Managing extreme water shortage in Victoria

Lessons from the Millennium Drought

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Executive summary

Australia is renowned for its highly variable climate and this is demonstrated in the rainfall records for Australia that go back more than 100 years. Water resource planning and infrastructure in Victoria has been developed in response to this climate variability, including severe droughts (for example, 1967/68 and 1982/83). Victoria's capability to manage severe drought is in part based on its water entitlement and planning frameworks.

Between 1997 and 2009, Victoria experienced unprecedented dry conditