost-effective carbon sequestration.

**Finding**

In the main, current water policy settings will not impede the cost-effective implementation of climate change mitigation policy. However, there are a small number of exceptions, including some that might affect the shift towards lower emissions energy sources.

6.2 Water policy settings that may impede the implementation of cost-effective adaptation

Climate adaptation policies are less well-defined and developed than mitigation policies. They include a diverse range of responses by governments, businesses and individuals to manage climate change risks in such areas as agriculture, coastal management, water infrastructure, significant natural systems and natural disaster management.

This makes it quite challenging to consider whether current water policy settings might impede climate adaptation.

In large part, water policy itself constitutes adaptation policy, as changes in water availability are one important potential impact of climate change, so it is helpful to consider the extent to which current water policy adheres to principles for efficient and effective adaptation.

As noted by the Productivity Commission, adaptation does not necessarily imply ‘climate proofing’ that completely avoids all impacts. It suggests that one possible interpretation of ‘effective adaptation’ is that which maximises the net benefit to the community as a whole:

> On this basis, adaptation can be considered effective if it is done at least cost, resources are allocated to activities that generate the greatest net benefits to the community, and if the timing of adaptation is ‘optimal’.

(Productivity Commission 2011b:5)

In considering what constitutes effective adaptation, the Productivity Commission and other authorities identify two key areas that provide some guiding principles:

+ standard public policy principles for government intervention
+ principles for the efficient allocation and management of risk.

Standard public policy principles suggest that it is important that adaptation is necessary and efficient (that is, that there is a case for intervention and that the benefits of the intervention exceed the costs). They also suggest that, where possible, governments should try to facilitate autonomous adaptation.

The second set of principles suggests that best practice risk assessment and management will be required to determine the appropriate course of action. As noted by the Department of Climate Change and Energy Efficiency:

> Adapting to the impacts of climate change is, in large measure, about managing risks. Risks will be dealt with most efficiently if they are well understood and allocated to those who are best placed to manage them. (DCCEE 2010a:7)

Building on that observation, the department suggests that the implication for policy is that:

> The process of embedding climate change in new policy reform will involve explicitly identifying climate change risks and ensuring appropriate account is taken of their implications in policy development and program delivery. In doing this, it will also need to allocate climate change risks to those best placed to manage them and promote active management of risks by those parties. (DCCEE 2010a:14)

These considerations imply that, given climatic uncertainty, there are likely to be benefits from implementing ‘low-regrets’ and ‘no-regrets’ policy and institutional reforms that provide benefits regardless of the climate change outcomes.
Moreover, if public investment is required, it should reflect a flexible or ‘real options’ approach. Real options approaches involve increasing flexibility and periodically reevaluating options as uncertainty resolves. They can involve deferring implementation until absolutely necessary, segmenting options into components and phasing in implementation over time, and investing in options that reduce response times (‘readiness options’).

Box 2 provides an overview of key principles for efficient and effective adaptation.

**Box 2: Principles for efficient and effective adaptation**

**Establishing whether there is a market failure**

Before intervening with adaptation policy, there is a need to first establish whether there is a market failure that justifies intervention.

**Passing the cost–benefit test**

As noted by the Queensland Government (2011), adaptation can be achieved in a variety of ways—some responses are economically efficient, others less so. Where the costs of certain adaptation responses are considered too high, some impacts of climate change may be economically tolerable. Even where the impacts are potentially extremely high (for example, as a consequence of sea level rise), the costs of preventing damage may be exorbitant.

As with all policy measures, it is important that adaptation measures pass the cost–benefit test. In practice, there are a number of challenges in assessing the costs and benefits with certainty, including the long timeframes over which climate change occurs, the profound uncertainty in climate change projections, and the difficulty in distinguishing between the impacts of climate change and underlying climatic variability. As a result, the following types of strategies may help manage the risk of inefficient or maladaptive policy responses.

**Adopting ‘no-regrets’ and ‘low-regrets’ reforms**

Many adaptation policy tools can provide benefits independent of climate change by correcting pre-existing inefficiencies. Such measures address current vulnerabilities and focus on increasing the ability of ecosystems and communities to cope with current environmental pressures and climate variability. They provide a benefit now and a benefit in the future, and potentially provide a benefit whether or not the projected climate changes occur. These options are more likely to gain political support, given that some climate impacts are very difficult to discern from underlying climate variability. They may also reduce the need for more expensive and risky options, such as direct public investment in infrastructure.

Adopting reforms that are robust in a wide range of future water availability scenarios also avoids the risk of acting prematurely to change water allocation and management arrangements in anticipation of major climate change impacts. Changing water allocation and sharing policy in preparation for impacts that have not yet occurred could result in significant productive opportunities being forgone. Similarly, waiting until climate change becomes more severe before making changes to water allocation and management policies risks incurring significant adverse impacts on economic, social and environmental outcomes.

**Facilitating autonomous adaptation**

Individuals and businesses have an interest in adapting to climate change and its impacts because climate change will affect their assets, the activities they are involved in, and other factors that affect their livelihoods and welfare. How autonomous adaptation takes place will vary between sectors and activities. In some sectors, notably agriculture, a relatively long history of adapting to climate variability has increased the capacity for autonomous adaptation to climate change.

Governments can facilitate autonomous adaptation in a number of ways, including by:

+ providing public information and research and development where it has public benefits
+ creating markets in new products
+ clarifying who bears particular climatic risks.

Clarifying policy positions is important. If they are uncertain, they may form a barrier to autonomous adaptation and strategic responses by creating principal–agent issues.* For example, individuals might not invest in appropriate insurance or prevention measures if they believe that governments would intervene following an extreme climatic event.
**Box 2: Principles for efficient and effective adaptation**

**Adopting a flexible or real options approach to capital investment**

The literature on real options analysis identifies a number of potential strategies that may help manage the risk of making inefficient capital investments where there is significant uncertainty. The strategies revolve around increasing flexibility and periodically reevaluating options as uncertainty resolves. Options include:

- deferring implementation until absolutely necessary
- segmenting options into components and phasing in implementation over time
- investing in options that reduce response times (‘readiness options’).

Such approaches tend to perform well in financial or net present value terms by reducing the need for large upfront expenditure without compromising risk management benefits.

**Using best practice risk management**

Other strategies that may be suited to effective and efficient risk management include:

- taking action to avoid passing irreversible thresholds
- investing in improved monitoring, evaluation and research in order to make better decisions
- building in redundancy and buffers.

* Principal–agent problems can occur where a principal pays an agent to do something that is costly to the agent and measuring the agent’s performance is costly to the principal.


Many aspects of current water policy are consistent with these principles. Much of the analysis in Section 5, based on the impacts and interactions identified in Section 4, could be said to be an assessment of whether current water policy settings support effective adaptation. The key conclusion from this analysis is that many aspects of current water policy—in particular the establishment of clearly defined water entitlements and water markets—support effective adaptation. Evidence of real options approaches to urban supply–demand planning and investment is also emerging.

Some other aspects of current water policy may be less conducive to effective adaptation. Those aspects particularly relate to areas of policy where governments intervene and distort market signals (for example, large government investments in sunk assets, subsidies for particular types of water sources, or the imposition of water use restrictions). Such policies seem to run counter to the tenet espoused by the Department of Climate Change and Energy Efficiency that ‘governments must ensure that regulatory arrangements do not distort market signals and facilitate the ability of all to adapt to climate change’ (DCCEE 2010a:8).

There is also a need to ensure that government interventions do not breach the cost–benefit test by making premature or excessively costly investments that seek to ‘climate proof’ infrastructure. For example, a recent suggestion (Maddocks 2011:73) that regulatory frameworks could include licences for water infrastructure operators requiring them to ‘undertake the necessary assessments and upgrade works to ensure that water infrastructure is resilient to the effects of climate change’ may breach this principle unless very carefully applied.

**Finding**

In large part, water policy itself constitutes adaptation policy. Many aspects of current water policy—in particular the establishment of clearly defined water entitlements and water markets—support effective adaptation. However, some other aspects of current water policy may be less conducive to effective adaptation.
7 Priorities for reform

7.1 Key directions

This study highlights a number of interactions between water and energy. For example:

+ many new investments in the urban water sector aimed at diversifying water supplies (such as desalination plants) require higher energy inputs
+ energy generation (including some new and lower emissions sources) can have significant requirements for water as an input.

However, the relationship between energy and water does not imply, as some have suggested, that governments need to become more directly involved in attempting to integrate investment and resource use decisions across the two sectors. Rather, what is needed is a framework that ensures that individuals and firms take into account the full water, energy and carbon costs and benefits of production, consumption and investment decisions. This highlights the importance of efficient and cost-reflective pricing of water-related services so that the new carbon price signal flows through into water use, investment and sourcing decisions.

Many elements of current water policy settings are well placed to manage potential impacts from climate change and related policies. Indeed, reforms to water pricing, entitlements and markets, particularly in the MDB, provide a world-leading example of climate change adaptation policy. In some cases, however, there is a need for better and more complete implementation of the National Water Initiative (NWI).

The analysis in this report also reveals that dealing with profound climatic uncertainty and the transition to a carbon-constrained economy adds a number of new dimensions to the water reform agenda. Institutional, policy and governance reforms that encourage flexibility should be at the heart of the water policy response to climate change, wherever possible. The water policy framework needs to be truly adaptive and able to effectively manage the uncertainties and risks associated with climate change.

Due to the uncertainty associated with climate change, decentralised approaches (such as water markets that clearly assign risks to those best placed to manage them) are likely to perform much better than attempts at centralised planning. In some remote areas where water markets are less feasible, other changes to water planning and regulation may be needed.

7.2 Recommendations

The analysis undertaken for this report has led the Commission to develop five overarching recommendations supported by more detailed actions. They focus on those areas assessed to be priorities using the framework in Section 2.2 (that is, they have the highest potential material impact and current policy settings are insufficient). Many of the areas are not new, but climate change mitigation and adaptation make them more urgent.
7.2.1 Implement further water entitlement and market reforms

Further water entitlement and market reforms should be implemented to provide security to water users and to flexibly manage changes in water supply and demand due to climate change.

+ Jurisdictions should extend NWI-consistent entitlements to all users where practicable, broaden their coverage to groundwater and unregulated surface water systems, and ensure that allocations to entitlements are robust and transparent under all inflow conditions.
+ The NWI parties should improve the functioning of water markets and further expand market coverage to a wider range of users, where practicable. In particular, facilitating the participation of the mining and electricity generation industries in water markets is likely to improve water management outcomes in the context of climate change. Eliminating artificial barriers to rural–urban water trading is also likely to enable urban WSPs to adopt more flexible and low-cost risk management and adaptation strategies.
+ Policymakers and environmental water managers should further develop the tools and governance arrangements that will enable environmental water holders to adapt and prioritise effectively in the face of climatic changes without significantly affecting the rights of other water users.
+ The NWI parties should review the risk assignment provisions in the NWI with a view to ensuring that the provisions provide greater certainty and consistency in practice.
+ Jurisdictions should improve arrangements for the quantification, reporting and management of interception activities.
+ Given that new or alternative sources of energy generation may develop with relatively short notice, appropriate arrangements to manage their water-related impacts should be put in place in good time. This will require monitoring the types of developments that may occur, rather than developing detailed regulatory arrangements for every possible emerging energy technology.
+ Governments and rural WSPs should undertake activities to further clarify water delivery rights and enable trade in those rights as a means of managing potential changes in the location and timing of irrigation demand.

7.2.2 Improve water planning and decision-making

Improvements to water planning and related decision-making processes should be implemented to better manage climate change risk and uncertainty.

+ Water planning should consider the full range of inflow sequences based on the latest climate change modelling. The flexibility to adapt in response to prevailing climatic conditions should be built into water plans in a manner that provides transparency and predictability to all water users and the public. This will provide greater clarity about the allocation of climatic risks between consumptive users and the environment.
+ The prioritisation of water planning should take into account potential changes in water supply and demand associated with climate change policies and adaptation responses.
+ Environmental managers should incorporate transparent public reviews of environmental objectives into their adaptive planning.

7.2.3 Reform regulation and pricing for greater flexibility and stronger price signals

Reforms to regulation and pricing should be made to provide greater flexibility to adapt to climate change and better signal all the relevant costs of managing it.

+ Appropriate mechanisms should be incorporated into economic regulatory processes to address the risks associated with forecasting energy costs at the start of a regulatory period. This is because energy-intensive sources, particularly desalination, are increasingly being used as opportunistic fallback supply options at times when water from traditional sources is in short supply and it is difficult to predict in advance the extent to which high-energy sources will be needed.
+ Water businesses should adopt transparent investment planning that explicitly builds in cost–benefit analyses of alternative climate risk management strategies. Regulators should adopt approaches that enable the recovery of responsive expenditure where that expenditure is deemed efficient.
+ Regulators and water businesses should consider reforms to the pricing of water to better reflect the scarcity value or opportunity cost of the resource.
+ Those setting standards for the protection of public health and the environment should subject the standards to cost–benefit analyses, consult about the trade-offs between standards and costs, and review the standards in the light of climate change.
7.2.4 Review approaches to investment in augmentation and infrastructure

Approaches to investment in urban supply augmentations and rural water infrastructure should be reviewed to ensure that they address water security but also to reduce the risk of poor investments.

+ Governments and WSPs should clarify roles and responsibilities for urban water supply security and develop plans that identify options for investment in new supply- and demand-side measures to be implemented depending on how conditions affecting the supply–demand balance develop.

+ Governments should remove policy bans on certain supply options (such as potable reuse and urban–rural water trading) and indirect limitations (such as treating mine water as wastewater). More attention should be given to greater levels of customer choice and the benefits of competition.

+ Governments and WSPs should review investment guidelines to more accurately take into account the whole-of-life costs of modernised irrigation systems, including higher future energy costs due to a carbon price.

+ Those making rural water infrastructure investments should carefully consider the potential impacts of climate change on the efficiency of those projects. In addition to full cost–benefit analysis, best practice approaches to investment under climatic uncertainty suggest potential benefits in real options’ approaches. Governments and rural WSPs should develop clear planning and policy guidelines to deal with the range of issues that could emerge when making decisions about how to adapt irrigation infrastructure and service provision to the impacts of climate change on their customers’ water demands.

+ Governments and WSPs should review the role and level of termination fees in the future to ensure that the balance between encouraging efficient investment and encouraging efficient rationalisation remains appropriate in the face of climate change. Rural WSPs also require guidance on whether and how decisions about nonvoluntary terminations of service should be made.

7.2.5 Prioritise the management of risks to water infrastructure and services

The management of climate change risks to water infrastructure and services, particularly in urban areas, should be given higher priority.

+ Governments and WSPs should give high priority to identifying and developing risk-based strategies to address the impacts of climate change on water, wastewater and stormwater networks, and storage and treatment infrastructure. Such assessments should be coordinated with supply–demand planning to ensure that opportunities for integrated water management are identified and adequately considered.

+ Governments and responsible authorities should involve the water sector in broader climate change adaptation planning and policy setting. WSPs should seek clarification of broader adaptation policies before undertaking any major investments to manage the risks of climate change.

+ Governments should carefully consider and clearly communicate their expectations and the roles and responsibilities of various agencies, particularly in relation to water-related risks associated with climate change. Further investment in skills and capacity may be needed to address the complex challenges arising from the water policy implications of climate change interactions.

7.3 Implementation

Climate change mitigation policy and adaptation responses pose a broad range of challenges to water policy. Further work in each jurisdiction is needed to understand which issues are most important at a local level.

Jurisdictions should continue to drive water policy and take responsibility for addressing the issues that arise from this assessment. In particular, reforms affecting the urban water sector are primarily the responsibility of the states. The Commonwealth also has a number of existing roles, particularly in the MDB, that are affected by climate change and related policy. With the recent easing of drought conditions, there is a risk of complacency about the water reform agenda at the state and national levels. Recent floods and droughts, combined with the range of risks identified in this report, mean there can be no excuses for lack of preparation in the future.

Climate change mitigation and adaptation are nationally important issues. For many adaptation challenges, water policymakers and service providers will need to participate in a coordinated whole-of-government approach to adaptation, particularly in coastal and urban areas. However, this does not mean that all actions and responsibilities should be centralised. On the contrary, water policy should aim to facilitate autonomous adaptation by individuals and firms, and planning should be informed by local conditions and institutions.
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Sectoral Assessments
8 Electricity generation

Many electricity generators rely on secure water supplies, and the impacts of climate change on water availability create important risks for them. Ensuring that they have clear entitlements, access to water markets, clear regulatory requirements and the ability to invest in alternative sources may provide an important means of minimising the costs of climate change adaptation.

Climate change mitigation policies, primarily the introduction of a carbon price signal and renewable energy target, are designed to change the mix of electricity generation sources. This will potentially have significant impacts on water extraction, use and discharge in the electricity generation sector.

In the short term, the main impacts relate to the potential switch from coal- to gas-fired generation and renewables (mainly wind energy). In general, that change will reduce aggregate water demand because coal-fired generation is typically an intensive water use (2–3 ML/GWh). Existing coal-fired generators are concentrated in the Latrobe Valley in Victoria, in the Hunter region in New South Wales and in southern Queensland.

Wind and some gas-fired technologies have very limited water requirements. Other gas-fired generation technologies do have substantial water requirements (up to 1 ML/GWh) that could create significant additional localised water demands.

Water planning and entitlements frameworks and water trading arrangements need to be developed with these potential changes in mind. If water policy is inflexible to these types of changes, that could have a material impact on the achievement of Australia’s mitigation policy objectives.

Under current mitigation policy settings, most of the renewable energy target is likely to be met through wind energy development, at least in the short term. Wind energy does not have any material water requirements or interactions. In the longer term, geothermal, solar thermal, and carbon capture and storage technologies could be adopted, increasing localised water demands and creating potential interactions with surface water and groundwater sources. Based on the lessons learned with coal seam gas (see Section 9), it is important that water planning, regulation and entitlements are established to deal with such issues before they arise.

This section applies the Commission’s assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian electricity generation sector, including renewable generation sources, in order to:

+ provide background on the electricity generation sector and its relationships with water, energy and emissions (Section 8.1)
+ describe the likely effects of mitigation policy on the sector, and their implications for water policy (Section 8.2)
+ describe the likely effects of climate change impacts and adaptation responses on the sector, and their implications for water policy (Section 8.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

Figure 21 summarises the interactions identified in this assessment.
Figure 21: Summary of interactions in the electricity generation sector

- Changes in climatic variables
  - Impact on water availability
  - Changes in temperature and extreme weather events

- Direct impact on energy generation sector
  - Impacts on electricity generation
  - Impacts on electricity demands

- Indirect impact on energy prices
  - Impacts on water demand, use, and wastewater disposal
  - Impacts on water availability and variability

- Adaptation responses

- Mitigation policy
  - Cleaner energy
  - Energy efficiency
  - Land-use change
8.1 Background

8.1.1 About the electricity generation sector

The Australian electricity generation sector is currently dominated by coal-fired power stations using black and brown coal. Gas-fired power stations, along with some renewable energy sources (hydro, biomass, wind, solar, etc.), accounted for just 23% of the electricity generated in 2010 (Figure 22).

Figure 22: Current electricity production, by fuel source, Australia, 2010 (%)


Figure 23 shows the locations of current electricity generation facilities (with capacity over 200 MW). The main generators are highly concentrated in the Latrobe Valley in Victoria, in the Hunter region in New South Wales and in southern Queensland.
8.1.2 The use of water in electricity generation

Overall, the electricity and gas supply sector accounts for approximately 2% of water use in Australia (328 GL/year), most of which occurs in Victoria (123 GL), New South Wales (92 GL), Queensland (82 GL) and Western Australia (27 GL) (ABS 2011).

In the electricity generation sector, water is primarily used for cooling in thermal power stations. Most large generators rely on surface water, and they generally extract and store water on site. Where the water is used in cooling towers it is lost to the atmosphere as water vapour. Where a large body of water, such as a lake, is available, the warmed water can be returned to it. Some power stations located on the coast are cooled using seawater.

A limited number of generation plants employ relatively high capital cost air-cooled condensers. This technology means that water is only required for steam generation and not for cooling. This enables water consumption to be as much as 90% lower than in similar sized wet (water) cooled power stations. While these generators have allowed vastly more efficient use of water, they have higher energy use and costs and generate higher greenhouse gas emissions. Most electricity generators in the National Electricity Market are likely to continue to rely on water cooling for the foreseeable future (ACIL Tasman 2007).

Figure 24 summarises the estimated gross freshwater intensity (the volume of water needed to produce a given amount of power) for different generators, showing that coal-fired generation is significantly more water intensive than gas-fired generation. Smart and Aspinall (2009) note that the water requirements for new gas plants vary from negligible for open cycle gas turbine (OCGT) and combined cycle gas turbine (CCGT) with dry cooling to approximately 1 ML/GWh for CCGT with recirculating cooling.

Total water use by these generators is shown in Figure 25.
Figure 24: Indicative gross freshwater intensity, by generator, and average, by type (ML/GWh)

CCGT = new combined cycle gas turbine; CCS = carbon capture and storage.

Note: Some plants, such as Vales Point B, Munmorah and Eraring, have low freshwater use because they use seawater from Lake Macquarie.

Source: Frontier Economics analysis of Smart and Aspinall (2009) and CCSD (2007)
Figure 25: Indicative total gross freshwater use, by generator (GL/year)

CCGT = new combined cycle gas turbine; CCS = carbon capture and storage.

Note: Some plants, such as Vales Point B, Munmorah and Eraring, have low freshwater use because they use seawater from Lake Macquarie.

Source: Frontier Economics analysis of Smart and Aspinall (2009) and CCSD (2007)
Water use in electricity generation is highly concentrated geographically (particularly in the Latrobe Valley in Victoria and the Hunter Valley in New South Wales), so the water resource impacts of generation are more significant in specific localised water systems. For example, the Yallourn coal-fired power station in the Latrobe Valley extracts water at the rate of around 35 GL/year, which is equivalent to roughly 10% of Melbourne’s recent annual use. Hazelwood, also in the Latrobe Valley, extracts 26 GL/year.

Together, the brown-coal-fired power stations in the Latrobe Valley in Victoria extract around 115 GL/year (see Box 13). However, some generators provide return flows to river systems, including Yallourn, which returns about 15 GL/year. Return flows are not included in figures 24 and 25, which focus on the gross use of freshwater.

**Box 3: Water use and entitlements in the electricity generation sector in the Latrobe Valley**

Brown coal in the Latrobe Valley is used to generate about 90% of Victoria’s electricity. The existing power generation plants require large volumes of lower quality water for cooling, as well as a small volume of high-quality water for their boilers and on-site water use.

Gippsland Water supplies almost all the surface water for the power generation companies at Morwell (Energy Brix) and Hazelwood (International Power). Gippsland Water also meets the high-quality water needs at Yallourn (TruEnergy), Loy Yang A (Great Energy Alliance Corporation) and Loy Yang B (International Power/Mitsui), but those companies pump their own lower quality cooling water from the Latrobe River.

Water entitlements in the Latrobe system provide power generators with a proportional share of the storage capacity of Blue Rock Reservoir and Lake Narracan and inflows to those storages. Power generators’ water entitlements do not guarantee a minimum annual volume, so they must manage the risks of drought within their individual shares. Surface water use for power generation is typically about 95 GL/year. The Jeeralang gas power plant uses a minimal amount of water.

The Yallourn, Morwell and Loy Yang A power generation companies also hold licences to pump about 45 GL/year of groundwater to drain and stabilise their open-cut coal mines. In recent years, the volume of groundwater extracted has been up to about 30 GL/year.


### 8.1.3 Electricity generation and carbon emissions

The electricity generation sector is responsible for over a third of Australia’s total greenhouse gas emissions (Australian Government 2011:12).

However, there is significant variation in the emissions intensity of different types of electricity generation (Figure 26), and between individual generators using a particular fuel source. In particular, brown-coal-fired generation produces much higher greenhouse gas emissions per megawatt hour of electricity generated than gas-fired generation, while some renewable sources do not produce any emissions during operation.
8.1.4 Other important drivers in the electricity generation sector

Of all the sectors examined in this study, the electricity generation sector is the most affected by climate change mitigation policy. Indeed, the sector is a key focus for government policy to reduce emissions. Climate change policy will have major impacts on the sector in the future. However, the sector will also be affected by a range of other factors.

Total demand for energy is affected by overall economic conditions and the circumstances of particular industries that are high energy users, as well as by population growth.

Energy generation requires access to raw energy sources (be they fossil fuels, wind or energy embodied in water), so access to those resources and to other necessary inputs is a critical prerequisite for electricity generators.

Environmental and other regulatory approvals have a significant impact on the sector and its ability to invest in new plant.

Brown-coal-fired generators emit close to 1.3 kt CO₂-e/GWh. Gas-fired generators emit approximately 0.5 kt CO₂-e/GWh. Figure 26 highlights the fact that coal-fired generators will face higher carbon price impacts than cleaner gas-fired generators. However, coal-fired generation is very inexpensive compared to gas-fired generation and renewables.

8.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of carbon dioxide and other greenhouse gases. They include:

+ **cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (such as coal-fired electricity generation) to lower emissions intensity sources (for example, gas-fired or renewable electricity generation)

+ **energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

The mitigation policies that most acutely affect the electricity generation sector are the cleaner energy measures (that is, the carbon price and renewable energy scheme).

Energy efficiency measures also slow the growth in electricity demand and hence defer or delay the need for new generation investment. However, their impacts are included in the Commonwealth Treasury’s modelling of the impacts of the carbon price, and therefore are addressed in the analysis of the carbon price.

Land-use change measures could also affect the electricity generation sector. In particular, the *Clean Energy Future* (CEF) package could provide incentives for investment in accredited carbon offsets (see Section 10, Forestry). If plantations are developed in catchments containing electricity generators (for example, the Hunter catchment in New South Wales), surface water runoff and the reliability of water entitlements to generators could decrease.

8.2.1 Cleaner energy measures

The energy generation sector will be heavily and directly affected by the cleaner energy measures, which in turn may have impacts for the use and management of water and the supply of water-related services.

The following discussion examines these interactions by:

+ assessing the potential impacts of the cleaner energy policies on the future mix of energy generation

+ identifying the potential implications of those changes in the energy mix for the use and management of water

+ assessing the potential impacts on electricity prices, which may in turn have implications for the costs of providing water-related services and the demand for water by energy-intensive users (as discussed in detail in other sector assessments).

8.2.2 Impacts on the mix of electricity generation

Projections based on current policy settings

Under the CEF package, the carbon price in Australia will be fixed by legislation for the first three years of the scheme (2012–13 to 2014–15). Beyond that, the scheme moves to emissions trading (with a floating price) and the Australian price will then be set by the global market. Figure 27 shows the CEF carbon-price projection by the Commonwealth Treasury.
The Treasury projects the carbon price to remain less than $40/t CO\textsubscript{2}-e by 2020. Analysis undertaken for this study suggests that that level is not sufficient to encourage new wind or other renewables in their own right, as those technologies require a price greater than $80/t CO\textsubscript{2}-e based on current generation costs. Therefore, investment in renewables is being driven through complementary assistance under the Large-scale Renewable Energy Target (LRET), which applies independently of the carbon price.\textsuperscript{17}

The projected carbon price is also too low to drive the early closure of most existing coal-fired plant before 2020 without additional measures, such as the Contract for Closure Program (which is part of the CEF package).

In the light of this, the expected direct effects of cleaner energy policies on the electricity sector are as follows:

+ There will be a slowing of projected electricity demand growth due to price increases.

+ There will be minimal requirements for new baseload capacity from large coal- or gasfired plants. Most of the new capacity required to meet baseload demand over the next decade is expected to come from wind farms incentivised through the LRET. This may require a limited quantity of new complementary capacity, such as gas plant, energy storage or demand-side response, since wind is not a reliable source for peak demand because it only generates when the wind blows.

+ The Contract for Closure Program may lead to the early closure of up to 2000 MW of emissions-intensive generation capacity, if the prices bid are acceptable (which may not be the case).

Figure 28 gives an indication, derived from Treasury modelling, of the projected generation mix.\textsuperscript{18} Without a carbon price (left side of the figure), the generation mix is relatively stable and the current mix is largely unchanged. With a carbon price (right side of the figure), there is a declining share of coal generation and a rising share of renewables (and gas).

\textsuperscript{17} Strictly speaking, a combination of design factors means that the LRET target may not be met. A potential shortfall may arise due to a combination of the current surplus of certificates in the LRET market (around 40 million, due to a glut of small-scale certificates created in 2010, which prompted the separation the small-scale scheme), the end of the LRET in 2030, and a declining real penalty price for noncompliance.

\textsuperscript{18} This excludes the Contract for Closure Program.
The absolute impact on the generation mix (Figure 29) shows that, in the absence of a carbon price (or the expectation of a carbon price), coal-fired generation would grow in line with overall energy demand growth, and almost all demand growth would be met with new coal-fired generation. The introduction of a carbon price slows this growth.
The projected new generation mix without a carbon price (Figure 30) is dominated by coal and to a lesser extent gas. With a carbon price, almost all growth in electricity demand is met with renewables and gas. There is no new coal without carbon capture and storage (CCS), and generation from existing coal-fired assets is negative in the long run (which represents plant closures/replacements).

**Figure 30: Change in generation relative to current mix, 2012 to 2050 (TWh)**

![Generation Mix Change](image)

Note: Estimates are adapted from Chart 4.13 (% generation mix without carbon), Chart 5.19 (% generation mix with carbon), Chart 4.11 (TWh generation sent out, without carbon) and Chart 5.17 (change in electricity demand from reference case, in petajoules). These are indicative estimates only.


The change in the projected future generation mix (with a carbon price) relative to the reference case shows similar results (Figure 31).

**Figure 31: Change in future generation with a carbon price, relative to the reference case, 2013 to 2050 (TWh)**

![Future Generation Change](image)

Note: Estimates are adapted from Chart 4.13 (% generation mix without carbon), Chart 5.19 (% generation mix with carbon), Chart 4.11 (TWh generation sent out, without carbon) and Chart 5.17 (change in electricity demand from reference case, in petajoules). These are indicative estimates only.

Figure 32 shows the estimated change from the current mix, but with renewable energy split by generation type. After 2020, some geothermal generation is projected; from 2030, a small volume of solar thermal generation is projected.

**Figure 32: Change in generation relative to the current mix (with renewables split), 2011 to 2050 (TWh)**

Note: Estimates are adapted from Chart 4.13 (% generation mix without carbon), Chart 4.14 (% renewable mix without carbon), Chart 5.19 (% generation mix with carbon), Chart 4.11 (TWh generation sent out, without carbon) and Chart 5.17 (change in electricity demand from reference case, in petajoules). These are indicative estimates only.

Sensitivity of projections

The foregoing analysis of the likely future generation mix is based on projections of a carbon price consistent with the current policy settings established under the CEF package. Were there to be significant changes to mitigation policy in the future (for example, a significant increase in the carbon price, or targeted assistance to particular technologies), then there would be changes in the expected energy generation mix. Similarly, major technological changes in energy generation could also substantially change the future generation mix.

8.2.3 Possible water-related impacts and policy implications of changes in the energy generation sector

In the context of this study, the likely change in the mix of energy generation sources arising from mitigation policy is important because of its consequent impact on the use and management of water resources.

In general, the introduction of a carbon price (and other mitigation policies) should slow the growth in water demand from electricity generation. This is driven by:

+ slower growth in energy demand, due mostly to energy efficiency measures (and to an extent due to higher electricity prices, as discussed below)

+ a shift towards renewable energy sources (mostly driven by the renewable energy target) and new gas-fired rather than coal-fired generation. Both renewables and gas are generally less water intensive than new coal-fired generation.

The impact of the carbon price on output from individual generators (and hence their water use) is not evident from the results reported by the Treasury, and additional modelling was not undertaken as part of this project. Given the variance in water use by existing plants, it is difficult to estimate the water consumption impacts of plant closures without knowing which plants are projected to close or reduce production as a consequence of the introduction of a carbon price. Nevertheless, some general observations can be made about the water-related implications of both the expected switching to gas-fired generation and the greater takeup of renewable energy.

Switching from coal-fired generation to gas-fired generation

In the short term, the main impacts on water use relate to a potential switch from coal- to gas-fired generation and renewables (mainly wind energy). In general, that change will reduce aggregate water demand because coal-fired generation is typically an intensive water use (2–3 ML/GWh). Wind and some gas-fired technologies (such as OCGT and CCGT with dry cooling) have very limited water requirements. However, some gas-fired generation technologies do have substantial water requirements (for example, CCGT with recirculated cooling uses up to 1 ML/GWh), which could create significant additional localised water demands (Smart and Aspinall 2009).

Some domestic gas-fired electricity generation may be sourced from gas extracted from coal seams in New South Wales and particularly in Queensland. The water-related issues associated with coal seam gas extraction are significant and are discussed in Section 9.

The overall impact on water will also depend on whether a power station uses fresh or saline water cooling. For example, Hazelwood uses fresh water cooling but Playford uses saline cooling. In addition, existing coal-fired generators have highly localised water demands. There is a question about what might happen to their water entitlements and usage if they are shut down or if output is reduced.

The location of gas-fired generation facilities is flexible, so it may be that existing water demand from coal-fired power stations will be replaced by demand from new gas-fired generators. However, where that approach is not taken, there may be large localised demand from new gas-fired generators and large reductions in demand from existing coal-fired power stations. In its review of the impacts of climate change policies on energy market frameworks, the Australian Energy Market Commission found that access to cooling water will have a major influence on the location of new generators, and that the cost of water can influence long-run operating costs (AEMC 2009).

Figure 33 shows the potential locations of new electricity generators with capacity greater than 200 MW by type, based on Geoscience Australia data. It is unclear whether these potential sites are based on the impacts of a carbon price signal, and there is no probability attached to the likelihood of each facility being commissioned.
Water planning and entitlements frameworks need to be developed with these potential changes in mind. Access to well-designed water markets would enable the flexible movement of water. For example, the independent panel reviewing the Gippsland Sustainable Water Strategy (which covers the Latrobe Valley in Victoria) called for ‘standardising the entitlements held by power generators to create a broader water market allowing all water users better opportunities to adapt to future water needs’. While acknowledging that it was a complex issue that may take time to resolve, the panel stated that ‘power generators hold substantial volumes of water and their ability to participate in water trading is currently constrained’ (Forster et al. 2011).
Greater takeup of renewable and other new energy sources

As noted above, most of the renewable energy target is likely to be met initially through wind energy development. Wind energy generation requires little or no water (except for relatively small quantities, such as to clean turbine blades in arid and semi-arid areas, and for amenities in control rooms etc.).

In the longer term, geothermal, solar thermal and carbon capture and storage technologies could come on line. Some solar thermal technologies (that heat water to generate steam or require water to wash mirrors) require significant amounts of water. This is a constraint to their development and deployment in Australia, where locations with the best solar resources have very little water.

The Victorian Government’s (2011) Gippsland Sustainable Water Strategy identified potential for a range of emerging technologies, including:

+ geothermal energy
+ carbon capture and storage
+ underground coal gasification/liquefaction
+ coal seam (methane) gas
+ coal-to-liquids.

These technologies would increase localised water demands and create potential interactions with surface water and groundwater sources (see Box 4). As noted by the Victorian Government (2011), each option raises new challenges for the licensing and management regime for groundwater under the Victorian Water Act 1989.

As with coal seam gas, it is important that water planning, regulation and entitlements are established to deal with such issues before they arise.

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**Box 4: The impacts of carbon capture and storage, geothermal electricity generation and solar-thermal generation on water resources**

**Carbon capture and storage**

Carbon capture and storage (CCS) refers to methods of capturing and storing carbon dioxide emitted by power stations before its release to the atmosphere. Options include storage in the ocean, storage deep underground and subjecting carbon dioxide to chemical reactions to produce inorganic carbonates. However, there are some financial impediments deterring the development of CCS projects. The slow pace and significant cost of demonstrations and deployments of such systems mean that large-scale development is highly uncertain (Stephens and Jiusto 2010).

It is generally acknowledged that power plants using CCS systems require additional water withdrawals and water consumption, and that the amounts can vary. Most of the increased water use is to meet the cooling requirements of the CCS system. Current estimates of additional water consumption range from 0.83 ML/GWh to 1.40 ML/GWh for the implementation of a CCS system at a supercritical pulverised-coal power plant (Bennett et al. 2007, Zhai et al. 2011). Zhai et al. (2011) indicate that the addition of an amine-based CCS system can potentially double water consumption at a coal-fired plant. Coal is the most widely used fuel for electricity generation in Australia.

In general, the impacts of increased water consumption due to the introduction of CCS at some of Australia’s coal-fired generators at some stage in the future could be constrained by water availability, particularly during times of drought.

**Geothermal**

A geothermal system comprises three elements: an underground heat source, permeable rock, and a fluid to transport heat to the surface. There are hydrothermal systems and hot rock systems (also known as engineered geothermal systems, or EGSs). Hydrothermal systems rely on naturally occurring hot water or steam circulating through permeable rock, whereas EGSs produce superheated water or steam by introducing fluid from outside the system and circulating it through the rock (Geoscience Australia 2007).
Box 4: The impacts of carbon capture and storage, geothermal electricity generation and solar-thermal generation on water resources

Geothermal continued

Hydrothermal systems are readily found in Australia but are unusable because they are neither hot enough nor possess sufficient pressure to produce the large amounts of steam required (Geoscience Australia 2007). Therefore, investment in geothermal plant in Australia has primarily been made via EGSs. Essentially, EGSs involve the pumping of external water down an injection well into hot rocks deep in the earth to be heated and returned via a production well. The hot water returned from the production well heats up a secondary fluid (called the ‘working fluid’), which is converted into high-pressure steam, which is used to spin turbines to produce electricity.

The most recent investment projects have been in South Australia (the Innamincka Project by Geodynamics, the Paralana Project by Petraetherm and the Penola Project by Panax Geothermal). Investment in EGSs, however, is a costly exercise and may not proceed as quickly in the short term based on currently forecast energy and carbon prices. One inhibitor of EGS growth is the high cost of drilling. This is estimated to account for a third to a half of projected costs of EGSs, and is a significant challenge to the technology. Drilling for EGSs is more difficult than the drilling involved in oil and gas exploration due to both corrosion and the large diameter of pipes required for sufficient flow rates (Tester et al. 2005, cited in Stephens and Jiusto 2010).

The type of power plant in Australia most suited to complement the EGSs is the binary-cycle plant (RPS Aquaterra and Hot Dry Rocks 2012). From a water perspective, if such investment in EGSs proceeds, investors must be aware of water requirements for EGS development and for cooling binary-cycle plants.

According to Cordon and Driscoll (2008), EGS development water requirements for drilling and construction are approximately 280 ML (based on a three-bore configuration with 8.5 inch borehole diameters for production wells). Though EGSs are characterised by closed-loop systems, water losses can still occur. This implies that EGS projects may require a permanent source of water to make up such water losses.

Water use for cooling depends on the type of coolers used by the binary-cycle plant. Coolers include air-cooled radiators, heat exchangers and cooling towers, and water-use figures for each cooling process are quite varied. For example, the Birdsville Power Plant in Queensland is air-cooled, and no water is required for that process. However, a once-through cooling system (although unlikely to be used in an Australian geothermal plant) can potentially require 50 litres per second per megawatt. Other water requirements include dosing systems, which can consume 0.1–0.2 litres per second per system in the absence of condensate.

The estimates for water use (on a per gigawatt basis) vary significantly depending on the cooling processes employed (Macknick et al. 2011). To produce 1 GWh of energy, EGSs using cooling-tower technology would require 10.9–19.5 ML of water, EGSs using dry-cooling technology would require 1.1–6.7 ML, and those using hybrid cooling technology would require 3.1–7.6 ML. For binary-cycle units, plants with cooling towers would require 6.4–15.0 ML of water to produce 1 GWh of energy, plants with dry-cooling would require 0.0–1.0 ML, and plants with hybrid cooling would require 0.3–1.4 ML.

Solar thermal

Solar thermal technology converts solar radiation into thermal energy (heat). Solar thermal systems, also known as ‘concentrating solar power’ systems, are typically designed for large-scale power generation (Geoscience Australia 2012). Concentrating solar power is a relatively recent and little-used technology and is costly compared to other forms of generation (Williges et al. 2010).

There are four types of concentrating solar power technology: parabolic trough; power tower; parabolic dish; and compound linear Fresnel reflectors. Parabolic-trough technology is the most prevalent globally. The most water-friendly is the parabolic dish setup, which uses up to 95% less water than the others.

There is a wide range of estimates for water use in such technologies. Parabolic-trough systems use 2.9–5.0 ML/GWh (Purohit and Purohit 2010, US DOE 2011). Power-tower systems use 2.6–4.1 ML/GWh (US DOE 2011). The estimates for these two systems include water consumption for recirculation, combination hybrid parallel systems, and air cooling.

Parabolic-dish systems use about 80 L/GWh, and the water is used for the washing of mirrors (US DOE 2011). Compound linear Fresnel reflectors require 2.8–3.79 ML/GWh for recirculating cooling processes (US DOE 2011, Purohit and Purohit 2010).

* The exception is the Penola project at Otway Basin (South Australia), in which the operation of the geothermal plant is intended to be based on hot sedimentary aquifer technology. Hot sedimentary aquifer systems are a subset of hydrothermal systems.
Electricity generation

Biomass is a potential fuel source for renewable electricity generation. For example, Delta Electricity co-fired the Wallerawang power station with coal and biomass from mallee eucalypts as part of a trial growing mallee as a biomass crop. This pilot demonstrated that new technology in biomass processing and changes to power station plant had the potential to displace over 20% of coal usage without affecting the continuity and quality of electricity supply (Delta Electricity 2011). Biomass generation is considered carbon neutral because the carbon dioxide generated from burning biomass is carbon that had previously been sequestered during the growth of the biomass crop.

Biomass co-firing, at around $75–$120/MWh, may be cost competitive with wind generation and will similarly be incentivised by the clean energy policy price on carbon because it is carbon neutral. Given the water used to grow the biomass, this will potentially have water policy implications. However, in the example of the use of mallee eucalypt, the biomass source generally has positive water management outcomes, such as assisting in salinity management in low-rainfall zones.

Table 12 summarises the plausible changes in the energy generation sector and impacts on water requirements associated with climate mitigation policy.

Table 12: Summary of the potential impacts of a carbon price on electricity generation sources and water demand

<table>
<thead>
<tr>
<th>Source</th>
<th>Impact of cleaner energy policies</th>
<th>Impact on water demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Significant reduction and potential early plant closure.</td>
<td>Localised reductions in water demand.</td>
</tr>
<tr>
<td>Gas</td>
<td>Increase in gas-fired generation.</td>
<td>Gas is less water intensive than coal but the impacts depend on the location of new investment.</td>
</tr>
<tr>
<td>Wind</td>
<td>Likely to increase due to renewable energy target.</td>
<td>Minimal water impacts.</td>
</tr>
<tr>
<td>Hydro</td>
<td>Unlikely to increase significantly due to the absence of cost-effective sites.</td>
<td>Minimal change in water impacts.</td>
</tr>
<tr>
<td>Coal and gas CCS</td>
<td>May come on line in the long term or if government invests directly, but significant uncertainty.</td>
<td>CCS impacts on groundwater are potentially significant, and there is potential for doubling of water use by generators with CCS, creating significant pressure on water resources. However, new investment is unlikely to occur for many years or decades, given the current status of the technology.</td>
</tr>
<tr>
<td>Biomass</td>
<td>May come on line in the long term or if government invests directly, but significant uncertainty.</td>
<td>Uncertain (water use depends on the location and the energy conversion processed used).</td>
</tr>
<tr>
<td>Solar thermal and geothermal</td>
<td>May come on line in the long term or if government invests directly, but significant uncertainty.</td>
<td>Water use depends on individual generators. Many of these sources can be designed for minimal net water usage. Geothermal and solar thermal impacts on groundwater are potentially significant, although new investment is unlikely to occur for many years.</td>
</tr>
</tbody>
</table>

8.2.4 Energy price impacts

The Australian Government’s cleaner energy policy measures (including a carbon price) will also have an impact on electricity prices. This may in turn have implications for the costs of providing water-related services that rely on electricity, for the demand for water by energy-intensive users (discussed in detail in other sector assessments), or both. The following discussion assesses the likely effects of the carbon price on electricity prices, which provides a basis for analyses of potential impacts in other sector assessments.

The electricity price effects will vary with the carbon price. After international linkage to other emissions trading schemes (as proposed from 2015), the carbon price will be determined globally. There is considerable uncertainty about the appropriate price to use for analysis, but this study has adopted the carbon price and average electricity price projections from modelling by the Commonwealth Treasury (Figure 34).

The key scenarios for comparison are:
+ ‘Global action’ (which assumes no domestic carbon price)
+ ‘Government policy’ (which reflects the $23/t CO₂-e starting price and the additional government policies).
The underlying data for Figure 34 is shown in Table 13 for selected years as national averages for wholesale prices. The figures show a 40% increase in wholesale electricity prices by 2015, 29% by 2020, and 62% by 2030.

Table 13: Average wholesale electricity prices, by scenario ($/MWh)

<table>
<thead>
<tr>
<th>Year</th>
<th>No carbon ('Global action')</th>
<th>Clean Energy Future (final package, $22/t CO₂-e)</th>
<th>Government policy (additional government measures)</th>
<th>High price (higher global carbon price)</th>
<th>% change (&quot;Government policy&quot; versus 'No carbon')</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>0%</td>
</tr>
<tr>
<td>2012</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>0%</td>
</tr>
<tr>
<td>2013</td>
<td>44</td>
<td>63</td>
<td>63</td>
<td>74</td>
<td>43%</td>
</tr>
<tr>
<td>2014</td>
<td>44</td>
<td>65</td>
<td>64</td>
<td>74</td>
<td>45%</td>
</tr>
<tr>
<td>2015</td>
<td>47</td>
<td>66</td>
<td>66</td>
<td>75</td>
<td>40%</td>
</tr>
<tr>
<td>2020</td>
<td>52</td>
<td>67</td>
<td>67</td>
<td>99</td>
<td>29%</td>
</tr>
<tr>
<td>2030</td>
<td>68</td>
<td>107</td>
<td>110</td>
<td>129</td>
<td>62%</td>
</tr>
<tr>
<td>2040</td>
<td>74</td>
<td>141</td>
<td>141</td>
<td>165</td>
<td>91%</td>
</tr>
</tbody>
</table>


The average wholesale and household price impacts by state are shown in Table 14. This generally suggests that wholesale electricity costs are around 20%–30% of household electricity costs (which also include transmission, distribution and retail costs).
Table 14: Average wholesale and household electricity prices (by state)

<table>
<thead>
<tr>
<th>Region</th>
<th>2013–17</th>
<th>2018–22</th>
<th>2046–50</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>10</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>Vic.</td>
<td>11</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>Qld</td>
<td>11</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>WA</td>
<td>10</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>SA</td>
<td>9</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Tas.</td>
<td>9</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>NT</td>
<td>9</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>Average</td>
<td>10</td>
<td>8</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>2013–17</th>
<th>2018–22</th>
<th>2046–50</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>39</td>
<td>35</td>
<td>122</td>
</tr>
<tr>
<td>Vic.</td>
<td>46</td>
<td>39</td>
<td>84</td>
</tr>
<tr>
<td>Qld</td>
<td>49</td>
<td>43</td>
<td>122</td>
</tr>
<tr>
<td>WA</td>
<td>33</td>
<td>37</td>
<td>101</td>
</tr>
<tr>
<td>SA</td>
<td>41</td>
<td>35</td>
<td>68</td>
</tr>
<tr>
<td>Tas.</td>
<td>42</td>
<td>43</td>
<td>80</td>
</tr>
<tr>
<td>NT</td>
<td>43</td>
<td>38</td>
<td>107</td>
</tr>
<tr>
<td>Average</td>
<td>39</td>
<td>35</td>
<td>122</td>
</tr>
</tbody>
</table>

Source: Treasury (2011: tables 5.15 and 5.14); based on reported scenario of ‘Government policy % change from No carbon’. Implies that wholesale costs are approximately 20% of household costs.

These projected increases in electricity prices provide a basis for assessments of impacts on other sectors that use both electricity and water, and for urban and rural WSPs (see sections 12 and 13).

8.2.5 Summary assessment of water-related impacts of mitigation policy in the electricity generation sector

Table 15 summarises the potential water-related interactions of climate change mitigation policy as it affects the electricity generation sector.

Table 15: Assessment of mitigation policy interactions in the electricity generation sector

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Changes in water demand and use due to impacts of carbon price on electricity demand and relative cost of fuel sources.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>Likely to be a reduction in water demand in existing coal-fired generation capacity, which is concentrated in the Latrobe Valley in Victoria, south-east Queensland and the Hunter region of NSW. Gas-fired generators are somewhat flexible in their location and may simply replace existing coal-fired plants at the same sites, partly offsetting the reduction in demand. In the future, solar thermal and geothermal sources may develop in various locations around Australia, thereby increasing water demand.</td>
</tr>
<tr>
<td>Location</td>
<td>Impacts will occur progressively upon the introduction of the carbon price. The CEF includes the potential early shutdown of some coal-fired generation capacity in the short term. Renewable energy sources (other than wind, which does not use water) are not expected to come on line in the short to medium term. In particular, geothermal, CCS and solar thermal technologies may have water impacts but they are unlikely to develop in the short term without government subsidies.</td>
</tr>
</tbody>
</table>
Electricity generation

8.2.6 Implications of current water policy for the implementation of mitigation policy

It is important to consider the implications of current water policy settings for the effective and efficient implementation of mitigation policy. A number of implications are important.

In the short term, water availability is critical for many coal- and gas-fired generators, and having clear and flexible water policy settings (including water entitlements and markets) will be important in enabling the transition to lower emissions generation, including the potential increase in gas-fired generation. Ensuring that there are adequate means of allocating water to competing interests (for example, electricity, agriculture and the environment) and dealing with the potential impacts of water issues associated with coal seam gas (see Section 9) will also be important to optimising investment in cost-effective greenhouse gas abatement measures.

In the longer term, clear and effective water policy settings for renewable sources such as solar thermal and geothermal, as well as for carbon capture and storage, will be important in enabling those sources to contribute to national mitigation efforts. If these matters are not addressed in advance, water issues may slow the transition to cleaner energy sources.

8.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise from adaptation policy and responses to climate change as they affect the electricity generation sector. Following the framework set out in Section 4, this involves:
+ identifying and categorising the potential impacts and risks of climate change as they affect the electricity generation sector
+ identifying the likely autonomous and policy responses to adapt to those changes
+ assessing the consequent water-related impacts and possible water policy issues.
8.3.1 Potential impacts of climate change on electricity generation

Climate change is forecast to have short- and long-term effects on natural variables, including more variable rainfall patterns, more frequent and intense storms, more heatwaves, increased risks of bushfires, a gradual increase in average temperatures and a gradual increase in sea level.

These potential changes pose a number of risks to the electricity generation sector. Broadly, the risks arise from:

+ changes in water availability and variability for electricity generators
+ changes in temperatures and extreme weather, which raise electricity demand and pose risks to the performance of energy generation and related assets—which in turn may affect the price and continuity of the supply of electricity.

Impacts on water availability and security

Climate change is projected to decrease rainfall and snowfall, increase rainfall variability, and reduce runoff in many areas of Australia. Reduced rainfall and runoff would reduce the reliability of water entitlements for thermal generators and reduce the water available for hydro-electricity generators.

In general, there is significant uncertainty in the climate change modelling, and the key issue for generators that rely on surface water is the potential for an increase in the severity, frequency and duration of droughts.

Some generators (for example, those in the Hunter Valley in New South Wales) have water licence conditions that enable extraction and discharge only when river heights exceed specific thresholds. During recent droughts, this led to increasingly limited water availability for those generators.

Risks to assets and their performance

The incidence of extreme weather is projected to increase under climate change. It may pose risks to electricity generation and related assets and their ability to maintain supply. For example, projected increases in average temperatures and the incidence of extreme weather (such as increased floods and storms) might result in a higher frequency of plant shutdowns. There are also significant risks to electricity networks from the expected increase in numbers of bushfires. Smoke and flames can cause 'flashovers' (between conductors and from conductors to ground), interrupting the operation of the network. Bushfires also increase the likelihood of multiple line outages within a short period, and hence the likelihood of supply interruptions. In more extreme cases, the heat from a severe bushfire can damage transmission line towers, which could result in prolonged outages until the towers can be repaired or replaced.

Some generators might be susceptible to floods and sea level rises that may become more prevalent under climate change, although most generators are thought to be located well above sea level.

Extreme events may also reduce the ability of transmission and distribution systems to deliver electricity (for example, thermal limits on transmission lines may mean that the lines are ‘derated’ on very hot days). Incidents affecting distribution systems may lead to more localised outages.

Electricity outages may have a significant impact on the ability of WSPs to maintain the continuity of supply of water-related services (see Section 12). Outages of particular plants may also lead to spikes in spot electricity prices.

An increase in temperatures and an increase in the number of hot days are also likely to increase electricity demand (for example, for air conditioners). This may also increase peak electricity demand, which is often met by hydro-electric and gasfired generators. The implications of this will largely play out in the electricity market and in the resulting prices paid by electricity consumers. However, there may also be implications for WSPs, which use energy as an input for water treatment and pumping, as well as for users that are major consumers of both electricity and water (see Section 12).
8.3.2 Adaptation responses and policies

Key issues are how individual generators and others adapt to these changes and what implications that may have for the use and management of water and the supply of water-related services.

Secure water supplies are essential for electricity generation. The recently released National Energy Security Assessment (DRET 2011) found that a number of the impacts affecting the 2009 National Energy Security Assessment, such as the drought, had largely passed the acute phase. For the future, generators have strong incentives to ensure that they are not susceptible to short-term production constraints or shutdowns due to limited water access. Low-cost adaptation responses by generators might include:

- using water markets to secure water requirements within the existing water system
- applying for increases in licensed volumes/entitlements (in uncapped surface water and groundwater systems).

If those options are not available or are insufficient, higher cost adaptation responses might include:

- increasing connectivity to other water systems (such as by constructing pipelines)
- switching to dry-cooled generation (which is more energy intensive)
- investing in onsite recycling and reuse (which will increase auxiliary power use and greenhouse gas emissions).

The specific adaptation responses made by existing generators would depend on the costs and benefits of alternative courses of action and would require case-by-case assessment.

In addition, investors in new capacity are likely to consider the security of water supplies in deciding where to locate new generation facilities and the type of technology employed. Gasfired generators have more locational flexibility (compared to coal-fired plant), so water availability is likely to be a key factor influencing location.

A number of other parties are also involved in adaptation responses to climate change in the energy generation sector. Planning for and maintaining power system security and reliability and dealing with contingency events is a key responsibility of the Australian Electricity Market Operator (AEMO). The AEMO has extensive powers to intervene in the processes of the spot market and issue directions to registered participants so as to maintain or re-establish a secure and reliable power system. In some circumstances, this may include involuntary load-shedding. Furthermore, the AEMO is required to publish the Energy Adequacy Assessment Projection, which is based on rainfall scenarios for the next two years (Box 5).

Box 5: The Energy Adequacy Assessment Projection

The purpose of the Energy Adequacy Assessment Projection is to provide greater transparency and more information to the market. It is a projection of the AEMO’s assessment of energy availability that accounts for energy constraints for each month over a 24 month period. The projection is based on three rainfall scenarios: low rainfall, short-term average rainfall and long-term average rainfall. Energy availability is measured in ‘unserved energy’ for each National Electricity Market region, as unserved energy is the key indicator of energy adequacy in the National Electricity Market.

Adequate availability is indicated by an unserved energy figure that is less than the reliability panel standard of 0.002%. This standard requires that, over a 12 month period, no more than 0.002% of each National Electricity Market region’s energy demand is unserved due to supply shortfalls.

Electricity users (including WSPs) also have various strategies open to them to adapt and manage physical supply risks. For example, water supply businesses may ensure that backup sources of power are available for critical assets and that plans are in place to deal with unanticipated interruptions to electricity supply.

The financial risks associated with potential spikes in spot electricity prices accompanying extreme events are matters for market participants to manage. Water supply businesses as electricity consumers manage those risks through their contractual arrangements with electricity suppliers.
8.3.3 Possible water policy issues

Existing electricity generators will seek to respond and adapt to the impacts of climate change. The adaptation responses will vary based on the type of electricity generation facility and its location, and particularly in relation to the availability of water resources and alternative supplies.

The key issue from a water policy perspective is whether all of the relevant water-related adaptation options are available. In particular, if electricity generators do not have access to lower cost adaptation options such as those offered by greater integration with water entitlements and water markets, their cost of adaptation is likely to increase significantly (if, instead, governments decide to freely grant water to generators during dry periods, then adaptation costs to other water users are high). Furthermore, if those options are not available, it is more likely that generators will need to invest in options that are not only more expensive, but also more energy intensive (for example, switching to dry cooling or investing in recycling and reuse).

Table 16 summarises the adaptation responses and potential water policy implications. These water policy implications are addressed in more detail in Section 6 in Part A of this report.

Table 16: Summary of interactions between energy, water resources and climatic impacts/adaptation

<table>
<thead>
<tr>
<th>Generator type</th>
<th>Interactions with water supply and use</th>
<th>Climatic impacts and adaptation responses</th>
<th>Potential water policy issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Generally highly dependent on water sources for cooling.</td>
<td>Generators will seek to secure water supplies if there is a reduction in water availability or more frequent droughts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>There are a number of alternative supply options, such as recycled water, saline water, seawater, groundwater and connection to other surface water systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>There is also potential to consider air cooling as an alternative to water cooling, although this entails lower efficiency or higher cost.</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>Generally highly dependent on water sources for cooling.</td>
<td>As above for coal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>In addition, investors in new plant are likely to consider water availability and the impacts of climate change in their decisions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature-related impacts of climate change may increase peak demand for electricity, which is likely to be met by gas-fired plants.</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>n.a.</td>
<td>Wind energy may be more competitive if water availability limits the development of other sources.</td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td>Water supplies drive generation.</td>
<td>Any reductions in rainfall and runoff could have an impact on hydro-generation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature-related impacts of climate change may increase peak demand for electricity, which is likely to be met by hydro-electric plants.</td>
<td></td>
</tr>
<tr>
<td>Coal and gas CCS</td>
<td>CCS adds to water requirements and has interactions with groundwater.</td>
<td>Reduced water availability may have implications for the viability of CCS.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highlights the need to ensure that effective and sustainable water planning and entitlements regimes are in place before CCS investments occur.</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>Water interception and use by biomass crops.</td>
<td>Potential changes in the viability of agricultural land for the cultivation of fuel crops.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential changes in interception due to changes in land use.</td>
<td></td>
</tr>
<tr>
<td>Solar thermal and geothermal</td>
<td>Various interactions with surface water and groundwater.</td>
<td>Reduced water availability and higher temperatures may have implications for the viability of solar thermal and geothermal generation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Highlights the need to ensure that effective and sustainable water planning and entitlements regimes are in place before these investments occur.</td>
<td></td>
</tr>
</tbody>
</table>
8.3.4 Summary assessment of climate change adaptation impacts in the electricity generation sector

The key adaptation impacts for the energy generation sector as a whole are summarised in Table 17.

### Table 17: Summary assessment of adaptation interactions in the energy generation sector

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Nature of impact</th>
<th>Location</th>
<th>Likelihood/timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>Changes in water availability pose a risk to electricity generation, particularly in times of drought</td>
<td>Existing generators are located around Australia. Generators in southern Australia are</td>
<td>Risks are expected to gradually increase due to climate change.</td>
</tr>
<tr>
<td></td>
<td>(which generally correspond with higher energy demands).</td>
<td>likely to experience the most significant reductions in water availability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The potential for increased flooding and storms due to climate change also poses a threat to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>electricity generators.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes in temperature may affect peak energy demand and the sources that provide</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>peaking capacity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>The reliance of existing electricity generators on water means that they are likely to consider a</td>
<td>The recent drought highlighted the reliance of the electricity generation sector on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>range of adaptation responses to avoid temporary shutdowns during droughts. The costs will vary</td>
<td>secure water sources.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>depending on the specific circumstances facing each generator and the adequacy and flexibility of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>water policy settings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>climate change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>impact compared</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to other drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>Potentially very high, given the importance of energy security to the Australian economy.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Potential policy issues

<table>
<thead>
<tr>
<th>Water policy issues</th>
<th>Enabling water to move to its highest value use without undermining the rights of existing users or adversely affecting the environment and other third parties.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current water tools</td>
<td>Water planning, entitlements and markets. Water-related environmental regulation.</td>
</tr>
<tr>
<td>Existing knowledge of the issue</td>
<td>The recent drought highlighted the reliance of the electricity generation sector on secure water sources.</td>
</tr>
<tr>
<td>Overall policy assessment</td>
<td>Increases the need for electricity generation to be integrated into water planning and access entitlements arrangements and for generators to be able to access water markets.</td>
</tr>
</tbody>
</table>

8.4 References


Electricity generation


9 Mining and minerals processing

The Australian mining and minerals sector is developing rapidly. Access to water is vital for mining, and there is a current and well-known need for the mining sector to be better integrated into water planning, entitlements and market arrangements. The impacts of climate change on water availability and temperature add to that imperative. Without efficient and sustainable water resource management arrangements in place, there are increased risks to the economic benefits provided by mining, to other water users (such as irrigated agriculture), and to the environment.

Climate change is also driving the need for improved water planning and regulation in the mining sector. International mitigation efforts are likely to increase demand for coal seam gas from Queensland and New South Wales, and coal seam gas developments have well known water management issues that need to be addressed. To the extent that mitigation policy results in early mine closures in the coal sector, problems involving mine pit water management and acidification may need to be addressed earlier than previously envisaged. Furthermore, stronger or more frequent storms associated with climate change may create additional pressure on the management and regulation of tailings dams, particularly for opencut mines in the tropics, including uranium and base metals mines.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian mining sector in order to:

+ provide background on the mining and minerals sector and its relationships with water, energy and emissions (Section 9.1)
+ identify, describe and assess the significance of interactions associated with mitigation policy, and identify relevant water policy implications (Section 9.2)
+ identify, describe and assess the significance of interactions associated with climate change impacts and adaptation responses, and identify relevant water policy implications (Section 9.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

Figure 35 summarises the interactions identified in this assessment.
Figure 35: Summary of interactions in the mining sector

- Changes in climatic variables
  - Impact on water assets and service performance
  - Impact on water supply and demand
  - Land-use change
- Mitigation policy
  - Cleaner energy
  - Energy efficiency
- Direct liability for fugitive emissions
- Indirect impact on energy prices
- Adaptation responses
- Changes in water demand, water extraction and use, water quality and discharges/releases
- Changes in climatic variables
  - Impact on water supply and demand
  - Water policy implications
- Changes in mine viability, assets, production and management practices
- Energy efficiency

Water policy implications
9.1 Background

9.1.1 About the mining sector

The Australian mining sector comprises a variety of small to very large companies involved in extracting natural minerals (for example, coal and ores), liquids (such as crude petroleum) and gases (for example, natural gas) for sale to domestic and international customers or for further processing. Key mining products include black coal, iron ore, bauxite, alumina and natural gas.

The Australian mining industry makes a major contribution to the Australian economy, and much of its production is exported. Major markets for Australian minerals and petroleum include Japan (25% of total mineral exports by value), China, South Korea and India (ABS 2010a). The value of mining exports tripled (to $117.6 billion) in the four years to 2008–09.

Table 18 lists the mining and minerals subsectors examined in this study.

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Main locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore</td>
<td>WA (established) and SA (growing)</td>
</tr>
<tr>
<td>Gas (coal seam)</td>
<td>Qld and NSW</td>
</tr>
<tr>
<td>Gas (conventional)—on-shore</td>
<td>NT, Qld, SA</td>
</tr>
<tr>
<td>Gas (conventional)—off-shore</td>
<td>WA, Vic.</td>
</tr>
<tr>
<td>Coal (open pit)</td>
<td>NSW, Qld, SA, Vic., WA</td>
</tr>
<tr>
<td>Coal (underground)</td>
<td>NSW, Qld</td>
</tr>
<tr>
<td>Base metals (zinc, copper, lead, nickel, manganese)</td>
<td>Across Australia</td>
</tr>
<tr>
<td>Uranium</td>
<td>Olympic Dam (SA) and Ranger (NT)</td>
</tr>
<tr>
<td>Mineral sands</td>
<td>WA, Vic.</td>
</tr>
<tr>
<td>Bauxite, alumina</td>
<td>Qld, NT, WA</td>
</tr>
<tr>
<td>Smelting (aluminium, steel, zinc, copper, lead)</td>
<td>Localised plants</td>
</tr>
</tbody>
</table>

A key feature of the sector is its diverse geographical locations (often but not always in remote areas), reflecting the location of natural resources. Figure 36 shows the distribution of mines across Australia. Figure 37 shows the locations of gas reserves in Australia.
Figure 36: Location of principal mineral resources (excluding gas resources), Australia

Legend
- Operating mines
- New major projects

Groundwater basins
- Fractured or fissured, extensive aquifers of low to moderate productivity
- Fractured or fissured, extensive highly productive aquifers
- Local aquifers, of generally low productivity
- Porous, extensive aquifers of low to moderate productivity
- Porous, extensive highly productive aquifers

Source: Developed by URS.
9.1.2 The relationship between water and mining

Water management in the mining sector encompasses water extraction, water use and reuse, the co-production of water, de-watering, wastewater treatment and disposal, and the management of return flows to the environment (Figure 38).
ACIL Tasman (2007) identified a number of aspects concerning both water and the mining industry:

+ Water is a critical input into all aspects of the sector, particularly for minerals processing.
+ Mines use a range of sources to secure a reliable water supply, including dams, weirs and pipelines, groundwater bores, wastewater from surrounding towns (by pipeline), processed water recycled from the mine, rainfall runoff and water released from the mine.
+ The mining industry operates in a wide range of environments, from tropical rainforest to desert, resulting in a wide range of approaches to water management within the industry.
+ Groundwater is the major source of water for the industry.
+ An essential part of many minerals operations is the pumping of groundwater out of the mine to allow ore extraction (known as mine dewatering).
+ The industry is often able to make use of water that is unavailable or unsuitable for other users because of the remote location of its operations, the poor quality of the water or other factors.
+ The industry is responsible for sourcing its own water in many cases, and is also responsible for building and maintaining a significant amount of water-related infrastructure (such as onsite storages and tailings dams).

+ Once mining is completed, one closure option is to allow open-cut mine pits (known as ‘final voids’) to fill with water to create artificial lakes.

Water use in mining

The mining sector accounts for approximately 3.5% of total water use in Australia. Metal ore (mainly iron ore) mining is the main consumptive water use, followed by coal mining. Despite significant growth in production, aggregate water consumption in the mining sector has not increased significantly since 2004–05, due to improved water-use efficiency. The biggest increase in water use in mining has occurred in Western Australia after recent investment and expansion of production (ABS 2010b).

The industry gross value added per unit of water used (a measure of the economic value) for mining industries is significantly higher than for agriculture. The Australian Bureau of Statistics (ABS) has found that water consumed in mining contributes to a gross value added of $196 million per gigalitre, whereas agriculture, forestry and fishing had an average gross value added of $4 million per gigalitre (ABS 2011b).

Water consumption in mining is concentrated in specific locations, mainly in Western Australia, Queensland and New South Wales (Figure 39). In some locations, water use for mining is the predominant use of water.

Based on ABS data (2010b), the mining industries accounting for the greatest level of water consumption in each state are:

+ coal mining in New South Wales
+ offshore oil and gas in Victoria
+ metal ore mining, coal mining and some oil and gas in Queensland
+ metal ore mining in South Australia, Western Australia, Tasmania and the Northern Territory.

Key types of water use in mining include dust suppression, wet grinding, construction and washing.

Figure 39: Water consumption in the mining sector, by commodity and state, 2008–09 (ML)
Sources of water for mining include self-extracted water (from surface water or groundwater), distributed water from rural WSPs, and on-site reuse.19

**Water and wastewater discharges**

Production processes in mining can result in significant return flows (for example, from dewatering) and wastewater discharges. A key waste issue in mining is the management of tailings (such as iron ore tailings), which are a combination of the solid material remaining after the recoverable metals and minerals have been extracted from mined ore, and remaining process water. Tailings dams are typically used to manage the water quality of discharges from mining sites. ABS (2010a) data suggests that regulated discharges are highest in metal ore mining, oil and gas extraction and coal mining.

### 9.1.3 Energy use and carbon emissions in mining

#### Energy use

Total energy use in the mining sector includes primary and secondary energy uses.20 In 2008–09, natural gas and liquefied petroleum gas were the main sources of primary energy used in the mining sector, while refined products (petrol, diesel etc.) and electricity were the main types of secondary energy used. Total energy use in the sector increased substantially between 1999–2000 and 2008–09, from 309 petajoules (PJ) to 494 PJ, mainly due to an increase in the use of natural gas (ABS 2011a). Specific mining activities that use large amounts of energy include mineral processing (such as grinding) and transport.

There are linkages between water outcomes and energy/emissions outcomes, such as where increasing water-use efficiency reduces energy requirements, or where onsite water recycling increases energy use.

#### Greenhouse gas emissions

Mining accounted for 10% of direct greenhouse gas emissions in Australia in 2009 (or 57.2 Mt CO$_2$-e) (DCCEE 2011). Coal mining accounted for the largest contribution of direct emissions in mining (31.8 Mt) due to fugitive releases of methane in the mining process, followed by oil and gas extraction (18 Mt). Direct emissions in the mining sector have increased by 62.7% (or 22.0 Mt) since 1990.

### 9.1.4 Other important drivers in the mining sector

Investment and production decisions in the mining and minerals sector are driven by global economic conditions. Strong demand, particularly from China, has led to a major boom in the Australian mining industry over the past decade (particularly for coal and iron ore for steel production). Based on international growth projections, significant investment in the mining sector is expected to continue.

Global demand for gas is leading to the expansion of coal seam (methane) gas (CSG) extraction and to investments in associated liquefied natural gas plants. While international action on climate change is expected to increase demand for CSG, substantial new investment in productive capacity is likely to proceed regardless of emissions reductions policies (see discussion below).

Growth in the mining sector will create further pressure on water management arrangements as the sector aims to secure its supply and competes with other water users. The Commission has previously identified a number of problems associated with the limited integration of mining in water markets and water planning processes, despite the potential for considerable benefits in many cases (SKM et al 2010).

The sector will also be affected by broader environmental, regulatory and policy settings, including environmental approvals and taxation arrangements.

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19 Understanding the relative importance of these sources is complicated by the fact that some water classified as self-extracted in ABS data comes from de-wathering (that is, it is a by-product of mining) and ABS data does not include on-site reuse (which may be substantial for some operations).

20 Primary energy sources include firewood, coal, crude oil, natural gas, petroleum gas, uranium, bagasse and solar energy. A secondary energy source is a product that has been derived from a primary energy source. They include refined petroleum products, coal by-products, coke and electricity.
9.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of greenhouse gases. They can be broadly categorised as:

+ **Cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (for example, coal-fired electricity generators) to lower emissions intensity sources (for example, gas-fired or renewable electricity generators)

+ **Energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **Land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

The following sections examine the potential impacts of these policies on the mining sector. Some may have direct or indirect water-related impacts.

9.2.1 Cleaner energy measures

Cleaner energy policies such as the carbon price signal will have direct and indirect impacts on the mining sector. For example, the carbon price will increase production costs through:

+ the direct liability of some miners (mainly coal miners) for fugitive emissions

+ the impacts of the carbon price on the cost of energy and energy-intensive inputs.

The carbon price will also influence the production of goods and services for which mining products are key inputs. These factors will in turn have implications for production and investment decisions in mining and associated water-related interactions.

**Potential effects of pricing fugitive emissions**

Under the Australian Government’s Clean Energy Future Plan, entities with facilities producing fugitive emissions above 25 000 t CO$_2$-e will be financially liable for those emissions.\(^{21}\) The government estimates that approximately 500 ‘heavy emitters’ will be obligated to surrender units under the scheme. Around 100 of those are expected to be miners (PWC 2011).

In the mining sector, the most common type of fugitive emission is methane, which occurs during coal mining. Some technology exists to limit fugitive emissions from mining. For example, abatement options for coal include capturing and burning methane. For certain types of mines, known as ‘gassy’ mines, there are few cost-effective abatement options (PWC 2011).

Government analysis suggests that an average non-gassy coal mine will incur additional costs of around $1.40 per tonne of production. For gassy mines that release fugitive emissions, this cost will rise to between $7.4 and $25 per tonne of saleable coal (PWC 2011).

Government assistance, as part of the CEF package, seeks to ameliorate the direct cost impacts of the carbon price on the coal industry (Box 6). However, that assistance will mainly apply to existing gassy mines, which have limited abatement options.

\(^{21}\) PWC (2011) notes that there are significant questions about the accuracy of data for fugitive emissions from coal mines. The range of uncertainty in the National Greenhouse and Energy Reporting System default factors is 50%.
Box 6: Coal industry assistance package

The Australian Government coal sector jobs package will provide $1.264 billion over six years for gassy mines, based on historical emissions intensity per tonne of saleable coal. Key features include:

+ an eligibility threshold of 0.1 t CO₂-e per tonne of production (18 mines in NSW and seven in Queensland are expected to be eligible)
+ rates of assistance of up to 80%
+ the restriction of assistance to existing mines only (expansion projects are excluded).

The Department of Resources, Energy and Tourism will administer the scheme.

A further package of $70 million is provided for coal mining abatement technology support. This is to be on a co-contribution basis.


Impacts of the carbon price on energy costs and other inputs

The carbon price will impose additional costs on miners as suppliers pass on the costs they incur. Additional costs include:

+ increased energy costs
+ increased transportation costs, in particular for rail transportation
+ increased contractor costs
+ increased capital expenditure costs (steel, cement, fuels, embodied carbon costs in other materials) (PWC 2011).

Impacts of the carbon price on demand for mining products

Commonwealth Treasury modelling indicates that most of the impacts of the carbon price on the mining sector will be limited and will be offset by the underlying growth in the sector (for example, iron ore fits in this category).

The carbon price is likely to have a range of direct effects on demand from downstream industries that buy mining products. Impacts are likely to be most significant in emissions-intensive, trade-exposed industries such as steel and aluminium production. However, those industries are expected to be partially shielded from the impacts of the carbon price through assistance measures provided by the Australian Government (see Box 7).

It is expected that there will be a reduction in output from the coal mining sector. Treasury modelling indicates a 2.3% reduction by 2020 and a 17.1% reduction by 2050, compared to a ‘no carbon price scenario’ (Treasury 2011).

The most susceptible coal mining operations are likely to be those that:

+ have high fugitive emissions
+ supply domestic coal-fired power stations
+ have limited access to transport and ports for overseas export.

For such mines, there could be production impacts on existing mines, early mine closures and a reduction in new investment.
Box 7: Assistance measures for downstream industries

Clean Technology Food and Foundries Investment Program
Special assistance will be provided to the food processing, metal forging and foundry industries. These industries are trade-exposed and have somewhat higher exposure to energy costs than general manufacturing businesses. Through the Food and Foundries Investment Program, the government will provide grants worth up to $150 million over six years to the food processing industry and up to $50 million over six years to the metal forging and foundry industries. The grants will assist the industries to invest in energy efficient equipment and low-pollution technologies, processes and products.

Jobs and Competitiveness Program
The Jobs and Competitiveness Program has been designed to provide assistance to the most emissions-intensive activities in the economy that are highly exposed to international competition, either in export markets or from importers.
There will be two categories of assistance. The most emissions-intensive and trade-exposed activities will initially be eligible for 94.5% shielding from the carbon price. A second category of assistance will provide an initial shielding level of 66% of the carbon price.

Steel Transformation Plan
Under the Clean Energy Future initiative, the steel sector will receive two assistance packages in addition to the transitional assistance available to emissions-intensive, trade-exposed industries:
+ The Steel Transformation Plan will provide $300 million over four years for investment and innovation, based on a self-assessment applicable to entities that meet a qualifying threshold of 500 000 tonnes of production of crude steel in 2009–10.
+ There will be a 10% increase in the allocative baseline for emissions-intensive, trade-exposed assistance from 2016–17 for specified steelmaking activities. As a result, in 2016–17 entities conducting those activities will receive over 98% of their permits at zero cost.


Before the Fukushima nuclear plant meltdown in Japan, the prospect of a global carbon price was likely to increase demand for uranium. Following the incident, the outlook is less optimistic and much less certain. A carbon price in Australia is unlikely to have any significant impact on demand for uranium, given current economic and policy settings.

Similarly, an Australian carbon price is unlikely to have an impact on bauxite mining and alumina production (as opposed to aluminium smelting undertaken in Australia). However, an international carbon price may increase demand for those products, for example if aluminium is used as a lighter weight substitute in vehicle production.

A carbon price is likely to drive a slight increase in demand for conventional gas, as it is a less emissions-intensive energy source than coal (see the energy sector assessment in Section 8). In addition, domestic and particularly international mitigation efforts are a factor likely to lead to increases in demand for CSG as an energy generation source.

Based on forecasts by ABARES and the Australian Energy Market Operator (AEMO), the projected domestic gas and export liquefied natural gas production from CSG in Australia is set out in Figure 40. Annual CSG production could rise from 100 PJ to 2748 PJ under a medium international carbon price and medium economic growth scenario. This compares to a much smaller increase (to 1300 PJ/year by 2030) under a slow growth and low international carbon price scenario. In accordance with the AEMO’s 2010 Gas Statement of Opportunities, export liquefied natural gas production is likely to rise from 2018.

The scenarios used in Figure 40 include various combinations of estimates of economic growth and the level of an international carbon price. Therefore, it is not possible to estimate the impacts solely attributable to the international carbon price. While the introduction of a carbon price in those countries that import liquefied natural gas would probably boost liquefied natural gas exports, economic growth is likely to be a bigger determinant. In any case, it is not clear that the key customers for the proposed Queensland liquefied natural gas projects—China, Malaysia and Korea—are likely to introduce a substantial carbon price any time soon.
Impacts of cleaner energy policies on water use in the mining sector

The overall impacts of domestic cleaner energy policies on water use in the mining sector are difficult to determine. The main effect of a carbon price may be to dampen domestic demand for some mining products in Australia. An exception is CSG which is likely to undergo an increase in demand due to both a domestic and an international carbon price signal. However, most Australian mining products are sold in international markets. Therefore, the additional costs associated with the carbon price may make Australian coal exporters less competitive if other countries do not have an equivalent carbon price.

Impacts on coal mines

The main impacts of a carbon price will be on coal mines that have traditionally supplied domestic power stations and have high transport costs, limited access to export markets, relatively high fugitive emissions (for example, those in New South Wales and Victoria), or any combination of the three. This suggests that the carbon price could potentially reduce water demand for coal mining by reducing production and new investment.

Potential water policy issues related to these changes include the regulatory arrangements for the management of water-related impacts from the closure of mines. For example, early closure creates significant water-related issues for open-cut coal mines—specifically, the need to either continually dewater or to otherwise address mine pit resaturation and potential acidification.

In the past, opencut mine closure practices involved fencing the site and allowing groundwater and surface water to flow back into the pit. This often resulted in the development of a stagnant pool with rising salinity and acidity. Current practice is to develop mine closure plans for sites that incorporate capping and revegetation strategies and water management plans.
**Coal seam gas**

An increase in demand for CSG due to an international carbon price has the potential to affect water resources in New South Wales and Queensland.

Coal seam gas extraction involves removing water and entrained gas from openings (cleats) in the coal seam using wells sealed from overlying aquifers. The gas is separated from the associated water at the wellhead, and the water may be treated through reverse osmosis at the surface to allow it to be used for beneficial purposes, including irrigation, controlled discharge or reinjection into the overlying aquifer system.

Key water issues that have been raised relate to the potential impact on the environment and consumptive users from discharges of water to aquifers (DERM 2012). They include:

+ the management of water that is extracted with the coal seam gas (associated water)
+ the treatment of associated water and the beneficial use of the treated water (irrigation, reinjection, discharge)
+ the management of reject brines from treatment processes
+ the potential impact of CSG and associated water extraction (for example, localised reduction of groundwater levels in the Great Artesian Basin)
+ potential interconnections with shallower aquifers used by others
+ potential impacts of extraction and reinjection on the structural integrity of aquifers
+ the management and containment of any impacts of chemicals used in hydraulic fracturing (‘fracking’).

RPS (2011) provides a summary of existing forecasts of water extraction in CSG operations into the future. Water extraction in Queensland could increase to 126–281 GL/year by 2020.

The development of CSG is focused in the Surat and Bowen basins in Queensland and in the Surat and Gunnedah basins in New South Wales. Those regions are also characterised by significant agricultural activity. If water policy and management issues associated with CSG cannot be dealt with effectively, there is some prospect that investment will shift to shale gas reserves in central Australia’s Cooper Eromanga Basin, which has fewer water issues.

**Figure 41: Locations of potential coal seam gas development**

![Map of Australia showing potential coal seam gas development areas](image)

Source: Geoscience Australia, Queensland Government.
The water issues associated with CSG arise with or without an Australian or international carbon price. However, pricing of carbon may increase the materiality of those issues due to increased demand.

The Australian Government and state governments are developing planning and regulatory arrangements to address problems associated with CSG. For example, the Commonwealth approved two major coal seam gas projects in southeast Queensland in October 2010, subject to more than 300 environmental conditions, including:

+ planning and monitoring to protect groundwater resources
+ the development and submission for approval of management plans for aquifers, groundwater and surface water
+ the maintenance of water pressures above conservative thresholds
+ the adoption of aquifer injection measures proven through pilot testing programs
+ surveys and maintenance of spring flows
+ the development of appropriate models to assess and allow for the mitigation of potential impacts
+ the rehabilitation of land.

The Australian Environment Minister recently approved the appointment of an expert panel to advise him on coal seam water management, including for Queensland CSG projects approved (subject to conditions) under the Environment Protection and Biodiversity Conservation Act 1999 (Cwth).

State agencies are also involved in CSG water management. The Queensland Department of Environment and Resource Management developed draft amendments to the Coal Seam Gas Water Management Policy June 2010 that aim to promote the sustainable management of Queensland’s groundwater resources. The draft amendments set aquifer injection or virtual injection of suitably treated water as the first priority management option for CSG water. Virtual injection is the treatment of CSG water to an appropriate standard and its provision to water users as a water source associated with the replacement or reduction of their traditional take of groundwater.

The draft amendments establish beneficial use as a second priority management option for CSG water. Beneficial use is the provision of treated CSG water to users as a resource, but does not involve any replacement or reduction of existing water use.

CSG water is defined as a waste under the Environment Protection Act 1994 (Qld), and it must be disposed of under the conditions of an environmental authority, or beneficially used under a beneficial use approval (which changes the status of a material from a waste to a resource). Under the beneficial use approval, the holder must manage the water in a way that minimises the risk of environmental harm. The Queensland Government is currently reviewing the CSG water policy guidelines.

In New South Wales, water is managed under the Water Act 1912 and the Water Management Act 2000. The Water Act regulates the drilling and licensing of bores and wells and the establishment of water supply works. The Water Management Act applies to surface water and groundwater in areas where a water sharing plan is in place. Under the Act, any proposed managed aquifer recharge scheme for CSG associated water may require:

+ water supply works approval
+ water access licence
+ water use approval
+ aquifer interference approval
+ managed aquifer recharge licence.

The application of various elements of water policy in the Gunnedah Basin is shown schematically in Figure 42.
Figure 42: Coal seam gas water management in the Gunnedah Basin, New South Wales

Source: Developed by URS.
Summary of the impacts of a carbon price on the mining sector

Table 19 summarises the assessment of the impacts of a carbon price signal and the flow-on impacts for water resources for each mining and minerals subsector.

Table 19: Impacts of a national and international carbon price on water use in the mining sector

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Impacts of a carbon price</th>
<th>Impacts on water resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore</td>
<td>A domestic carbon price will increase costs.</td>
<td>Current water uses relate mainly to dust suppression, wet grinding and construction. Managing groundwater inflows is also an issue.</td>
</tr>
<tr>
<td></td>
<td>A carbon price may marginally reduce water use in iron ore mining. This may somewhat alleviate competition for water resources in some systems, against a baseline of significant development.</td>
<td></td>
</tr>
<tr>
<td>Coal seam gas</td>
<td>International carbon prices and mitigation efforts are likely to drive a major increase in demand for gas. Domestic demand is likely to be less of a driver than international demand. Because domestic prospects for expanding conventional gas production are relatively limited, growth in demand is most likely to be met by CSG.</td>
<td>The key water issues include: + management of extracted water (e.g. use, discharge, treatment, reinjection and brine disposal) + potential localised reduction of groundwater levels in the Great Artesian Basin + potential interconnections with shallower aquifers used by others + the management and containment of any impacts of chemicals used in hydraulic fracturing (‘fracking’).</td>
</tr>
<tr>
<td>Conventional gas</td>
<td>Limited impact on water resources.</td>
<td>A reduction in coal demand would reduce water demand in the coal industry. Early closure creates significant water-related issues for open-cut coal mines: the need to either continually dewater or to otherwise address mine pit resaturation; and potential deteriorating water quality.</td>
</tr>
<tr>
<td>Coal</td>
<td>A carbon price will reduce demand for coal as an energy source and increase costs. The impacts will be most significant for coal mines that directly supply domestic generators, have high transport costs or have relatively high fugitive emissions (e.g. those in NSW and Victoria). Growth in new development may slow and some mines may be closed earlier, depending on the magnitude of the carbon price.</td>
<td>Limited additional water policy issues; however, acid-generating wastes and tailings will remain a key potential water impact.</td>
</tr>
<tr>
<td>Base metals (zinc, copper, lead, nickel, manganese)</td>
<td>Potential reduction in demand and increased costs, but not likely to have a significant impact.</td>
<td>Limited additional water policy issues unless there is a significant change in perceptions about nuclear energy. In the long term, further development may occur under a strong international carbon price signal. Tailings management is a key potential water quality risk if new development does emerge.</td>
</tr>
<tr>
<td>Uranium</td>
<td>Before the Japanese nuclear plant meltdown, the prospect of a global carbon price increased uranium demand. Following the incident, the outlook is less optimistic and much less certain. In addition to the existing Ranger, Olympic Dam and Beverley mines, there are other potential uranium mine sites.</td>
<td>Limited additional water policy issues unless there is a significant change in perceptions about nuclear energy. In the long term, further development may occur under a strong international carbon price signal. Tailings management is a key potential water quality risk if new development does emerge.</td>
</tr>
<tr>
<td>Mineral sands</td>
<td>Potential reduction in demand and increased costs, but not likely to have a significant impact.</td>
<td>Limited additional water policy issues, but sand mining may create water quality and quantity management issues.</td>
</tr>
<tr>
<td>Bauxite, alumina</td>
<td>Potential increase in demand if aluminium is used as a lighter substitute for steel under a global carbon price signal. In the long term, with a potential international carbon price, aluminium smelting and hence bauxite demand may be affected.</td>
<td>Limited additional water policy issues.</td>
</tr>
<tr>
<td>Smelting (aluminium, steel, zinc, copper, lead)</td>
<td>It is assumed that Australian industries would be shielded from a domestic price signal. Any increase in aluminium demand would probably be met by offshore refineries (e.g. in the Middle East).</td>
<td>Limited additional water policy issues.</td>
</tr>
</tbody>
</table>
9.2.2 Energy efficiency

Energy efficiency measures are policies designed to slow the growth in energy demand and thereby reduce emissions. For example, Centennial Coal has begun energy efficiency assessments in response to state and federal legislation (DRET 2010).

Specific energy efficiency measures in the mining sector include using advanced sensors to characterise ore and developing excavation techniques that optimise particle size and crushability. Past studies suggest that the largest opportunities for energy efficiency in mining relate to beneficiation (treating ore to make it more suitable for smelting), processing (particularly grinding) and transportation (Sterling 2009).

In most cases, these energy efficiency measures are likely to have very little impact on water resources. However, if different production techniques are adopted, there is potential for water use and effluent water quality to either increase or decrease.

Overall, such changes are unlikely to have significant implications for water use or water policy.

9.2.3 Land-use change measures

Some mining companies also own large tracts of land. There may be potential for some of them to offset their emissions by establishing carbon plantations or implementing other forms of land-use change, potentially by participating in the Carbon Farming Initiative or the Biodiversity Fund. Such actions could have water interception impacts; however, those impacts are expected to be very small in comparison with impacts in the forestry and agricultural sectors. Any water policy implications associated with interception could also be applicable to any mining companies involved in carbon sequestration (see Section 10).

9.2.4 Summary assessment of water-related impacts of mitigation policy in the mining sector

Table 20 summarises the assessment of water-related impacts of the main mitigation policies in the coal sector.

<table>
<thead>
<tr>
<th></th>
<th>Impacts of carbon prices on demand for coal</th>
<th>Impacts of carbon prices on demand for coal seam gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature of impact</strong></td>
<td>Reductions in water demand and an increase in water-related impacts associated with potential early mine closures due to the carbon price.</td>
<td>Increase in water-related impacts due to an increase in CSG production in response to an international carbon price.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>NSW, Qld, Vic.</td>
<td>Qld, NSW.</td>
</tr>
<tr>
<td><strong>Likelihood/timing</strong></td>
<td>Impacts will be felt upon the introduction of the carbon price, although it is difficult to estimate when the price will result in changes affecting water demand.</td>
<td>Significant increase in CSG production is likely over the next five years, with increases in water extraction until at least 2030.</td>
</tr>
<tr>
<td><strong>Magnitude/sensitivity</strong></td>
<td>Low</td>
<td>Moderate to high.</td>
</tr>
<tr>
<td><strong>Importance of climate change impact compared to other drivers of change</strong></td>
<td>Low. These impacts are likely to occur against a backdrop of significant new investment in the mining sector, which will create a range of water challenges unrelated to mitigation policy.</td>
<td>The main driver of CSG development is global economic growth, although an international carbon price signal would have some impact. The domestic carbon price is unlikely to have a significant impact on CSG development.</td>
</tr>
<tr>
<td><strong>Overall materiality of impact</strong></td>
<td>Low</td>
<td>Moderate to high.</td>
</tr>
<tr>
<td><strong>Potential water policy issues</strong></td>
<td>Water-related risks associated with early closures of mines.</td>
<td>Potential third-party impacts on water supply (quality and volume of supply).</td>
</tr>
<tr>
<td><strong>Current water policy tools</strong></td>
<td>Currently managed through broader environmental approvals and regulatory processes.</td>
<td>Currently managed through state and Commonwealth approvals processes.</td>
</tr>
<tr>
<td><strong>Existing knowledge of the issue</strong></td>
<td>This issue is mainly addressed through environmental regulation, not water policy and management.</td>
<td>Knowledge is increasing as CSG production is trialled and implemented, although there remains technical uncertainty about the nature of the water-related impacts.</td>
</tr>
<tr>
<td><strong>Overall policy implications</strong></td>
<td>It is unclear whether there are appropriate levels of coordination between environmental regulation and water policy in relation to mine closures.</td>
<td>Water-related issues are well known, and processes are in place for them to be addressed, regardless of climate change.</td>
</tr>
</tbody>
</table>
9.2.5 Implications of current water policy for the implementation of mitigation policy

The most important implications of current water policy settings for the effective and efficient implementation of mitigation policy relate to the development of CSG. If water policy and other regulatory issues associated with water are not effectively addressed, there is potential for less than optimal investment in CSG development.

Governments are aware of these issues. The Australian Government has recently appointed a technical expert panel to advise it on matters associated with CSG projects.

9.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise in the mining sector from adaptation responses to climate change.

Following the framework set out in Section 2, this involves:

+ identifying the potential impacts and risks of climate change (in this case, as they affect mining)
+ identifying the likely autonomous and policy responses to adapt to those changes in the mining sector
+ assessing the consequent water-related impacts
+ identifying possible water policy issues.

9.3.1 Potential impacts of climate change on mining

The potential impacts of climate change on the mining sector examined in this assessment include:

+ changes in water availability and security for mining
+ changes in extreme weather and sea level rise, which can affect mining production and assets and have the potential to result in third-party impacts on surrounding environments.

Because the mining industry operates in a wide range of environments, from tropical rainforest to desert, there is likely to be significant variation in the impacts of climate change on mining activities. A detailed assessment of those varying impacts is beyond the scope of this assessment.

Impacts on water availability and security

Reduced average rainfall and increased temperatures in southern Australia are likely to reduce water available to the mining sector from natural sources, such as surface water and groundwater, and could potentially increase competition with other sectors that use those resources, such as agriculture.

Furthermore, higher temperatures may increase water requirements in mining (for example, higher temperatures increase dust and therefore the volume of water required for dust suppression). Where water becomes a limiting factor, that could result in a cutback in production (McInnes et al. 2008).

Examples of potential water security issues in the mining sector include the following:

+ **Iron ore (WA, and SA to a lesser extent):** Increased temperatures increase dust and therefore water requirements. Magnetite operations would be less viable if drier conditions create water shortages.
+ **Coal (NSW, Qld):** Hotter and drier conditions will increase competition for water in areas where coal mining is carried out adjacent to agricultural areas reliant on groundwater, such as the Namoi Basin (NSW).
+ **Uranium (SA):** Drier conditions may increase pressure on water supply to Olympic Dam and increase the need to rely on desalinated water.
+ **Base metals (NSW, Qld, Tas., WA):** Drier conditions affect the costs of supplying communities (such as Mt Isa and Broken Hill), and the viability of those communities.
McInnes et al. (2008) note that lack of access to water due to climate change may also limit the ability of companies to rehabilitate mine sites (such as bauxite mines in Western Australia). For example, decreased water availability may limit the establishment of vegetation on disturbed land.

Impacts on the operation of water-related assets

More severe storms associated with climate change have the potential to severely affect mining operations in several ways, including by:

- causing temporary shutdowns in mining activities (in particular, open pit mines face a significant risk of flooding during heavy rains)
- damaging equipment and infrastructure
- damaging operations at shipping ports, which could potentially hamper export flows (McInnes et al. 2008).

From a water policy perspective, however, the impacts of interest are those that affect the performance of water-related infrastructure (such as tailings dams or wastewater treatment facilities) and the extent to which third-party impacts on the environment and other users can continue to be managed in accordance with relevant standards and regulations. Examples of potential pressures on water-related infrastructure in the mining sector include the following:

- **Iron ore (WA) and base metals (NSW, Qld, Tas., WA):** Increased frequency of extreme weather events increases the risk of breaches of tailings storage facilities, particularly if climate change results in significant shifts in the probability of exceedance (for example, 1 in 100 year floods becoming 1 in 5 year floods).
- **Coal (NSW, Qld):** Increased risk of pit flooding if the frequency of storms or extreme weather increases, and associated issues involving the offsite disposal of water.
- **Uranium (NT):** Wetter conditions in the Northern Territory can increase the burden of tailings management, particularly if there are significant shifts in the probability of exceedance (for example, 1 in 100 year events becoming 1 in 5 year events).

9.3.2 Adaptation responses and water policy issues

The potential types of adaptation responses to changes in water security and risks to water-related assets are outlined below, along with water policy implications.

Notably, adaptation in the mining sector tends to be more autonomous than in other sectors that have historically had a greater amount of government involvement in operations (such as urban water). However, autonomous actions are often dependent on the water policy settings that are in place.

Water availability

Obtaining secure access to water is an essential prerequisite for most mining and mineral processing operations. If there were a reduction in rainfall and surface water and/or groundwater availability (or even a risk that this might occur), miners would be likely to invest in options to secure their supplies, or alter their investment decisions (for example, decisions about the location of processing facilities).

Potential responses to water scarcity include the following:

- **Increasing water use efficiency:** As water scarcity increases, miners would have incentives to invest in improving the efficiency of their water use to reduce their risk.
- **Increasing water availability and supply diversification:** A number of water supply augmentation and diversification strategies are possible:
  - **Water entitlements and trading:** Miners may seek to increase the volume of water available under their entitlements, either through administrative processes (in systems that are not fully allocated) or through participation in water markets. For example, mines in New South Wales, South Australia, Victoria and Queensland could potentially access surface water or groundwater markets in the MDB.
  - **Pipelines:** In some cases, accessing additional water may require investment in pipelines to connect to larger or more reliable water systems and water markets.
  - **Accessing lower quality sources and on-site treatment:** Where conventional sources become increasingly scarce, some miners may need to increase their use of lower quality groundwater, which may require some onsite treatment. They may also invest in the onsite collection of rainfall and runoff.
Mining and minerals processing

- **Desalination**: Where mine operations are close to the coast, or where low-quality saline water sources are available, there is some potential for miners to invest in their own desalination plants to ensure access to water.

- **Recycling and reuse**: Most mines already treat wastewater for use in their operations. The process of water treatment can range from sediment stilling ponds to sophisticated filtering, dosing and reverse osmosis plants (McInnes et al. 2008). Variable water availability in the future is likely to encourage companies to utilise or develop more ways to treat water on site and increase the rate of water recycling.

From a water policy perspective, adaptation responses to reduced water availability could affect regional water demand and competition for the resource, particularly in areas where mining competes with other sectors for water (for example, New South Wales coalfields and opencut coal mines in the Gippsland Basin).

Some types of mining activities, such as coal and CSG, are already in competition with other water users, including agriculture and environmental users. However, it is important to recognise that those competing claims on water resources would be part of any baseline that did not include climate change.

Consequently, in a future in which higher temperatures and drier conditions could lead simultaneously to higher demand and reduced water availability, the tensions created by competition for water could increase. For activities such as uranium and base metals mining, competition with non-mining activities may be less of an issue because of their remote locations. However, obtaining access to additional water supplies may raise questions about sustainable water management and third-party impacts.

To implement many of the adaptation responses outlined above, miners will be reliant on a range of water policy tools, including water entitlements and markets. The mining sector will also need to be adequately considered in regional and catchment-based water planning, and regulatory arrangements will need to ensure that diversification strategies adopted by miners do not create significant third-party impacts on the environment and other users.

In the case of CSG, reduced water availability due to climate change potentially increases the value of co-produced water from CSG processes for reuse in other consumptive uses (such as irrigation or urban water systems) and non-consumptive uses (such as the restoration of aquifer pressure to maintain springflow). The main water policy question here is whether the regulatory arrangements would allow those benefits to be realised if there were demand for associated water. However, CSG extraction has a lifespan of only 25–35 years in any particular region, and co-produced water from each well declines over time, so this source of water cannot be relied upon in the long term (which may affect investment decisions associated with beneficial uses).

Some of the diversification strategies outlined above also increase energy use and so could increase greenhouse gas emissions. A similar issue exists in the urban water sector (see Section 12). The policy implications of this interaction between adaptation and mitigation are discussed in Section 5 in Part A of this report.

**Risks to water-related assets in mining**

To adapt to any increase in storms, the mining sector will need to resolve significant water storage and management issues. They include direct mine impacts (such as mine flooding), as well as indirect impacts when logistics chains are interrupted (such as by the flooding of train lines and the closure of ports).

A key issue for iron ore extraction, uranium and base metals is the management of environmental impacts, particularly those associated with environmental flows, the contamination of groundwater and tailings management.

Miners are already subject to environmental regulation to mitigate environmental contamination risks associated with the transmission of pollutants via water. For example, while tailings dams are already the subject of specific regulation, the questions are whether an increase in extreme weather increases the risks of contamination, and about the appropriate regulatory response. More or stronger storms may create additional pressure on the management and regulation of tailings dams, particularly for opencut mines in the tropics, including the Ranger uranium mine in the Northern Territory.

One option for adapting to the impacts of climate change is to alter water infrastructure to continue to meet the same environmental standards (for example, upgrading wastewater treatment facilities or tailings dams). Alternatively, companies could relocate assets to areas with fewer risks. In practice, however, those options can be very costly:

> Onshore fixed or very large assets, such as grinding mills, will invariably be very costly to alter or relocate, and economic benefit–cost analyses would be required on a case by case basis to assess the financial viability of such measures. (McInnes et al. 2008)

Another option is additional efforts by government to examine the specifications and the costs and benefits of the standards and regulations (see Section 5.5).
Regulatory risks

With the increasing focus on the potential impacts of climate change, the mining sector may face a number of regulatory risks related to water access and use. They include increased pressure to recycle or reuse water and the risk of increased water costs, as well as more stringent discharge limits, water quality limits, or both. There may also be increased disclosure requirements for water risks due to climate change (that is, reputational and community-related risks).

These risks are not readily quantifiable and are not discussed further in this report.

Summary of adaptation interactions in the mining sector

Table 21 summarises adaptation interactions in the various subsectors of the mining industry.

Table 21: Summary of adaptation interactions in mining industries

<table>
<thead>
<tr>
<th>Activity and locations</th>
<th>Interactions with water</th>
<th>Climatic impacts and adaptation responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore (WA, and SA to lesser extent)</td>
<td>Groundwater use (dust suppression, grinding operations, wet separation techniques, particularly for magnetite ores). Dewatering (opencut iron ore mine sites). Regulation to mitigate environmental contamination risks (e.g. tailings management and impacts on water quality).</td>
<td>Increased temperatures increase dust and therefore water requirements. Reduced groundwater availability may affect the viability of magnetite operations. Increased frequency of extreme weather increases risk of breaches of tailings storages.</td>
</tr>
<tr>
<td>Coal seam gas (Qld, NSW)</td>
<td>Growing community concern about groundwater and CSG extraction. Co-produced water can be treated and used for irrigation, reinjected into an aquifer, or disposed of. Potential contamination of groundwater sources as a consequence of hydraulic fracturing (‘fracking’).</td>
<td>Hotter and drier conditions may reduce water availability and increase the value of treated co-produced water from CSG extraction.</td>
</tr>
<tr>
<td>Coal</td>
<td>Water is used for lubrication, dust suppression and washing Groundwater depletion from mining operations in land contiguous with aquifers. Dewatering to facilitate open pit mining. Flooding of open pit mines after closure.</td>
<td>Hotter and drier conditions may reduce water availability, and open pit mining may accelerate aquifer depletion. Increased risk of pit flooding if frequency of storms and extreme weather increases, and associated issues of offsite disposal of contaminated water. A growing regulatory focus on restrictions on stream diversions and maintaining existing overland flow if a mine is constructed on a floodplain.</td>
</tr>
<tr>
<td>Base metals (NSW, Qld, Tas., WA)</td>
<td>Regulation to mitigate environmental contamination risks (e.g. tailings management and impacts on water quality). Potable water supply for remote mining communities.</td>
<td>Higher frequency of extreme weather increases risks in tailings management. Drier conditions affect costs of supplying some mining communities (e.g. Mt Isa, Broken Hill) and their viability.</td>
</tr>
<tr>
<td>Uranium (SA, NT)</td>
<td>Water for dust suppression. Extraction processes are water intensive. Tailings management.</td>
<td>Drier conditions may increase pressure on water supply (Olympic Dam). Wetter conditions can increase the burden of tailings management (Ranger).</td>
</tr>
<tr>
<td>Bauxite (South West WA)</td>
<td>Regulatory requirement for rehabilitating exploited areas through replacing topsoil and reforestation.</td>
<td>Reduced water availability in locations where there are competing water uses.</td>
</tr>
<tr>
<td>Alumina (NT, Qld, WA)</td>
<td>Water used for refining.</td>
<td>Impacts of reduced water availability can be alleviated through the use of wastewater.</td>
</tr>
</tbody>
</table>
### 9.3.3 Summary assessment of adaptation interactions in the mining sector

Table 22 summarises the water-related impacts of climate change adaptation responses in the mining sector.

**Table 22: Summary of adaptation interactions in the mining sector**

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Adaptation responses to reduced water availability</th>
<th>Adaptation responses to impacts on water-related assets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature of impact</strong></td>
<td>Increased water demand in mining, leading to increased competition for scarce water resources and potential third-party and environmental impacts.</td>
<td>Potential increased risk of contamination from site runoff and tailings dams (e.g. iron ore extraction, uranium and base metals) and costs of managing those risks. Capacity to discharge surplus water dependent on environmental and regional water policy settings.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>More of an issue where mining is located near agricultural demand (e.g. NSW, Qld, Vic.).</td>
<td>Mainly WA, SA, NT, NSW, Qld.</td>
</tr>
<tr>
<td><strong>Likelihood/timing</strong></td>
<td>Risks are expected to gradually increase due to climate change.</td>
<td>Risks relate to extreme events (expected to increase due to climate change).</td>
</tr>
<tr>
<td><strong>Magnitude/sensitivity</strong></td>
<td>Potentially significant, although there is uncertainty about the impacts of climate change.</td>
<td>Potentially significant, although there is uncertainty about the impacts of climate change.</td>
</tr>
<tr>
<td><strong>Importance of climate change impact compared to other drivers of change</strong></td>
<td>Low—miners already face challenges in sourcing water and being integrated into water planning and entitlements frameworks.</td>
<td>Moderate—mines already need to be designed to manage severe storms and floods.</td>
</tr>
<tr>
<td><strong>Overall materiality of impact</strong></td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Potential water policy issues</strong></td>
<td>Water is allocated to highest value uses without undermining the rights of existing users or adversely affecting the environment and other third parties.</td>
<td>Appropriately regulating risks of pollution during floods and storms.</td>
</tr>
<tr>
<td><strong>Current water policy tools</strong></td>
<td>Water planning, access entitlements and markets.</td>
<td>Water and broader environmental regulation.</td>
</tr>
<tr>
<td><strong>Existing knowledge of the issue</strong></td>
<td>Issues involved in the incorporation of the mining into water planning and access entitlements are well known.</td>
<td>Known, but addressed in environmental regulation.</td>
</tr>
<tr>
<td><strong>Overall policy implications</strong></td>
<td>Increases the need for mining to be integrated into water planning and access entitlements arrangements.</td>
<td>Potential need for further assessment and review of existing regulatory and institutional arrangements.</td>
</tr>
</tbody>
</table>
9.4 References


ACIL Tasman (2007). Water reform and industry: implications of recent water initiatives for the minerals, petroleum, energy, pulp and paper industries, Department of Industry, Tourism and Resources, Canberra.


PWC (PricewaterhouseCoopers) (2011). Carbon pricing implications for the mining sector, PWC.


Sterling D (2009). Identifying opportunities to reduce the consumption of energy across mining and processing plants, Schneider-Electric.

The forestry sector in Australia manages native forests and establishes and manages forest plantations. This assessment incorporates the establishment and management of permanent ‘carbon plantings’ (such as carbon sink forests) specifically for carbon sequestration and climate change mitigation.

The introduction of the carbon tax under the Clean Energy Future (CEF) policy package is likely to have a direct impact on the cost of production for plantations managed for wood production. The costs of production for permanent carbon plantings are also likely to increase, although potentially to a lesser extent. However, the carbon tax impacts are not likely to be sufficient to significantly alter the pattern of investment in either type of planting and thus are unlikely to have water resource impacts in the short to medium term.

With the CEF package and its price signal on carbon, demand for offset-based credits created under the Carbon Farming Initiative (CFI) is expected to increase. In turn, that may stimulate further expansion of permanent carbon plantings. Currently, forestry plantations for wood production are not eligible under the CFI.

According to ABARES analyses, the regions with highest potential for permanent carbon plantings as a result of the CFI are north-east New South Wales and the mid-coast region of Queensland. Additional investment in those areas may influence water use and interception in local catchments. However, the impacts of the CFI on permanent plantation investment are not expected to be large at the national level in the short to medium term unless there is further policy change.

The impacts on water resources from climate change adaptation responses by the forestry sector are not known with any precision. However, with the expectation of lower annual rainfall and an increase in temperatures across most areas in Australia where forests are growing or may be established in the future, rainfall interception could be expected to increase and groundwater recharge to decrease. The extent to which these trends result in a net increase or decrease in runoff is not yet clear because of the interplay between reduced rainfall and increased temperatures.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian forestry sector in order to:

+ provide background on the forestry sector and its relationships with water, energy and emissions (Section 10.1)
+ identify, describe and assess the significance of interactions associated with mitigation policy, and identify relevant water policy implications (Section 10.2)
+ identify, describe and assess the significance of interactions associated with climate change adaptation responses, and identify relevant water policy implications (Section 10.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

The interactions discussed in this assessment are summarised in Figure 43.
Figure 43: Summary of interactions in the forestry sector
10.1 Background

10.1.1 About the forestry sector

Australia has approximately 147 million hectares (ha) of native forest and 2 million ha of forestry plantations. Together, native forest and plantations cover about 19% of the continent (ABARES 2011a). The area of multiple-use public forests in which wood production is an objective is estimated to be 9.4 million ha. Of the total forest estate, about 70% is privately managed (MPIGA 2008).

Forestry, logging and wood manufacturing were estimated to employ 75 800 people in 2009, generating turnover of $22 billion in that year. In 2008, the forestry and forest products industries were estimated to contribute 0.6% of Australia’s gross domestic product (ABARES 2011a).

Plantations

Australia is estimated to have around 2 million ha of plantation forests, covering about 0.2% of the total land area (ABARES 2011a). Figure 44 shows the main regions where plantations are grown in Australia.

Figure 44: National Plantation Inventory regions

Approximately 50% of plantation forests are exotic softwood species (mainly radiata pine); the other half are largely native hardwood species (ABARES 2011a). The plantations are usually in areas of arable soils where annual rainfall is greater than 700 mm/year in temperate regions and in subtropical and tropical regions with higher rainfall.

Table 23 summarises plantation areas planted over the period from 2000 to 2010 by region. Over that period, the average annual rate of change in each of the plantation regions is estimated to have ranged from –2% (Southern Tablelands, NSW) to 18% (Northern Territory).
Table 23: Total plantation area, by region, Australia, 2000 to 2010

<table>
<thead>
<tr>
<th>Region Description</th>
<th>2000 ('000 ha)</th>
<th>2005 ('000 ha)</th>
<th>2010 ('000 ha)</th>
<th>Average annual change (2000–2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Western Australia</td>
<td>314</td>
<td>378</td>
<td>413</td>
<td>3%</td>
</tr>
<tr>
<td>2 Northern Territory</td>
<td>7</td>
<td>16</td>
<td>38</td>
<td>18%</td>
</tr>
<tr>
<td>3 Mt Lofty Ranges and Kangaroo Is.</td>
<td>21</td>
<td>29</td>
<td>34</td>
<td>5%</td>
</tr>
<tr>
<td>4 Green Triangle</td>
<td>224</td>
<td>299</td>
<td>345</td>
<td>4%</td>
</tr>
<tr>
<td>5 North Queensland</td>
<td>24</td>
<td>29</td>
<td>37</td>
<td>4%</td>
</tr>
<tr>
<td>6 South-east Queensland</td>
<td>165</td>
<td>194</td>
<td>192</td>
<td>2%</td>
</tr>
<tr>
<td>7 Northern Tablelands NSW</td>
<td>17</td>
<td>17</td>
<td>24</td>
<td>4%</td>
</tr>
<tr>
<td>8 North Coast NSW</td>
<td>57</td>
<td>67</td>
<td>101</td>
<td>6%</td>
</tr>
<tr>
<td>9 Central Tablelands NSW</td>
<td>81</td>
<td>80</td>
<td>81</td>
<td>0%</td>
</tr>
<tr>
<td>10 Southern Tablelands NSW</td>
<td>27</td>
<td>22</td>
<td>22</td>
<td>–2%</td>
</tr>
<tr>
<td>11 Murray Valley</td>
<td>179</td>
<td>185</td>
<td>195</td>
<td>1%</td>
</tr>
<tr>
<td>12 Central Victoria</td>
<td>50</td>
<td>57</td>
<td>69</td>
<td>3%</td>
</tr>
<tr>
<td>13 Central Gippsland</td>
<td>90</td>
<td>93</td>
<td>96</td>
<td>1%</td>
</tr>
<tr>
<td>14 East Gippsland–Bombala</td>
<td>43</td>
<td>46</td>
<td>52</td>
<td>2%</td>
</tr>
<tr>
<td>15 Tasmania</td>
<td>185</td>
<td>227</td>
<td>309</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1484</strong></td>
<td><strong>1739</strong></td>
<td><strong>2008</strong></td>
<td></td>
</tr>
</tbody>
</table>


The Bureau of Rural Sciences estimated that the rate of growth in plantations declined by approximately 30% in 2009, which continued a downward trend that began in 2007. The total area of new plantings was about 50,000 ha, most of which (87%) was planted to hardwood species (BRS 2011).

About 70% of the new plantations established in 2009 were funded by managed investment schemes (BRS 2010). Government agencies accounted for around 17% of new plantation establishment over the same period. The remaining 12% of new plantations were funded by timber industry companies, superannuation funds and other private owners. In recent years, the level of investment in forests through managed investment schemes has declined considerably.

National plantation area data does not currently include commercial-scale carbon plantings (plantations that are not harvested for commercial wood production but are maintained permanently solely for the purpose of capturing carbon), which have emerged as a result of the voluntary carbon offset market. Those areas are currently small in comparison to plantations managed for wood production.

**Native forests**

In the context of climate change policy impacts on water use, there has so far been much less focus on native forests than on plantation development in Australia. This can be attributed largely to the primary focus on land-use change, and specifically afforestation and reforestation, as the basis for significant carbon sequestration.

Furthermore, across state jurisdictions, native forests are managed in accordance with sustainable forest management policies and practices. Notwithstanding the impacts of bushfires, water use and water impacts do not change significantly over the longer term.

23 New plantations are defined as those that are established on land that has not previously been used for plantation forestry, as opposed to replantings on existing plantation land.
In the Australian forestry sector, climate change mitigation policy has had minimal impact on the management of native forests to date. While there is some scope for forest management practices in native forests to be recognised under a range of forest carbon frameworks, including the CFI, there has been limited work in Australia develop methodologies and large-scale projects that could lead to significant impacts on water use.

Therefore, the focus of this section of the report is on the plantation forestry sector, which includes plantations for wood production and permanent carbon plantings. This report does not address deforestation and its potential impacts on water resources.

10.1.2 The relationship between water and forestry

Plantations and native forests intercept water by reducing surface water runoff and groundwater aquifer recharge and, in areas with shallow watertables, by directly extracting groundwater. The water resource impacts from forests can be geographically concentrated.

There is ongoing research and debate about the extent of the impact of forests on water resources. In relation to water yield, it is generally accepted that, on an average annual basis, forests consume more water than pastures or annual crops, so that less runoff results from forested areas (see Zhang et al. 2001, Vertessy et al. 2003 and Benyon et al. 2007).

Forests can also produce positive environmental outcomes in relation to water resources, such as:

+ reduced local recharge, which assists in salinity control
+ reduced stream pollutant loads, including salinity. (CSIRO, n.d.)

The extent of these impacts on water quantity and quality varies depending on site characteristics and plantation management, including the proportion of area planted, the planting location within catchments, and variations in stand age and site productivity (Vertessy et al. 2003).

Water use in forestry

Measuring forestry interception activities is inherently difficult due to the multiple biophysical interactions contributing to forest growth over long periods. To determine meaningful trends requires measurements over long time-series to account for variable rainfall, age, growth rates and rotations. Other challenges arise from the differing hydrological behaviour of forests depending on soils, slope, topography and position in the landscape (see Vertessy et al. 2003).

Table 24 summarises the results of research by Benyon et al. (2007), which estimated average water use for different land uses in Victoria. Water use is defined in terms of evapotranspiration, which includes interception (evaporation from the wet exterior surfaces of vegetation), soil evaporation and transpiration.

This research suggests that water use by all of the forest types considered in the study was more than that for average crop/pasture and environmental plantings. However, in lower rainfall areas the difference between the land uses was found to be less.24

<table>
<thead>
<tr>
<th>Land use</th>
<th>Mean annual rainfall (mm/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Average 'generic' forest</td>
<td></td>
</tr>
<tr>
<td>Short (12-year) rotation plantation</td>
<td>460</td>
</tr>
<tr>
<td>Long (30-year) rotation plantation</td>
<td>470</td>
</tr>
<tr>
<td>High-rainfall native forest (ash type)</td>
<td>n.a.</td>
</tr>
<tr>
<td>Environmental planting</td>
<td>450–470</td>
</tr>
<tr>
<td>Average crop/pasture water use</td>
<td>410</td>
</tr>
</tbody>
</table>

n.a. = not applicable.


24 The values in Benyon et al 2007 may overestimate runoff consequences for all land use types, when compared to CSIRO sustainable yield modelling. If the difference between land uses is overestimated, that could act as a disincentive for carbon sequestration (Richard Beecham, A/Manager of Water Resource Management Modelling Unit, NSW Office of Water, pers. comm., 21 February 2012)
Vertessy et al. (2003) estimated the reduction in mean annual runoff associated with eucalypt afforestation in areas of mean annual rainfall between 600 mm and 1600 mm. The results suggested that the reduction ranges from approximately 1 ML/year (in areas with 600 mm mean annual rainfall) to about 1.7 ML/year (in areas with 800 mm of annual rainfall). This compares with an estimated mean annual runoff reduction of 2–3 ML for each megalitre of farm dam storage established in a catchment (Vertessy et al. 2003).

SKM et al. (2010) estimated the total interception of runoff associated with current forestry plantations across Australia as 2000 GL/year (equal to about 1 ML/ha on average). They found that the most highly affected surface water management areas included Moore – Hill Rivers (Western Australia); Millicent Coast, Glenelg and Latrobe River (Victoria); Lower Limestone Coast (South Australia); and Mary (Queensland).

Forests can also affect groundwater aquifer recharge and, in areas with shallow watertables, can affect groundwater levels by directly extracting groundwater. Benyon and Doody (2004) showed that where the median depth to groundwater was less than 6 metres plantations extracted groundwater directly from the rootzone in addition to using available rainfall. Where the aquifer was deeper, the impact on groundwater was solely a reduction in recharge (that is, trees did not directly extract groundwater).

Updating that research, SKM et al. (2010) estimated that, under long-term average climatic conditions, plantations could extract groundwater at the rate of just over 1 ML/ha per year in areas of shallow watertables. By comparison, using climatic conditions for the past decade as the reference, they found that the rate of extraction could be just over 2 ML/ha per year, because the reduced rainfall resulted in an increased reliance on groundwater.

Climatic conditions, especially rainfall and temperature (which affects evaporation), influence extraction rates and hence the impact of forests on interception. Similarly, site conditions such as geology and soils also affect the extent to which forests can use groundwater.

Institutional arrangements for water use in forestry

Currently, there are limited institutional arrangements for the management of water in the forestry sector. Water licences, which are common instruments for managing water use in irrigated agriculture, have not typically been needed to establish large-scale plantations.

However, under the NWI, jurisdictions have committed to implementing a series of measures to account for and manage the water interception effects of land-use change by no later than 2011.25

In reviewing progress under the NWI, the Commission’s water planning report card (NWC 2011a) found that interception activities are not consistently managed in accordance with the NWI across all jurisdictions. Furthermore, it found that water planning instruments often do not contain a transparent assessment of the significance of interception activities (including forestry) for catchments and aquifers.

A notable exception to this is South Australia, which has introduced new water plans that include measures to account for and manage the risk associated with plantation forestry in the state’s south-east. Further expansion of plantation forestry in that region will be subject to development thresholds that require the acquisition of an offsetting water access entitlement to account for the interception impact (NWC 2011b). This may constrain further plantation expansion in the region. By comparison, farmers making dryland agricultural land-use changes are not required to acquire water entitlements.

The Victorian Government recently released the Western Region Sustainable Water Strategy, which includes a number of policies and actions for the sustainable management of water resources over the next 50 years (DSE 2011). The strategy recognises rights to existing use in declared areas, but controls expansions of new forestry developments. It does so by requiring approval for developments covering 20 ha or more, or more than 10% of a property, whichever is greater. Approval will only be granted if the proponent is able to offset, within the declared area, the extra water used. The offset requirement could be met by purchasing an appropriate water access entitlement. Similarly to the situation in South Australia, farmers making dryland agricultural land-use changes are not required to acquire water volumes.26

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25 While interception by forests has been a key focus, the NWI also requires jurisdictions to consider water interception effects for all land-use change activities, including farming land-use change to high water-use vegetation.

26 The Western Region Sustainable Water Strategy notes that ‘Dryland farmers responded to dry conditions by managing their pastures and land to capture more moisture. The cumulative impacts of these changes over a catchment can be significant, even though they are not as water intensive as forestry on a unit area basis’ (DSE 2011:139).
10.1.3 Energy use and emissions in forestry

Energy use

Energy used in the forestry sector is primarily in the form of fuels used for forest management, including planting and harvesting operations. The forest processing sector is generally more energy intensive, depending on the scale of primary processing and secondary manufacturing processes and the distances that logs and wood products are transported.

Greenhouse gas emissions

The forest-growing sector removes carbon dioxide from the atmosphere through sequestration in expanding areas of plantation forests. The latest estimate of Australian forestry carbon ‘removals’ (or sequestration) was 23 Mt CO₂-e for 2008. Indicative modelling suggests that forestry removals in Australia will decline to 7 Mt CO₂-e in 2020 and stabilise at around 4 Mt CO₂-e in 2030 (DCCEE 2010b).

10.1.4 Other important drivers in the forestry sector

There are different drivers for investments in wood production plantations and permanent carbon plantings.

Plantations primarily for wood production

The economic factors driving plantation development for wood production relate primarily to harvest yields and log prices at the end of the rotation (the cycle of growing and harvesting trees), which must provide adequate returns to cover the establishment and management costs through the rotation, plus profit. For a plantation to be an economic proposition on a particular piece of land, the expected returns need to outweigh potential returns in other land uses, particularly in dryland agriculture.

The significant up-front establishment costs of plantations mean that the availability of funds for long-term investment is a key driver of plantation development. Access to investment funds is determined by the competitiveness of returns from forestry relative to other investment options. Tax-effective structures, such as managed investment schemes, have previously attracted considerable retail-based investment to the plantation forestry sector. However, with the recent collapse of a number of Australia’s largest forestry managed investment scheme companies, investment in the forestry sector through that mechanism has declined.

The availability and cost of suitable land near to timber mills or ports have limited plantation expansion in a number of regions, prompting plantation companies to seek new locations for plantation development (BRS 2007). Most Australian commercial forestry species are suited to areas that receive more than 650–700 mm of rainfall per year in temperate regions and areas with higher rainfall in subtropical and tropical zones.

The availability of suitable land is also influenced by local planning regulations. Currently, the planning treatment of plantations differs from that for other agricultural activities across jurisdictions, making it more or less attractive to invest in commercial forestry in some regions compared to others.

Permanent carbon plantings

Just as in plantation forestry, the drivers of investment in permanent carbon plantings include the availability and cost of suitable land. However, carbon plantings are not constrained by a need for proximity to processing facilities and other infrastructure. Historically, large-scale permanent carbon plantings have been established on marginal agricultural land in regions with lower than average annual rainfall. Having obtained affordable land, developers of permanent carbon plantings will typically select species suitable to the land and rainfall conditions.

As in plantations developed for wood production, establishment and maintenance costs are significant in permanent carbon plantings. The returns are also highly dependent on the carbon price. However, there is potential for carbon plantings to recognise revenue streams from sequestration early in their lives. This could improve the cashflow of projects and hence their competitiveness.

Previous uncertainty about a national emissions trading scheme and regulated carbon markets limited the development of permanent carbon plantings. With the introduction of the CEF package and the CFPI, there is now greater certainty about the recognition and eligibility of permanent carbon plantings. Such initiatives should reduce policy constraints to further investment in eligible projects.

27 See also sections 3.1 and 10.2.3.
10.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of carbon dioxide and other greenhouse gases. They can be broadly categorised as:

- cleaner energy measures, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (for example, coal-fired electricity generation) to lower emissions intensity sources (such as gas-fired or renewable electricity generation)
- energy efficiency measures, which aim to slow the growth in total energy demand and hence reduce the growth in emissions
- land-use change measures, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

10.2.1 Cleaner energy policy impacts

Impacts on forestry investment and management

There are three broad types of potential impacts of the carbon price on the plantation forest-growing sector:

- Impacts of the carbon price on plantation input costs: The introduction of a carbon price under the CEF is likely to have a direct impact on the costs of production for plantations managed for wood production, primarily through the cost of fuel for establishment, maintenance operations, harvesting and haulage. The costs of production for permanent carbon plantings are also likely to be directly affected, but with reduced maintenance costs and no harvesting or haulage costs. Those impacts are not likely to alter the pattern of investment or water resource impacts.
- The effects of the carbon price on demand for carbon sequestration products: The introduction of a carbon price creates a signal for forestry-based carbon sequestration credits that was previously created only through demand in voluntary carbon offset markets. With the CEF package and its price signal on carbon, demand for offset-based credits created under the CFI is likely to increase. In turn, that may stimulate further expansion of the area of permanent carbon plantings. This impact is addressed in Section 10.2.3, as the carbon price signal is linked to the incentives provided by land-use change measures.
- The effects of the carbon price on demand for wood products: Other segments of the forest sector supply chain are more likely to be affected by the introduction of the carbon tax. For example, the processing segment, which tends to be relatively energy intensive, is expected to incur significantly higher costs of production. Higher processing costs are typically not able to be passed on to consumers in full. Australia’s wood products sector is exposed to international competition, including imports from countries that are not currently subject to carbon emissions regulations. Therefore, increases in the cost of production in Australia have the potential to result in downward pressure on the price that processors are able to pay growers for logs. This has the potential to reduce the areas of plantation forestry that are economically viable.

Impacts on water use

Changes in the extent of plantations for wood production or carbon plantings could have a consequential effect on interception. The impacts of cleaner energy policies on water use differ between production plantations and carbon plantings:

- Plantations primarily for wood production: To the extent that the carbon tax has an impact on the costs of production and prices received for wood products, it could influence the scale, nature and location of production plantations in Australia, which would in turn influence water use and interception in particular locations. However, other factors described in Section 10.1.4, such as the availability and cost of suitable land and access to investment funds, are likely to be more significant drivers of plantation expansion, at least in the next 10 years.
- Permanent carbon plantings: The CEF package creates a national market for carbon offset credits, which can be supplied via the CFI by eligible projects developed for carbon sequestration. To the extent that demand for carbon offset credits is stimulated by the carbon price signal, and to the extent that offset credits can be competitively supplied to the market, demand for offset credits provided by permanent carbon plantings can be expected. This will influence the location and scale of such plantings, which would influence water use and interception in any particular location.
10.2.2 Energy efficiency

The Australian Government’s Clean Technology Program aims to slow the growth in energy demand. It is not yet known what the impact may be. However the forestry sector’s reliance on stationary energy is significantly less than that of the downstream processing sector (and other industry sectors), so the scope to reduce non-renewable energy inputs in this sector through the Clean Technology Program may be limited.

Forest processing enterprises may be able to apply for funding to invest in energy-efficient equipment and low-pollution technologies, processes and products under the program. This may offset, to some extent, the impact of higher energy prices resulting from the introduction of the carbon tax. Such changes are unlikely to have any water-related impacts in this sector.

10.2.3 Land-use change measures

The CFI is a voluntary carbon offsets scheme implemented by the Australian Government to provide opportunities for farmers, forest growers and landholders to contribute to activities that reduce carbon pollution (DCCEE 2011a).

For a given project to be considered eligible under the CFI, it must:

+ demonstrate that it will operate within the scope of the CFI
+ demonstrate that it will conform with an approved methodology
+ be on the ‘positive list’ of activities recognised under the CFI
+ not be on the ‘negative list’ of activities explicitly excluded from the CFI.

The CFI provides for the recognition of projects that occur in the agricultural and land-use sectors, as well as projects to reduce emissions from legacy landfill waste. Box 8 gives an overview of the positive list guidelines, with an emphasis on the implications for forestry. The positive list for the CFI includes most types of permanent carbon plantings.

Box 8: Overview of Carbon Farming Initiative ‘positive list’ guidelines affecting the forestry sector

The positive list guidelines include the following types of forestry projects*:

+ The establishment of permanent plantings since 1 July 2007
  – ‘Permanent plantings’ refers to the establishment of either native or non-native plant species, with the requirement that the plantings are not harvested.
  – The establishment of most types of ‘not for harvest’ permanent plantings has been determined to be not common practice and therefore eligible for inclusion in the CFI. Most commercial plantation activities are considered common practice and are therefore not included in the positive list.
+ Transitioning of existing forest carbon offset projects, including
  – forestry projects accredited under the Greenhouse Friendly initiative
  – permanent plantings accredited under the Greenhouse Gas Reduction Scheme (NSW) or the Greenhouse Gas Abatement Scheme (ACT)
  – permanent plantings established before 1 July 2007, in which the primary purpose of the plantings was the generation of carbon offsets.

Furthermore, eligible projects:

+ will need to comply with all local, state and Commonwealth government water, planning and environment requirements
+ will be required to take account of regional natural resource management plans
+ can be excluded by the ‘negative list’.

* Non-forestry projects include the application of biochar to soil, the capture and combustion of methane from livestock manure, and early dry-season burning of savannah areas.

Source: URS analysis derived from DCCEE guidelines and fact sheets
The Department of Climate Change and Energy Efficiency has also specified on a negative list activities that are not eligible to generate carbon credits. The negative list guidelines encompass the government’s approach to managing adverse environmental, social or economic impacts from CFI activities (see Box 9). This includes disallowing an activity where there is a material risk that the activity will have an adverse impact on one or more of:

+ the availability of water
+ the conservation of biodiversity
+ employment
+ the local community
+ land access for agricultural production.

**Box 9: Overview of Carbon Farming Initiative ‘negative list’ guidelines affecting the forestry sector**

The negative list includes the following forestry-related activities:

1. the establishment of a forest as part of a forestry managed investment scheme
2. the cessation or avoidance of harvest of a plantation forest
3. the establishment of vegetation on land subject to illegal clearing of native forest or draining of a wetland
4. the establishment of vegetation on land that has been subject to clearing of a native forest, or draining of a wetland
5. specified tree planting (the planting of trees in an area that, according to the CFI rainfall map, receives more than 600 mm long-term average annual rainfall), except where one or more of the following apply:
   - the project is a permanent planting that is also an environmental planting
   - the project contributes to the management of dryland salinity in accordance with the Salinity Guidelines
   - the project occurs in an area where the relevant jurisdiction has been determined by the National Water Commission as meeting its NWI commitment to manage interception by plantations
   - the project holds a suitable water access entitlement for the life of the project
   - it is not possible to obtain a water access entitlement, and the CFI administrator is satisfied that the project causes no material impact on water availability.

Source: Based on Carbon Credits (Carbon Farming Initiative) Regulations 2011.

On the basis of the requirements of the positive list, there is currently no opportunity for plantation forestry incorporating wood production to participate in the CFI. Commercial forestry projects for traditional wood production would not be considered ‘additional’ under the CFI guidelines for assessing eligibility. However, as methodologies continue to evolve and develop, wood production plantation forestry activities that can be demonstrated to be beyond common-practice activities to increase carbon sequestration could be considered additional and therefore potentially eligible activities under the CFI. The Commission understands that the Department of Climate Change and Energy Efficiency is investigating the potential for certain commercial wood production forestry activities to be considered additional, and therefore eligible under the CFI.

The negative list provides the framework by which activities are assessed as ineligible under the CFI. Reflecting concerns about the potential adverse impacts on interception, the planting of trees in areas of high mean rainfall (above 600 mm/year) is generally deemed to be ineligible, unless at least one of five specific conditions that may ameliorate those concerns has been met. Some conditions relate to the treatment of water interception (for example, where the project occurs in the area of an approved water plan that addresses interception or the proponent holds a suitable water access entitlement).
Effects on land use in the forestry sector

So far, limited analysis of the likely expansion of permanent carbon plantings under the CFI has been done. In 2011, ABARES estimated the abatement potential from reforestation under the CFI (Burns et al. 2011). The study incorporated modelling for two scenarios: ‘medium’ global action and ‘ambitious’ global action, which corresponded to the stabilisation of atmospheric greenhouse gases at 550 parts per million (ppm) and 450 ppm, respectively. ABARES estimated the reforestation for two different carbon prices drawn from the ‘world carbon price’ series that would be necessary to maintain those levels of atmospheric greenhouse gases in the future. The medium global action scenario corresponds with a global carbon price that begins at $23/t CO₂-e. This aligns with the value at which Australia’s carbon tax will be fixed for its first three years of operation. On this basis, it could be argued that the medium global action scenario is broadly consistent with current policy settings.

ABARES defined reforestation activity as comprising long-rotation hardwood plantations and carbon plantings, which were assumed at the time of the study to create eligible carbon sequestration credits under the CFI. Short-rotation hardwood plantations as well as softwood plantations were not included in the study, as it was assumed that such plantings would not be eligible under the CFI. As noted above, long-rotation hardwood plantations managed for wood production are also not eligible under current CFI requirements.

ABARES estimated the total area of agricultural land that would be potentially economically feasible for reforestation under the medium global action scenario to be around 350 000 ha between 2012–13 and 2049–50 (Burns et al. 2011). This comprised long-rotation hardwood plantations totalling 190 000 ha and permanent carbon plantings of around 160 000 ha. Table 25 indicates relatively minimal land-use change until the 2032–2042 assessment period.

The rules for eligibility under the CFI currently exclude all wood production plantations, ABARES’ modelled estimates of the area of long-rotation hardwood plantations would not be achieved under the policy as it stands. Any prospect of encouraging additional reforestation through these plantings would require a change to the current eligibility rules to specifically incorporate long-rotation hardwood plantations.

In contrast, permanent carbon plantings are currently eligible under the CFI, so the ABARES estimates of those areas provide an indication of the potential impact of the CFI on the area of land that may be converted to plantation forests.

Table 26 lists the estimated areas of reforestation under the ‘ambitious’ global action scenario. Over the period from 2012–13 to 2049–50, the estimated area planted to long-rotation hardwood is around 1.2 million ha, while the carbon plantings area is estimated at 3.7 million ha.

28 Environmental plantings are ‘plantings that consist of Australian native species that are native to the local area of the plantings and may be: a mix of tree and understory species; or a single species if monocultures occur naturally in the area’ (DCCEE, undated).
### Table 25: Additional areas of reforestation projected under the medium global action scenario, by state and territory, 2012–13 to 2049–50 ('000 ha)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Long-rotation hardwood timber plantations</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NSW</td>
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</tr>
<tr>
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<tr>
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<td>77.9</td>
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<td>Carbon plantings</td>
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<tr>
<td>NSW</td>
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<td>14.6</td>
<td>44.1</td>
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<td>Qld</td>
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<td>58.1</td>
</tr>
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<td>&lt;0.1</td>
<td>&lt;0.1</td>
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<tr>
<td>WA</td>
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<tr>
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<td>Australia</td>
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<td>66.9</td>
<td>53.5</td>
<td>157.1</td>
</tr>
</tbody>
</table>

Source: Burns et al. (2011).

### Table 26: Additional areas of reforestation projected under the ambitious global action scenario, by state and territory, 2012–13 to 2049–50 ('000 ha)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Long-rotation hardwood timber plantations</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>331.1</td>
<td>381.7</td>
<td>182.8</td>
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Forestry

<table>
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<td>1.5</td>
<td>1.2</td>
<td>4.0</td>
</tr>
<tr>
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<td>30.6</td>
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<td>78.9</td>
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<tr>
<td>Australia</td>
<td>503.2</td>
<td>817.3</td>
<td>1345.8</td>
<td>1076.7</td>
<td>3743.0</td>
</tr>
</tbody>
</table>

Source: Burns et al. (2011).

ABARES modelling under the more ambitious scenario suggests that by 2032 the CFI could result in significant expansions of long-rotation hardwood plantations (were they to be eligible under the CFI) and carbon plantings in a range of areas. The probability of the ambitious global action scenario estimates being realised in the future is currently low, as they are based on carbon prices significantly higher than Australia’s current carbon pricing policy under the CEF (and on a change to the current policy to include long-rotation hardwood plantations within the scope of the CFI).

Generally, based on modelling under both scenarios, ABARES found that the economic viability of the projected CFI reforestation appears to be confined to areas that are currently used for dryland grazing. This is largely because the land value in those areas tends to be lower than in areas used for irrigated agriculture (Burns et al. 2011).

These results reflect scenario-based analysis to determine when land would become economically viable for reforestation, with reference to current agricultural land uses, based on relative net returns across various land uses and under selected carbon price paths. The analysis did not include consideration of changes to long-term average rainfall that may occur as a result of climate change; nor did it incorporate the margin by which returns from reforestation must exceed those from agriculture to induce changes in land use.

Furthermore, the study findings do not reflect other factors that may affect the takeup of CFI-compliant reforestation projects, such as sociocultural factors that may favour agricultural land use (Burns et al. 2011).

However, the ABARES research stands as the only known published modelling at a national level of the potential impacts of current climate change policy on reforestation activity. As such, it provides contextual guidance on the magnitude of those impacts and the regions in which they would be most likely to occur.

Water-related impacts from changes in land use

As described above, ABARES modelling reforestation under the CFI suggests that by 2050 the area of permanent carbon plantings could be about 160 000 ha Australia-wide under the medium global action scenario, most of it in north-east New South Wales (approximately 100 000 ha) and along the mid-coast region of Queensland (around 60 000 ha). This would occur if the returns that could be made from carbon plantings equal or exceed returns to current land uses in these areas, so it is technically feasible that the land use may change. It should be noted that these areas are only small proportion of the total land area in the two states, that most of the investment is forecast to occur after 2030, and that long-rotation hardwood plantations are not currently eligible under the CFI.

Figure 45 shows the estimated areas of reforestation associated with ABARES (2011a) modelling under the medium global action scenario. It also shows the catchments in which that reforestation is projected to occur.
Figure 45: Potential Carbon Farming Initiative reforestation and catchment locations

Legend
- Catchments with potential carbon plantings
- Potential carbon plantings
- Catchment boundaries
- Murray–Darling Basin

Source: URS, based on ABARES (2011b).

Impacts on runoff

As noted in Section 10.1.2, Vertessy et al. (2003) estimated reductions in catchment runoff per hectare of eucalypt afforestation to be 1.7 ML/year in 800 mm annual rainfall areas and 1.0 ML/year in areas receiving 600 mm.

Based on that research, the total reduction in mean annual runoff associated with ABARES’ (2011b) estimates of new permanent carbon plantings under the medium global action scenario could be between 160 GL and 272 GL by 2050.

A large proportion of permanent carbon plantings to date have been in areas with low to medium annual rainfall (350–800 mm) (Benyon et al. 2007). If that trend holds, the reduction in runoff would be closer to 160 GL by 2050, which would be equal to about an extra 8% reduction in total runoff due to interception from plantations from current levels of 2000 GL/year (based on SKM et al. 2010).

ABARES’ modelling suggests that much of the carbon plantings will occur in the period from 2032 to 2050. On that basis, significant additional impacts on runoff would not occur in the short to medium term.
Impacts on groundwater

As noted in Section 10.1.2, SKM et al. (2010) estimated that plantations could extract groundwater at the rate of just over 1 ML/ha per year in areas with shallow watertables (under long-term climatic conditions) or up to just over 2 ML/ha per year (under climatic conditions of the past decade). However, those results are highly dependent on the climatic assumptions and the site geology and soils.

Based on the SKM research, total groundwater extraction associated with ABARES’ (2011b) estimates of new areas of permanent carbon plantings could be from 160 GL to 320 GL by 2050.

Impacts on other water users and the environment

Understanding the potential water-related impacts of increased interception from plantations associated with the CFI also requires looking not just at the aggregate volumes but at the location of the impacts. They will be of more concern in water systems that are fully allocated, approaching full allocation or overallocated. ABARES’ modelling suggests that CFI-related reforestation will be mainly in north-east New South Wales and along the mid-coast region of Queensland.

Few carbon plantings linked to the CFI are forecast to occur in the MDB, suggesting that the initiative in its current form may not add significantly to water resource management pressures in the basin. However, that may change if the CFI regulations change (for example, to enable some plantations involving wood production to be eligible). Also, the ABARES study is a modelled assessment of where investment is likely to occur, so it should be treated as indicative only. Actual investment may occur in other areas.

Wherever new carbon plantings occur, the impact of their interception of water on other users and the environment will depend on the arrangements in place to address these issues. Under the CFI, the potential impacts of carbon plantings are intended to be managed to avoid or mitigate any adverse impacts on the availability of water. The CFI requires that all eligible activities must:

+ comply with all Commonwealth, state and local government water, planning and environmental requirements
+ take into account the objectives of regional natural resource management plans
+ not be excluded by the requirements of the CFI ‘negative’ list.

Those requirements are also intended to address the potential for cumulative impacts if a number of projects are proposed for a given catchment. The way that the CFI negative list operates means that the interception impacts of permanent plantings that are also environmental plantings will largely depend on the effectiveness of the Commonwealth, state and local government water, planning and environmental requirements referred to in the positive list.

10.2.4 Summary assessment of water-related impacts of mitigation policy in the forestry sector

The potential water-related impacts of climate mitigation policy in the forestry sector are summarised in Table 27.

Overall, for owners of plantations for wood production, the CEF and CFI currently do not provide incentives for land-use change. Therefore, there are not likely to be any water-related impacts associated with production plantations unless there is policy change.

The CEF and CFI have the potential to provide incentives for land-use change to permanent carbon plantings. However, under current settings, that area potentially involved is small relative to Australia’s total area of plantations for wood production, which grew by about 50 000 ha in 2009 (ABARES 2011a). In comparison, ABARES’ modelling suggests that the CFI may result in an additional 160 000 ha of carbon plantings in total by 2050.
<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Impacts of cleaner energy and energy efficiency policies</th>
<th>Impacts of land-use policies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature of impact</strong></td>
<td>The CEF creates a price signal, which will create demand for least-cost carbon abatement and offsets. In turn, this is expected to create demand for plantation-based offsets, which could affect water demand and interception.</td>
<td>The CFI indicates that eligible plantation activities are likely to be limited to permanent carbon plantings. Research indicates that plantations can result in higher water use than crops and pasture in most settings; however, the impact on groundwater and interception will depend on biophysical interactions.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Not location specific.</td>
<td>Recent ABARES (2011b) modelling indicates that the areas with the highest potential for land-use change to permanent carbon plantings include north-east NSW and the mid-coast region of Queensland.</td>
</tr>
<tr>
<td><strong>Likelihood/timing</strong></td>
<td>Effective immediately, with interest running ahead of the carbon price to be introduced in mid-2012.</td>
<td>Project development is expected to occur slowly at first. ABARES (2011b) modelling suggests a significant increase in the 2032–2042 period. Further change in eligibility and approved methodologies under the CFI may occur.</td>
</tr>
<tr>
<td><strong>Magnitude/sensitivity</strong></td>
<td>Unlikely to directly result in significant land-use change (plantations for wood production); however, this result is sensitive to the current ineligibility of production plantations for the CFI.</td>
<td>ABARES study in 2011 estimated the potential for carbon plantings as a direct result of the CFI to be about 160,000 ha by 2050. Based on relevant research, this is estimated to potentially result in a reduction in mean annual runoff of around 160 GL by 2050. The potential groundwater extraction associated with these carbon plantings is estimated to be about the same volume. Th interception effects could be greater if CFI policy changes in the future to include short-rotation hardwood plantations or other forms of reforestation.</td>
</tr>
<tr>
<td><strong>Importance of climate change policy impact compared to other drivers of change</strong></td>
<td>Minimal for wood production plantations, based on current CFI regulations. High for permanent carbon plantings (through the CFI).</td>
<td>Business-as-usual investment in plantation forestry for wood production may have more significant water interception impacts than new investment under the CFI. High impacts for plantations for carbon sequestration, although in absolute terms modelling suggests that the potential area of growth in carbon plantings is limited.</td>
</tr>
<tr>
<td><strong>Overall materiality of impact</strong></td>
<td>No impact from wood production plantations, based on current CFI regulations. Moderate for permanent carbon plantings (through the CFI).</td>
<td>No impact from wood production plantations, based on current CFI regulations. Localised to moderate water impacts from permanent carbon plantings (through the CFI).</td>
</tr>
<tr>
<td><strong>Potential water policy issues</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water policy issues</strong></td>
<td>Impacts of water interception and potentially unaccounted use on the environment and third parties.</td>
<td></td>
</tr>
<tr>
<td><strong>Current water policy tools</strong></td>
<td>Water planning, entitlements and markets, and regulation to manage interception impacts, including existing regulations in the CFI.</td>
<td></td>
</tr>
<tr>
<td><strong>Existing knowledge of the issue</strong></td>
<td>Water implications of plantation interception are well known. This study shows that the impact attributable to climate change policies may be limited unless there is further policy change.</td>
<td></td>
</tr>
<tr>
<td><strong>Overall policy implications</strong></td>
<td>Interception is a well-known water policy issue that needs to be addressed for plantations and for land-use change driven by a range of factors, including climate change policies.</td>
<td></td>
</tr>
</tbody>
</table>
10.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise from adaptation policy and responses to climate change in the forestry sector.

In accordance with the framework set out in Section 4, this requires:

+ identifying the potential impacts and risk of climate change (in this case, as they affect the forestry sector)
+ identifying the likely autonomous and policy responses to adapt to those changes in the sector
+ assessing the consequent water-related impacts and identifying possible water policy issues

10.3.1 Potential impacts of climate change on forestry

ABARES’ recent series of reports on the potential effects of climate change on forests and forestry in Australia (ABARES 2011b) describes possible effects on forest growth in six regions:

+ the Green Triangle region (south-east South Australia and south-west Victoria)
+ north-east New South Wales
+ south-east Queensland
+ northern Australia
+ south-east New South Wales and eastern Victoria
+ Tasmania.

The reports also describe the effects on wood production, the forestry and forest products industries and the communities that depend on those industries.

The ABARES study concluded that, compared to 2005, most production forest areas in Australia are likely to receive lower rainfall and experience an increase in temperature by 2030. The implications for forest productivity will vary across regions, subregions and species. Some important commercial forest species, such as radiata pine, may become less productive under projected warmer and drier conditions, while others, such as maritime pine, might not be significantly affected (ABARES 2011b).

The study did not include the potential impacts of high atmospheric carbon dioxide on tree growth. The carbon dioxide ‘fertilisation effect’ may offset productivity declines from warmer and drier conditions. The study also excluded consideration of adaptation measures that the industry may adopt in response to climate change (ABARES 2011b).

With lower rainfall and higher temperatures, climate change also has potential to result in an increase in the frequency and intensity of bushfires, and may affect the distribution of pests and diseases that affect forestry species. Weeds, which compete with trees for soil resources, especially water, may also become more prolific, especially if wider tree spacing is used as an adaptation to lower rainfall (Stokes and Howden 2008).

10.3.2 Adaptation responses and policies

The plantation forestry sector has considered a range of adaptation measures in response to climate change. They are outlined in the National Climate Change and Commercial Forestry Action Plan 2009–2012 (DAFF 2009), which was endorsed by the Natural Resource Management and Primary Industries ministerial councils. The measures included in the action plan are:

+ the development of tools to promote tree survival
+ improved water efficiency
+ improved responses to pest attacks and other hazards, such as fire.

The Primary Industries Ministerial Council is responsible for overseeing the implementation of the action plan.

Variables such as species mix, new genetics, location and silvicultural practices will be particularly important considerations for the establishment of new forests, and to a lesser extent for the management of existing production forests (DAFF 2009).
10.3.3 Possible water-related impacts and policy issues

The impacts on water resources from climate change adaptation responses by the forestry sector are not known with any precision. However, with the expectation of lower annual rainfall and an increase in temperatures in most areas of Australia where forests are currently growing or may be established in the future, rainfall interception by plant canopies will probably be lower, evaporation from soil and surface water bodies will probably be higher, and groundwater recharge may be reduced. Transpiration from vegetation is also expected to be generally higher in the future (ABARES 2011b).

The extent to which these trends will result in changes in runoff is not yet clear because of the interplay between reduced rainfall and increased temperatures. However, Benyon et al. (2007) note that evapotranspiration is the second largest component of the hydrological cycle after rainfall, and could therefore be considered to be affected more in the context of climate change. Streamflow and groundwater recharge are relatively small components of the overall water balance (Benyon et al. 2007).

Currently, water policy settings do not generally have direct impacts on the location of new plantations, because most jurisdictions have not met their NWI obligations regarding the management of the water interception effects of land-use change. However, as more jurisdictions address their NWI obligations, it can be expected that measures will be put in place to better manage and account for any third-party impacts of plantations.

In turn, such regulations may affect the location of future plantations, because they could increase plantation owners’ costs of production. If applied inconsistently, water-related regulation may mean that plantation owners seek to establish plantations in areas that are not subject to regulation (such as in a catchment that is not fully allocated). However, the impact may be only marginal because rainfall, soil and proximity to markets are also key determinants of plantation location.

10.3.4 Summary assessment of climate change and adaptation policy

Table 28 summarises the potential impacts of climate change adaptation on the forestry sector.

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Nature of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Responses to reduced rainfall and warmer temperatures are expected to include changes to the location of plantations, the plantation species mix, new genetics, forest management silviculture and fire management practices. These responses may result in changes to patterns of water interception and use.</td>
</tr>
<tr>
<td>Location</td>
<td>Most current production forest areas in southern Australia are expected to receive lower rainfall and experience an increase in temperature. Forest owners and managers in key plantation regions will need to consider adaptation strategies and changes.</td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td>The impacts on runoff from forest areas are uncertain and depend on the counteracting impacts of reduced rainfall and increased temperature.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Potentially moderate impacts, but there is a high level of uncertainty about climate outcomes and adaptation responses.</td>
</tr>
<tr>
<td>Importance of climate change impact compared to other drivers of change</td>
<td>Over the short to medium term (up to 10 years), the importance of climate change impacts on forest management is expected to be low to moderate, given the range of other drivers of change. Over the longer term (10+ years), the risks and uncertainty posed by the impacts of climate change may become a highly significant factor affecting land-use change.</td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>Over the short to medium term (up to 10 years)—low to moderate. Over the longer term (10+ years)—moderate to high.</td>
</tr>
</tbody>
</table>

Potential policy issues

<table>
<thead>
<tr>
<th>Potential policy issues</th>
<th>Water policy issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impacts of water interception and use on the environment and other users.</td>
</tr>
<tr>
<td>Current water policy tools</td>
<td>Water planning, entitlements and markets, and regulation to manage interception impacts.</td>
</tr>
<tr>
<td>Existing knowledge of the issue</td>
<td>There is some uncertainty about the likely impacts.</td>
</tr>
<tr>
<td>Overall policy assessment</td>
<td>Highlights the importance of best practice water planning and access entitlements regimes and water markets enabling the flexible movement of water without creating third-party impacts.</td>
</tr>
</tbody>
</table>
10.4 References


CSIRO (Commonwealth Scientific and Industrial Research Organisation) (no date). Maximising the benefits of new tree plantations in the MDBA, CSIRO, Canberra.


SKM (Sinclair Knight Merz), CSIRO and Bureau of Rural Sciences (2010). Surface and/or groundwater interception activities: initial estimates, Waterlines report, National Water Commission, Canberra.


11 Agriculture

The impacts of climate change, particularly on water availability, have the potential to result in significant changes in the structure and size of the irrigated agriculture sector in Australia. New areas of irrigation may develop and others may shrink or move out of irrigation entirely. Climate change mitigation policies may also influence the viability of individual irrigation enterprises and their water demands.

Because agriculture is Australia’s largest water-using sector, these impacts are particularly important for water policy. However, the cumulative effect of climate change on water availability, demand and use in the irrigated agricultural sector is extremely hard to predict. Therefore, a flexible, risk-based approach to water policy will be needed to incorporate future uncertainty and cope with a range of possible local climatic changes.

Water planning, entitlements and market-based arrangements need to be clearly defined for the full set of climate scenarios. Climate change will test the robustness of water markets in areas, such as the southern MDB, where systems are relatively mature. Perhaps more significantly, climate change may create resource development and adjustment pressure in areas where water planning entitlements and market systems are absent or very immature and under-resourced.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian agricultural sector in order to:

+ provide background on the agricultural sector and its relationships with water, energy and emissions (Section 11.1)
+ describe the likely effects of mitigation policy on the sector, and their implications for water policy (Section 11.2)
+ describe the likely effects of climate change impacts and adaptation responses on the sector, and their implications for water policy (Section 11.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

Figure 46 summarises the interactions identified in this assessment.
Figure 46: Summary of interactions in the agricultural sector

- **Mitigation policy**
  - Cleaner energy
  - Energy efficiency
  - Land-use change

- **Adaptation responses**
  - Indirect impact on energy prices
  - Agricultural emissions (not included)
  - Impacts on agricultural land use and management practices

- **Changes in climatic variables**
  - Changes in water supply and demand
  - Impact on water assets and service performance

- **Water policy implications**
  - Impacts on rural water service providers (see Section 13)
  - Impact on water assets and service performance
  - Impacts on water assets and service performance
  - Changes in the size and spatial distribution of water demand
  - Impacts on interception of water
11.1 Background

11.1.1 About the agricultural sector

The Australian agricultural industry comprises approximately 121,000 farms (ABS 2008), which produce a variety of commodities for sale on domestic or export markets. In some cases, agricultural producers sell their products to domestic processors for secondary production (such as wine and dairy products).

There are two broad types of agricultural production:

+ **Irrigated agriculture** involves extracting surface water or groundwater to supplement rainfall to grow crops. Examples include irrigated pasture (for dairying), horticulture (fruits and nuts, vegetables) and viticulture (wine grapes).

+ **Dryland agriculture** largely relies on rainfall. Examples include beef (cattle and calves) and wheat production.

The gross value of all Australian agricultural production (at the farm gate) was approximately $41 billion in 2009–10 (Hogan and Morris 2010). The main agricultural products (by value) were cattle and calves, wheat, milk, vegetables, and fruits and nuts (Figure 47). According to the ABS (2010), the gross value of irrigated agriculture in Australia was $11.5 billion in 2009–10, of which $4.4 billion was generated in the MDB.

While the focus of this assessment is on the irrigated agricultural sector, interactions with dryland agriculture are also considered.

Figure 47: Share of major commodities in Australia’s gross value of farm production, 2009–10 (%)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle and calvesa</td>
<td>16.7</td>
</tr>
<tr>
<td>Wheat</td>
<td>11.1</td>
</tr>
<tr>
<td>Milk</td>
<td>7.1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>6.3</td>
</tr>
<tr>
<td>Fruit and nuts</td>
<td>5.4</td>
</tr>
<tr>
<td>Sheep and lambsa</td>
<td>5.0</td>
</tr>
<tr>
<td>Wool</td>
<td>4.5</td>
</tr>
<tr>
<td>Poultry</td>
<td>3.6</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>3.0</td>
</tr>
<tr>
<td>Barley</td>
<td>2.9</td>
</tr>
<tr>
<td>Cotton</td>
<td>2.4</td>
</tr>
<tr>
<td>Pigs</td>
<td>2.0</td>
</tr>
<tr>
<td>Canola</td>
<td>1.8</td>
</tr>
<tr>
<td>Wine grapes</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Source: Hogan and Morris (2010).
11.1.2 The relationship between water and agriculture

There is a range of interactions between water and the agricultural sector. Surface water and groundwater are used for irrigated agricultural production and for stock and domestic purposes. Irrigation water is often stored in dams, and supply and distribution services are provided by rural WSPs (see Section 13).

Irrigators extract and use water for productive purposes using a variety of techniques (for example, flood, sprinkler and drip irrigation). Excess water that drains from an irrigation farm can become a return flow in waterways or enter groundwater aquifers. Some irrigators have access to both surface water and groundwater sources, and the water-use practices of irrigators can influence the quantity and quality of both sources.

While dryland agricultural producers do not apply water from rivers and aquifers to crops, they do use water for stock and domestic purposes. Many dryland farmers construct farm dams and other works to intercept water that would otherwise run off to surface water and groundwater systems.

Water use in agriculture

Agriculture is the largest water-using industry in Australia and typically accounts for around two-thirds of total Australian water use each year, although this fell to around half of all water use in the recent drought (ABS 2010). Irrigated agriculture accounts for the vast majority of total water use in agriculture. For example, it accounted for 90% (or 6596 GL) of total agricultural water use in 2009–10 (ABS 2011).

In 2009–10, 52% of Australian agricultural water use was in the MDB. Other significant water-using agricultural regions included south-west Western Australia and regions in Victoria, South Australia and Queensland outside the MDB. There are smaller irrigated agricultural industries in the north of Western Australia (such as the Ord Scheme) and a number of irrigation systems in coastal and northern Queensland and in Tasmania.

In 2009–10, the main types of water use in the MDB states were for cotton, pasture for grazing (for example, for dairy farming), cereals (including rice), grapevines, fruits and nuts. Pasture for grazing was the major agricultural water use in Western Australia and Tasmania (Table 29).

<table>
<thead>
<tr>
<th>Table 29: Main water-using industries, by state or territory, 2009–10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>NSW</td>
</tr>
<tr>
<td>Vic.</td>
</tr>
<tr>
<td>Qld</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>WA</td>
</tr>
<tr>
<td>Tas.</td>
</tr>
<tr>
<td>NT</td>
</tr>
</tbody>
</table>


Water use for irrigated agriculture varies substantially from year to year depending on seasonal conditions (Figure 48). For example, total water use in irrigated agriculture in Australia declined by 39% from 2005–06 to 2009–10 due to drought.
Water use by each agricultural industry does not necessarily change in proportion to total agricultural water use. For example, the share of agricultural water use by water-intensive annual crops such as rice and cotton tends to be higher in wetter years and lower in drier years (see ABS 2008). Water use by agricultural industries with relatively fixed water demands (such as permanent horticulture) is less variable from year to year (NWC 2010).

Institutional arrangements for the supply of water to irrigated agriculture

State governments are responsible for managing water resources in their jurisdictions, including establishing and administering rights to take and use water. Individual irrigators typically hold water access entitlements or licences, which provide an ongoing right to access to a share of water available from a specified surface water or groundwater source each year. The volume available from water entitlements each year is known as the seasonal allocation, which is expressed as a percentage of the entitlement. Irrigators can often trade water entitlements and allocations with other water users to manage their water supply security.

The main source of water supply to agriculture in 2009–10 was water supplied by government or private irrigation schemes (see Section 13), followed by self-extracted groundwater and surface water. Reuse from off-farm sources is relatively modest.
Energy use and carbon emissions in agriculture

Energy use

Energy use in agricultural production includes electricity and fuel to operate farm infrastructure (for example, on-farm irrigation systems and cool storage facilities) and machinery (such as harvesters). In general, these direct energy costs account for less than 10% of total production costs in agriculture. Electricity accounts for a higher share of costs for dairy farming, which consumes significant electrical power for refrigeration. In contrast, fuel costs account for a relatively high share of direct energy costs for broadacre and cropping systems (Table 30).

Agricultural production often uses inputs that are energy intensive. For example, the production of fertiliser and chemicals uses energy-intensive processes. These inputs typically account for a higher share of costs in cropping industries. Freighting produce to market also uses large amounts of fuel. Pressurised irrigation water delivery and application systems require electricity or (diesel) fuel. Electricity costs are also included in water delivery charges levied on irrigators by rural WSPs, particularly for pumped and pipelined systems.

Table 30: Inputs as a share of total farm costs, by agricultural industry (%)

<table>
<thead>
<tr>
<th></th>
<th>Broadacre</th>
<th>Wheat and other crops</th>
<th>Mixed livestock/crops</th>
<th>Dairy</th>
<th>Sheep</th>
<th>Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>0.8</td>
<td>0.7</td>
<td>0.8</td>
<td>2.6</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Fuel</td>
<td>7.6</td>
<td>9.8</td>
<td>8.8</td>
<td>3.7</td>
<td>6.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Freight</td>
<td>3.2</td>
<td>4.5</td>
<td>3.2</td>
<td>1.1</td>
<td>2.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>9.5</td>
<td>15.3</td>
<td>12.0</td>
<td>7.4</td>
<td>8.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Chemicals</td>
<td>6.0</td>
<td>12.4</td>
<td>7.6</td>
<td>0.6</td>
<td>2.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Other costs</td>
<td>72.8</td>
<td>57.3</td>
<td>67.7</td>
<td>84.6</td>
<td>78.5</td>
<td>87.0</td>
</tr>
</tbody>
</table>

Source: Tulloh et al. (2009).

These are average costs for each industry. Cost structures (for example, energy inputs for refrigeration) could vary by region.
Greenhouse gas emissions

Although the agricultural sector accounts for a comparatively small proportion of total domestic energy use in Australia, it produced 15% of Australia’s greenhouse gas emissions in 2009 (DCCEE 2011). Important sources of agricultural emissions include livestock (enteric fermentation and manure) and soil management practices (Figure 50).

**Figure 50: Emissions in the Australian agricultural sector, 2007 (%)**

| Source: DCCEE (2009). |

11.1.4 Other important drivers in the agricultural sector

Much of the Australian agricultural industry is highly trade exposed and, for many products, Australian farmers are price takers in global markets (Garnaut 2008). Consequently, any changes in input costs, global commodity prices or exchange rates can have significant implications for farm profitability and production.

Australia’s agricultural industry has undergone continual structural change for decades in response to economic pressures. Over that period, there have been significant efforts to increase productivity through increased economies of scale. Before the drought of the 2000s, for example, the number of commercial farms in Australia almost halved, from around 200,000 in 1961 to just over 100,000 in 2001. Over the same period, the average area of land operated by farms increased by almost 50%, from 2800 hectares in 1961 to around 4100 hectares in 2001. Hooper et al. (2002) suggest that the changes in farm numbers and farm area occurred incrementally rather than suddenly as farmers continually adjusted the size and nature of their operations in response to changes inherent in an open market economy.

The need for adjustment in the irrigated agricultural sector can be traced back to the early development of water resources in Australia. For most of the 20th century, governments presided over the construction and operation of substantial headworks and delivery systems designed to drought-proof the settled parts of the country (see NWC 2011). One consequence of this irrigation development was that many of Australia’s surface water and groundwater systems, particularly in the MDB, were overallocated, leading to serious environmental problems.

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30 ABS energy accounts suggest that agriculture accounted for less than 1% of domestic primary energy use and less than 5% of domestic secondary energy use in 2008–09. Primary energy sources include firewood, coal, crude oil, natural gas, liquefied natural petroleum gas, uranium, bagasse and solar energy. A secondary energy source is a product that has been derived from a primary energy source (refined petroleum products, coal by-products, coke, electricity etc.).
Since that time, a major aim of water policy has been to address overallocation. It is envisaged that an eventual shift to more sustainable levels of diversion will result in an overall reduction in water available for use by the irrigation sector. While the task of reducing overallocation may be made more difficult by climate change, it is an issue to be addressed regardless of climate change. Furthermore, allocation decisions will need to be robust to climate change and consider how impacts are shared between environmental and consumptive water users.

While the rebalancing of water between consumptive and environmental uses is an issue in many areas across Australia, attention and priorities for action are currently focused on the MDB. Two key initiatives with major implications for irrigated agriculture in the MDB are the development of the Murray–Darling Basin Plan and the Australian Government’s water buyback program.

The Murray–Darling Basin Authority (MDBA) has been assigned the task of preparing a plan for the integrated and sustainable management of water resources across the whole MDB (the Basin Plan) (MDBA 2011a). A key goal of the Basin Plan is to shift consumptive water extraction onto a more sustainable footing through the establishment of new sustainable diversion limits (MDBA 2011b). The release of the draft Basin Plan by the MDBA has provided indications of the reductions in water usage sought over the next seven years. The plan indicates that across the MDB the water still to be recovered for the environment equals around 13% of the baseline diversion limits (that is, the limits at 2009 levels of development). Because that there is little scope to reduce conveyance volumes and town water, reductions to irrigated agricultural volumes will be proportionally greater than the average reduction in diversions.

The Australian Government’s Restoring the Balance in the Murray–Darling Basin Program is a component of Water for the Future, the government’s national plan for water. Under the program, the government has committed $3.1 billion over 10 years to purchase water from willing sellers in the MDB. The buyback program is aimed directly at addressing overuse in the MDB and protecting and maintaining important water-dependent environmental assets.

The buyback program is explicitly targeted as a tool to facilitate adjustment and transition to a future in which less water will be available for consumption due to climate change and the implementation of new and lower sustainable diversion limits under the Basin Plan.

11.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of greenhouse gases. They can be broadly categorised as:

+ **Cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (for example, coal-fired electricity generation) to lower emissions intensity sources (such as gas-fired or renewable electricity generation)

+ **Energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **Land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

The following sections examine the potential impacts of these policies on the agricultural sector, which may in turn affect water demand, use and management.

11.2.1 Cleaner energy policy impacts

As discussed in Section 3, the cleaner energy policies will impose a carbon price on major producers of emissions and as a consequence lead to an increase in the price of energy. The following discussion assesses the potential impacts of cleaner energy policies on irrigated agricultural producers and their demand for water (such as impacts on volume and location) and methods of extraction (such as pumping). It examines:

+ the potential impacts of direct liability for agricultural emissions

+ the impacts of the carbon price on farm input costs

+ the effects of the carbon price on farm-gate prices and incomes

+ the consequential impacts on water use.
Direct liability for emissions

The Australian Government has decided to exclude the agricultural sector from the carbon pricing scheme under the Clean Energy Future (CEF) package (see Section 3). This means that farmers will not be liable to pay a carbon price for emissions from livestock, fertiliser, off-road use of fuel, or on-road use of light vehicles (Combet 2011). However, agricultural producers will be eligible to receive credits for certain activities that are deemed to reduce emissions (see Section 11.2.3).

It is possible that agriculture may be included in a carbon pricing or emissions trading scheme at some time in the future. This has occurred internationally. For example, agricultural emissions are being incorporated into the emissions trading scheme in New Zealand, where reporting is to commence from 2012 and permits are to be surrendered by 2015. Direct emissions from agriculture have not been included under the European Union’s arrangements to date.

If agricultural emissions were included in pricing carbon in the future, there could be significant impacts on farm costs. For example, modelling by ABARES (Tulloh et al. 2009) suggests that including direct agricultural emissions in a carbon pricing regime would more than double the overall effects on farm input costs in some industries (such as beef and sheep farming) compared to the indirect increases in electricity, freight and fuel costs from the carbon price. However, in other industries (such as dairying and wheat and other cropping) this effect was not estimated to be as great.31 The overall modelled increase in farm input costs from the carbon price (including agricultural emissions) was still generally below 2.5%.

A number of agricultural crops can be used to produce biofuels such as ethanol (as an additive to petrol) and biodiesel. This production is considered to be carbon neutral because the carbon dioxide generated from burning the biofuel has been previously sequestered during the growth of the crop. However, because petrol and diesel are not currently covered by carbon policy initiatives there is little incentive for biofuel use attributable to mitigation policy. This could change in the future if fuel were included in a carbon price or emissions trading scheme.

Impacts on farm input costs

As noted in Section 3, the cleaner energy policies and in particular the carbon price will lead to an increase in the price of electricity, which will increase the costs of energy-intensive agricultural inputs (such as fertiliser and chemicals). Because heavy on-road vehicles will be subject to a carbon price from July 2014, freight costs for agriculture will also probably increase (Australian Government 2011a).

Irrigation water pumping costs may increase, and the carbon price may prompt changes in pump types and fuel sources, particularly from electrical to diesel or solar power. For example, Mushraq and Maraseni (2011) undertook an economic analysis of adopting sprinkler and drip irrigation technologies. Sensitivity analysis found that a carbon price of $10–$30/t CO₂-e would have a small impact of the net present value of adopting those technologies, although in some cases the higher carbon price resulted in switching from a positive net present value outcome to a negative result.

Electricity costs are also embodied in water delivery charges levied on irrigators by rural WSPs, particularly for pumped and pipelined systems. Higher electricity prices may therefore result in higher water delivery charges for irrigators, although those impacts are likely to be small (see Section 13).

The overall effect of the carbon price on farm costs is likely to be relatively modest, at least at the initial level of the price. Energy accounts for a relatively small share of total farm input costs (see Table 30 in Section 11.1.3). International competition will limit scope for domestic suppliers of inputs such as fertiliser and chemicals to drive up their prices (Tulloh et al. 2009).

Recent partial equilibrium modelling suggests that the increase in farm input costs three years after the introduction of the carbon price will be less than 2% for most agricultural industries (Australian Farm Institute 2011).32 The exceptions are Victorian and New South Wales dairying (2.7% to 2.8%) and New South Wales rice growing (3%).

In contrast, general equilibrium modelling by the Commonwealth Treasury suggests long-term increases in agricultural production due to the carbon price. As agricultural output is traded, the modelling indicates that the sector gains a competitive advantage from lower wages and exchange rates in the carbon pricing scenarios, and all parts of the agricultural sector grow more rapidly.

The two modelling approaches indicate a potential transitional issue, but with short-term impacts being ameliorated in the longer term, based on current carbon prices (Treasury 2011).

The CEF package also includes a range of transitional assistance measures that may ameliorate the impacts of the carbon price on agricultural producers (see Australian Government 2011b for details).

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31 Tulloh et al. (2009) assume a carbon price of $28/t CO₂-e and transitional assistance to rice and livestock industries under the scenario in which agricultural emissions are covered.

32 Assuming the current coverage of the carbon pricing regime and a $25/t CO₂-e carbon price.
Impacts on farm-gate prices and income

A carbon price may also affect the prices received by farmers for their produce and thus their overall income and viability.

Processors of agricultural products will face increased production costs, as processing is generally energy intensive. Transport costs may also increase. The impact of higher electricity prices on processors may affect farm-gate prices, as processors have limited scope to pass on increased costs to consumers due to international competition. To maintain their margins, they may reduce farm-gate prices paid to producers (Australian Farm Institute 2011).

Recent modelling suggests that percentage decreases in farm income due to the carbon price will be larger than percentage increases in costs. Particularly affected industries include dairying in Victoria and New South Wales (Figure 51).

Figure 51: Change in farm input costs and farm cash income three years after the introduction of a carbon price (%)

Impacts on water use

To the extent that cleaner energy policies have a material impact on farm viability by affecting both the costs of production and farm-gate prices, they could influence the size, nature and/or location of irrigated agriculture in Australia, which could change water demand in any particular location.

The impacts are difficult to predict and will vary between industries. Increased costs are likely to have a negative impact on farm viability, which would tend to reduce water demand. However, demand for irrigation water could increase in some areas if production moves location. For example:

+ dairy production could contract due to increased costs and/or relocate to cooler climates to reduce energy costs for refrigeration
+ the cost of rice production could increase, leading to a contraction in production
+ wine-grape producers are more likely to be affected by higher electricity costs (given their greater reliance on pumping), and many wine-grape growers are currently struggling due to depressed wine-grape prices.

In practice, other economic factors such as general changes in commodity prices and input costs may have a larger effect than a carbon price on farm profitability and the fortunes of specific industries. For example, higher costs for agricultural inputs, particularly for fuel, fertiliser and chemicals, have been observed in recent years, driven primarily by high global prices for petroleum and higher demand for these inputs (Garnaut 2008).

Overall, it is difficult to determine the impact of the introduction of the CEF package on the viability of agricultural producers. The impacts will depend on other market factors influencing the particular industry. However, there may be some irrigators who are more exposed to higher electricity costs, particularly those with significant electric pumping requirements (which have higher emissions than diesel-fuelled pumping). Furthermore, recent work by ABARES highlights the very low returns that many irrigators have achieved during the drought and the significant debts they have incurred. Therefore, even modest cost increases could adversely affect the viability of many irrigators.
11.2.2 Energy efficiency

While many energy efficiency measures are targeted at households, buildings and transport, some may affect the agricultural sector. In particular, food processors may be able to apply for funding to invest in energy-efficient equipment and low-pollution technologies, processes and products under the Australian Government’s Clean Technology Program. To some extent, this may reduce the impact of higher energy prices associated with the carbon price.

In general, energy efficiency measures are likely to have very limited impact on water demand and use. By reducing energy use, any impact they do have may ameliorate the impacts of cleaner energy policies.

11.2.3 Land-use change measures

Land-use change measures such as the Carbon Farming Initiative (see Section 3) alter the relative profitability of different land uses and land management practices in agriculture. In general, the policies aim to increase the extent of perennial vegetation, which acts as a net store of carbon.

Land-use change measures may produce:

+ changes in irrigated and dryland farming, from agriculture to permanent carbon (tree) plantings (see Section 10)
+ changes in farming practices and crop types (for example, greater use of perennial pastures and actions to increase soil carbon).

Early indications are that there may be limited take-up of initiatives based solely on returns for carbon because of the underlying economics. The cost of carbon capture and the mitigation of agricultural emissions suggests that the carbon price may need to increase substantially to encourage major changes in irrigated agriculture management practices or crop types (see CSIRO 2009).

CSIRO (2009) and the Garnaut Review (2008) both indicate that the options likely to produce the highest national abatement involve the rehabilitation of overgrazed rangelands to build carbon stores. Such options have very limited interactions with water resources.

Both reports also found that building soil carbon storage and mitigating nitrous oxide emissions from cropped land also have potential. However, CSIRO (2009) found that the technical potential for mitigation was unlikely to be realised due to economic and management challenges. That conclusion is supported by work commissioned by Dairy Australia, which indicated that the price for carbon would need to be very high (greater than $200/t CO\textsubscript{2}-e) for carbon storage to offer greater returns than using additional feed in milk production (McKenzie Soil Management, 2010).

More generally, the immediate opportunities for agriculture under the CFI are limited until additional methodologies are approved. Currently, only two methods are approved (landfill gas capture and piggery methane management). Four others have been proposed:

+ avoided emissions from diverting waste from landfill for process engineered fuel manufacture
+ management of large feral herbivores (camels) in the Australian rangelands
+ environmental plantings (reforestation)
+ savannah burning.

Many practices that increase soil carbon and vegetation are also likely to improve yield and farm productivity, and are already part of recognised best practice in agricultural systems. Therefore, one of the challenges in this area relates to the development of approved accounting methods that demonstrate the ‘additionality’ of the action. Soil carbon measurement for verification of carbon storage is a complex issue. Methodologies for measurement and verification therefore need to be developed and their costs better understood before they can be widely applied. This challenge may mean that change is likely to be some time away.

In the short term, the Biodiversity Fund, another component of the CEF package, is the most likely option for revegetation and the restoration of habitats in targeted areas of the landscape.

Carbon sequestration on irrigated farmland (such as tree growing) is unlikely to be a significant area of sequestration activity based on current carbon price signals alone. However, it may be an attractive ‘add-on’ to support beneficial change. For example, it could be used to assist and expand on-farm tree-growing activities that have multiple benefits, such as shade, shelter and biodiversity enhancement.

In a similar way, carbon credits may be a valuable component of packages to support wider land-use change as the area of irrigated land contracts in response to reduced water availability resulting from climate change and the return of water to the environment.
In theory, land-use change activities in agriculture could have several impacts on water resources, including:

+ changes in the nature of regional demands for water (and other inputs, such as labour) as farmers substitute some sequestration activities for conventional farming
+ localised changes in water quality because of changes in land- and water-use practices (for example, low tillage and reforestation)
+ reduced water availability due to the interception of surface water and groundwater flows.

Compared to changes in plantation forestry, changes in agricultural practices generally have smaller impacts on interception on a per unit area basis. However, there is some evidence of significant changes in water use associated with shifts from annual to perennial crops, such as from wheat to lucerne (see, for example, Keating et al. 2002). Also, agriculture occurs over a much greater area than forestry, so even marginal changes in interception associated with agriculture may have significant catchment-wide impacts.

Despite these potential interception impacts, the impact of mitigation policy associated with agricultural land-use change is likely to be very small (at least in the short term and at current carbon prices). Most of the viable mitigation options relate to rangeland systems where the impacts on interception are lower, or to livestock management practices that are not expected to result in significant changes in water interception.

The technical and economic merits of agricultural land-use change mitigation measures may change over time and may necessitate further consideration of interception impacts.

11.2.4 Summary assessment of water-related impacts of mitigation policy in the agriculture sector

Table 31 summarises the potential water-related impacts of climate mitigation policy as it affects the agricultural sector. Overall, the impact on water demand and water use in the sector is likely to be moderate, particularly compared to the influence of other factors.

Table 31: Water-related impacts of mitigation policies in the agricultural sector

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Impacts of cleaner energy and energy efficiency policies</th>
<th>Impacts of land-use change measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>Changes in water demand due to impacts of carbon price on farm viability.</td>
<td>Changes in interception due to land-use changes incentivised by carbon sequestration policies. This could have impacts on water interception, water quality and water demand.</td>
</tr>
<tr>
<td>Location</td>
<td>Currently irrigated areas (particularly rice growing and dairying in the MDB) and areas with potential for increased irrigation (e.g. Tasmania, northern Australia).</td>
<td>Across Australia.</td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td>Impacts on farm viability will occur upon the introduction of a carbon price.</td>
<td>Some potential to occur upon the introduction of a carbon price, although methodologies need further development.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Likely to have a modest impact on farm returns due to higher input and processing costs, although the overall impact on farm viability is difficult to predict. Impact would be higher if agricultural emissions were to be liable for the carbon price.</td>
<td>The CFI is unlikely to result in significant land-use change at the current carbon price. The Biodiversity Fund has potential to result in land-use change and may provide benefits where land is no longer irrigated due to the movement to sustainable diversion limits. It may also increase interception.</td>
</tr>
<tr>
<td>Importance of climate change impact compared to other drivers of change</td>
<td>Other economic factors and the implementation of other water reform policies are likely to have a greater short-term impact.</td>
<td>Low. Agricultural practices are constantly changing, and such changes generally have a marginal impact on interception, although there are some exceptions.</td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>
### Impacts of cleaner energy and energy efficiency policies vs. Impacts of land-use change measures

<table>
<thead>
<tr>
<th>Potential water policy issues</th>
<th>Impacts of land-use change measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water policy issues</strong></td>
<td>Potential changes in demand create a potential challenge to the optimal allocation of water resources.</td>
</tr>
<tr>
<td><strong>Current water policy tools</strong></td>
<td>Water planning, entitlements and markets.</td>
</tr>
<tr>
<td><strong>Existing knowledge of the issue</strong></td>
<td>Changes in water demand are ongoing, with well-known implications for water management.</td>
</tr>
<tr>
<td><strong>Overall policy implications</strong></td>
<td>The focus of water policy has been on interception in forestry. Limited attention has been paid to potential impacts from agricultural land-use change.</td>
</tr>
</tbody>
</table>

#### 11.2.5 Implications of current water policy for the implementation of mitigation policy

Existing water policy settings will influence the ability of irrigators to adjust and respond to the introduction of mitigation policy measures (for example, changes in land use sought under the CFI).

In some cases, water policy settings may directly influence the mitigation efforts. For example, Mustaq and Maraseni (2011) found that on-farm water-use efficiency measures (conversion to sprinkler and drip irrigation) increase energy use and greenhouse gas emissions. Therefore, any water policies that subsidise such investments may increase emissions. While these impacts are unlikely to be material in relation to national mitigation efforts, they should be considered in the implementation of water policy (see Section 6 of this report).

#### 11.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise from adaptation responses to climate change in the agricultural sector.

Following the framework set out in Section 2, this involves:

+ identifying the potential impacts and risks of climate change (as they affect agriculture)
+ identifying the likely responses to adapt to those changes in the sector
+ assessing the consequent water-related impacts and identifying possible water policy issues.

#### 11.3.1 Potential impacts of climate change on agriculture

The impacts of climate change on agriculture examined in this assessment include:

+ changes in water availability for irrigated agricultural production
+ changes in temperatures and extreme weather, which can affect the suitability of land in various locations for specific types of agriculture.

The focus of this assessment is the irrigated agricultural sector, as changes in dryland agriculture are likely to have limited impacts on surface water and groundwater resources, apart from the possible interception issues discussed in Section 11.2.3.
Water availability

Climate change is projected to increase rainfall variability and reduce runoff in key agricultural regions. By 2030 (under a median climate scenario), for example:

+ the MDB, south-west Western Australia and southern Queensland are projected to experience moderate to high decreases in runoff
+ southern Victoria and Tasmania are generally projected to experience slight to moderate decreases in runoff.

More detailed discussion of these impacts is in Section 4.

Reduced runoff would lead to reduced reliability of water entitlements for irrigators, which could in turn affect the size of the irrigation sector and the mixture of permanent and annual crops that can be grown under irrigation.

Climate change will tend to compound stresses on the environment that have arisen through the historical overallocation of water resources.

Higher temperatures and extreme weather

Projected increases in average temperatures and the incidence of extreme weather will have implications for the cost, quality and quantity of agricultural production. For example, higher temperatures would lead to increased evaporation and increased potential for crop damage. They could also increase the incidence of some pests, such as fruit fly, which could have detrimental impacts on production (DPI 2011).

Other potential impacts include the following:

+ Higher temperatures and greater evaporative demand by crops may adversely affect the yield and fibre quality of cotton in northern New South Wales and southern Queensland.
+ Higher temperatures in dairying regions of the MDB (such as the Murray Valley) are likely to create heat stress for stock and increase energy demand for cooling production sheds.
+ Higher temperatures and extreme weather (such as frosts and heatwaves) will affect the quality of wine-grape varieties originally planted on the basis of historical climatic conditions.
+ The combination of higher summer maximum temperatures and reduced winter chill and frost may mean that some areas that currently produce stone fruit will not be suitable for that activity in the longer term.
+ A moderate increase in temperatures (for example, 1°–2°C by the middle of the century) may lead to an increase in cereal yields in mid- to high latitudes, but would have adverse effects on yields at lower latitudes, especially in seasonally dry and tropical environments. That would imply a long-term shift in the comparative advantage of broadacre agriculture in certain parts of Australia (see Cline 2007).
+ Increases in storms increase the risk of waterway pollution due to fertiliser and chemicals runoff, and from manure in intensive livestock industries (such as piggeries and dairies).

In general, there is a much higher level of confidence in the predicted temperature increases and much more uncertainty about the specific impacts on rainfall and runoff, and the incidence of extreme events.

In addition to influencing the nature of regional water demand and competition for water, these changes have implications for rural WSPs, which are responsible for planning infrastructure investments based on future water demand and service requirements (see Section 13).
Summary of potential impacts of climate change on agricultural industries

Table 32 summarises the potential impacts of climate change on different agricultural regions and sectors in Australia.

### Table 32: Potential impacts of climate change on irrigated agricultural industries

<table>
<thead>
<tr>
<th>Industry</th>
<th>Impacts</th>
</tr>
</thead>
</table>
| Cotton                    | Northern MDB and Queensland: Less irrigation water, higher temperatures and greater evaporative demand by crops will reduce yield and fibre quality.  
                           | Southern and central MDB: Warmer conditions may allow for improved growing conditions.  
                           | Non-MDB: Conditions may facilitate the establishment of a sizeable cotton industry in the Ord Irrigation Area. |
| Rice                      | Southern MDB (NSW Riverina): Less irrigation water available. Decline in likelihood of cold damage during head formation.  
                           | Increased risk of crop heat-damage.                                       |
| Viticulture               | Southern MDB and SA: Ripening in a warmer part of the season and impacts on quality. Water may become a limiting factor for production.  |
| Intensive livestock       | South-west WA and southern MDB: Irrigated dairying likely to be affected by reduced water allocations and higher temperatures.  
                           | Some heat-stress problems for stock. Possible increased energy demand for cooling or warming production sheds  
                           | Tasmania and southern Victoria: Dairying likely to benefit from warming and drying. Possible reduced energy demand for heating production sheds. |

Source: Adapted from CSIRO (2008a).

Australian agriculture will also be affected by climatic shocks in other parts of the world via international markets. The effects of climate change on the global commodity prices that govern the returns to much of Australian agriculture are mixed. A study by the International Food Policy Research Institute estimates that prices for wheat, rice and maize in 2050 would be up to 23.1%, 19.8% and 32.2% higher, respectively, than they would have been without further climate change beyond 2000 (Nelson et al. 2010). However, Garnaut (2011) questions some of the assumptions in that assessment. Moreover, the 2007 Intergovernmental Panel on Climate Change reports concluded that ‘globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1 to 3 degrees Centigrade’ (IPCC 2007:11). This net gain was expected to be driven by increased crop productivity in mid- to high latitudes due to temperature increases and increased concentrations of carbon dioxide, which plants use in photosynthesis. These conflicting views on the direction of change highlight significant uncertainty in this field.

11.3.2 Adaptation responses

Given that some potential impacts of climate change are ‘locked in’, a key issue is how the agricultural sector will adapt to those changes and the implications that may have for the use and management of water. It is worth noting that the Australian agricultural sector has a long history of managing climatic extremes of floods, droughts and heatwaves. The sector has developed technologies and other management practices to cope with climatic variability.

Adaptation interactions for the agricultural sector are complex and difficult to predict in any definitive manner. Some adaptations are likely to be relatively simple and low cost (for example, changing crop varieties) and to occur at the farm level. Others might involve industry-wide and transformational change in farming systems and land use (see Stokes and Howden 2010).

It would be attractive to pursue the notion of an ‘irrigation industry’ response to external factors such as climate change and policy change, but the reality is that the industry is composed of a multitude of individual businesses that are all likely to respond and adapt to climate change in different ways, depending on their circumstances. The response of farm businesses will depend on factors such as their debt levels, access to finance, position in the farm investment and development cycle, skills and ability to change farming techniques or modify their crop mix. Despite the likely diversity in responses, it is possible to make some broad assumptions about possible adaptation responses in irrigated agriculture that may have implications for water use and demand in the sector, including the following.

**Increases in on-farm and off-farm water-use efficiency and reuse**

One of the main responses to reduced water availability will be to increase on-farm water-use efficiency. The recent drought has already initiated much activity in this area. Where this leads to increased uptake of drip or sprinkler irrigation, there could be some interactions with increased energy costs under a carbon price.
Increasing use of water markets to make the best use of available water

Reduced water availability and increased input costs will encourage farmers to seek the best returns for irrigation water. This is likely to see water move between farms and between regions.

Reduced water availability and greater variability may influence the mix of permanent and annual summer crops that can be grown (as well as the extent of supplementary watering of winter crops). While reductions in the reliability of entitlements may prompt irrigators with inflexible water demands (such as horticulturalists) to purchase additional water, there may be a movement to more flexible irrigation systems.

It could be expected that areas with disadvantages such as saline soils, which have already lost water through trading, will continue to see trading out in response to climate change pressures. Moving land out of irrigation may also have onsite impacts on soil health and offsite impacts (such as salinity) that might need to be managed.

Changes in the location of agricultural activities

Climate change may create opportunities for certain types of agricultural production to move to or expand in less traditional growing areas (Table 32). For example:

+ some areas in southern Victoria and Tasmania that were previously too cool for viticulture may become suitable for that activity
+ dairy production in Tasmania and southern Victoria may increase compared to dairy production in the MDB
+ cotton production may expand in southern New South Wales and the Ord (Northern Territory) compared to northern New South Wales. (CSIRO 2008a, PMSEIC 2007)

Anecdotal evidence suggests that the recent drought resulted in cereal growing occurring in areas previously deemed too wet or cool for that activity.

Changes in crop varieties, types or production methods

Agricultural industries may also respond to climate change by switching to (or developing) crop varieties or production methods that are more suited to new climatic conditions:

+ The cotton industry may develop varieties with heat shock resistance, drought tolerance and higher agronomic water-use efficiency.
+ Wine producers in traditional wine-growing regions may gradually switch to warmer climate grape varieties.
+ There is some scope to adapt rice production in current ponded culture or change to aerobic and alternate wet-and-dry rice production (PMSEIC 2007, CSIRO 2008a, Stokes and Howden 2010).
+ EverGraze perennial pasture (which has only recently been developed) increases resilience to within-year climatic variability and longer term climate change. A targeted outcome of EverGraze research and development was reducing groundwater recharge to reduce the risk of land salinisation. However, the perennial pasture may increase water use in doing so (Sanford et al. 2006, Future Farm Industries CRC 2011).

Greater use of resources that are not yet fully allocated (or subject to formal extraction caps)

Irrigators may look to secure their water needs in areas where markets and caps are not fully in place (for example, by increasing their licensed volumes).

This may also result in substitution between groundwater and surface water sources.

Exits from the industry

Ultimately, some irrigators may choose to exit the industry in response to climate change and other factors. This creates a potential for the permanent or semi-permanent contraction of irrigation in some areas.

Effects of other government policies

In addition, some other government policies might influence adaptation responses. For example, governments have continued to provide financial drought assistance to farmers. Other policy settings may also influence the propensity of farmers to make major adjustment decisions.
### 11.3.3 Possible water-related impacts and policy issues

Climate change has the potential to significantly affect the extent and distribution of irrigated agriculture, and hence water demand and use. However, predicting such trends is fraught with uncertainty.

External factors such as world commodity markets and impacts on the supply of agricultural commodities due to climate change in other parts of the world may significantly influence the demand for Australian agricultural products. The transmission of world climatic shocks via international markets will combine with local climatic developments to shape the future extent and nature of activities that currently rely on irrigation. These factors are difficult to predict with any certainty.

Nevertheless, potential impacts include changes in the nature of water demand within the MDB, greater demands on water resources and water management outside the MDB, or both.

Changes in the mixture of agriculture in a region could affect future groundwater supplies. For example, CSIRO suggests that changing from cropping to grazing in drier areas may have a much greater direct effect than climate change on recharge if it occurs over large areas (CSIRO 2011). CSIRO notes that the degree to which such changes occur is difficult to predict because they will depend on a number of factors, including social and economic factors.

Without appropriate mechanisms to manage these changing activities, they could adversely affect other water users, the environment, or both. For example, inadequate arrangements to facilitate increases in water transfers or water extractions could compromise supply security or have environmental impacts. These factors may be particularly pronounced in regions where entitlement arrangements are less developed (that is, outside the MDB and some groundwater systems). In 2008, the CSIRO Sustainable Yields project found that:

> Groundwater use across the MDB, given current groundwater management arrangements, could more than double by 2030 to exceed one-quarter of total average water use. This is despite existing planning controls that will reduce groundwater extraction to below current levels in some areas. It highlights the need to bring all groundwater use into the water entitlement system.33 (CSIRO 2008b:10)

These potentially major structural changes in agriculture—Australia’s biggest water-using sector—highlight the importance of the full implementation of best practice policies for water planning, water entitlements and water markets.

### 11.3.4 Summary assessment of climate change and adaptation policy

#### water-related impacts in the agriculture sector

Table 33 summarises the potential impacts of climate change adaptation on the agriculture sector.

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Nature of impact</th>
<th>Location</th>
<th>Likelihood/timing</th>
<th>Magnitude/sensitivity</th>
<th>Importance of climate change impact compared to other drivers of change</th>
<th>Overall materiality of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Responses by irrigators to changes in water availability and other impacts of climate change, which result in changes to patterns of water extraction and use and generally greater competition for limited resources.</td>
<td>Southern Australia is likely to experience the most significant reductions in water availability.</td>
<td>The impacts are highly uncertain. Some evidence links recent droughts to the impacts of climate change. Other modelling suggests gradual reductions in water availability over several decades.</td>
<td>Potentially very significant impacts (particularly on rainfall and runoff), but high level of uncertainty about climatic outcomes and adaptation responses.</td>
<td>There are many other immediate drivers of change in the agricultural sector. However, the impacts of climate change have the potential to fundamentally change the sector at some time in the future.</td>
<td>Potentially very high, particularly as agriculture is the largest water-using sector.</td>
</tr>
</tbody>
</table>

---

33 The NSW Achieving Sustainable Groundwater Entitlements program occurred after the CSIRO assessment.
Potential policy issues

| Water policy issues                                                                 | Changes in water availability and associated demand-side responses to climate change create a challenge to the optimal allocation of scarce water resources. If new development occurs in areas less affected by climate change, there is also a risk of environmental and third-party impacts if existing water policy tools are insufficiently developed. |
| Current water policy tools                                                           | Water planning, entitlements and markets. |
| Existing knowledge of the issue                                                      | The impacts of climate change on water resources have been a major driver of rural water policy for some years, including under the NWI. |
| Overall policy assessment                                                            | Climate change adaptation responses highlight the importance of best practice water planning, water access entitlements regimes and water markets in enabling the flexible movement of water without creating third-party impacts. |

11.4 References


Combet G (2011). ‘Rural Australians supported under a carbon price’, joint media release by the Minister for Climate Change and Energy Efficiency, Greg Combet, the Minister for Agriculture, Fisheries and Forestry, Senator Joe Ludwig, and the Parliamentary Secretary for Climate Change and Energy Efficiency, Mark Dreyfus QC MP, 10 July.


PMSEIC (Prime Minister’s Science, Engineering and Innovation Council) Independent Working Group (2007), Climate change in Australia: regional impacts and adaptation: managing the risk for Australia, PMSEIC, Canberra.


The urban water sector is tasked with providing secure, safe, healthy and reliable water-related services to urban communities in an economically efficient and sustainable manner. Climate change and policy responses to it will create challenges for the sector in achieving those objectives.

A key question will be how to ensure urban water security in the light of climate change, which will potentially exacerbate rainfall variability and lead to overall declines in long-term average rainfall. Arguably, however, problems with variable water availability are already well recognised and have been a key focus of the urban water industry and government in recent years.

More recently, focus has shifted to how incremental changes in climatic variables and extreme events may affect the performance of water-related infrastructure (including wastewater and stormwater infrastructure), with potential secondary impacts on customers, the broader public and the environment. While some urban WSPs are well placed to manage these issues, there are implications for governments in planning, standard setting and regulation.

Mitigation policies, and in particular the carbon price, will have implications for operating and investment decisions in the sector. For example, the carbon price will change the costs of sourcing water from natural water sources compared to energy-intensive sources, such as desalination and recycled water. It will also increase the costs of treating wastewater for disposal to the environment. These pressures reinforce the need for institutional and policy settings in the urban water sector that promote efficient investment, service provision, and water sourcing and use decisions.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian urban water sector in order to:

+ provide background on the urban water sector and its relationships with water, energy and emissions (Section 12.1)
+ describe the likely effects of mitigation policy on the sector, and their implications for water policy (Section 12.2)
+ describe the likely effects of climate change impacts and adaptation responses on the sector, and their implications for water policy (Section 12.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

Figure 52 summarises the interactions identified in this assessment.
Figure 52: Summary of interactions in the urban water sector
12.1 Background

12.1.1 About the urban water sector

The urban water sector provides a number of services:

+ **Potable water services**, including harvesting and manufacturing water, storing it, treating it to a standard fit for human consumption, and transporting it through transmission and distribution networks for delivery to end users.

+ **Recycled water services**, including harvesting wastewater or stormwater, treating it to a quality that is fit for purpose (including to potable standard), and transporting it to end users.

+ **Wastewater services**, including transporting sewage and trade waste from customers to where it is treated, and then either disposing of it or recycling it.

+ **Stormwater services**, including collecting stormwater runoff, and transporting it to where it is either disposed of or recycled.

There are many links between these services. Stormwater infrastructure and services play a major role in flood mitigation but can also feed into the water supply system. Similarly, some dams and reservoirs have dual purposes of both water supply and flood mitigation.

In recent years, the definition of the urban water sector has expanded to include aspects of the broader urban environment (Figure 53). In considering the impacts of climate change on the sector, this assessment includes broader urban water cycle management, which encompasses flood mitigation, drainage and stormwater management. However, it does not address in detail broader urban and regional planning aspects of ‘liveable’ cities or consider non-water aspects of catchment management.

Figure 53: The expanding definition of the urban water sector

<table>
<thead>
<tr>
<th>Liveable cities</th>
<th>+ Regional planning + Urban planning + City liveability + Water-sensitive urban design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban water cycle management</td>
<td>+ Water harvesting + Surface water storage + Stormwater collection</td>
</tr>
<tr>
<td>+ Flood mitigation + Catchment management + Waterway health</td>
<td></td>
</tr>
<tr>
<td>Traditional water and wastewater service provision and management</td>
<td>+ Bulk water supply + Water manufacturing + Water treatment</td>
</tr>
<tr>
<td>+ Water distribution + Retail services + Wastewater collection</td>
<td></td>
</tr>
<tr>
<td>+ Wastewater treatment + Wastewater recycling + Effluent discharge</td>
<td></td>
</tr>
</tbody>
</table>

Source: NWC (2011a).

Structure and governance of the urban water sector

The Australian urban water sector comprises more than 150 entities that provide services to urban customers in large cities and regional towns. Government-owned WSPs and local councils have traditionally dominated the Australian urban water sector. However, the private sector often provides water-related services, including building and operating key infrastructure (such as desalination plants).

In many cases, different organisations are responsible for different water services in the same city or town. For example, water businesses often provide water and wastewater services, while local councils manage stormwater (see Productivity Commission 2011:44).

Government agencies, economic regulators or both typically set prices and standards for water, wastewater and stormwater services and oversee planning and investment.

A variety of environmental and health regulations govern the provision and use of potable water, recycled water, wastewater and stormwater services. Examples include drinking water quality standards and environmental standards for treating wastewater before release to the environment. There are also health and safety and environmental regulations for operating water and wastewater infrastructure. Different government agencies administer these regulations in each state.
Location of the urban water sector

The urban water sector is concentrated in the populated coastal areas of south-east Australia, Queensland and south-west Western Australia (Figure 54). Large urban water utilities service major urban populations in Sydney, Melbourne, Perth, south-east Queensland, Canberra, Adelaide and Darwin. Smaller water businesses and councils service regional urban centres in Victoria, Tasmania, Queensland and New South Wales.

Figure 54: Locations of major urban water service providers

Source: NWC (2012).
Sources of water supply

The main sources of urban water supply are surface water and groundwater (Table 34). Cities in coastal areas (for example, Sydney, south-east Queensland and Perth) often draw on desalination or have desalination plants under development (for example, Melbourne and Adelaide). Many inland cities and towns (particularly in the MDB) rely on bulk water services from rural WSPs (see Section 13).

Table 34: Sources of supply for urban areas, 2009–10

<table>
<thead>
<tr>
<th>Area</th>
<th>Total water sourced</th>
<th>Surface water</th>
<th>Groundwater</th>
<th>Desalination</th>
<th>Recycled water</th>
<th>Bulk water purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GL</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>NSW—metro</td>
<td>692.3</td>
<td>94.2</td>
<td>1.0</td>
<td>2.9</td>
<td>1.9</td>
<td>–</td>
</tr>
<tr>
<td>NSW—regional urban</td>
<td>311.0</td>
<td>66.9</td>
<td>14.8</td>
<td>–</td>
<td>2.6</td>
<td>15.8</td>
</tr>
<tr>
<td>Vic.</td>
<td>615.8</td>
<td>87.6</td>
<td>4.1</td>
<td>–</td>
<td>3.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Qld</td>
<td>435.4</td>
<td>86.5</td>
<td>3.1</td>
<td>5.3</td>
<td>5.1</td>
<td>–</td>
</tr>
<tr>
<td>SA</td>
<td>177.2</td>
<td>83.9</td>
<td>2.0</td>
<td>–</td>
<td>14.0</td>
<td>0.1</td>
</tr>
<tr>
<td>WA</td>
<td>309.5</td>
<td>47.1</td>
<td>42.3</td>
<td>10.4</td>
<td>1.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Tas.—metro</td>
<td>43.2</td>
<td>100.0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>NT</td>
<td>52.5</td>
<td>68.3</td>
<td>29.7</td>
<td>–</td>
<td>2.0</td>
<td>–</td>
</tr>
<tr>
<td>ACT</td>
<td>49.6</td>
<td>91.4</td>
<td>–</td>
<td>–</td>
<td>8.6</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>2686.4</td>
<td>81.1</td>
<td>9.0</td>
<td>2.8</td>
<td>3.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Note: Includes utilities with more than 10,000 connections.

12.1.2 Urban water use

Urban water use includes water use by residential, commercial, municipal and industrial customers and water use by the water supply industry itself. Residential households typically account for around two-thirds of total urban water consumption; the remainder is used by commercial, municipal, industrial and other users (Figure 55). However, the relative importance of the different uses varies between cities and water businesses. Commercial, municipal and industrial use generally accounts for a higher proportion of urban consumption in regional urban areas serviced by non-major utilities.

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34 This includes water consumed when supplying water and sewerage and drainage services, as well as water losses.
35 Other uses would include firefighting, mains flushing, losses due to customer meter errors, leakage or contractors’ consumption due to operations.
Residential water use

Household water uses include garden watering and other outdoor uses, shower/bathroom, toilet, clothes washing and other indoor uses (such as kitchen uses). The relative importance of the different uses varies by location. For example, outdoor water use accounts for a higher proportion of household water use in Perth and Melbourne than in Queensland (Table 35).

Table 35: Residential water end-uses

<table>
<thead>
<tr>
<th>Location</th>
<th>Outdoor</th>
<th>Shower/bathroom</th>
<th>Toilet</th>
<th>Clothes washing</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Coast</td>
<td>12%</td>
<td>33%</td>
<td>14%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>Toowoomba</td>
<td>0%</td>
<td>45%</td>
<td>13%</td>
<td>23%</td>
<td>16%</td>
</tr>
<tr>
<td>Melbourne</td>
<td>28%</td>
<td>21%</td>
<td>13%</td>
<td>17%</td>
<td>19%</td>
</tr>
<tr>
<td>Perth</td>
<td>38%</td>
<td>13%</td>
<td>8%</td>
<td>10%</td>
<td>31%</td>
</tr>
<tr>
<td>South-east Queensland</td>
<td>5%</td>
<td>31%</td>
<td>16%</td>
<td>21%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Source: Beal et al. (2011).

During the past decade, per household residential water use has fallen significantly as a result of water efficiency and demand management policies.

Commercial, municipal and industrial water use

Commercial, municipal and industrial use covers a range of different activities. Figure 56 breaks down different non-residential water uses for Sydney in 2010–11. However, the relative importance of different non-residential water uses is likely to vary by city.
Utilities with a particularly high proportion of non-residential water use include Gladstone Water Authority, City West Water (Victoria), SA Water (Whyalla) and regional local councils.

Enduse studies and case studies provide additional insight into non-residential water use:

- **Commercial buildings**: Enduse studies (for Sydney and California) suggest that the main types of water use in commercial buildings include water for cooling (31% to 48%), indoor domestic and restrooms (31% to 37%) and leakage (26%) (GHD 2006).
- **Food processing**: Key types of water use include process operations and plant cleaning in the beverage, vegetable, dairy and meat processing industries (Coliban Water 2005).
- **Heavy manufacturing**: Key types of water use include plant and equipment cooling, product cleaning and preparation, and equipment and site wash-down. Major water users include basic metal manufacturing and paper manufacturing (Coliban Water 2005).
- **Local government**: Watering of parks and sporting fields is often a key water-using activity for local governments. For example, the irrigation of parks, gardens and playing fields is the largest use of water by local governments in Western Australia, constituting in most cases over half the local government’s water consumption (ICLEI 2011).

Increased water-use efficiency has contributed to a reduction in average water use in the non-residential sector over the past two decades. For example, Sydney Water (2011b) notes that average water use per non-residential property has halved since the early 1990s.

### 12.1.3 Energy use and carbon emissions in the urban water sector

**Energy use**

The urban water supply sector uses significant amounts of energy. For example, Sydney Water is one of the largest energy users in New South Wales, consuming almost 1% of the state’s electricity (Sydney Water 2009a).

Some aspects of urban water supply are particularly energy intensive, including water treatment, wastewater treatment, water supply pumping and wastewater pumping. The level of wastewater treatment is also an important driver of energy use. For example, the tertiary treatment of wastewater—to remove nutrients that may cause eutrophication and to prevent degradation in the quality of receiving waters—creates a significantly higher energy demand than secondary or primary treatment. On average, energy intensity doubles between primary and secondary treatment and doubles again between secondary and tertiary treatment (Kenway et al. 2008).
The relative contribution of these activities to total energy use depends on regional factors. Because Melbourne has protected local catchments, for example, energy demand for water treatment and pumping is a comparatively small proportion of total energy use. In contrast, Adelaide sources large volumes of its potable water supply from the River Murray, which requires energy for pumping and treatment.

Figure 57 shows energy use by water and wastewater services in Australian capital cities in 2006–07. Notably, overall energy use, and the relative contribution of different operating activities, have changed following recent investments in desalination and large-scale recycling in several metropolitan areas, including Sydney, Melbourne, Perth and Adelaide (see Productivity Commission 2011). For example, in south-east Queensland, desalinated and recycled water made up around 10% of the water supplied in 2009–10, and the energy used to treat that water was 40% of the total energy for water supply treatment and pumping (Cook et al. 2012).

Figure 57: Energy use by water and wastewater services, Australian capital cities, 2006–07 (MJ/year)

However, the energy required to operate desalination plants has been offset by renewable energy options required by government (Table 36).

Table 36: Energy sources for desalination plants in Australia

<table>
<thead>
<tr>
<th>Plants in operation</th>
<th>Energy sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Coast Desalination Plant (Qld)</td>
<td>100% offset by the purchase of renewable energy certificates</td>
</tr>
<tr>
<td>Perth Seawater Desalination Plant (WA)</td>
<td>100% renewable energy from Emu Downs Wind Farm</td>
</tr>
<tr>
<td>Kurnell Desalination Plant (NSW)</td>
<td>100% renewable energy from wind farm</td>
</tr>
<tr>
<td>Southern Seawater Desalination Plant (WA)</td>
<td>100% renewable energy—wind and solar</td>
</tr>
<tr>
<td>Wonthaggi Desalination Plant (Vic.)</td>
<td>100% renewable energy—green power</td>
</tr>
<tr>
<td>Port Stanvac Desalination Plant (SA)</td>
<td>100% renewable energy—green power</td>
</tr>
</tbody>
</table>

Source: WSAA (2011a).

On-site water supplies such as rainwater tanks can have a relatively low energy intensity (Rocheta and Peirson 2011). However, the energy intensity of rainwater tanks depends on a number of factors, including the type of pump and specific end use (Hall et al. 2009).

Energy use for water and wastewater is projected to increase in several urban areas. Figure 58, for example, shows projected energy use for south-east Queensland to 2056; a relatively large increase in energy use for water supply reflects desalination investments.
Greenhouse gas emissions attributable to urban water utilities in 2009–10 mostly came from energy use, which was mostly grid electricity, as shown in Figure 59 (Cook et al. 2012).

Some urban water utilities have invested in their own energy supplies:

+ Melbourne Water has six mini-hydro generating plants producing 40 GWh/year and biogas generators at both the Western Treatment Plant and the Eastern Treatment Plant. Approximately 50% of Melbourne Water’s total energy needs come from renewable sources powered from by-products of its operations (Melbourne Water 2011a).

+ Sydney Water operates 11 gas cogeneration and hydro-electric facilities supplying about 20% of its energy needs (WSAA 2011a). During 2010–11, the Bondi co-generation plant generated over 8000 MWh of electricity and supplied up to 85% of the Bondi wastewater treatment plant’s electricity usage.
At the customer level, some water uses are energy intensive and can account for a large proportion of total household energy use. In 2006–07, for example, water heating accounted for 25% of household energy use (ABS 2010). Notably, energy consumption for residential hot water is several times the energy used in the provision of residential water services (Figure 60).

Kenway et al. (2008) note that only minimal data is available on the energy requirements associated with water use in the commercial and industrial sectors.

**Figure 59: Energy-related greenhouse gas emissions of water utilities, Australian capital cities, 2009–10 (%)**

Source: Cook et al. (2012).

**Figure 60: Energy use associated with residential water use (%)**

Source: ATSE (2010).
Greenhouse gas emissions

Direct emissions of greenhouse gases by water utilities include fugitive emissions from wastewater treatment processes and stationary energy (for example, the combustion of sludge biogas). Fugitive emissions are not consistently measured or reported by utilities. Figure 61 shows the water utilities that had the highest direct emissions in Australia in 2009–10. However, these figures are likely to decrease under recent changes to the methodology used to calculate nitrous oxide emissions related to sewage outfalls. This may reduce the estimated fugitive emissions for some coastal utilities by more than 50%.

Figure 61: Major direct emitters in the urban water sector, 2009–10 (t CO₂-e)

Note: Brisbane City Council water and wastewater services are now operated by Queensland Urban Utilities.

12.1.4 Other important drivers in the urban water sector

In addition to climate change, a range of other factors are likely to drive demand for urban water and services into the future, including:

+ rapid population growth and urban development
+ increasing labour and capital costs
+ technological change
+ changing customer needs and expectations
+ changing community expectations (such as environmental standards) (NWC 2011a).

However, the Water Services Association of Australia (WSAA) suggests that population growth and climate change are the key drivers of urban water demand in the long term (WSAA 2011a).
12.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of carbon dioxide and other greenhouse gases. They include:

+ **cleaner energy measures**, which aim to reduce the emissions intensity of energy supply, mostly by incentivising ‘fuel switching’ from high-emissions sources (for example, coal-fired electricity generation) to lower emissions intensity sources (such as gas-fired or renewable electricity generation)

+ **energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

12.2.1 Cleaner energy policy impacts

Cleaner energy policies such as a carbon price will have direct and indirect impacts on the urban water sector through:

+ making some urban water businesses liable for fugitive emissions

+ the cost impact of higher input costs for energy and energy-intensive inputs

+ impacts on the demand for urban water and wastewater services, reflecting higher energy costs faced by users.36

These factors will have implications for operational and investment decisions in the urban water sector.

Direct liability for emissions

The urban water industry’s fugitive emissions are mainly from sewage transport systems, treatment plants and treated effluent disposal to receiving waters (WSAA 2009).

Under the legislated carbon pricing mechanism, some urban water businesses may be liable to pay the carbon price for direct emissions because they exceed the 25 000 t CO₂-e threshold. However, there is ongoing debate about whether a utility’s individual wastewater treatment plants should be treated jointly as one ‘facility’ for the purposes of the carbon tax or as separate facilities, many of which would fall below the threshold.37

The carbon price on emissions will increase the cost of operating facilities that produce emissions (such as sewage treatment plants). However, the estimated cost of a water business’s liability for direct emissions is relatively low compared to its overall operating costs. For example, Sydney Water (2011a) may be required to spend around $0.9 million a year to purchase carbon permits for its direct greenhouse gas emissions from wastewater treatment (methane and nitrous oxide emissions). This is less than 1 % of Sydney Water’s total operating costs.

In principle, urban water businesses may be able to reduce their liability by changing their processes to capture or alter their greenhouse gas emissions. For example, capturing and burning methane (which would otherwise be released into the atmosphere) from a wastewater treatment plant turns the methane into carbon dioxide, which is a less potent greenhouse gas. The WSAA notes that:

> the use of biogas as an energy source has a double benefit in that it reduces fugitive methane emissions from entering the atmosphere as well as reducing use of standard imported electricity. (Kenway et al. 2008, Cook et al. 2012).

There are also opportunities to produce biochar from sludge as a form of biosequestration.

When viewed in isolation, there are limited cost-effective opportunities to reduce fugitive emissions at treatment plants. However, in combination with increases in the cost of electricity, the carbon price could make capturing biogas from wastewater treatment more financially attractive in the longer term.

36 The broader effects on the carbon price on the structure of the Australian economy may also affect regional water demand. However, understanding that effect requires detailed modelling at a regional scale.

37 The WSAA has indicated that a number of utilities are treating each treatment plant as a separate facility. The Australian Government and the water industry are still resolving the precise definition of ‘facility’.
Direct cost impacts arising from increased energy costs

Water businesses will face increased energy costs as a result of the carbon price. The following discussion:

+ identifies the nature and possible magnitude of those cost impacts
+ examines the potential implications for customers’ bills
+ identifies potential means to manage the direct cost impacts
+ identifies other potential impacts of higher energy costs on operations and investments in the urban water sector.

Nature and possible magnitude of the cost impacts

Cleaner energy policies, and in particular the imposition of a carbon price, are expected to result in an increase in the price of energy. Some aspects of urban water supply are particularly energy intensive, including water treatment, wastewater treatment, water supply pumping and wastewater pumping. The level of wastewater treatment is also an important driver of energy use.

While energy use in urban water service provision varies around the country, it is generally increasing, reflecting recent investments in recycling and desalination and increasing standards for wastewater treatment. The carbon price will lead to further increases:

+ Sydney Water (2011a) estimates that it will face increased energy costs of $8.6 million a year due to the carbon cost pass-through of electricity prices and some fuel prices.
+ Preliminary modelling by the Western Australian Water Corporation suggests that the carbon tax will lead to an increase in annual operating costs of around $14 million due to increased energy costs and a carbon price on wastewater treatment plant direct emissions (WA Treasury 2011).

It is important to note that baseline energy use in the water sector is typically increasing (for example, due to investment in desalination). This may have a greater effect on future water supply costs and investment decisions than the introduction of the carbon price. For example, Sydney Water estimates that its total costs for electricity use will increase from $40 million in 2009–10 to almost $60 million over the next five years, without accounting for any carbon price impacts (Sydney Water 2011a).

Energy cost increases are likely to be less in regional urban areas, which have not invested in desalination or large-scale recycling. However, they face increased costs for treatment and pumping.

The carbon price may also increase the costs of energy-intensive inputs (for example, inputs into capital works such as steel and cement and operational inputs such as chemicals). The extent of any input price increases will depend on various factors, such as the significance of energy in the cost structures of particular goods and services and the nature of the markets for those products (such as whether prices are determined in international markets or whether cost increases can be passed through).

Many water utilities are still assessing the impacts of the carbon price on materials and other inputs (see, for example, Melbourne Water 2011a). Sydney Water (2011a) expects increases in the costs of carbon-intensive inputs to its supply chain to increase its operating costs by $5.9 million a year. It also expects capital costs to increase by up to $3 million a year. Most of the direct cost impact relates to energy and fuel (Figure 62).
**Scope to manage the cost impacts**

Some factors will ameliorate the potential effect of the carbon price on energy costs. The Water Services Association of Australia notes that the carbon price will not increase electricity costs for urban water desalination plants for at least 20 years, as the contract conditions of the operators’ long-term energy supply agreements typically include no pass-through of carbon costs, which are offset with green power and wind power (WSAA 2011a). Melbourne Water (2011a) notes that approximately 50% of its total energy needs come from renewable sources powered from by-products of its operations; the other half are met by a 20-year agreement with AGL signed in 2010, which ‘locks in competitive prices’ and protects its cost base from future price volatility (Melbourne Water 2011a).

There may also be scope for water businesses to manage the potential cost increases from higher energy charges by changing their patterns of energy consumption or energy supply.

Significant investment in renewable energy and energy capture has already occurred in the urban water sector. It appears that voluntary and regulatory emissions reductions and renewable energy targets have partly driven those investments (see Section 12.2.2).

Increasing costs of carbon-intensive energy sources (such as fossil fuels) will provide an incentive for further investments in renewable or alternative energy generation, such as:

- energy capture—installing biogas engines
- waste heat—capturing heat from biogas engines to run steam turbines
- alternative or low-emissions sources—wind farms and solar (Woods et al. 2011).

The cost-effectiveness of these options will vary by city. Several utilities are using a cost of carbon abatement tool developed by Sydney Water to consider different options. However, the carbon price may need to increase substantially to make large-scale investment in some renewable options commercially viable. Energy efficiency measures may provide greater opportunities for cost-effective abatement.

The effect of the carbon price on levels of investment in renewable energy and carbon abatement, and hence supply costs, will depend on future policy settings, including the level of the carbon price.
Impacts on customer bills

All of the impacts discussed above will lead to an increase in the total costs of supplying water and wastewater services and, assuming those cost increases are passed through, to increases in customers’ bills.

Although the carbon price on direct emissions and energy inputs will increase the cost of water and wastewater services to end users, the impact is likely to be moderate. For example, Sydney Water (2011a) estimates that the initial increase in the typical water and wastewater bill, due to the carbon price, will be less than $10 per year over the 2011–12 to 2015–16 period (Table 37). This increase is less than 1% of the typical water and wastewater bill in Sydney in 2011–12.

That finding is likely to extend to other Australian cities. For example, the Western Australian Treasury estimates that the carbon price will increase the ‘representative’ household’s yearly expenditure on water services by $13.25 or 1.0% per year (WA Treasury 2011).

In the longer term, however, the carbon price may increase and hence have a greater effect on water and wastewater bills and demand for those services.

Table 37: Indicative breakdown of typical water and wastewater bill increase from 2011–12 to 2015–16, Sydney

<table>
<thead>
<tr>
<th>Driver of increase</th>
<th>Indicative proportion ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintaining and renewing assets</td>
<td>55.00</td>
</tr>
<tr>
<td>Servicing urban growth</td>
<td>45.00</td>
</tr>
<tr>
<td>Demand adjustment</td>
<td>41.00</td>
</tr>
<tr>
<td>Overflow abatement, meeting standards and Priority Sewerage Program</td>
<td>15.00</td>
</tr>
<tr>
<td>Other, including carbon price</td>
<td>10.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>166.00</strong></td>
</tr>
</tbody>
</table>

Source: Sydney Water (2011a).

Other potential impacts on operations and investment in the urban water sector

In addition to increasing the costs of urban water-related services, higher energy prices stemming from cleaner energy policies may have a number of other implications for urban water sector operations and investment.

First, higher energy prices may change the relative costs of alternative supply options. This may influence investment and sourcing decisions between traditional and new or alternative sources with higher energy use (including decentralised solutions). For example, by increasing the cost of energy-intensive supplies (such as desalination and large-scale recycling), the carbon price could encourage water utilities to switch to less energy-intensive supply options, such as drawing more water from dams or importing it from other catchments.

This is most likely to occur in major coastal cities (for example, Adelaide, Sydney, Melbourne, south-east Queensland and Perth) that have access to a range of bulk supply sources (such as local dams, large-scale recycling, desalination, groundwater or water trading). However, it may still be relevant for inland urban areas with opportunities to use recycled water or water trading to supplement existing sources.

Second, higher energy costs may increase uncertainty about future urban water supply costs. In particular, this arises from the fact that desalination is increasingly being used as a fallback supply option at times when water from traditional sources is in short supply. It may become increasingly difficult to predict how much water will be required from a desalination plant, as orders may vary depending on how much water is available from traditional sources (orders are often triggered by levels of water in storages). While this is already an issue, increases in the price of electricity will further increase the potential variation in costs faced by urban water suppliers. Similar considerations apply to other energy-intensive supply sources that are used opportunistically (for example, pumping to Sydney from the Shoalhaven).

Finally, higher energy prices associated with a carbon price may increase the costs of meeting environmental standards for wastewater discharge, particularly if the standards are tightened (for example, by increasing requirements for tertiary treatment).
Impacts of higher energy costs on demand for urban water services

Higher energy costs may also affect the demand for urban water and wastewater services through their effect on the level or nature of activities in energy-intensive activities that also use water. For example, higher energy prices may:

+ lead to contraction in some energy-intensive activities that use water supplied by urban water businesses as an input, perhaps leading to a reduction in demand for water by those users
+ increase demand for mains water if users look to substitute away from energy-intensive water supplies (for example, the carbon price may increase the cost of on-site reuse relative to mains water)
+ lead to changes in demand (up or down) as water users invest in energy efficiency
+ feed into higher water and wastewater bills, which may in turn encourage users to moderate their water demands.

Predicting the impacts of the carbon price on water demand is complex because it requires a detailed understanding of the customer base and how various other factors will affect customers’ operations. However, there are a number of reasons why the impacts on demand for urban water services (attributable to higher energy prices) might be expected to be relatively small.

First, most urban WSPs have diverse customer bases, which means that the overall demand for urban water services is typically not highly dependent on specific businesses or industries that may be particularly affected by energy price rises. Of course, there may be some exceptions in certain regions (for example, the Gladstone Area Water Board has a small number of large industrial customers). However, even in those cases, it is not clear that a carbon price will have a significant impact on activity, at least in the short to medium term, as the government’s support package for industry will apply. It is conceivable that in the longer term, if the carbon price were to increase significantly, structural change could reduce demand significantly. This could potentially affect the financial position of some water suppliers. However, such impacts are likely to be insignificant when compared to changes arising from general economic conditions and other industry drivers.

Second, it is also not evident that higher energy prices will lead to systematic changes in demand for water where water is a complement or substitute in energy-intensive activities. One reason is that any such impacts will tend to offset each other.

The vast majority of urban water use is accounted for by households. While some water uses (such as water heating) are energy-intensive, it is not clear that changes in water heating appliances motivated by higher energy prices (for example, a switch to solar) will necessarily lead to significant changes in the volume of hot water used by households.

Finally, the impact on water demand of increases in water bills associated with urban WSPs passing through the higher energy costs they face is likely to be minimal. This is because the bill impacts are expected to be moderate. As a result, the response to any such bill increases (given the low elasticity of demand for water) is generally held to be low (see Abrams et al 2011).

12.2.2 Energy efficiency

Overview of energy efficiency policies

Energy efficiency measures that may affect the urban water sector include:

+ regulatory or policy requirements to adopt energy efficiency measures imposed specifically on water utilities
+ national measures cited in the Australian Government’s Clean Energy Future Plan to encourage energy efficiency in homes, including a household advice line and website; standards and energy rating labelling of household appliances; and a renewable energy bonus to help households replace electric storage household hot water systems with clean energy alternatives
+ measures to encourage energy efficiency by all businesses, including Clean Technology Program grants to manufacturers to invest in energy-efficient capital equipment and low-pollution technologies, processes and products, and the Energy Efficiency Opportunities program, which requires Australia’s biggest energy-using companies (including water businesses) to identify efficiency opportunities and report on their implementation (Australian Government 2011).
**Water-related impacts of energy efficiency policies**

Energy efficiency policies may have both direct and indirect impacts on water use and the supply of urban water services:

+ Direct impacts may arise where water supply businesses are subject to energy efficiency programs or regulations.
+ Indirect impacts may arise where the specific activities or behaviours that are the subject of energy efficiency measures lead to consequent changes in water use (where water is a complement to or substitute for electricity).

**Impacts where water businesses are subject to energy efficiency measures**

Existing energy efficiency programs generally focus on larger businesses or facilities with high energy use. For example, the Australian Government’s Energy Efficiency Opportunities program applies to corporations that consume more than 0.5 PJ a year. Melbourne Water is subject to this program.

Energy efficiency programs targeted at water businesses often only require those businesses to identify and invest in cost-effective energy efficiency opportunities:

+ Under the Energy Efficiency Opportunities program, businesses must identify, evaluate and report publicly on cost-effective energy savings opportunities (DRET 2011). Melbourne Water has completed reports for its Western and Eastern treatment plants (Melbourne Water 2011b).
+ Under EPA Victoria’s environment and resource efficiency plans, Melbourne Water is required to invest in energy efficiency projects that have a three-year or less payback period at sites exceeding energy and water use thresholds (Melbourne Water 2008).
+ The NSW Office of Environment and Heritage requires energy saving action plans for all sites that use more than 10 GWh a year, including Sydney Water and Hunter Water (OEH 2011, Sydney Water 2010).

To the extent that there are impediments to water businesses identifying or adopting cost-effective energy efficiency opportunities, energy efficiency programs could help reduce water businesses’ energy use.

In practice, it is difficult to see why businesses would not exploit these opportunities in response to commercial drivers, such as rising energy costs, regardless of the existence of energy efficiency programs.

The introduction of a carbon price will reinforce the financial incentives for energy efficiency, particularly if the price increases in the longer term. For example, Sydney Water notes that:

> Beyond the potential regulation and pricing of carbon emissions, increasing and volatile electricity prices create a significant financial incentive for Sydney Water to reduce energy consumption. (Sydney Water 2011a:184)

In some cases, the obligations imposed on water businesses can be very general and the businesses must interpret how to apply them in practice. For example, Melbourne Water’s Statement of Obligations requires it to develop and implement programs for assessing, monitoring and continuously improving its sustainability performance, including ‘responding to climate change’, ‘using resources more efficiently’ and ‘managing everyday environmental impacts’. Melbourne Water attributed $1.3 million in operating costs to meeting this obligation in the 2005 regulatory period. Unclear policy obligations could actually increase the cost of water supply to the extent that businesses invest in energy efficiency measures that are not cost-effective.

The range of existing energy efficiency programs operating at multiple levels of government may increase compliance and reporting costs for some WSPs, or increase uncertainty about obligations that extend beyond prudent commercial decisions.

**Water-related impacts arising from specific uses targeted by energy efficiency programs**

Some energy efficiency measures target specific uses of electricity (water heating in homes, showers etc.) that may also have water-use implications. In most cases, the aims will be complementary, in that more energy-efficient appliances tend also to be more water-efficient. For example, analysis has shown that installing a Water Efficiency and Labelling Standard (WELS) 3-star shower rose would cut both water and hot water system energy consumption by 45% in households with high water use.

In the industrial sector, some energy efficiency measures (such as the replacement of electrical water heating) can also result in water savings. However, in other cases energy and water may be substitutes in production processes, so that initiatives to reduce energy use could conceivably lead to greater water use (such as greater use of evaporative cooling).

In general, however, the impacts on water demand of energy efficiency programs targeted at specific energy uses are expected to be minimal.
12.2.3 Land-use measures

Land-use measures seek to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

There may be a number of opportunities for urban water supply providers under the Carbon Farming Initiative or Biodiversity Fund (see Section 3), including:

+ using surplus land at sewage treatment plants or in other areas to grow trees
+ protecting forests in urban water catchments
+ rehabilitating stream frontage in urban areas.

Some water authorities have invested in plantations, including to offset greenhouse gas emissions. For example, Goulburn Valley Water in Victoria has established 139 hectares of tree plantations.38 These activities could affect the volume and quality of water resources in the regions where land-use changes occur. For example, the sequestration of carbon in forests could improve water quality but reduce runoff to dams (see Section 10).

However, overall, land-use change measures are not expected to have a material impact on the urban water sector. Any investments (for example, in tree planting) are unlikely to have material impacts on water interception. Moreover, there may be a number of constraints to developing such plantations. For example, Melbourne Water (Baxter, n.d.) has identified a number of barriers to large-scale tree planting at the Western Treatment Plant, including:

+ the long payback period
+ limited profitability compared to cropping options
+ poor nutrient export off the site
+ initial high recycled water usage
+ the sensitivity of plantations to salinity
+ biodiversity impacts.

38 Goulburn Valley Water does not include these plantations in its greenhouse gas inventory.
12.2.4 Summary assessment of water-related impacts of climate mitigation policies on the urban water sector

This analysis suggests that the overall impact of mitigation policies on the urban water sector is likely to be moderate.

While there will be some increases in the costs of providing urban water and wastewater services (reflecting costs associated with direct liability for emissions, higher energy costs, and higher costs of energy-intensive inputs), they are likely to be moderate compared to other factors. However, the costs will affect some urban water businesses more than others, and their magnitude will depend on the level of the carbon price.

Impacts associated with other mitigation policies, including energy efficiency programs and land-use change initiatives, are likely to have minimal impacts on the sector.

Changes in the relative costs of alternative water supply sources and the unpredictability of such costs may have implications for bulk water sourcing decisions. This raises questions about whether there are policy or institutional impediments to efficient sourcing decisions, such as:

+ the extent to which there is efficient pricing of water (without an explicit scarcity value on dam water or clear water security requirements, there may be an additional incentive to draw down water from storages as the price of energy-intensive sources such as desalination and recycled water increases)
+ any policy bans on supply options (for example, bans on rural–urban trading that may prevent the use of what may be a relatively low-cost supply option)
+ inflexible operating arrangements (for example, the Sydney desalination plant operating rules are linked to storage levels, and the plant operates at full capacity when dams are below a certain level regardless of the energy cost)
+ existing urban water planning policies that favour specific sources (such as recycling targets)
+ the ways that regulatory arrangements deal with unpredictable costs associated with the use of energy-intensive sources used opportunistically.

On the wastewater side, higher energy prices will increase the costs of wastewater treatment for disposal to the environment. This raises questions about the costs of meeting environmental standards and how those standards are set. There are also questions about how water prices are set, and whether the full costs of the carbon price signal are passed on to customers efficiently.

Table 38 summarises the impacts of mitigation initiatives on the sector.
Table 38: Impacts of mitigation policies on the urban water sector and possible policy issues

<table>
<thead>
<tr>
<th>Impacts of carbon price on incentives for water businesses to invest in renewable energy</th>
<th>Impacts of carbon price on the relative cost of supply options</th>
<th>Impacts of carbon price on demand for water and wastewater services</th>
<th>Impacts of carbon price on costs of energy and other inputs</th>
<th>Impacts of energy efficiency measures</th>
<th>Impacts of land-use changes on land owned/controlled by urban water service providers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact assessment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nature of impact</strong></td>
<td>These investments have implications for the cost of urban water supply.</td>
<td>Low-energy supply sources (such as dams) become relatively cheaper.</td>
<td>Reduced water demand by high energy-use or trade-exposed customers.</td>
<td>Increases in costs of supply, leading to higher customer bills.</td>
<td>Impact on costs of supply. Increases/decreases in water demand in residential and industrial sectors.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Large utilities in capital cities with wastewater assets.</td>
<td>Major coastal cities with access to multiple supply sources.</td>
<td>May be localised impacts in areas with a high proportion of industrial use.</td>
<td>National</td>
<td>National</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Medium to long term</td>
<td>Immediate</td>
<td>Medium to long term</td>
<td>Current</td>
<td>Current</td>
</tr>
<tr>
<td><strong>Magnitude/sensitivity</strong></td>
<td>If voluntary and regulatory cleaner energy targets are driving investments by WSPs in renewable energy, the carbon price may need to increase substantially to stimulate additional investment and affect water charges.</td>
<td>Moderate, but sensitive to the level of the carbon price and the existing water pricing arrangements.</td>
<td>Depends on the sensitivity of customers to increased energy costs and other factors.</td>
<td>Low–moderate</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Importance of climate change impact compared to other drivers of change</strong></td>
<td>Low to moderate. Investment in renewable supply appears to be driven by other policies (voluntary targets).</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Overall materiality of impact</strong></td>
<td>Low to moderate. Investment and hence costs driven by other factors in the short term.</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
</tbody>
</table>
### Impacts of carbon price on incentives for water businesses to invest in renewable energy
- Efficient investment.
- Scope to distort efficient sourcing decisions.
- Flexibility and the incentive to respond to changing demand patterns.
- Minimal, assuming cost passed on to users.
- Efficient service provision.
- Water interception.

### Current water policy tools
- Urban investment planning.
- Urban investment planning.
- Water pricing.
- Economic regulation.

### Existing knowledge of the issue
- Economics of technologies generally understood.
- Moderate
- Well known that likely response will be small.
- General understanding of materiality of increased costs.
- Growing recognition that carbon price may override need for schemes.

### Overall policy implications
- Scope to rationalise voluntary mitigation policies in the water sector once the carbon trading scheme is operational.
- Need to ensure efficient water pricing.
- Minimal
- Effectiveness and coverage of economic regulation.
- Scope to rationalise voluntary mitigation policies in the water sector once the carbon trading scheme is operational.
- Extent to which water management arrangements are able to address the potential for increased interception.
### 12.2.5 Implications of current water policy for the implementation of mitigation policy

Several issues associated with existing urban water policy that may need to be considered in the light of their implications for mitigation policy:

- state government and voluntary emissions targets applying to, or adopted by, urban WSPs
- investments in energy-intensive sources
- pricing of water and wastewater services

#### State government and voluntary emissions targets applying to urban water service providers

In addition to the energy efficiency programs that apply to all sectors (discussed above), water businesses are also subject to specific voluntary and regulatory targets for emissions reductions and renewable energy at the state level. In this sense, these programs can be seen as part of policy for the water sector, even though they are also climate mitigation initiatives.

**Table 39: Voluntary mitigation targets and those set by state and local governments**

<table>
<thead>
<tr>
<th>Utility</th>
<th>Greenhouse gas emissions reduction target</th>
<th>Renewable energy target</th>
</tr>
</thead>
<tbody>
<tr>
<td>ActewAGL</td>
<td>40% reduction of 1990 levels by 2020; 80% reduction by 2050; zero net emissions by 2060.</td>
<td>15% of energy supplied in the ACT from renewable sources by 2012; 25% by 2020.</td>
</tr>
<tr>
<td>Gosford City Council</td>
<td>Reduction of 2001 levels by 50% by 2020.</td>
<td>Sourcing 50% of council’s requirements by 2020.</td>
</tr>
<tr>
<td>Melbourne Water</td>
<td>Zero net greenhouse gas emissions by 2018.</td>
<td>100% renewable energy use.</td>
</tr>
<tr>
<td>SA Water</td>
<td>From 2008 to 2012, constrain net greenhouse gas emissions to the Kyoto target of 108% of 1990 levels.</td>
<td>Current target is 20% from self-generated and purchased renewable energy.</td>
</tr>
<tr>
<td></td>
<td>From January 1, reduce net greenhouse gas emissions so that by the end of 2050 emissions will be no greater than 40% of 1990 levels.</td>
<td>In addition, the Adelaide desalination plant and pipeline will be operated using 100% accredited renewable energy.</td>
</tr>
<tr>
<td>Sydney Water</td>
<td>Carbon neutral by 2020 for energy and electricity.</td>
<td>No set target.</td>
</tr>
<tr>
<td>Yarra Valley Water</td>
<td>Zero net scope 1 and 2 emissions by 2013.</td>
<td>No set target.</td>
</tr>
</tbody>
</table>

These targets are likely to interact with the carbon price. For example:

- if the level of investment prescribed by existing targets exceeds that which would occur as a result of commercial investment decisions (incorporating the carbon price), the carbon price may have limited effect on investment in renewable energy
- as the carbon price increases, businesses may choose to invest in renewable energy and other forms of abatement at levels that make targets redundant.

The relationship between the carbon price and clean energy targets raises policy questions about efficient investment in the urban water sector and impacts on service costs. To the extent that the carbon price provides an efficient signal of the cost of emissions, undertaking investments that are not commercially viable (even after factoring in the carbon price) to meet emissions reduction targets will be inefficient and increase service costs unnecessarily.

The economic regulator of the Victorian water industry (the Essential Services Commission) has suggested that a price on carbon means that any carbon mitigation programs proposed by businesses will now need to be justified through a commercial cost–benefit analysis. The Essential Services Commission will ‘exclude from approved revenue requirements the costs associated with alleged but unclear Government obligations’ (ESC 2011:4).
Investments in energy-intensive sources

A major thrust of urban water policy in recent years has been to diversify water sources into non-traditional sources. However, many of those sources, such as desalination and recycled water, are energy-intensive.

This ‘energy–water nexus’ has given rise to concerns that water policy may be working at cross-purposes to climate change mitigation policy (that is, while climate change policy seeks to reduce energy use, some aspects of water policy may increase the demand for energy).

The fact that some water sources use high volumes of energy does not in itself indicate a policy disconnection—provided that decisions to invest in energy-intensive water sources reflect the full economic and environmental costs. From an economic efficiency perspective, the objective should be to optimise the value of all resources (including energy and water), rather than to minimise the use of any particular resource. However, to the extent that some investments in energy-intensive water sources have been subsidised or are the results of artificial targets, it could be argued that those policies run counter to climate change policy objectives. The imposition of a carbon price should, in principle, provide a better signal of the social cost of energy use and thus encourage users to consume energy only where the benefits justify the costs. In effect, water sector policies that subsidise or artificially promote energy-intensive water sources of supply undermine the signals sent through the carbon price.

Pricing of water and wastewater services

A carbon price signal will only be effective in influencing energy use if urban water businesses pass the cost through to customers in full. The Commission has previously identified inadequacies in water pricing (particularly in regional areas) (NWC 2011b) which may mean that this does not occur, or does not occur in a cost-reflective manner.

Standards for wastewater treatment

Another aspect of water policy that may have implications for the implementation of climate change policy is the imposition of standards for wastewater treatment. Treating wastewater involves the use of increasing amounts of energy as treatment moves from primary through secondary to tertiary treatment. Higher standards for discharges to protect receiving environments therefore involve higher energy consumption and greenhouse gas emissions.

However, this would only be a policy disconnection if the benefits of the environmental standards that are set do not justify the cost of meeting them (including the energy costs and associated greenhouse gas emissions). If standards are set without a cost–benefit assessment, there would be potential for them to be set at a level that resulted in costs (including greenhouse gas emissions) greater than their benefits.

12.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise from adaptation responses to climate change as they affect the urban water sector. Following the framework set out in Section 3, this involves:

+ identifying the potential impacts and risks of climate change as they affect the urban water sector
+ identifying the likely responses to adapt to those changes
+ assessing the consequent water-related impacts and possible water policy issues.
12.3.1 Potential impacts of climate change on the urban water sector

Climate change will have short- and long-term effects on natural variables, including:

+ more variable rainfall patterns and dam inflows
+ more frequent and intense storms
+ more and stronger heatwaves
+ increased risks of bushfires in catchment areas
+ lower average annual rainfall and runoff
+ a gradual increase in average temperatures
+ a gradual increase in sea level.

Those changes pose a number of risks to the urban water sector, including by:

+ reducing the availability of potable water for cities and towns
+ affecting the condition and reducing the performance of water-sector infrastructure
+ reducing water quality in urban waterways and receiving waters.

Table 40 summarises some of the key risks for the urban water sector associated with climate change.
Table 40: Potential impacts of climate change on the urban water sector

<table>
<thead>
<tr>
<th>Climate change impacts</th>
<th>Sea level rise</th>
<th>Increased heavy precipitation and flooding</th>
<th>Decreased precipitation, water scarcity and drought</th>
<th>Higher temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply services</td>
<td>Saltwater intrusion at river mouths, into aquifers and into water supply pipe networks, reducing the available potable water supply.</td>
<td>Soil fluvial erosion, causing an increase in suspended solids. This turbidity can affect water supply by interfering with disinfection processes, increasing the need for coagulant use, increasing handling costs etc. Can also lead to sedimentation of reservoirs and reduced water storage capacity. Drinking water storage capacity decrease, because of the need to maintain more flood storage capacity. Increased virus and pollution loading in groundwater. Decrease in groundwater recharge, as heavy precipitation exceeds soil infiltration capacity and increases surface runoff. Capacity overload of water treatment plants. Water treatment and abstraction facilities are likely to be located near rivers and are the first to be affected by flooding, causing contamination of water and damage. Erosion of pipelines due to heavy rainfall.</td>
<td>Reduced streamflow, decreasing water supply. Increased pollution concentrations. Saltwater intrusion at river mouths. Resuspension of river bottom sediments and liberation of compounds. Falling groundwater tables due to reduction in recharge and decreased river flow. Increased groundwater use as surface water availability declines. Reduced precipitation decreases groundwater recharge, leading to saltwater intrusion into coastal or inland aquifers. Potential for intermittent operation of urban water supplies during droughts, adversely affecting water quality. Increased water withdrawals from low-quality sources due to shortages will increase treatment requirements. Reduced available soil moisture, leading to degradation of water pipes.</td>
<td>Reduced water quality due to reduced oxygen concentrations, release of phosphorus from sediments and altered mixing. Deterioration of chemical and biological river features. Post-bushfire runoff of dissolved materials into receiving waters; changes in turbidity and chemistry of water. Increased evaporation. Increased occurrence of eutrophication and toxic algal blooms in rivers, reservoirs and lakes, requiring additional treatment to remove odour and taste. Snow and ice cover changes: reduced or earlier peak streamflows and/or extension of lowflow periods. Increased evapotranspiration and improved growth conditions increase biomass, which affects groundwater. Salinisation of groundwater due to increased evapotranspiration. Increased microbiological activity, leading to an increase in disinfection by-product levels.</td>
</tr>
</tbody>
</table>
### Climate change impacts

<table>
<thead>
<tr>
<th>Impact</th>
<th>Wastewater services</th>
<th>Stormwater services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level rise</td>
<td>Sewer outfalls into sea exposed to damage during coastal flooding.</td>
<td>Stormwater outfalls into sea exposed to damage during coastal flooding.</td>
</tr>
<tr>
<td></td>
<td>Coastal wastewater pipe networks and treatment infrastructure damaged.</td>
<td>Coastal stormwater pipe infrastructure damaged.</td>
</tr>
<tr>
<td></td>
<td>Coastal flooding: temporary increases in salinity of influent to wastewater treatment plants, leading to disruption of biological processes and corrosion of equipment.</td>
<td>Stormwater overflows, causing urban flooding and increased discharge to the environment.</td>
</tr>
<tr>
<td></td>
<td>Salinisation of recycled water.</td>
<td>Reduced available soil moisture, leading to degradation of wastewater pipes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impact on temperature-related wastewater treatment processes (for example, reduction of oxygen levels and transfer rates).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced oxygen content in wastewater effluent receiving waters, leading to additional wastewater treatment requirements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corrosion of sewers.</td>
</tr>
<tr>
<td></td>
<td>Capacity overload of wastewater treatment plants.</td>
<td>Stormwater overflows, causing urban flooding and increased discharge to the environment.</td>
</tr>
<tr>
<td></td>
<td>Sewer overflows, causing urban flooding and increased discharge to the environment.</td>
<td>Reduced available soil moisture, leading to degradation of wastewater pipes.</td>
</tr>
<tr>
<td></td>
<td>Increased runoff of nutrients, pathogens and toxins, requiring more treatment.</td>
<td>Corrosion of stormwater pipes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased heavy precipitation and flooding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased precipitation, water scarcity and drought</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher temperatures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Based on Loftus et al. (2011)
Changes in climatic variables will also have indirect effects on the urban water sector though their impacts on other sectors. For example, reduced water availability will increase competition for water between urban, rural and environmental users. Increased storms and bushfires may also increase the risks of energy supply failures to the water industry and cut off access to some sites.

The impacts of climate change on the urban water sector will occur at various timescales. Some factors will pose more immediate risks to service performance and the continuity of supply. For example:

+ a dramatic reduction in dam inflows associated with increased rainfall variability could result in severe short-term water shortages
+ extreme storms or bushfires could result in temporary interruptions to urban water and wastewater services.

In contrast, other impacts will emerge over time. For example:

+ reduced average rainfall will combine with population growth to place pressure on the urban supply–demand balance in the longer term
+ degradation of asset condition will gradually reduce water businesses’ capacity to meet service standards
+ sea level rise will gradually put a greater proportion of low-lying assets at risk of inundation.

These risks and the adaptation responses to them can be broadly categorised as those that relate to:

+ the supply–demand balance and long-term water security
+ the integrity of infrastructure and service performance (including the extent to which regulatory obligations can be met).

The following two sections examine each of these in turn.

12.3.2 Adaptation responses relating to the water supply–demand balance

Impacts on water supply and demand

Perhaps the most obvious water-related impact of climate change is that it is projected to result in more variable rainfall and lower average runoff. This may result in lower and more variable water availability from traditional sources. In particular, climate change could affect water available for consumptive use by:

+ decreasing average annual streamflows over time
+ increasing the variability of annual streamflows (and the frequency of very low flow events)
+ increasing the risk of bushfires in catchment areas, with associated risks of reduced streamflows and adverse water quality impacts
+ reducing the environmental condition of streams, with implications for water harvesting in regulated and unregulated streams
+ increasing the risk of saline groundwater intrusion due to sea level rise (for example, in Western Australia).39

Reduced rainfall is already contributing to water security problems in many urban centres, particularly in southern and eastern Australia. Extremely low rainfall contributed to acute urban water shortages across most of Australia during the 2000s (NWC 2011a). For example, annual inflows to urban catchments in Perth and Melbourne have been well below historical averages in recent years (Figure 63).

There is high confidence that reduced precipitation and increased evaporation will further intensify water security problems in southern and eastern Australia in the coming decades (PMSEIC Independent Working Group 2007). Both are widely seen as being at least partly attributable to climate change.

39 Contamination of freshwater by seawater at the level of only 5% could render it unsuitable for domestic water consumption and for some irrigation and industrial uses (DCC 2009).
A recent risk assessment of water supply in Australian capital cities (which focuses on potential water shortages) suggests that climate change risks are particularly pronounced for Western Australia and South Australia, and are high in Victoria, New South Wales, Queensland and the Australian Capital Territory (Maunsell Australia Pty Ltd 2008).

Climate change could also affect the demand for urban water services. For example, increases in temperatures and more frequent and severe droughts would increase the demand for water.

**Adaptation responses to changes in the water supply–demand balance**

Increasing water scarcity at particular times and locations and greater uncertainty about water availability could make it difficult to meet major cities’ demands for water.

There have already been a wide range of policy-induced and autonomous adaptation responses to lower and more variable water availability over the past decade. Climate change projections indicate that these trends are likely to continue or become even more pronounced in the future. Indeed, in many ways recent water policy has been focused on how best to balance supply and demand for water in the face of reduced and more variable water availability. Those responses could be viewed as adaptation responses to climate change.

Adaptation to reduced water availability in the urban water sector has mainly involved direct intervention by state governments, which have used both supply-side and demand-side measures, including:

- diversifying towards new and alternative sources that are less climate-dependent
- constraining demand through demand management, restrictions, water efficiency programs and pricing
- making investment decisions centrally under conditions of supply crisis
- increasing volumetric prices for water, including through prohibitive inclining block tariffs
- using financial incentives and direct government subsidies to encourage the takeup of alternative water supplies that reduce pressure on potable supplies (for example, recycling, stormwater reuse and rainwater tanks)
- using water planning policies to influence the mix of supply- and demand-side options and the level of water security provided by water businesses (such as water security targets and targets for water reuse)
- promoting integrated water management and water-sensitive urban design.
These options include a mix of strategies. Supply-side options generally reduce the impact of climate change and sensitivity to it. Water restrictions and other demand-side options are more concerned with tolerating and sharing the losses.

Increasingly, urban water planning is seeking to embed climate change adaptation. Rather than simply planning for a continuation of ‘average’ conditions, various rainfall scenarios are modelled. For example, the Sydney metropolitan water planning process led to investments in a diverse portfolio of water supply options designed to be robust to future droughts and climate change.

A recent study examined the potential impact of climate change on water supply and demand in Sydney (NOW 2010), and that approach is now being extended to regional areas. For example, a pilot study by the NSW Government sought to provide insights on the impacts of climate change on the secure yield of the water supplies for New South Wales local water utilities (Samra and Cloke 2010).

While responses to emerging water scarcity have been dominated by direct government interventions, individual water users are also playing a significant role in adaptation. Households have changed their water-use behaviour to reduce per capita consumption and installed more water-efficient appliances. Similarly, industry has invested in efficient water-use technologies and processes to reduce its sensitivity to the impacts of climate change on water supply.

**Impacts of adaptation responses and possible water policy issues**

The various responses over the past decade have undoubtedly helped to ameliorate the impacts of shortfalls in supply relative to demand. However, this does not necessarily mean that they have balanced supply and demand at the least cost (that is, they have not necessarily been efficient adaptation responses). For example, while no city has run out of water, the imposition of restrictions on water use and subsequent investments in urban water security have come at a significant financial and economic cost.

Climate change and adaptation responses have the potential to increase water supply costs to urban customers as a result of supply diversification. The cost associated with supply augmentation has been substantial in recent years. For example, the combined capital expenditure program of 30 of Australia’s largest water utilities was approximately $30 billion over the period from 2005–06 to 2011–12 (Productivity Commission 2011). Much of that investment has been in rainfall-independent supplies, such as desalination and recycling, in major cities.

It is extremely difficult to predict precisely where the supply–demand balance for urban water will be most acutely affected by water availability changes reflecting both the potential impact of climate change on the supply of water and underlying trends in demand (and any changes in demand associated with climate change).

While most cities on the east coast can now be considered to have a ‘buffer’ of water reserves after recent investments in water supply, that buffer will progressively erode with population growth. Projections for Perth suggest an ongoing challenge in providing for urban water security.

Clearly, the economic, social and environmental impacts of potential changes in water availability associated with climate change will be significantly affected by the efficacy of adaptation responses such as planning and investment, water allocation arrangements, and rural–urban water trading.

Climate projections suggest that changed rainfall patterns are likely to lead to a less secure supply of naturally occurring water more often, and in more locations, in the future. Assessing the robustness of current water policy settings necessarily involves considering whether water policy encourages, or at least enables, adaptation to those circumstances. The strengths and weaknesses of existing water policy settings for balancing urban water supply and demand are examined extensively in other reports (most notably NWC 2011a).

In some cases, institutional settings in the urban water sector can inhibit efficient adaptation responses. The Commission’s *Urban water in Australia: future directions* (NWC 2011a) notes that barriers to efficient urban water investment can include:

- policy bans on some supply and demand options (such as water trading)
- inflexible pricing arrangements
- increasing recourse to government subsidies for infrastructure projects
- excessive focus on restrictions and other demand management measures.

These issues are explored further in Section 6 in Part A.
12.3.3 Adaptation responses to factors affecting water assets and service performance

Impacts on the condition and operation of water infrastructure

Climate change could affect the condition and performance of urban water, wastewater and stormwater assets in many ways:

+ Increased variation in wet and dry spells and decreases in soil moisture will increase the risk of pipe cracks.
+ Increased rainfall intensity and peak flows will increase the risk of sewer overflows, stormwater flooding, and damage to stormwater infrastructure and facilities (underground drains, levee banks, pumpstations etc.).
+ Water conservation, increasing ambient and seasonal temperatures, and longer travel times within the sewer network will increase sewage concentrations and the potential for corrosion and odours.
+ Rising seawater levels will result in increased saltwater intrusion to sewerage networks and at wastewater treatment plants.
+ Sea level rise and increased storms will mean that low-lying water assets, such as drainage infrastructure and treatment plants, will be increasingly affected by inundation.
+ Extreme daily rainfall and sea level rise could worsen environmental outcomes by increasing sewer spills to rivers and bays. (Howe et al. 2005, CSIRO et al. 2007, DCCEE 2009, Short et al. 2010)

In general, these impacts could hamper the ability of urban WSPs to provide reliable and safe services to customers, increase the costs of doing so, or both. They could also lead to major costs for other parties (for example, risks to human life and damage to property from flooding) and the environment (such as sewer spills to waterways).

Past risk assessments suggest that, in addition to water shortages, climate change poses high risks to stormwater drainage, increasing the likelihood of flooding:

+ A national study found that the most significant impact on the water sector from the assessed climate change scenarios was drought in the more southern regions of Australia. However, it also noted that the risk of increased local flooding had potentially serious consequences, particularly when associated with sea level rise and storm surges (ATSE 2008).
+ A study in Victoria ranked water shortages and stormwater and flooding damage as the highest risks to the urban water sector associated with climate change (CSIRO et al. 2007).

To provide some context, Australian water infrastructure assets are valued at billions of dollars (see Figure 64). There may be implications for the maintenance and repair of those assets in response to the implications of climate change. There may also be cost implications from the need to upgrade or replace assets to meet regulatory obligations that may be compromised by climate change.

While there is limited national data comparing the relative risks to distribution and treatment infrastructure in each state and territory, Figure 64 shows that most fixed water and wastewater assets in Australia (by replacement value) are in metropolitan New South Wales, Victoria and Queensland.
Responses to potential impacts on water assets and performance

While the water sector has been adapting to lower and more variable water availability for some time, adaptation responses to the impacts of changes in other climatic variables on water infrastructure and service performance are in their formative stages.

Urban water utilities have begun to analyse the risks that climate change impacts pose to their businesses and to implement climate change adaptation planning. This analysis has been developing around the key elements of the business cycle (strategic and tactical planning; design and installation; operations and maintenance; customer service; and business continuity), and until recently has been focused on qualitative assessments of impacts (WSAA 2011). Utilities have developed approaches to the immediate challenges posed by climate change, and are continuing to develop strategies for managing its long-term impacts. Approaches implemented to date include responding to water scarcity with infrastructure investment programs, water conservation and efficiency measures and strategic responses; asset management strategies; planning for urban development; monitoring for health impacts; and climate vulnerability research (WSAA 2011b).

The WSAA has acknowledged that, as regulated authorities, urban water utilities must select climate change adaptation responses that are cost-effective, defensible and representative of sound investment (WSAA 2011b). To facilitate robust decision-making and to make a quantitative assessment of climate change risks, the association and its members are undertaking the AdaptWater project (co-funded by the Department of Climate Change and Energy Efficiency), which will develop a pilot climate change adaptation tool for the Australian water industry. The objective of AdaptWater is to capture and quantify the complexity of modern water utilities’ economic, social and environmental performance requirements and integrate the effects of evolving direct and indirect climate change hazards.

Further work to quantify the impacts of climate change on the urban water sector will be required in determining costs and other operational impacts (such as on service standards and environmental outcomes) attributable to climate change.
For the purposes of this report, the key risks (and responses) have been categorised as:

+ risks associated with high rainfall and storms
+ the inundation of low-lying water-related assets due to sea level rise
+ the degradation of distribution and other network infrastructure
+ interruptions to supply caused by extreme events.

Risks associated with high rainfall and storms

One potential impact of climate change is an increase in the frequency and severity of heavy rainfall and severe storms. This poses a number of risks to the urban water supply chain, both to the condition of water sector assets and to how those assets are managed to mitigate flood damage on the broader community. They include risks associated with:

+ storage management
+ stormwater management
+ sewer overflows
+ other water infrastructure.

Storms and heavy rain may also contribute to the inundation of low-lying assets (see below).

Storage management

One of the major issues for urban WSPs in relation to increased rainfall intensity is the operation of reservoirs. Increased flows due to heavy storms, especially after a drought, can sweep large quantities of eroded soil and contaminants into water storages. Heavy storms can also mobilise contaminants inside the storages.

While the primary role of storages is to provide for secure water supplies where rainfall is inherently variable, they also play a key role in flood mitigation. For that reason, urban water suppliers are subject to regulation and guidelines for maintaining dam safety. They have typically managed storages to avoid the risks of excessive spills. While some spills do not have major negative impacts (indeed, spills can provide positive benefits to the environment), large-scale and/or unplanned spills from storages have the potential to cause major damage to downstream infrastructure and communities.

The operation of storages therefore entails some trade-offs between water security and flood mitigation. The likelihood of more frequent and severe rainfall associated with climate change potentially makes the management of those trade-offs more difficult. For example, following the 2010–11 floods in eastern Australia, there were calls from some affected communities for changes to operational procedures at public reservoirs to provide greater flood mitigation. Reviews have been commissioned in Queensland and Victoria to examine the management of floods, including the operation of water storages for flood mitigation purposes.

The Victorian review has recommended that:

> the state require that dam owners and operators inform people situated downstream of water storages if the owners/operators become aware of an immediate threat arising from the dam to the safety of those people.
> The owner/operators should provide this information as soon as the owner/operators become aware of the threat.
> (Comrie 2011)

The interim report of the Queensland Floods Commission of Inquiry makes similar recommendations for more advice from dam operators to downstream communities (QFCI 2011). Both the increased frequency of floods and the increased requirements to provide information directly to downstream communities will have resourcing and cost implications for storage operators.

This is expected to be an area in which WSPs will need to review their current storage operational strategies and procedures to ensure that flood mitigation opportunities have been maximised, subject to water security objectives. One key issue will be the availability of reliable, accurate forecasts of future rainfall at weekly, monthly and seasonal timescales to improve storage operational planning.

A number of storages are already operated under target filling curves, which establish a controlled rate of reservoir filling to maintain storage space for flood mitigation during higher risk periods, without reducing the overall water yield of the system. A critical question for those dam operators is how any available storage space should be best used to mitigate flood risks. One option is to mitigate all flood events, including minor floods, to the maximum extent possible given the available space. An alternative, in an environment of increased rainfall intensity, is to provide limited mitigation of minor to moderate floods to preserve space for larger events with the potential to do more damage.
Given the dual water security and flood mitigation objectives of some storages, two important questions are how accountabilities for those outcomes are maintained and how the service delivery and broader roles and responsibilities of urban WSPs are reconciled.

**Stormwater**

Increased rainfall intensity and peak flows will also increase the risk of stormwater flooding and damage to stormwater infrastructure and facilities (underground drains, levee banks, pumpstations, etc.).

Stormwater assets may need to be redesigned to improve their capacity to cope with more intense rainfall. However, the cost of safeguarding against all possible storms may be very high. This raises questions about the standards of protection that would be appropriate (for example, what were previously 1 in 20 year storms may now be much more frequent).

More frequent floods may also influence the economic viability of integrated water management options that capture or divert (and potentially reuse) stormwater before it reaches public infrastructure (that is, harvesting in wetlands, ponds and aquifers), particularly where such options may reduce the costs of maintaining existing flood protection levels.

From a water policy perspective, there are difficulties in clarifying regulatory obligations and in making decisions under uncertainty. Obtaining optimal outcomes in stormwater management is often challenging because multiple stakeholders and organisations are involved.

**Sewer overflows**

Urban wastewater service providers are issued with operating licences and environmental discharge licences that specify water quality standards. Operating licences can give specific targets for the permissible number of dry-weather and/or wet-weather sewer overflows onto private property. Environmental discharge licences limit the quantity and quality of discharges from a wastewater treatment plant to a receiving environment (such as the ocean or a river). Increased rainfall intensity and peak flows will increase the risk of sewer overflows, which may pose dangers to the ability of service providers to meet these standards and to public health and the environment.

Possible adaptation responses include investments in refurbishing existing infrastructure, stricter design standards for new infrastructure, and plans to manage the impacts of overflows where they occur. In the future, if the costs of upgrading infrastructure are prohibitive, changes to the requirements or more flexible operating or environmental discharge licences could be considered as adaptation responses.

**Other water-related infrastructure**

Water treatment and abstraction facilities for surface water sources are likely to be near rivers and could be affected by flooding, which could contaminate water supplies and damage infrastructure. Some wastewater infrastructure is also located in low-lying riverine areas vulnerable to flooding. Floods could also have impacts on water supply distribution infrastructure.

There is some risk that increased flooding could have combined impacts on water supply, sewerage and stormwater systems, potentially resulting in the cross-connection or cross-contamination of sources.

**Inundation of low-lying assets due to sea level rise**

Most urban wastewater infrastructure is on the coast, making it highly vulnerable to sea level rise. Several studies (for example, Loftus et al. 2011 and ATSE 2008) suggest that the level of vulnerability is significant. However, quantitative climate change risk analysis by urban water utilities is in its very early stages and has currently only been considered by a few large capital city utilities.

How the urban water sector should respond to sea level rise vulnerability and the role that governments should play are key questions that need answering. If climate change results in the relocation of assets, decisions to relocate will be complex and costly because it is likely that the move will impinge on an existing urban land use. Wastewater (and other) services could also be disrupted as a result of relocation, and new investment may be deferred to meet relocation costs.

In addition to the direct impacts of climate change, the urban water sector will be influenced by broader climate change adaptation policy in this area. For example, emerging national, state or local planning requirements for coastal infrastructure (relating to sea level rise risks) will also influence decisions about coastal infrastructure, particularly new wastewater infrastructure (treatment plants, pipelines, pumping stations and discharge outfalls). The planning requirements will also influence the pattern of urban development and demand for water-related services. Coastal land-use planning regulations will also have an impact on the demand for urban water services.
Longer term degradation of asset integrity and performance

Changes in climatic variables could progressively undermine the condition of existing infrastructure, create difficulties in operating it, or both.

For example, increased variation in wet and dry spells and decreases in soil moisture will increase the risk of asset failures (including pipe cracking and leaks, building cracking, and sewer chokes and overflows) due to increased movement and tree root incursion. Similarly, higher temperatures and longer hot periods promote hydrogen sulfide generation, increasing the risk of infrastructure corrosion and odours. In addition, a greater number of extremely hot days could pose a threat to worker safety.

Possible adaptation responses include:

+ changing the maintenance of assets (for example, adequate ventilation, chemical dosing and silt removal to reduce odour and corrosion)
+ replacing or renewing assets (for example, relining pipelines)
+ relocating assets from high-risk areas
+ allowing some assets to fail under certain conditions, while ensuring that the system as a whole continues to operate
+ changing the management of wastewater sources, including trade waste
+ changing design and maintenance standards to minimise erosion, odour and corrosion
+ mapping and assessing vulnerability to erosion
+ research and development to identify the causes and effects of degradation.

Interruptions to supply from extreme events

If the incidence of extreme events increases, so too will the risk of interruptions to the continuity of supply of key urban water and wastewater services.

Such interruptions might not reflect simply the effects of extreme events on water-related infrastructure, but also outages in other services and infrastructure (for example, disruption to electricity supplies due to increased storms and heatwaves, or loss of access to sites during extreme storms) that have consequences for urban water service provision.

This highlights the need for the urban water sector to understand critical infrastructure and its interdependencies and to develop adaptation responses. Adaptation could involve investments in understanding the nature and likelihood of such risks, options to reduce the impact of such events on the continuity of supply (for example, through reserve electricity supply capacity and investments to enable the remote management of water systems), insurance, and strategies to respond to extreme events.

Complex institutional arrangements exist to respond to floods, storms, cyclones and other extreme events. As the incidence of extreme events increases due to climate change, governance relating to the management of these risks, clarity about roles and responsibilities for decision-making, and communication protocols will be important.

Impacts of adaptation responses in the urban water sector and possible policy issues

Adaptation responses involving water infrastructure assets and their performance could substantially increase the cost of water services in particular areas of Australia. Conversely, failing to adapt effectively could have major adverse impacts on water users, urban communities and the environment.

In many respects, urban WSPs are best placed to deal with the technical, operational and asset management challenges posed by any climate change impacts on their assets and service performance, and to ensure that the adaptation responses employed are effective and efficient.

However, it is unlikely that urban WSPs are best placed to make all of those decisions in the absence of clear and effective institutional, policy and regulatory settings. For example, a key driver of adaptation costs is the level of service being offered. Currently, the acceptable level of risk is not well defined; nor are the climate change scenarios that need to be considered in decision-making. It is understood that service providers are seeking advice on the planning, regulatory, insurance and legal standards associated with climate change impacts. Therefore, there may be a role for governments in providing clarity about service and performance expectations (particularly where there are impacts on the community as a whole).
Governments may also have a role in clarifying the nature and scale of potential risks from climate change to water assets and their performance. While some major urban water businesses have begun such processes, the capacity of smaller urban WSPs to participate in similar exercises is questionable.

In addition, risks such as sea level rise and urban flooding may have impacts on the entire urban landscape. Many water-infrastructure-related adaptation responses will only be possible if action is coordinated. Therefore, governments have an important role in ensuring that approaches to adaptation are consistent across public services and infrastructure in the urban sector.

12.3.4 Summary assessment of water-related impacts of climate adaptation responses in the urban water sector

Overall, adaptation responses in the urban water sector raise key questions about water policy settings, including in relation to:

+ whether existing arrangements for pricing and investment promote the right mix of options for balancing urban water supply and demand
+ the appropriateness of standards based on assumptions about historical conditions
+ the capacity of smaller regional water authorities to undertake robust risk assessment and implement appropriate risk management strategies
+ clarifying regulatory obligations, such as for flood mitigation
+ clarifying roles and responsibilities, including for emergency management.
### Table 41: Summary of climate adaptation impacts

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Supply–demand balance</th>
<th>High rainfall and flooding</th>
<th>Inundation of low-lying assets from sea level rise and flooding</th>
<th>Progressive impact on condition and operation of assets</th>
<th>Disruptions from extreme events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>More variable and reduced average water availability.</td>
<td>Risk to community assets and populations.</td>
<td>Increased costs as a result of expenditure to protect or relocate assets.</td>
<td>Increased costs as a result of expenditure to protect or renew assets.</td>
<td>Impacts on customers.</td>
</tr>
<tr>
<td>Location</td>
<td>All urban areas.</td>
<td>Riverine areas.</td>
<td>Coastal areas.</td>
<td>All urban areas.</td>
<td>Coastal and riverine areas.</td>
</tr>
<tr>
<td>Timing</td>
<td>Short and long term.</td>
<td>Discrete events with uncertain timing.</td>
<td>Impacts occur progressively but exacerbated by discrete events with uncertain timing.</td>
<td>Impacts occur progressively.</td>
<td>Discrete events with uncertain timing.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Impacts potentially severe.</td>
<td>Impacts potentially severe and damage to assets may be major.</td>
<td>Impacts potentially severe and damage to assets may be major.</td>
<td>Impacts potentially severe and costs may be very high.</td>
<td>Impacts depend on frequency of events and ability to manage.</td>
</tr>
<tr>
<td>Importance of climate change impact compared to other drivers of change</td>
<td>Moderate—climate change exacerbates underlying variability.</td>
<td>Moderate—climate change expected to increase frequency of these events.</td>
<td>Moderate—climate change expected to increase frequency of these events.</td>
<td>There are other drivers, but climate change impacts are significant.</td>
<td>Moderate—climate change expected to increase frequency of these events.</td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Potential water policy issues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water policy issues</td>
<td>The efficiency of policy settings and institutional arrangements for decisions affecting supply and demand.</td>
<td>Appropriate service standards and storage management policies. Integrated urban planning.</td>
<td>Appropriate service standards and regulatory requirements. Integrated urban planning. Governance and institutional arrangements.</td>
<td>Appropriate service standards and regulatory requirements.</td>
<td>Appropriate service standards and regulatory requirements. Integrated urban planning.</td>
</tr>
<tr>
<td>Current water policy tools</td>
<td>Planning and investment, entitlements, restrictions, pricing, conservation.</td>
<td>Flood management policies and regulations.</td>
<td>Service standards and regulatory requirements.</td>
<td>Service standards and regulatory requirements.</td>
<td>Service standards and regulatory requirements. Links to emergency management policies.</td>
</tr>
<tr>
<td>Existing knowledge of the issue</td>
<td>High</td>
<td>More limited and patchy.</td>
<td>More limited and patchy.</td>
<td>More limited and patchy.</td>
<td>More limited and patchy.</td>
</tr>
<tr>
<td>Overall policy assessment</td>
<td>The challenges in decision-making and accountability for major investments and policy decisions are well known as a crucial policy question for the future of the urban water sector.</td>
<td>Further case-by-case examination required to assess whether existing approaches to flood management are appropriate.</td>
<td>Requires further risk assessment and policy direction that is integrated with overall urban responses to climate change.</td>
<td>Requires further risk assessment and policy direction that is integrated with overall urban responses to climate change.</td>
<td>Requires further risk assessment and policy direction that is integrated with overall urban responses to climate change.</td>
</tr>
</tbody>
</table>
12.4 References


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The implementation of climate change mitigation policy is unlikely to have a major impact on rural WSPs because of their comparatively limited direct greenhouse gas emissions and low energy use. However, piped and pumped systems may be affected by higher energy prices. Given that governments are considering investing in these types of systems to reduce water delivery losses, there are important linkages between water policy and the implementation of mitigation policy.

The impacts of climate change, particularly on water availability, have the potential to result in significant changes in the structure and size of the irrigation sector in Australia, with resultant impacts on rural WSPs. New areas of irrigation may develop and others may shrink or move out of irrigation. From the perspective of rural WSPs, there has been significant reform over recent years, and they have demonstrated their ability to adapt and change to new settings. However, to date, change has occurred within a framework based on the assumption of relatively marginal changes to static networks. The adaptation pressures flowing from climate change pose significant challenges to that assumption.

Climate change will also create a number of technical, operational and occupational health and safety challenges that need to be addressed by operators, but which also influence major investment decisions that are being made by governments in pursuit of water savings.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian rural water sector in order to:

+ provide background on the rural water sector and its relationships with water, energy and emissions (Section 13.1)
+ identify, describe and assess the significance of interactions associated with mitigation policy, and identify relevant water policy implications (Section 13.2)
+ identify, describe and assess the significance of interactions associated with climate change impacts and adaptation responses, and identify relevant water policy implications (Section 13.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.

Figure 65 summarises the interactions identified for the rural water sector.
Figure 65: Summary of interactions in the rural water sector
13.1 Background

13.1.1 About the rural water sector

The rural water sector in Australia harvests and delivers water to businesses primarily involved in agriculture. Australian Bureau of Statistics data shows that just over half of the total water consumption by Australian agriculture is distributed to farms by rural WSPs (ABS 2011).

The rural water sector supplies a diverse range of services to support agriculture, including:

+ network supply services: regulated river supply, gravity irrigation\(^{40}\), gravity non-irrigation, pressurised irrigation, pressurised non-irrigation
+ drainage services: surface drainage, piped subsurface drainage, pumped subsurface drainage
+ diversion services: unregulated surface, regulated surface, surface drainage, groundwater diversion.

As a result of the development of water access entitlement arrangements and related water reforms under the NWI, most water entitlements used for agricultural purposes are directly owned by the end users, or can be transformed into individually owned entitlements on demand. As a result, the rural water sector is predominantly a supplier of water delivery services to water entitlement owners (that is, irrigators). For the most part, the only entitlements the rural water sector controls directly are those required to cover the losses in supply systems (necessary to enable the delivery of water to end users), although in some cases this can be a significant proportion of total water volumes.\(^{51}\)

Rural water services generally involve the delivery of large volumes of untreated water for use in irrigated agriculture. Much of the water is delivered through open channel systems or natural river networks that deliver water under gravity. In some cases, rural water providers operate piped, pressurised delivery systems, but such systems are generally confined to lower volumes for supply to higher value uses, including horticulture and stock water needs. Figure 66 shows the proportion of total water volumes supplied by each category of rural water supply service. The data is drawn from 13 rural WSPs across Australia, representing 90% of Australia’s rural network water supply and 92 000 customer accounts. It shows that gravity-based services\(^{42}\) account for around 92% of the total volume of water delivered by those rural WSPs.

Figure 66: Proportion of total volume supplied by rural water service providers to customer service points, by water service category, 2009–10 (GL, %)

![Proportion of total volume supplied by rural water service providers to customer service points](image)


The delivery of most of the water supplied by rural WSPs relies on the operation and management of large reservoirs to harvest and store water, which is subsequently released into river systems and then pumped directly from the rivers by water users or diverted into supply networks to be delivered to users.

The demand for rural water supply services is largely determined by the demand for commodities produced by the irrigation sector, which is discussed in Section 10. The states with the largest irrigation water demands are Queensland, New South Wales, Victoria and South Australia.

\(^{40}\) Drainage is sometimes combined with this network supply service.

\(^{41}\) In gravity-fed systems, losses can be in the order of 10%–40%, depending on system characteristics and seasonal conditions (based on data in NWC 2010).

\(^{42}\) These comprise regulated river, gravity irrigation, regulated surface diversion, unregulated surface diversion and gravity non-irrigation services.
Institutional arrangements in the rural water sector

The current institutional arrangements in the Australian rural water sector are the product of legislative arrangements dating back to 1901 and subsequent reforms. Table 42 provides a snapshot of the institutional arrangements for the major rural WSPs. There are also a number of other smaller organisations that supply irrigation water. In 2008–09, it was estimated that there were some 108 irrigation/rural water providers in Australia (ABS 2010).

Table 42: Institutional arrangements for rural water service providers

<table>
<thead>
<tr>
<th></th>
<th>Government departments or authorities</th>
<th>Private trusts</th>
<th>Private irrigation companies</th>
<th>Irrigation schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Qld</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vic.</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>4a</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tas.</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WA</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>n.a.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Central Irrigation Trust is included as one provider, which manages nine private trusts. Data does not include numerous private trusts with allocations of 8 ML or less. Source: Compiled from data provided on the Commission’s website.

A number of the private irrigation companies in New South Wales and Western Australia are established as cooperatives owned by their irrigator customer-shareholders. This diversity of institutional arrangements means that the management of the rural water sector is divided between government departments, authorities and boards on the one hand and private companies and trusts (most of which are irrigator controlled) on the other. Significant quantities of water are managed and delivered by both those groupings.

Unlike the urban water sector, in which standards of service are often mandated based on human health and minimum water quality requirements that are common across providers, the rural sector has a far more diverse range of services and service levels. The Commission’s rural WSP national performance report (NWC 2011) recognises 12 separate categories of service provided by rural WSPs, compared to three service categories for urban WSPs. Service levels often reflect the needs, and the ability to pay, of the agricultural industries that dominate in a particular area, and are often negotiated with customers. One example of a service level that varies markedly between different gravity irrigation supply networks is the order notice required for deliveries, which can range from less than 12 hours to four days or more. Water quality (particularly salinity) can also vary significantly between different systems.

The setting of prices for rural water services differs for the two key groupings of rural WSPs. Prices charged by government-owned suppliers are generally either directly set by an economic regulator, or determined under a process approved and monitored by an economic regulator.

For the private companies and trusts, which are mainly irrigator controlled, prices are established by the entity in consultation with its customers or shareholders. In some jurisdictions, pricing principles for these entities are established in legislation or in the operating licences issued by state governments. There is generally a requirement for an economic regulator (for example, Western Australia) or a relevant minister (for example, South Australia) to approve the basis used for pricing. As part of the reforms under the Water Act 2007 (Cwth), the Australian Competition and Consumer Commission now has a role in the monitoring and regulation of charges imposed by irrigation infrastructure operators within the MDB.

Locations of rural water providers

The states with the largest irrigation demands are Queensland, New South Wales, Victoria and South Australia. The MDB is a focus of irrigation activity, as 72% of Australia’s irrigated land is in the basin (Meyer 2005).

While irrigation is practised in most areas, not surprisingly the major rural water providers tend to be located in those areas where irrigation demands and intensities are highest. The only exception to this arrangement is Grampians Wimmera Mallee Water, which is a major rural WSP in a very low rainfall region where virtually no irrigation is undertaken. GWMW is almost unique, in that its supply network is devoted almost entirely to the supply of water for stock and domestic purposes on farms and water for numerous small urban centres located throughout its rural supply area.

43 The only exception to this arrangement is Grampians Wimmera Mallee Water, which is a major rural WSP in a very low rainfall region where virtually no irrigation is undertaken. GWMW is almost unique, in that its supply network is devoted almost entirely to the supply of water for stock and domestic purposes on farms and water for numerous small urban centres located throughout its rural supply area.
Figure 67: Locations of major rural water service providers

Source: NWC (2012).
Rural sector water use

Rural water use is dominated by irrigation (Section 10 provides details of the water use for different irrigated crop types across Australia).

Water deliveries by rural WSPs vary in response to constrained supply in dry years, when farmers receive limited allocations against their water entitlements. Low demand can also be a limiting factor in water deliveries by rural WSPs. In years with above-average rainfall during the main growing season, demand for irrigation water deliveries can be significantly reduced compared to average conditions. Figure 68 summarises water volumes supplied to rural customers over the four-year period from 2006–07 to 2009–10. The significant variations in the volumes of water delivered from year to year reflect the high exposure of the rural sector to climatic conditions. Above-average rainfall in northern and eastern Australia in 2009–10 supported an increase in rural water supplies, compared to 2007–08 and 2008–09, when there were reduced deliveries as a result of severe drought.

Figure 68: Total volumes supplied at customer service points by rural water service providers, 2006–07 to 2009–10 (ML)


The conclusion that can be drawn from this is that rural water providers operate in an environment of significant water delivery variability. As discussed below, this has implications for the way they manage their operations and structure their tariffs and charges.

13.1.2 Energy use and emissions by rural water providers

Since most rural water is untreated, the major energy inputs for water supply purposes are fuel for vehicles and electricity for pumping. Electricity for pumping water is a major component of total energy use by rural water providers. Figure 69 shows the energy consumption of the 13 rural WSPs covered in the Commission’s National performance report 2009–10. The chart also shows the volume of water that passed through the intakes of each organisation’s supply networks in 2009–10.
Energy use is quite low for most of the major WSPs, reflecting the high reliance on gravity systems by the large volume providers. Lower Murray Water and Central Irrigation Trust operate pumped and pipelined supply systems, mainly supplying horticulture, which have higher energy costs. SunWater also uses significant energy to pump water from river systems in a number of its supply schemes.

Where drainage services are provided, rural WSPs collect agricultural runoff and discharge it to streams (or occasionally evaporation basins) or facilitate its reuse for irrigation without treatment. These activities generate little or no greenhouse gas emissions.

The main source of direct emissions in the rural sector is vehicle fuel use for operational activities.

There have also been some limited investigations of the potential for greenhouse gas emissions to be generated by thermal stratification, which can occur at the bottom of large reservoirs (Sherman et al. 2001). It was found that releases of water from deeper levels of stratified reservoirs (for example, through hydropower turbines) were likely to be the major component of greenhouse gas emissions from those reservoirs. In the absence of turbine releases, most of the gases would not move through the reservoir water column and enter the atmosphere. It was concluded that fitting multilevel offtakes to deeper, stratified reservoirs could significantly reduce greenhouse gas emissions, and also reduce cold water pollution downstream of the dam. Based on (limited) measurements taken at Dartmouth Dam, it was estimated that drawing water only from the upper layers of the dam could reduce emissions by roughly 10 000 t CO$_2$-e per year. In the future, retrofitting multilevel offtakes may create an opportunity for some water storage operators to claim carbon credits.
13.1.3 Other important drivers in the rural water sector

The widespread development and utilisation of Australia’s water resources began in the mid 1800s. Drought and water shortages have often been the catalyst for policy development or reform. In earlier times, the response to water shortages was often to build further infrastructure to harvest and deliver more water, or to improve the security of supply.

More recently, there has been a recognition that many of Australia’s catchments are fully developed, or in some cases overallocated. Consequently, attention has turned to restoring a more sustainable balance between consumptive use and instream and other environmental needs. The 1994 Council of Australian Governments water reforms and the 2004 NWI have set the agenda for recent reforms in the rural water sector.

Key factors that are likely to affect way the rural water sector deliver services include the following:

+ **Extraction limits**: The requirement to return water systems to environmentally sustainable levels of water extraction is being achieved through a mixture of infrastructure measures to reduce losses in supply systems and government buybacks of water entitlements in the MDB.

+ **Water-saving infrastructure**: Infrastructure works to create water savings will change the nature and cost profile of the asset base managed by many WSPs. Innovations include automating regulating structures in open channel systems, installing new meter outlets that enable the remote collection of data and control of meter operations, pipelining open channels, and lining channels with plastic. This will lead to significant changes in the way systems are operated and maintained, the skills and capabilities required to manage the systems, and the costs to renew and replace the assets. Levels of service available to farmers will also improve as a result of these works.

+ **Recovery from drought**: Extended drought across much of the area served by rural WSPs reduced water deliveries. This affected WSPs’ revenues and the incomes of farm businesses that rely on water deliveries. WSPs need to manage their financial viability, but many farmers accumulated significant debt during the drought and are sensitive to price rises for water delivery services.

+ **The Basin Plan**: The Murray–Darling Basin Plan will provide a framework for the return of water to the environment across the basin. Adjusting to sustainable diversion limits may affect overall demand for water services.

+ **Delivery of environmental water**: The Commonwealth Environmental Water Holder (CEWH) is a new and significant water owner, and its plans for managing water delivery to the environment are still evolving. Environmental water supplies will be delivered via rivers and in some cases via water supply systems managed by WSPs. Significant time and effort by rural WSPs will be required to understand these new delivery needs and how they can be best accommodated.

+ **Structural change**: Irrigators’ demand for water services is changing in response to structural change in the irrigated agricultural sector (see Section 10). For example:
  - the oversupply of wine grapes is resulting in a contraction in the overall area of plantings, especially in the Murray Valley
  - the collapse of managed investment schemes investing in horticulture (such as almond and olive groves), coupled with changes in taxation treatment for those enterprises, is likely to restrict growth in that sector
  - changes in world demand for commodities produced by Australian irrigators and movements in exchange rates can have profound impacts on the demand for irrigation supplies in some sectors of the irrigation industry.

13.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of greenhouse gases. They can be broadly categorised as:

+ **Cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (for example, coal-fired electricity generation) to lower emissions intensity sources (such as gas-fired or renewable electricity generation)

+ **Energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions

+ **Land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

The following sections examine the potential impacts of these policies on the rural water sector and then identify the potential water policy issues that may arise as a result of those impacts.
13.2.1 Cleaner energy policies

Cleaner energy policies, such as a carbon price, may have direct and indirect impacts on the rural water sector. For example, the carbon price could increase service costs through:

- the direct liability of some water businesses for fugitive emissions
- the impacts of the carbon price on the cost of energy and energy-intensive inputs for rural water services.

The carbon price will also potentially influence demand for rural water services by:

- increasing the cost of energy-intensive water-use activities
- increasing rural water charges to customers.

These factors will in turn have implications for infrastructure operation and investment decisions in the rural water sector.

In addition to the Australian Government’s cleaner energy policies, there are also emissions and energy efficiency targets for rural water businesses imposed by state governments or adopted voluntarily.

Direct liability for emissions

Under the Clean Energy Future package, facilities that emit more than 25 000 t CO$_2$-e per year will be liable to pay the carbon price for those direct emissions. In the urban water sector, direct emissions are created from wastewater treatment processes (see Section 12). In contrast, the rural water sector provides untreated raw water for agricultural uses. The main source of direct emissions in the rural sector is vehicle fuel use for operational activities, which are exempt from the carbon pricing arrangements at this time.

As a result, it is unlikely that any rural water providers will face direct costs for carbon emissions.

Effects of increased energy costs

The key input of rural WSPs that is likely to be affected by the carbon price is electricity. However, because most rural water systems rely on gravity rather than pumping, the sector is unlikely to be significantly affected.

In the water industry overall, energy costs are a relatively low component of total costs. The Victorian Essential Services Commission has identified electricity costs as making up 5%–10% of total operating expenditure (ESC 2011). It is likely that energy costs for rural providers will generally be at the lower end of that range.

However, some businesses that operate pumped and pipelined supply systems are significantly more energy intensive per unit of water delivered than the general industry norm, and may face greater cost impacts.

SunWater is the largest electricity user of the rural WSPs (Figure 69). Electricity costs make up around 15% of its operating costs for its bulk water and irrigation distribution schemes (SunWater 2011). SunWater expects that the introduction of a carbon price will result in a one-off increase of approximately 10% in electricity costs.

For schemes in which there is a strong relationship between electricity costs and water usage, the impacts of a carbon price can be estimated per megalitre of water used. Current electricity costs for SunWater irrigation distribution schemes range between $0.83/ML and $50.10/ML. The two largest schemes (by volume) have electricity costs of between $14.80/ML and $30.99/ML (SunWater 2011). This implies a cost impact due to the introduction of a carbon price of between $1.48/ML and $3.10/ML.

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44 The broader effects on the carbon price on the structure of the Australian economy may also affect regional water demand. However, understanding that effect requires detailed modelling at a regional scale.
Impacts of cleaner energy policies on irrigation water demand

Increased costs for electricity used on-farm and for other farm inputs as a result of a carbon price may affect demand for irrigation water (and associated services provided by rural WSPs). However, other economic factors, such as changes in commodity prices and other input costs, may have a larger effect than a carbon price on farm profitability and the fortunes of specific industries.

Recent activity in the water allocation market during drought also suggests that increased costs arising from a carbon price are unlikely to significantly affect demand for irrigation water. Over recent years, water allocation prices have generally ranged between $20/ML and $200/ML, but have occasionally spiked above $500/ML. Demand in the market was strong even at those prices, which indicates that farmers are prepared to pay significantly increased prices for water. It is unlikely that electricity cost increases forecast to result from a carbon price will affect farm demand for irrigation water significantly.

Some individual irrigators may be unable to absorb any additional cost increases and may cease irrigation. In that case, their entitlements may be traded to other growers and continue to be used, with no net impact on overall demand for irrigation deliveries.

Rural WSPs may find that there are indirect pressures on their services as irrigators change their crop types in response to carbon price impacts at the farm level. For example, crops using sprays or drips require pressurised water delivery. Other crops require timely water supply to be available on demand. While some service improvements may be able to be retrofitted to existing irrigation supply networks (for example, channel control), others would require wholesale renewal of the major assets in a system (such as conversion to a pumped and piped supply). Individual irrigators also have a range of options available to them at the farm scale (for example, pipelining and pumping on farm or on-farm storage) that can also enable change in irrigation enterprises without a change in service levels from WSPs.

13.2.2 Energy efficiency

Because much of the water in this sector is delivered via gravity systems, there is limited scope for major energy efficiency activities to reduce carbon emissions. Nevertheless, service providers will look to install the most efficient pumping systems (for example, variable speed controllers and efficient pump designs) as part of normal asset replacements and upgrades and in response to a carbon price signal.

Rural WSPs tend to be low-cost, high-volume service providers compared to urban water providers. Their prices are heavily scrutinised by regulators and/or irrigators who are highly cost conscious and eager to see input costs kept as low as is reasonably possible. Most rural WSPs have been pursuing cost-saving and efficiency measures over a number of years, and some have already implemented a range of cost-effective energy efficiency measures. Higher energy prices under a carbon tax should increase the incentive to implement energy efficiency actions.

Businesses that use very large amounts of energy are required to participate in energy efficiency programs. The Australian Government’s Energy Efficiency Opportunities program applies to corporations that consume more than 0.5 PJ/year. SunWater appears to be the only rural WSP currently participating in the program. Such programs have a compliance cost for reporting and assessment obligations, so the businesses involved could be expected to identify opportunities to reduce energy consumption to offset or outweigh the cost of compliance.

Most of the government-owned rural WSPs have adopted greenhouse gas emissions reduction targets, energy efficiency targets or objectives, or both to reduce their emissions in line with state government policy directions (Table 43). One question that arises is how those targets will interact with the imposition of a carbon price under the Australian Government’s cleaner energy policy.

Table 43: Voluntary mitigation targets set by rural water service providers

<table>
<thead>
<tr>
<th>Water service provider</th>
<th>Greenhouse gas emissions reduction target</th>
<th>Renewable energy target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grampians Wimmera Mallee Water (Vic.)</td>
<td>15% reduction in ‘business as usual’ emissions compared to 2005–06 levels by 2013 (including 100% offset of fleet emissions).</td>
<td>10% of electricity from renewable sources.</td>
</tr>
<tr>
<td>Goulburn–Murray Water (Vic.)</td>
<td>25% reduction compared to 2005–06 levels by 2013, and carbon neutral by 2050.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Southern Rural Water (Vic.)</td>
<td>100% offset of fleet emissions.</td>
<td>Electricity for offices from renewable sources.</td>
</tr>
</tbody>
</table>

n.a. = not applicable.

13.2.3 Land-use change measures

Land-use change measures are policies that seek to reduce emissions through changes to land use, including measures to reduce deforestation or encourage reforestation.

The Carbon Farming Initiative (CFI) is a voluntary carbon offsets scheme recently established by the Australian Government. It will provide opportunities for farmers, forest growers and landholders to contribute to activities that reduce carbon pollution.

It is possible that rural WSPs may consider tree planting activities that may qualify under the CFI, but the scope for this is considered to be quite limited. Rural water providers do not generally hold large tracts of land that would be suitable for plantings. Most of the land in distribution networks owned by rural WSPs is occupied by assets such as open channels. Planting trees close to those assets can create access problems and increase the risk of channel leakage and bank failure.

Rural storage reservoirs are located in open catchments, with usually quite limited buffer land around the storages that could be used for tree planting. There may be some opportunities for plantings around drainage assets such as evaporation basins, and the ability to access payments under the CFI may offer an additional incentive or top-up funding for programs that have beneficial impacts (for example, biodiversity or aesthetic benefits).

Overall, there is unlikely to be significant scope for rural WSPs to participate in land-use change measures.

13.2.4 Summary of water-related impacts and possible policy issues for climate mitigation

In summary, the climate change mitigation measures in the Australian Government’s cleaner energy policies are expected to have relatively small impacts on the rural water sector, particularly compared to other factors (Table 44).

Increases in the costs of rural water resulting from higher energy prices would be passed through to irrigation customers under current price-setting arrangements without raising any significant policy issues. Impacts on on-farm costs and on demand for irrigation water will also generally be moderate. There may be some exceptions for supply systems or agricultural production processes that are particularly energy intensive.

Similarly, the impacts of land-use policies on the rural water sector are expected to be minimal, given the current carbon price and WSPs’ limited suitable landholdings.

Table 44: Water-related impacts of mitigation policies in the rural water sector

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Impacts of cleaner energy policies</th>
<th>Impacts of energy efficiency policies</th>
<th>Impacts of land-use policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>Increases the cost of service delivery.</td>
<td>Affects cost of service delivery.</td>
<td>Changes in interception due to land-use changes in response to incentives provided by carbon sequestration policies could have impacts on water availability, water quality and water demand.</td>
</tr>
<tr>
<td>Location</td>
<td>Currently areas within the supply boundaries of rural WSP delivery systems.</td>
<td>Mandatory efficiency programs only relevant to large energy users—not relevant to most WSPs.</td>
<td>Surplus land held by rural WSPs, possibly around reservoirs or evaporation basins.</td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td>Impacts will occur upon introduction of carbon price.</td>
<td>Immediate.</td>
<td>From introduction of Carbon Farming Initiative.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Likely to have a modest to low impact on overall cost structures for most providers that use mainly gravity supply systems. Impacts higher for those WSPs with significant deliveries via pressurised pipeline systems.</td>
<td>Low</td>
<td>Unlikely to result in significant land-use change, given current carbon price and limited suitable landholdings of rural WSPs.</td>
</tr>
</tbody>
</table>
13.2.5 Implications of current water policy for the implementation of mitigation policy

Three aspects of current water policy may have implications for the implementation of mitigation policy:

+ **Investment in irrigation infrastructure:** Governments are investing in major upgrades of some rural water supply networks. Some of the options being implemented to improve water efficiency involve the replacement of open channel systems with pumped, pipelined systems that will use more energy. Government funding for those upgrades is usually being provided for capital costs in return for a share of the water savings generated. The ongoing operating costs of the schemes are the responsibility of the WSPs and customers. The split responsibilities for the capital and operational expenditure components have the potential to create incentives that may be contrary to climate change policy objectives. A prudent agency offering capital grants for water savings may seek to minimize the capital cost to achieve an agreed level of water savings. However, that may tend to favor more energy-intensive solutions (involving pumping) over gravity-fed options, which generally have higher capital costs.

+ **Pricing of irrigation services:** A carbon price will only be effective in influencing energy use in rural water systems if rural WSPs pass its cost through to customers in full. The Commission has previously identified inadequacies in rural water pricing (NWC 2011) that may mean that pass-through does not occur, or is not cost-reflective.

+ **Voluntary emissions targets:** Where voluntary targets have been established, it is unclear that they are required by governments or endorsed by customers. With a carbon price, there is a risk that voluntary targets could result in inefficient national investment in mitigation.

While these impacts are unlikely to be material in relation to national mitigation efforts, they should be considered in the implementation of water policy (see Section 6 of this report).

### 13.3 Climate change adaptation interactions

This section examines the water-related impacts that may arise from adaptation responses to climate change as it affects the rural water sector. Following the framework set out in Section 2, this involves:

+ identifying the potential impacts and risks of climate change as they affect the rural water sector
+ identifying the likely responses to adapt to those changes
+ assessing the consequent water-related impacts and possible water policy issues that may arise.
13.3.1 Potential impacts of climate change on the rural water sector

Climate change is projected to have impacts on a range of climate variables, such as rainfall and temperature. The impacts of climate change that are most relevant to the rural water sector are those that will affect agricultural activities that drive demand for rural water supply services: water availability changes, higher temperatures and increased incidence of extreme weather.

Climate change is projected to increase rainfall variability and reduce runoff in key agricultural regions. For example, by 2030 (under a median climate scenario):

+ the MDB, south-west Western Australia and southern Queensland are projected to experience moderate to high decreases in runoff
+ southern Victoria and Tasmania are generally projected to experience slight to moderate decreases in runoff.

Reduced runoff would lead to reduced reliability of water entitlements for irrigators, which could change the size of the irrigation sector and the mixture of permanent and annual crops that are grown under irrigation. In turn, that could affect the demand for rural WSPs’ water delivery services.

Those reductions in water availability would combine with reductions associated with moving towards more sustainable levels of extraction in the MDB. The Murray–Darling Basin Authority and the Australian Government are pursuing infrastructure works to help bridge the gap between current levels of use and the lower levels of use proposed under sustainable diversion limits. However, if a significant component of the water recovery is purchased or achieved through on-farm irrigation efficiency, large rural WSPs in the southern MDB could be facing reductions in water delivery volumes through their networks of up to 40% by 2030, assuming median climate change in combination with returns of water to the environment.45

Projected increases in average temperatures and the incidence of extreme weather will have implications for where crops can be economically grown in the future, irrespective of the challenges of water availability (Section 11 details the likely implications). Changes in temperatures and extreme weather can affect the suitability of land in various locations for specific types of agricultural production and thereby change demand for rural water services. Some regions may see the introduction of new crops and a higher demand for services.

The potential for contraction in the extent of irrigated agriculture, in conjunction with the movement of remaining water to new areas and crops, poses challenges for operators of fixed supply networks, who are responsible for planning infrastructure investments based on future water demand and service requirements.

The most important current proposals for the expansion of irrigation through the development of new supply schemes are in the Ord River in Western Australia and in Tasmania:

+ **Ord Irrigation Expansion Project**: This $220 million project, which is overseen and funded by the Western Australian Government, will develop further land for irrigation in the Ord river system. The first phase involves the development of 7400 ha of new irrigation, expanding the total area under irrigation from 14 500 ha to around 22 000 ha. A total volume of up to 400 GL is potentially available for additional irrigation development in the system (Department of Water 2010). However, the volume of entitlements to be issued for the 7400 ha expansion phase is likely to be up to a maximum of 120 GL. Requests for proposals for irrigation land use have been invited for the take-up of land in the expansion area. The Western Australian Government has also invited expressions of interest for the medium to longer term development of a further 7600 ha for irrigation in this area (Landcorp 2011).

+ **Tasmanian irrigation development projects**: Total funding of $220 million has been made available by the Tasmanian and Australian governments (together with private sector investors) for the development of new irrigation schemes in Tasmania. Tasmanian Irrigation Pty Ltd was established in July 2011 as a state-owned company to manage existing schemes and to investigate and, where appropriate, develop schemes identified by the state’s Water Development Plan as having potential to better utilise and manage the available resources. Currently identified or developed projects offer the potential for approximately 160 GL/year of additional water to support new irrigation developments. Current government-initiated irrigation schemes in Tasmania account for about 40 GL of water entitlements (Tasmanian Irrigation Development Board 2010).

In addition to the impacts of climate change on rural WSPs stemming from effects on their customers, rural water WSPs may also be directly affected by the effects of climatic changes on their assets and operations. In particular, more frequent and intense storms could affect water storage operations and the management of assets to ensure ongoing service provision and to protect against third-party impacts (such as flooding).

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45 Based on estimated reductions of approximately 17% in water available for consumptive use in the southern MDB under sustainable diversion limits proposed in the Basin Plan, in conjunction with projected reductions in water use for the Murray and Goulburn–Broken catchments of 23% and 29%, respectively, under a 2030 dry extreme climate change scenario (CSIRO 2008).
13.3.2 Adaptation responses and policies

The major adaptation issue that will face rural WSPs is changing demand for irrigation delivery services, which is likely to arise as irrigators adapt to climate change pressures and respond to climate change policies.

Despite the uncertainties associated with predicting the agricultural sector’s response to climate change adaptation pressures, which will occur gradually over an extended period, some assumptions can be made about the key implications for rural WSPs, including about adaptation responses to:

+ impacts on water supply and demand
+ risks to assets and their performance.

Adaptations to changed water availability

One set of adaptation responses seeks to manage the impacts of reduced water availability and reduced demand for rural water services. These responses entail actions by rural WSPs as well as policy responses by government, and include:

+ managing the impacts of reduced demand, including those arising directly from climate change and those resulting from government-initiated measures to restore extractions to environmentally sustainable levels
+ managing changing demand patterns
+ investing in system upgrades and renewal.

Managing the impacts of reduced demand

One potential impact of climate change (in combination with other factors) is that, over time, existing rural water supply networks may become underutilised. That may create future difficulties for rural WSPs seeking to recover the ongoing costs of service provision and asset maintenance from a reducing customer base.

In some areas, there may be a need for wholesale adjustments to the size of rural supply systems. For example, agreement was recently reached with irrigators in the Campaspe Irrigation District near Rochester in northern Victoria to decommission the irrigation system. This is now under way with the support of funding from the Northern Victorian Irrigation Renewal Project.

However, experience suggests that there will not be uniform or consistent responses to reduced water availability across a region that might allow whole networks or portions of them to be closed down. It is more likely that the contraction of irrigation demand will occur in a patchwork fashion, based on a range of complex factors.

The principal mechanism for addressing the risk of stranded assets in the rural water sector is the imposition of termination fees, which are payable by irrigators who permanently disconnect from the network. Current termination fee arrangements offer some price protection for remaining customers in the medium term (10–12 years), but after that remaining customers will be exposed to price pressures unless the size and therefore the operating costs of the system can be reduced in line with reductions in delivery volumes.

Termination fee arrangements assume that most users will continue to require delivery services. However, there is potential for significant community unrest if large numbers of customers have to pay for delivery services they no longer require or face termination fee payments. The level of the termination fee represents a trade-off between the objectives of encouraging efficient rationalisation and encouraging efficient investment. A future review of termination fees may be needed to ensure that the balance between the two objectives remains appropriate in the face of climate change.

In some areas where the long-term future of irrigated agriculture is in doubt and demand for services is contracting, WSPs may consider reducing preventive and programmed maintenance and effectively opt to run systems to failure. This may also require negotiation with customers (and economic regulators), and their support, if deferrals of renewal work impinge on the ability of rural WSPs to meet previously agreed target service standards.

Ultimately, these sorts of strategies are likely to mean that some rural WSPs will have to consider shutting down supply systems or subsections of their networks. This is a complex issue, particularly if there is not universal agreement among water users that closure is the best option. There are a range of different governance models in this sector, and there is little guidance for rural WSPs on how such decisions on non-voluntary terminations of service should be made, who should make them and what the role of government should be in such situations.
Changing demand patterns

While the overall outlook under climate change is for a significant reduction in water availability and the overall demand for water supply services from WSPs, other factors may influence demand for services and further confound the WSPs’ decisions about the size and location of assets needed for the future.

In particular, changes in climate variables (such as changed rainfall patterns, higher temperatures and an increased incidence of extreme weather) may contribute to changes in the type and location of irrigated agriculture.

During the recent drought, many irrigators involved in ‘interruptible’ or ‘semi-interruptible’ sectors, including cropping, fodder production and dairying, responded to reduced water availability by reducing their production. There was also a move away from summer crops and perennial (summer active) pastures towards winter crops and annual pastures. Total annual deliveries of water fell, but much of the remaining demand was concentrated in the spring and autumn periods to service the changed crop mix. Industry sources in northern Victoria expect that this change in demand patterns will continue even with the return to higher water availability, and that there is unlikely to be a major shift back to perennial pastures or summer crops.

The challenge that this poses for rural WSPs supplying interruptible and semi-interruptible industries is that, even though total demand may fall with climate change, peak demand (such as in spring and autumn) may not reduce and may even increase in absolute terms. Pressure on the delivery capacity of some systems may also increase if irrigators choose to relocate production to new areas if climate change renders their current region unsuitable for their particular irrigated enterprise or crop.

A widespread enlargement of delivery systems is considered unlikely, although some targeted upgrades may be economic in specific situations. Investments that reduce losses and improve the efficiency of existing infrastructure may increase the effective capacity of some systems. This occurs where technologies such as channel lining and system automation are used to reduce seepage and outfall losses, enabling more of the capacity of the existing infrastructure to meet irrigator demands, rather than ‘supplying’ losses.

It is not yet possible to predict how the various forces of reduced demand, changing patterns of use and relocations of irrigation demand in response to climate change will interact and affect future demand for rural WSPs’ services. This is an extremely challenging situation for rural WSPs needing to make decisions on the replacement and renewal of long-lived assets. The most appropriate response is likely to be the retention of as much flexibility as possible, which could include deferring asset renewal decisions (and carrying out only targeted maintenance or minor works) to provide more time for trends in future demands to become clearer.

One of the key tools available to help rural WSPs manage a scenario of possible increased peak demand and network congestion is markets in delivery capacity access shares. Those markets are relatively immature, having emerged only with the separation of water entitlements and delivery rights in irrigation systems (which began around 2007). Delivery capacity shares are a quite different product from water access entitlements, and the markets for them will also be quite different. Two important differences are market size and the value of shares:

+ **Market size:** Delivery capacity markets may be much more localised than water entitlement or allocation markets. Buyers may be limited to landholders adjacent to infrastructure physically interconnected to the seller’s supply channel or pipeline.

+ **Value:** Values are likely to vary widely, partly because of the small market size and the range of localised supply and demand combinations that will arise. Anecdotal evidence points to a negative value for delivery capacity shares in some situations, for example where a potential ‘seller’ may pay a ‘buyer’ to take over a delivery capacity share, rather than pay a costly termination fee.

Actions that may help to improve the depth and performance of delivery capacity markets include:

+ clarification and consistent specification of the products being offered for sale

+ better descriptions of who can participate in the market as buyers and sellers, such as which properties are linked to interconnected delivery infrastructure (equivalent to trading zones in water allocation and entitlement markets)

+ publicly available information on volumes of delivery share trading and prices, together with key factors that may influence prices, such as the degree of infrastructure utilisation

+ guidelines for the activities of market intermediaries to build confidence and participation in the markets (rural WSPs, which are likely to be potential sellers in these markets, would also benefit from clear guidelines).
The other area of water policy that may require further consideration and development is the framework for sharing the capacity of regulated or supplemented river channels between users. Some limited arrangements exist to manage major capacity constraints in regulated river systems, most notably the restrictions on water trading used to manage capacity constraints at the Barmah choke on the Murray River. With the emergence of environmental water managers as major entitlement holders in the MDB, and the potential for changes in demand patterns and the location of large volumes of water to meet environmental water demands, there may be increasing congestion in natural river channels. This issue should be monitored: policy principles for sharing the capacity of natural delivery systems may be needed.

**Investing in system upgrades and renewal**

Governments are investing in major upgrades of some rural water supply networks to improve delivery efficiency as a response to water scarcity and to generate water savings for the environment. However, there is some risk that government investments may be made inefficiently if the risk of future impacts of climate change and the likely future demand for irrigation services are not effectively factored into decision-making.

The Australian Government currently operates programs to help rural WSPs undertake future infrastructure planning, including the Irrigation Modernisation Planning Assistance program and the Irrigation Hotspots Project under the Water for the Future initiative. Any Australian Government investment in infrastructure would consider the outcomes and directions of those plans as part of the government’s evaluation.

Options being implemented for water efficiency include the replacement of open channel systems with pumped, pipelined systems that require higher energy inputs. As discussed above, this creates the potential for some conflicts between climate change policy and water policy.

**Adaptation responses to risks to assets and their performance**

Climate change poses a number of risks for the condition and management of assets owned and operated by rural WSPs.

**Responses to higher temperatures**

Higher temperatures will mean more frequent very hot days during summers. Upgrades to rural WSPs’ infrastructure to improve water delivery efficiency often involve the installation of automated monitoring and control equipment to improve delivery system operations. This electronic equipment is exposed to extremes of temperature and must be designed to withstand such conditions in order to operate reliably. A greater incidence of very hot days will increase heat stress on equipment, but it is not expected to be a major cause of equipment failure.

There may also be a need to increase preventive maintenance to ensure that cooling vents in equipment housings are not blocked, which could have some cost implications for rural WSPs. In contrast, the forecast reduction in rainy days may produce an improvement in the effectiveness of solar power systems installed to power automated control systems.

Higher summer temperatures will also increase heat stress risks for field staff who operate rural supply networks. This may require changes to work practices to limit their exposure to high temperatures. In addition to improving water delivery efficiency, the installation of automated control systems for rural supply systems will also offer benefits by reducing field operators’ exposure to high temperatures.

**Responses to sea level rise**

Most irrigation in Australia is in the MDB, and virtually all major rural WSPs are some distance away from the coast. Therefore, there is little risk to rural WSPs’ assets from higher sea levels and storm surges.

**Responses to increased rainfall intensity and floods**

Changes to rainfall intensity could produce more flooding in irrigated regions, with the potential to damage a wide range of infrastructure and assets. This includes the supply networks owned and operated by rural WSPs.

In addition to managing flood damage to their own assets, rural WSPs may face pressure to improve cross-drainage facilities along channels. Gravity irrigation supply channels have raised banks, which allow water to be held above the natural ground surface so that water can flow out of the channel outlets and irrigate the adjacent land. Where raised banks cross significant drainage paths, it is usual practice to provide for cross-drainage by piping the channel underneath the drainage line or vice versa. A higher incidence of flooding may create pressure on rural WSPs to install additional cross-drainage or upgrade existing installations, which would increase their capital and maintenance costs.
More frequent extreme weather and floods could also damage automated monitoring and control equipment. Rural WSPs that have automated large parts of their systems may no longer have enough field staff to revert to manual operations in such circumstances. There may be a need to identify and put in place appropriate risk assessment and mitigation strategies to deal with these climate change impacts.

Another major issue for rural WSPs is the operation of reservoirs. While the primary role of storages is to provide for secure water supplies where rainfall is inherently variable, they also play a key role in flood mitigation. The operation of storages can therefore entail some trade-off between water security and flood mitigation objectives. Where the operation of storages has dual objectives, a key question is how accountabilities for those objectives are maintained and reconciled.

The efforts of governments to return water to the environment and increase the frequency of floods in important wetlands and floodplains raises important questions about how best to optimise flood mitigation benefits for downstream communities (from storage operation) with the creation of environmental benefits. A consistent approach would be of particular benefit in the southern MDB, where shared storages may come under differing state regulations or obligations in relation to flood mitigation.
### 13.3.3 Summary assessment of adaptation impacts in the rural water sector

Table 45 summarises the assessment of adaptation impacts in the rural water sector.

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Impacts of changes in water availability</th>
<th>Impacts related to risks to assets and their performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impact</td>
<td>Changes in demand for water delivery services due to changes in water availability and other impacts of climate change, which result in changes in the extent and location of irrigation—with financial and other implications for rural WSPs.</td>
<td>Higher temperatures may affect the reliability of automated monitoring and control equipment, or require increased maintenance. More intense rainfall and extreme weather will increase the frequency of flooding, with potential for damage to WSP assets and increased costs for flood operations and warnings at storages.</td>
</tr>
<tr>
<td>Location</td>
<td>Southern Australia is likely to experience the most significant reductions in water availability, and is also the location of the largest rural water systems.</td>
<td>Rural WSPs across Australia are expected to be affected. The largest impacts are expected in the MDB, where the largest rural WSPs are located.</td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td>The specific impacts are uncertain. Potential timing for the emergence of significant impacts is the next 20 years.</td>
<td>Impacts are expected to occur progressively with climate change.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Potentially very significant impacts, but a high level of uncertainty in climate outcomes and adaptation responses.</td>
<td>Impacts related to higher temperatures are expected to be relatively modest. Damage to assets and costs for changes to storage operations due to increased flood frequency could be moderate to high in some cases.</td>
</tr>
<tr>
<td>Importance of climate change impact compared to other drivers of change</td>
<td>The impacts of climate change have the potential to fundamentally change the irrigation sector. The other major inter-related issue is the return of water to the environment, which could lead to significant change in the industry.</td>
<td>The impacts of climate change on asset performance are likely to be less than the impacts arising from changes such as reduced water availability and changing customer demand for services.</td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>Potentially very high: agricultural water users are most exposed to climate change and use large volumes. Experience in the recent drought has shown that water delivery volumes and changes in demand can lead to major impacts on rural WSPs.</td>
<td>Overall materiality of changes is expected to be moderate. Many of these impacts are already experienced, and climate change will increase their frequency rather than increasing their severity or creating new impacts.</td>
</tr>
</tbody>
</table>

### Potential policy issues

| Water policy issues                       | Management of changing demands for irrigation water, including possible increases in congestion in supply networks. Decision-making on investments in system renewals and upgrades and on the decommissioning of systems, and the service standards and pricing issues that are linked to those decisions. | Pricing issues associated with increased asset damage, maintenance and occupational health and safety issues arising from more frequent extreme weather. Management of storages to optimise flood mitigation and environmental benefits while safeguarding water security. |
| Current water policy tools                | Water pricing, economic regulation and termination fees. Delivery capacity shares and trading. Infrastructure investments and buybacks. | Water pricing and economic regulation. Flood mitigation and operational objectives for rural WSPs. |
| Existing knowledge of the issue          | The impact of climate change on water resources has been a major driver of rural water policy for some years, including under the NWI. | Nature and extent of impacts of extreme weather on rural WSPs are not well detailed. Achieving flood mitigation benefits without affecting water entitlement security requires access to accurate seasonal rainfall forecasts. |
| Overall policy assessment                 | Policy frameworks may be needed to support decision-making on the decommissioning of supply systems where decommissioning cannot be achieved totally by voluntary processes. There may also be a need for frameworks to guide decision-making on deferrals of asset replacements (and potentially on changes to service standards and costs). Further development of delivery capacity share regimes and markets for trading in delivery capacity (and river channel capacity) may be beneficial. | Development of policy principles and guidelines for the optimisation of flood mitigation and environmental benefits from storage operations would support consistent, repeatable processes. |
13.4 References


14 The environment

While mitigation policies can influence the choice of mechanism for environmental watering (such as between relying on engineering works and relying on high-flow events), the legislated carbon price and other mitigation policies will not be a significant driver of environmental water management.

However, the impacts of climate change have the potential to result in significant changes in ecosystems that rely on surface water and groundwater resources. The expected impacts will test water planning arrangements and challenge environmental management decision frameworks. Rigorous water planning and the right mix of responsive, defensive and preventive environmental water management will assist in effective adaptation.

Environmental assets should not bear an inappropriate amount of climate-change risk compared to other water users. Ideally, a balanced approach, informed by community values, needs to be adopted so that the environment is neither oversheltered nor overexposed to the impacts of climate change compared to consumptive users. This may require obtaining additional water for the environment and improving the effectiveness of environmental watering. Also, a major challenge imposed by climate change could be the need to significantly alter environmental objectives to develop a more tailored and focused approach, given that there simply may not be enough water available to meet current objectives.

Because of increased uncertainty about water availability, watering plans and the management of environmental entitlements need to be flexible and adaptable to prevailing conditions. Some changes in water management policies, such as carryover and storage management, may be required to provide that flexibility.

This section applies the assessment framework (detailed in Section 2.2) to the interactions between water and climate change in the Australian environmental water management sector in order to:

+ provide a definition of the environmental water sector and background on the sector and its relationships with water, energy and emissions (Section 14.1)
+ identify, describe and assess the significance of interactions associated with mitigation policy for environmental water, and identify relevant water policy implications (Section 14.2)
+ identify, describe and assess the significance of interactions associated with climate change impacts and adaptation responses, and identify relevant water policy implications (Section 14.3).

Water policy implications arising from this assessment are discussed in more detail in Part A of the report, with references to relevant issues in this section.
Figure 70 summarises the interactions identified in this assessment.

**Figure 70: Summary of interactions in the environmental water sector**
14.1 Background

14.1.1 About the environmental water sector

The Commission has defined environmental water as ‘the water regime provided to achieve environmental objectives’ (NWC 2010). As water resources have been developed, the volume that remains in the system for environmental use has decreased. Also, the harvesting of water into storages and its later release to meet consumptive demands has significantly changed the seasonal pattern of flows in many river systems, with consequent impacts on ecosystem health.

Efforts are now underway across Australia to determine the optimal balance between environmental water and water for consumptive use (such as the Basin Plan and the water entitlement buyback program in the MDB). The development of environmental water managers has been a significant recent step in the management of environmental water, particularly ‘held’ environmental water (defined below).

This assessment of the environmental water sector is confined to ecosystems that are dependent on surface water or groundwater. It does not examine marine ecosystems or exclusively rainfall-dependent ecosystems, the health of which is not closely linked to water policy. The assessment considers estuaries because of their links with surface water systems and environmental flows.

Two types of environmental water are considered:

+ **Planned environmental water**: Water plans generally prescribe certain characteristics of volumes or flows that must be met (such as minimum flows) before water is permitted to be extracted by consumptive users. ‘Planned’ environmental water (sometimes called ‘rules-based’ environmental water) exists in regulated and unregulated systems in many regions.

+ **Held environmental water**: In some water systems (notably many regulated water systems in the MDB), water access entitlements of the type issued to irrigators are held on behalf of the environment. Organisations such as the Commonwealth Environmental Water Holder (CEWH), NSW Water for Rivers, the Victorian Environmental Water Holder, and others use this ‘held’ environmental water to achieve environmental objectives over and above those associated with planned environmental water. This may involve using water for activities such as flooding a wetland or increasing passing flows in a river. Held environmental water provides environmental water managers with water that is available for discretionary use to respond to opportunities and priorities that may change in response to prevailing conditions.

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46 Including non-government and private individual holders.

47 Held environmental water is also referred to in some jurisdictions as ‘callable’ water (as it can be ‘called out’ for release from storages) or as ‘adaptive environmental water’ (as it supports adaptive environmental management).
The environment

14.1.2 The relationship between water and the environment

Currently, the environment accounts for a large proportion (50%–100%) of the available resource in each water system. For example, approximately 42% of annual surface water runoff in the MDB is diverted for consumptive use, while 58% remains in the environment (MDBA 2011a). Within the MDB, about 1212 GL of water entitlement is held by the Commonwealth and managed by the CEWH.48 Table 46 summarises current volumes of environmental entitlements.

Table 46: Environmental water entitlements in the Murray–Darling Basin (GL)

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Total volume of environmental water entitlements</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>352(^a)</td>
</tr>
<tr>
<td>SA</td>
<td>238(^a)</td>
</tr>
<tr>
<td>Victoria</td>
<td>350(^a)</td>
</tr>
<tr>
<td>Commonwealth</td>
<td>1212</td>
</tr>
</tbody>
</table>

\(^a\) Includes the Living Murray program entitlements


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Note: Groundwater is typically unregulated. Groundwater regulation has been developed to cater for managed aquifer storage and recovery (also known as ‘managed aquifer recharge’) where natural (or unregulated) groundwater levels are supplemented (or regulated) by injections of water for recharge.

Source: Garry Smith, Director, DG Consulting, pers. comm., 17 April 2012.

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48 An additional 500 ML is held on behalf of the environment by The Living Murray Initiative. Further additional water is held by the NSW Water for Rivers program and the Victorian Environmental Water Holder.
Environmental water contributes to ecosystem health and the function and services of environmental assets:

- Outcomes include the maintenance and enhancement of native aquatic and riverine flora and fauna, entire ecosystems and water quality. Different components of the flow regime (for example, floods, freshes/pulses, base flows) contribute to different environmental outcomes and values.
- By contributing to the long-term sustainability of the water system, environmental water provides services to other water users. For example, good water quality is beneficial to all consumptive users, and healthy estuaries provide value to commercial and recreational fishers.
- Environmental flows may also benefit other water users in the system (for example, environmental base flows provide a basis for delivering water to consumptive users through the river system).

In general, governments act on behalf of society to protect or maintain environmental values because of the public good attributes of those values.

A number of international commitments and legislative requirements must be taken into account in determining environmental water management objectives and environmental watering actions.

### 14.1.3 Energy use and carbon emissions in environmental water use

**Energy use**

Energy use in the environmental water sector is minimal, except for some pumping for the management of held environmental water (see discussion in Section 14.2.1).

**Greenhouse gas emissions**

Environmental systems are generally carbon sinks in which plant respiration consumes carbon dioxide from the atmosphere and releases oxygen through photosynthesis. The carbon from the carbon dioxide is stored in plant biomass.

In some ecosystems, such as wetlands, organic decomposition occurs in the absence of air, releasing methane. Emissions from wetlands are not included in Australia’s National Greenhouse Gas Inventory.

### 14.1.4 Other important drivers in the environmental water sector

Increased community concerns, combined with visible signs of environmental decline during the prolonged drought of the 2000s, have focused the attention of the public and policymakers on the issue of environmental water.

Addressing the imbalance between consumptive and environmental water use is a fundamental element of the NWI, and is an area in which progress has been particularly challenging (see NWC 2009, 2011).

States have attempted to address overallocation to consumptive users in their water allocation plans, and the Australian Government and the Murray–Darling Basin Authority (under the *Water Act 2007*) have responsibilities to address ecological sustainability in the MDB.

While the visible signs of drought and the legacy of overallocation were the main drivers of these reforms, the potential link between drought and climate change means that climate change adaptation is also a potentially significant driver of environmental water reforms.

While the risks associated with climate change are a driver for reform, environmental water is not the only means of addressing concerns about the health of environmental assets. Other policy tools and measures, such as landuse planning, access controls and revegetation, can all play a role in the achievement of environmental outcomes. This means that environmental water management needs to be coordinated with other elements of natural resource management.

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49 Similarly, the delivery of water to consumptive users can provide a range of environmental benefits.
14.2 Mitigation policy interactions

As explained in Section 3, mitigation policies are designed to reduce emissions of carbon dioxide and other greenhouse gases. They can be broadly categorised as:

+ **Cleaner energy measures**, which aim to reduce the emissions intensity of energy supply mostly by incentivising ‘fuel switching’ from high-emissions sources (such as coal-fired electricity generation) to lower emissions intensity sources (for example, gas-fired or renewable electricity generation).

+ **Energy efficiency measures**, which aim to slow the growth in total energy demand and hence reduce the growth in emissions.

+ **Land-use change measures**, which aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors.

The following sections examine the potential impacts of these policies on the environmental water sector and environmental outcomes.

14.2.1 Cleaner energy policy impacts

Australia’s current cleaner energy policies will impose a carbon price on major producers of emissions and as a consequence lead to an increase in the price of energy.

Most environmental outcomes from environmental water use occur in natural systems that, although they may be regulated by a weir or large storage, are generally gravity fed, and therefore largely immune to any rise in energy prices caused by the introduction of a carbon price.

However, some environmental watering techniques use energy and would therefore be affected by climate change mitigation policies. One example is wetland watering that is carried out by pumping water into the wetland, rather than releasing of large volumes of water to create overbank flow into the target area. Such measures are often seen as a way to improve the efficacy of environmental water use, because they can achieve a particular environmental outcome using less water.

In theory, a carbon price that increases energy costs will increase the costs of such watering. However, in practice, diesel pumps are mainly used and that fuel use is currently outside of the carbon price policy. Even if the carbon price were applied to diesel fuel combustion, that would be unlikely to significantly change environmental watering decisions. For example, the inclusion of diesel under a carbon price of $23/t CO$_2$-e could increase the price of diesel by $0.06/litre. This equates to an increase of $0.36–$1.02 in fuel costs to pump each megalitre of water. Given that the total cost of labour, capital and fuel is around $35/ML (not including the transport, setup and packup of pumps), this would equate to a 1%–3% increase in total watering costs. This cost increase is negligible when compared to the cost (or opportunity cost) of the water volume that would otherwise need to be used for the environmental watering. For example, when wetland pumping options were adopted in the MDB during the recent drought, water allocation prices were $200–500/ML.

Small impacts from increased energy costs could be expected where electric pumps are used at environmental sites, such as at Hattah Lakes (Mallee CMA 2011).

Overall, there are unlikely to be any material impacts of cleaner energy policies on energy use in the environmental water sector.

14.2.2 Energy efficiency

No current energy efficiency measures directly target energy use for environmental water management.
14.2.3 Land-use change measures

Land-use change measures aim to reduce aggregate emissions through changes to land use that sequester carbon, including measures to encourage reforestation, reduce deforestation, and abate emissions in the agricultural, waste and other sectors. This section examines the potential impacts of such policies on environmental water management.

Land-use change to promote environmental outcomes

In general, much environmental water use in Australia is to protect and maintain existing ecosystems and environmental values (and, by implication, to maintain existing biomass rather than to expand it). This suggests that environmental water use will have limited impact on the amount of carbon sequestered in the biomass of surface water and groundwater dependent ecosystems. Some exceptions that could have consequences for carbon sequestration or offsets include the following:

- **Rehabilitating (increasing) or preventing decline in biomass (such as red gum forests).** Where environmental water management results in an increase in the area of native forest it would also increase carbon sequestration and result in improved environmental outcomes. Similarly, conservation and discretionary environmental watering activities that prevent decline in a forest also maintain the carbon sequestered in the forest. For example, the Barmah–Millewa Forest on the Murray is the largest river red gum forest in Australia. River red gums require frequent and periodic flooding to regenerate and grow. Environmental watering actions that expand (or prevent a reduction in) the area of the forest effectively result in carbon offsets. Watering actions can also contribute to other improved environmental outcomes, including increasing the number and diversity of fauna, filtering sediments, recycling nutrients (enhancing water quality), mitigating floods, providing breeding and other lifecycle habitat, and replenishing nutrients and micro-fauna for birds, fish and other organisms during floods.

- **Changing wetland management.** The carbon sequestration/offset consequences of reducing wetland methane emissions from the breakdown of organic matter are controversial. This is because methane reductions are difficult to achieve without drying the wetland, which in some circumstances can lead to a loss of its environmental values. Some scientists do not see any way to control methane emissions from wetlands.

Land-use change mitigation policies may have a positive impact on environmental water management outcomes. In particular, elements of the Biodiversity Fund may help to fund land-use change on environmental watering sites where the achievement of environmental outcomes depends on environmental watering but also on other nonwater-related activities, such as revegetation. Section 4.1 of the Biodiversity Fund guidelines (DSEWPaC 2011) provides that government-related entities may apply for part of the funds of $946 million over six years. Community groups may be eligible if they are incorporated associations or cooperative societies. Therefore, environmental water managers that are government agencies or community groups may directly apply for Biodiversity Fund grants.

In a strict sense, environmental water managers are not generally responsible for making non-water-related changes in land use and land management practices. For example, the CEWH is responsible for managing the Commonwealth portfolio of environmental water entitlements and for delivering that water in accordance with environmental watering plans. It does not own or manage land, and cannot purchase land or make payments for land-use change under the provisions of the Water Act 2007 (Cwth).

Other parties are responsible for land management, most notably state government agencies and catchment management authorities that undertake revegetation works and control access to environmental assets. This could create a coordination issue. In particular, there may be a need for coordination where the optimal environmental outcomes for a site depend on both water-related and nonwater-related inputs (for example, revegetation), and there is separate responsibility for those inputs. The coordination of land and water management may lead to better environmental outcomes and provide important opportunities for better adaptation to climate change impacts.

Based on current regulations under the CFI, permanent environmental plantings are on the ‘positive list’ of projects deemed to provide additional carbon sequestration (and therefore likely to be eligible for carbon credits). Where such activities both sequester carbon and provide biodiversity benefits, they may also be eligible for funding under the Biodiversity Fund.

Presumably, permanent environmental plantings in wetlands or other environmental assets will only occur where there is a net environmental benefit. However, they do not trigger the water management regulations on the CFI negative list as it is currently drafted. Therefore, there is some potential for additional water interception by such projects.

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53 It should be noted, however, that some ponding of water might not be natural and so the loss of environmental outcomes may not be significant. For example, in situations where previously ephemeral wetlands have become permanent wetlands as a result of river regulation or irrigation drainage disposal, restoring drying cycles may create environmental benefits.

54 Including Paul Palmer, a geoscientist at the University of Edinburgh and a co-author of Bloom et al. (2010) (Walsh 2010).

Land-use change associated with voluntary actions by environmental water managers

Some environmental water managers may choose to pursue carbon neutrality objectives by offsetting some emissions through tree plantings. Although the offset emissions associated with pumping are unlikely to be significant, this will increase the costs of the activities of environmental water managers. This may be inefficient if emissions are already priced into the cost of their activities (such as through a carbon price on energy).

### 14.2.4 Summary assessment of water-related impacts of mitigation policy in the environmental water sector

Table 47 summarises the assessment of the water-related impacts of the two main mitigation policy impacts in the environmental water sector. Overall, mitigation policies are not expected to have a major impact on environmental water.

**Table 47: Water-related impacts of mitigation policies in the environmental water sector**

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Impacts of cleaner energy and energy efficiency policies</th>
<th>Impacts of landuse policies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nature of impact</strong></td>
<td>Changes to cost of environmental water delivery via pumping.</td>
<td>CFI and Biodiversity Fund provide incentives for land-use change that may affect water systems (i.e. interception).</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Mainly MDB, where there are wetland pumped watering sites.</td>
<td>National</td>
</tr>
<tr>
<td><strong>Likelihood/timing</strong></td>
<td>Will occur with a carbon price for electric pump sites, and will occur for diesel pump sites if and when diesel fuel is included.</td>
<td>Could occur with current CFI and Biodiversity Fund policies.</td>
</tr>
<tr>
<td><strong>Magnitude/sensitivity</strong></td>
<td>Low impact even at high carbon prices.</td>
<td>Low impact.</td>
</tr>
<tr>
<td><strong>Importance of climate change impact compared to other drivers of change</strong></td>
<td>Low, given the small potential impacts of a carbon price on overall pumping costs.</td>
<td>Medium. The CFI and Biodiversity Fund may significantly incentivise land-use change for owners of water-dependent environmental assets.</td>
</tr>
<tr>
<td><strong>Overall materiality of impact</strong></td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Potential water policy issues**

<table>
<thead>
<tr>
<th>Water policy issues</th>
<th>Impacts of water extraction, interception and use on the environment and third parties.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current water policy tools</td>
<td>Water planning and tools to manage interception impacts.</td>
</tr>
<tr>
<td>Existing knowledge of the issue</td>
<td>Limited attention paid to potential interception impacts of permanent environmental plantings in wetlands and other water-dependent environmental assets.</td>
</tr>
<tr>
<td>Overall policy implications</td>
<td>Some potential for additional interception, if the CFI and Biodiversity Fund promote significant land-use change.</td>
</tr>
</tbody>
</table>
14.3 Climate change adaptation interactions

The potential impact of climate change on water-dependent ecosystems is a major water policy issue. Following the framework set out in Section 2, this section:

- identifies the potential impacts and risk of climate change (in this case, as they affect environmental water outcomes)
- identifies the likely environmental water management and policy responses to adapt to those changes in the environmental water sector
- assesses consequent water-related impacts
- identifies possible water policy issues.

14.3.1 Potential impacts of climate change on environmental water

The key potential impacts of climate change on the environmental water sector include:

- the impacts of reduced environmental water availability on surface water and groundwater dependent ecosystems, including the likelihood of prolonged droughts and higher or more frequent floods
- other direct impacts on water-dependent environmental assets, including changes in temperatures and sea level rise.

These climate change impacts will affect the water supply and demand in the environmental water sector. For example, the supply of water to the environment is likely to be reduced due to changes in average water availability and droughts, including through the impacts of temperature on evaporation from storages. There may also be periods when supply may be quite high, with the potential for increased periodic flooding.

The demand for water by the environmental water sector is likely to increase due to the impacts of higher temperatures and extreme events, such as heatwaves and frosts, on environmental assets. Demand for water may also be affected by sea level rise impacts on environmental assets. For example, demand for freshwater for an asset that has been changed to a saltwater environment may decline. Similarly, there may be changes in the location of demands for environmental water if species or vegetation communities can no longer survive in a given location because of changes in local climate. For example, Bates et al. (2011) found that some species may be close to the limit of their physiological capacity and might be unable to adapt to climate changes.

Water availability and the condition of water-dependent ecosystems

Impacts of reduced inflows on environmental water availability

Climate change impacts on water availability will affect both planned and held environmental water. Under current water planning regimes, climate change risks are shared (albeit unevenly) between consumptive users and the environment. Broadly speaking, water planning often allocates water in a hierarchical fashion that first ensures that minimum flows are provided for certain environmental purposes (highest priority), before making water available for consumptive users (medium priority) and then considering flooding and highflow events as environmental flows (low priority).

The supply of planned environmental water (which is made up of both minimum flows and flooding and highflow events) may therefore be affected by:

- increases in the extent to which minimum flow standards are violated (for example, due to drought sequences)
- reduced flood frequency and changes to the seasonal flow regime that divert further from pre-development conditions.

Flooding and highflow events provide a significant component of total environmental water volumes in many areas. However, that component has the lowest priority and is held by the environment. This means that any reduction in long-run water availability may lead to considerably less environmental water from flooding and highflow events. Therefore, total environmental flows may be reduced significantly more than water for consumptive users.
The environment

This was demonstrated in the hydrological modelling undertaken for Victoria’s Northern Region Sustainable Water Strategy. The modelling found that, under the operating and allocation rules that applied prior to the strategy, climate change impacts on total inflows have disproportionate impacts on the availability of water for consumptive use and the environment. For example, under one modelling scenario in which overall water availability (total inflows) declined by 25% in the Goulburn system, water availability for consumptive use (diversions) was reduced by 15%, while water availability for the environment (environmental water) was reduced by 38%. Under more extreme climate change assumptions, that effect was exacerbated.56

These outcomes are consistent with the fact that most environmental flows are provided by unregulated flooding and highflow events that spill from reservoirs or cannot be harvested. Those flows are most affected by climate change because, with less rainfall, existing reservoirs will be able to capture a greater proportion of inflows.

In addition, the supply of the environment’s ‘held’ water would be expected to fall. This would happen if climate change leads to reduced allocations to water entitlements—including those held by environmental water managers and other consumptive users. The extent of the impact will depend on the type of water entitlements held by the environmental water manager. For example:

+ higher reliability water shares are less affected by climate change
+ lower reliability water shares are significantly affected by climate change.

The effect of climate change in reducing the reliability of entitlements will be significant for held environmental water in Victorian systems, where the environment holds 248 ML of lower reliability water shares under the Living Murray initiative.

In general, groundwater is expected to be less directly affected by climate change. However, increased pressure on groundwater resources due to greater competition for resources and reduced availability of surface water could have adverse impacts on groundwater-dependent ecosystems if groundwater plans are not well developed. A recent Commission project on the impacts of climate change on groundwater systems identifies the groundwater systems likely to be most heavily affected by climate change (Barron et al. 2011). The project found that the median future climate scenario at 2030 and 2050 projects a decrease in diffuse recharge across most of the west, centre and south-east of Australia, and increases in recharge in northern Australia and in a small area of eastern Australia. It also found that interannual rainfall variability is magnified two to four times in recharge variability. This would mean that climate change increases the volatility of seasonal conditions will significantly affect recharge, with the greatest impact in areas of low recharge.

**Impacts of changed water availability on water-dependent ecosystems**

The expected average reduction in water availability due to climate change could affect the long-term average frequency of inundation at various sites. The expected increase in drought frequency, duration or both will also affect environmental outcomes. The length of dry periods is known to be ecologically sensitive, and may lead to the following outcomes:

+ **The viability of wetland plant seeds declines over time.** For example, ribbon weed, a common aquatic plant, has seed that will remain viable in dry wetland sediments for up to nine years (Roberts and Marston 2011). The resilience and productivity of wetlands would be lost if the seed viability thresholds of aquatic plants are exceeded.

+ **Risks to plants that require intermittent flooding.** For example, lignum shrublands require flooding every five to seven years to maintain vigour. Rootstock may survive up to 10 years without flooding (Roberts and Marston 2011). If dry periods exceed that length, extensive loss occurs. Lignum provides habitat for a range of birds, amphibians and other animals and is particularly important for bird breeding. Loss of this species would have a range of negative flow-on effects. Regeneration requires seed dispersal from other areas, as well as appropriate watering conditions for seedling growth (Roberts and Marston 2011). Similarly, river red gum communities along the River Murray and other rivers in the MDB declined extensively during the recent drought. The length of time between waterings was seen as a major contributing factor to the decline. In those areas that received water through actions such as pumping, the decline in condition was less significant, showing that the period between waterings is a significant factor (MDBA 2011b).

If dry periods extend beyond the timeframe that certain species can tolerate, regeneration may take a very long time. Consequently, the Murray-Darling Basin Authority has emphasised the significance of maximum dry periods in formulating the proposed Basin Plan, and noted that a key objective of environmental water management will be the maintenance of resilience, which will require reducing the length of dry periods for key wetlands and floodplains (MDBA 2011b).

There are other climate change impacts that may also affect the infrastructure, assets and services of the environmental water sector. They are likely to be limited, but may include flooding and storm impacts on pumps, impacts on electricity supply security (limiting opportunities for pumping), or risks to diesel storages from floods or storms.

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56 For example, where overall water availability (total inflows) falls by 48% in the Goulburn system, water availability for consumptive use (diversions) is reduced by 30% and water availability for the environment (environmental water) is reduced by 69%.
Location of impacts

The impacts of any reduction in water volumes for the environment are uncertain and would vary by region. Where such changes occur, they could have profound impacts on environmental outcomes in surface water and groundwater dependent ecosystems. The effects of climate change on water-dependent environmental outcomes are likely to be greatest where climatic changes are greatest, where ecosystems are most sensitive to the changes, and where current levels of water extraction and water planning and management arrangements expose the environment to the greatest climate risk.

Other impacts, including temperature change and sea level rise

Other events linked to climate change could adversely affect surface water and groundwater dependent environmental assets. They include:

- temperature change
- bushfires
- water quality/"black water" events
- sea level rise.

Higher average temperatures would lead to increased evaporation, which is likely to reduce the supply of water, including to the environment. Higher temperatures, reduced rainfall and more hot days could have a significant impact on the health and integrity of environmental assets, regardless of what happens to their watering regimes.

Bushfires damage or destroy the flora and fauna in affected areas and significantly degrade catchment water quality. They also reduce the supply of environmental water because water yields decline in subsequent periods as fire-affected vegetation regenerates.

More environmental water may be needed to manage water quality problems caused by weather events that become more prevalent due to climate change. For example, although ‘black water’ events\(^{57}\) are a natural part of the ecology of lowland river systems in variable climates, they are also considered to be emergencies that require management intervention if possible. Such events may increase in frequency if climate change leads to greater variability in seasonal conditions. In some circumstances, environmental water management can dilute black water, making it less of a danger to fish populations.

Sea level rise has potential impacts on estuarine water assets such as the Coorong and the Gippsland Lakes. It could also lead to greater saline intrusion into groundwater aquifers near the coast. This may affect environmental water demand if sea level rise transforms environmental assets from freshwater systems into saltwater systems. This may lead to a reduction in demand for freshwater if environmental water managers respond by altering their objectives in response to the condition of those environmental assets.

A focus of MDB environmental water management has been the provision of sufficient freshwater flows into the Coorong and Lower Lakes. CSIRO research on the effect of management actions and climate change scenarios on the Coorong (Lester et al. 2009) found that sea level changes had a mixed impact on the hydrodynamics and ecosystem states of the Coorong. Lower-end estimates for the broader region including the Coorong include a decrease in sea level of up to 100 mm. Such a decrease would exacerbate the effect of climate change by decreasing the connectivity in the system, leading to a small increase in the proportion of degraded ecosystem states in the Coorong. Either a 200 mm or a 400 mm sea level rise by 2030 would increase the hydrodynamic connectivity in the Coorong, and thus alleviate some of the more severe effects of climate change at current extraction levels (Lester et al. 2009).

The potential for sea level rise to affect the Gippsland Lakes was considered in the Victorian Government’s Gippsland Region Sustainable Water Strategy (DSE 2011). The strategy found that rising sea levels, increases in storm surges and potential reductions in streamflows are likely to result in an increasingly marine environment in the lakes. This would have the effect of raising salinity levels in the fringing wetlands. Furthermore, it found that erosion-prone areas along Gippsland’s coast, such as Corner Inlet and the Gippsland Lakes, will be particularly susceptible to the impacts of rising sea levels. The interaction of sea level rise and future changes in rainfall patterns may also affect the volume of streamflows entering the wetlands and estuaries, altering the location of the freshwater–saltwater interface.

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\(^{57}\) Black water events occur when large amounts of accumulated leaf litter are washed from floodplains into water bodies or rivers. The decay of the leaf litter results in a significant increase in the concentration of dissolved organic carbon in the water, which gives the water column a dark colour. Often, it also produces low dissolved oxygen levels, which have the potential to cause fish kills (DPI 2011).
14.3.2 Adaptation responses and water policy implications

This section considers several broad types of adaptation responses, including:

+ securing more water for the environment
+ improving environmental outcomes from a given volume of environmental water
+ changing underlying environmental objectives.

Securing more water for the environment

The previous section notes that the impacts of climate change on the environment are likely to be significant. One response is to secure more water for the environment to ameliorate the impacts. This could be achieved through:

+ increases in planned water through changes to water planning regimes
+ increases in held water through market purchases (such as buybacks) or other means (such as infrastructure upgrades that reduce system losses), and perhaps through seasonal buying and selling in water markets.

A key water policy issue concerns the balance between environmental and consumptive water uses. An important objective of much water resource management policy (such as the NWI) is to efficiently allocate water resources in a way that optimises economic, social and environmental outcomes. Therefore, decisions will have to be made about:

+ how much water is set aside as planned environmental water
+ how much water entitlement is held by environmental water managers (and how much is bought or sold in a given season).

It would be problematic to ascribe the maintenance of particular environmental values to either planned or held environmental water, given that both types of environmental water work in combination. Furthermore, the volumes of planned and held environmental water are not static, and can respond to prevailing seasonal conditions and to environmental asset condition.

More broadly, the policy tools of water planning, entitlements, markets and arrangements for sharing the risk of climate change impacts on water availability between the environment and consumptive users all affect the dynamic balancing of water between environmental and consumptive uses. These issues are discussed further in Part A of this report.

Planned water

An extreme approach to safeguarding environmental outcomes would be to revise water planning arrangements to provide sufficient volumes and patterns of water for all environmental outcomes to be met under the full range of possible climate change conditions.

Such an approach would shift climatic risks to consumptive users and could lead to mounting public pressure to revise water planning and other water management arrangements. It would also be undesirable, because it would reduce the incentive for environmental water managers to pursue low cost adaptation opportunities while consumptive users face the high costs of climate change impacts.

Bates et al. (2010:48) found that ‘a greater degree of responsibly on planning as opposed to demand-driven water use … has the potential to limit rather than promote adaption.’

Revising water planning arrangements to provide more water for the environment would have impacts on other water users. If water that would have otherwise been provided to the consumptive pool is administratively reallocated to the environment, the rights of users who share the consumptive pool are altered (for example, the reliability of entitlements may be reduced, so that a smaller volume is received under some seasonal conditions). This can undermine water property right arrangements and have negative consequences, such as disincentives for investment by consumptive water users.

Increasing planned water volumes may be a suitable approach for water resources that are not fully allocated or developed, as there would be no or very limited third-party impacts. This would ensure that there are sufficient reserves of water to sustain environmental values as part of the water sharing arrangements before the resource is fully allocated.

Held water

Held environmental water has been developed as a means of increasing flexibility, and is essentially an adaptation response by water policymakers. It enables environmental water managers to increase the frequency of environmental watering without adversely affecting the reliability of the entitlements held by consumptive users. Providing flexibility to environmental managers is desirable because adaptation and innovation are not only opportunities for consumptive water users, but also for environmental water managers.
Held environmental water can be secured through:

+ **purchases of water entitlement**, including through tenders and the use of water brokers or water exchanges (the largest series of market purchases has been the Commonwealth buyback under the Restoring the Balance in the Murray–Darling Basin program)

+ **investments in infrastructure**, including delivery system upgrades to reduce system losses and on-farm efficiency upgrades (for example, investments under the Australian Government’s Sustainable Rural Water Use and Infrastructure Program)

+ **combinations of purchases and investments** (such as irrigator-led group proposals under the Restoring the Balance Program, which allow groups of irrigators to develop coordinated proposals for selling their water entitlements to the Commonwealth and decommissioning or altering shared irrigation supply infrastructure)

+ **seasonal buying and selling** in water markets to purchase water allocations to respond to prevailing conditions or to sell excess environmental volumes to optimise the management of the portfolio of held environmental water.

In the MDB, there have been significant increases in volumes of held environmental water in recent years (mainly secured through widespread purchases of water entitlement). The Commission’s assessment of the impacts of water trading in the southern MDB (NWC 2012) found that this is likely to have contributed to positive environmental outcomes. However, we also found that environmental watering plans and monitoring and evaluation will be required in order to assess the environmental benefits of water purchases in the future.

A key policy issue associated with held environmental water relates to determining the best portfolio of water products to meet clearly defined environmental objectives. A related question is whether existing entitlements provide the right reliability of water to meet environmental requirements under extreme climatic events. This is not solely about managing climate change; rather, it is a challenge to the management of environmental water under the significant climate variability that occurs in Australia. This issue is further complicated by the reductions in entitlement reliability expected because of climate change.

The possibility of environmental managers taking action in the water market (and using this as an adaptation tool to manage climate variability and climate change) has raised some concerns in the public debate and has been the topic of a CEWH discussion paper (CEWH 2011b). The large volume of entitlement now held by a small number of environmental managers has the potential to affect water market dynamics. This creates a challenge for environmental managers in considering how and when they might enter the market, and what type of public disclosure of activity or intent may be appropriate (CEWH 2011). It is also a challenge for water market regulatory arrangements, and there may be questions about the accounting treatment of trades between consumptive and environmental users.

Adaptation opportunities may also be limited by the broader water management structures within which the environmental water sector is operating. This may limit the actions available to environmental water managers, constraining their responses to climate change and variability:

+ The NSW Murray Wetlands Working Group found that significant delays in obtaining approvals resulted in a prime environmental watering opportunity at the Cliffhouse Station wetland being missed. The wetland was originally scheduled to be watered in October 2005 (within the optimal ecological period for flooding such systems), but the watering was conducted in March 2006. Monitoring results suggest that the watering did not produce a strong ecological response (MWWG 2008).

+ Owners of held environmental water are generally liable to pay storage charges and work within existing carryover provisions. If climate change means that more of the environment’s water is held as entitlements, environmental managers may be increasingly liable for storage charges and their strategies may be affected by carryover provisions, which have largely been developed to suit irrigation water demands. For example, carryover arrangements are often based on irrigation water seasons and are of limited use for carrying over large volumes of water due to the risk of forfeiture (or the risk of forgoing future allocations). An alternative to carryover could be to use ‘extended use’ provisions, which are found in some northern Victorian environmental entitlements. Under that arrangement, the environmental water manager has 18 months to use the water, rather than the standard 12 months. However, there would be value in ensuring that any changes to carryover provisions apply to all entitlement holders, rather than providing special arrangements that are only available to environmental water managers.

+ In some regions, environmental water managers have sought and made arrangements to supplement current water management arrangements with added ‘opportunities’. Prime examples are the ‘water shepherding’ arrangements in the New South Wales and Queensland regions of the MDB, which allow the movement of parcels of water through unregulated systems. Agreements are in place between the Commonwealth and both the New South Wales and Queensland Governments on the implementation of water shepherding. A key principle of the agreements is that shepherding of the Commonwealth’s environmental water will neither enhance nor diminish the property rights of other water users (CEWH 2011a).
+ Water accounting has been developed to manage irrigator-type water demands. This means that return flows (extracted water that returns to the river and may provide environmental benefits or benefits to other users, such as volumes that are reregulated and allocated) are generally not treated as credits to the source of the return flows. This is because there would be significant measurement problems and because return flows from irrigation are generally a smaller proportion of the extracted volume than occurs in environmental water use. This means that water accounting generally does not account for environmental water deliveries in a way that recognises the non-consumptive nature of in-river deliveries and the significant return flows that generally occur from wetland waterings.58 Such accounting treatments are not incorporated into general practice, but there have been some ad hoc examples:

- CEWH releases for within-river Goulburn flows in 2010–11 were recorded as a special accounting item in intervalley water trading accounts, in which the water was effectively being traded from the Goulburn to the Murray.
- A ‘return flows’ portion of the 428 ML inundation of the Barmah–Millewa Forest was protected from extraction and transferred to South Australia for ultimate delivery to the Lower Lakes (Garry Smith, Director, DG Consulting, pers. comm., 17 April 2012).
- In some systems, environmental entitlements are deemed to be using water when flow is allowed to proceed downstream without being diverted. In 2010–11, 34.3 ML of Living Murray water was deemed to be transferred from Victoria to South Australia and hence to the Coorong when flow was unregulated and could not have been stored in either Lake Victoria or the Lower Lakes. The environmental outcomes were unaffected by the decision to deem the water to be used (MDBA 2011c).

Use of additional water for the environment

Regardless of how water for the environment is sourced, several factors affect how the environmental water sector can adapt and use it for environmental purposes:

+ Most environmental water managers have roles that are limited to the use of environmental water. However, environmental outcomes also depend on other factors, such as land management, access controls and revegetation efforts. This potentially creates a coordination challenge in prioritising environmental management efforts.

+ There are linkages between environmental watering objectives, river operations (such as dilution flows) and interstate water sharing arrangements.

+ The delivery of large volumes of water to meet environmental objectives may cause third-party effects. Where there is the potential for flooding low-lying private property, the delivery may not be permitted by river managers. Alternatively, the liability for compensation may be assigned to the environmental water manager, in which case the manager might not proceed with the action. There is also the potential to create increased congestion and competition for available river channel capacity. This will be highly dependent on both future environmental objectives and future agricultural demand patterns.

Improving environmental outcomes from a given volume of environmental water

Adaptation in the environmental water sector can involve altering the ways environmental objectives are achieved, including:

+ how water is delivered (such as through combinations of storage releases, tributary flows and pumping)

+ how environmental water management decisions respond to prevailing conditions (such as piggybacking on small and medium floods, or triaging critical sites during drought).

In general, the provision of environmental water has features common to all water–production relationships—simply put, water and other inputs lead to the environmental outputs. However, knowledge of those relationships is still being accumulated. Environmental water management may involve making a range of trade-offs. For example:

+ A reduction in applied environmental water volumes may only lead to a small reduction in a given environmental outcome. Conversely, it may lead to a large environmental decline if a threshold is breached.

+ A given environmental outcome may be achieved using a smaller volume of water if other inputs are used (for example, pump-assisted wetland watering).

+ A given environmental outcome may be achieved using a smaller volume of water if other management practices are used (for example, wetland restoration assisted by fencing out livestock or other land management actions).

58 Sometimes this is appropriate because of the nature of the environmental entitlement, such as for the Barmah–Millewa Forest allocation, where return flows are allocated to consumptive use.
This means that environmental outcomes may still be able to be maintained at acceptable levels (or, at least, environmental damage may be minimised) in situations where water availability is constrained. A prime example of this is the number of wetlands in the MDB that were the sites of pumping during drought to achieve watering events. They included the Hattah Lakes, Coombool Lake, Merriti Lake, the Paiwalla wetlands and numerous sites across the lower Murray–Darling region.

Box 12 describes examples of the delivery of environmental water to respond to drought and other prevailing conditions.

**Box 12: Delivery of environmental water**

The NSW Murray Wetlands Working Group Inc. has managed an adaptive environmental water entitlement of up to 32 ML in the Murray Valley of New South Wales since 2000. Between 2004 and 2008, the group used over 28 ML of that water to inundate 93 wetlands covering some 4000 hectares. In some cases, this required the construction of temporary earthen banks to help deliver the water or contain it in the target area. In some cases, the water was pumped.

More recently, and at a larger scale, 554 GL of Commonwealth environmental water has been delivered for the environment across the MDB since 2009, of which 387 GL was delivered in 2010–11. An additional 417 GL was contributed by state governments, the Living Murray program and private donations.


**Adapting objectives for particular environmental assets**

Another potential climate change/climate variability adaptation response is the refinement of environmental objectives to pursue outcomes for the environment that remain achievable.

Environmental water is already managed in a manner that is responsive to climate variability (that is, prevailing seasonal conditions). For example:

+ The proposed Basin Plan uses ‘resource availability scenarios’ (very dry, dry, moderate, wet and very wet) to guide decisions about environmental watering (Section 7.39 of the plan). Environmental water management outcomes and priorities for applying environmental water depend on the resource availability scenario. For example, environmental water management under very dry conditions may be focused on avoiding irretrievable loss of or damage to environmental assets. Under dry conditions, priorities may be to ensure that environmental assets maintain their basic functions and resilience. Under wet conditions, the focus may be on improving the health and resilience of water-dependent ecosystems.

+ The CEWH also pursues varying ecological objectives for the use of held environmental water under different water resource availability scenarios (CEWH 2011a):
  - Extreme dry—avoid damage to key environmental assets
  - Dry—ensure ecological capacity for recovery
  - Median—maintain ecological health and resilience
  - Wet—improve and extend healthy and resilient aquatic ecosystems.

If climate change alters the relative likelihood of given sets of prevailing conditions, adaptation may require a revision of the definitions of ‘dry’, ‘moderate’ and ‘wet’ conditions. Because environmental outcomes are linked to the long-term expected mix of dry, moderate and wet conditions, a change in that mix is likely to affect the achievability of environmental objectives for particular assets.

This illustrates the importance of regular reviews of management objectives in a changing climate. Adaptation may require environmental objectives to be reviewed in the light of performance, knowledge improvements and observed changes in environmental conditions. This might include decisions to cease pursuing some environmental objectives in some circumstances. For example, it might not be feasible to maintain some environmental assets, given competing environmental and consumptive demands for water. Alternatively, difficult ‘triage’ decisions may need to be made, such as the choice between increasing the probability of maintaining pristine environments or continuing to water already degraded sites that are unlikely to survive because of other factors, such as the direct impacts of climate change. Adapting to a changing climate may mean that in the future some current environmental objectives cannot be met.
The option to cease pursuing certain environmental outcomes has been identified in a number of watering plans. For example, Victoria states in the recent Gippsland Sustainable Water Strategy:

> Should it become apparent with defensible scientific evidence that environmental objectives can no longer be met as a result of long-term changes in climate and water availability, amendment of the objectives will be formally considered as part of the development of regional Strategies for Healthy Rivers and Wetlands in consultation with the community. (DSE 2011:90)

Similarly, environmental objectives may need to be reviewed when more water is available because of increased climate variability. Climate change may provide the driver for the review of environmental objectives, especially where conditions have changed so much that some environmental objectives cannot be met. The challenge will be to know when, and to what extent, climate change is occurring, against a background of climatic variability.

### 14.3.3 Summary assessment of climate change and adaptation policy

**Water-related impacts in the environmental water sector**

Table 48 summarises water-related impacts of climate change adaptation responses in the environmental water sector.

<table>
<thead>
<tr>
<th>Impact assessment</th>
<th>Nature of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Australia-wide.</td>
</tr>
<tr>
<td>Likelihood/timing</td>
<td>The impacts are highly uncertain. There is some evidence linking recent droughts to the impacts of climate change.</td>
</tr>
<tr>
<td>Magnitude/sensitivity</td>
<td>Potentially very significant impacts, but a high level of uncertainty in climate outcomes and adaptation responses. Recent and ongoing reforms to water planning will, in part, ensure that the environmental water sector shares impacts with consumptive users, rather than facing the residual risk.</td>
</tr>
<tr>
<td>Importance of climate change impact compared to other drivers of change</td>
<td>Climate change and climate variability are the principal drivers of outcomes in the environmental water sector. It is difficult to separate climate change adaptation policies in the sector from water management policies more broadly.</td>
</tr>
<tr>
<td>Overall materiality of impact</td>
<td>Potentially very high, given that the environment generally uses more of a given water resource than is made available for consumptive use.</td>
</tr>
</tbody>
</table>

### Potential policy issues

| Water policy issues                      | Optimal allocation of scarce water resources—how climate change impacts will be shared between consumptive users and the environmental water sector. The extent to which environmental water management under current arrangements provides enough flexibility for adaptation, and where arrangements need to be refined to recognise common differences between environmental and consumptive water use (water accounting, water shepherding etc.) |
| Current water policy tools               | Water planning, entitlements and markets. |
| Existing knowledge of the issue          | The impacts of climate change on water resources have been a major driver of rural water policy for some years, including under the NWI, the Water Act 2007 and the proposed Basin Plan. |
| Overall policy assessment                | Policy frameworks may be needed to facilitate best practice water planning so that the environment is not oversheltered from or overexposed to the impacts of climate change compared to consumptive users. Management of held environmental water using arrangements developed for irrigator-type water users may constrain opportunities for adaptation in the environmental water sector. |
14.4 References


Appendix A: Stakeholder engagement

Objectives

The main objective of the stakeholder engagement process for the Water and Climate Change Policy Project was to support and facilitate the achievement of the overall project objectives.

The specific objectives for stakeholder engagement were to ensure that:

+ the project had access to and an understanding of information on current and future water and climate change policies
+ the project had access to and incorporated the latest information and advice on likely industry responses to climate change policy and the interaction of those responses with water policy
+ the industry sectors relevant to the project were aware of the project and how inputs were being gained from their sectors, to help build confidence in and support for the project outcomes
+ the project helps to build an improved, shared understanding among the stakeholders of the interactions between climate change policy and water policy and helps to positively influence future water policy development and implementation at the national, state and catchment levels.

Stakeholder groups

The project engaged with a wide variety of policymakers, academics, consultants and practitioners, including:

+ Australian Government agencies
+ state and territory government water agencies
+ local government
+ the Australian water sector
+ large water-using industry sectors.

The project was advised by a Commonwealth Reference Panel and an Industry Reference Panel. A stakeholder workshop was held during the project to test the project outcomes with national, state, territory and local government representatives, as well as water sector and industry representatives.
Australian Government agencies

Climate change and water policy are wide-ranging issues that involve a number of different areas of government activity. Because climate change is a national (and international) issue, some major policy development is being led by the Australian Government and its agencies.

To ensure that the project addressed its objectives in an informed and holistic manner, Australian Government agencies with responsibilities in the climate change and water areas participated in the Commonwealth Reference Panel for the project, including:

+ the Department of Sustainability, Environment, Water, Population and Communities
+ the Department of Climate Change and Energy Efficiency
+ the Treasury
+ the Department of the Prime Minister and Cabinet
+ the Department of Resources, Energy and Tourism
+ the Department of Agriculture, Fisheries and Forestry.

State, territory and local government stakeholders

State, territory and local government are involved in setting and implementing climate change mitigation and adaptation policy and water policy. To ensure that the project addressed its objectives in an informed and holistic manner, state and territory government agencies with responsibilities for water were included and considered in stakeholder engagement, as was the peak local government body. State, territory and local governments were invited to participate in the project stakeholder workshop and to comment on a draft version of this report.

State and territory agencies

+ Environment and Sustainable Development Directorate (ACT)
+ Office of Water (New South Wales)
+ Department of Environment and Resource Management (Queensland)
+ Department of Natural Resources, Environment, the Arts and Sport (Northern Territory)
+ Department for Water (South Australia)
+ Department of Primary Industries, Parks, Water and Environment (Tasmania)
+ Department of Sustainability and Environment (Victoria)
+ Department of Water (Western Australia).

Local government

+ Australian Local Government Association.

Other government agencies

+ Productivity Commission (which is undertaking an inquiry into climate change adaptation)
+ Victorian Environmental Water Holder.
Australian water sector

To better understand the interaction between water and climate change policy and the possible implications for the rural and urban water sectors in the context of current and future climate change mitigation and adaptation, the Australian water sector and the urban water industry are key stakeholders. The sector and industry were represented by industry associations on the project's Industry Reference Panel:

+ Australian water sector: Australian Water Association
+ Urban water industry: Water Services Association of Australia
+ Irrigation sector: Irrigation Australia Limited.

Water-using industry sectors

For the project to consider the likely impact on water resources of climate change mitigation and adaptation policy options in water-using industry sectors such as energy, renewables, agriculture, forestry and mining, stakeholders from those sectors were engaged. The sectors were represented by industry associations and independent government agencies on the project's Industry Reference Panel:

+ Agriculture: National Farmers’ Federation
+ Energy markets: Australian Energy Market Commission
+ Forestry: Australian Forest Products Association
+ Infrastructure: Infrastructure Australia
+ Irrigated agriculture: Irrigation Australia Limited
+ Mining: Minerals Council of Australia
+ Renewable energy: Clean Energy Council
+ Research: National Climate Change Adaptation Research Facility; Australian National University
+ Urban water industry: Water Services Association of Australia.

Representatives from the environment sector and the energy generation and distribution sector were invited but declined to participate. Investors in water-using industry sectors were represented by the Investor Group on Climate Change at the project's stakeholder workshop.
### Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABARES</td>
<td>Australian Bureau of Agricultural and Resource Economics and Sciences</td>
</tr>
<tr>
<td>AEMO</td>
<td>Australian Electricity Market Operator</td>
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<tr>
<td>CCGT</td>
<td>closed cycle gas turbine</td>
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<tr>
<td>CCS</td>
<td>carbon capture and storage</td>
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<tr>
<td>CEF</td>
<td>Clean Energy Future package</td>
</tr>
<tr>
<td>CEWH</td>
<td>Commonwealth Environmental Water Holder</td>
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<tr>
<td>CFI</td>
<td>Carbon Farming Initiative</td>
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<tr>
<td>CO₂-e</td>
<td>carbon dioxide equivalent</td>
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<tr>
<td>CSG</td>
<td>coal seam gas</td>
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<tr>
<td>DCCEE</td>
<td>Department of Climate Change and Energy Efficiency</td>
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<tr>
<td>EGS</td>
<td>engineered geothermal system</td>
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<td>GL</td>
<td>gigalitres</td>
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<tr>
<td>GWh</td>
<td>gigawatt hours</td>
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<tr>
<td>ha</td>
<td>hectares</td>
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<tr>
<td>kt</td>
<td>kilotonnes</td>
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<tr>
<td>LRET</td>
<td>Large-scale Renewable Energy Target</td>
</tr>
<tr>
<td>MDB</td>
<td>Murray–Darling Basin</td>
</tr>
<tr>
<td>MDBA</td>
<td>Murray–Darling Basin Authority</td>
</tr>
<tr>
<td>ML</td>
<td>megalitres</td>
</tr>
<tr>
<td>MWh</td>
<td>megawatt hours</td>
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<tr>
<td>NWC</td>
<td>National Water Commission</td>
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<td>NWI</td>
<td>National Water Initiative</td>
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<tr>
<td>OCGT</td>
<td>open cycle gas turbine</td>
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<tr>
<td>PJ</td>
<td>petajoules</td>
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<tr>
<td>t CO₂-e</td>
<td>tonnes carbon dioxide equivalent</td>
</tr>
<tr>
<td>TWh</td>
<td>terawatt hours</td>
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<tr>
<td>WSAA</td>
<td>Water Services Association of Australia</td>
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<tr>
<td>WSP</td>
<td>water service provider</td>
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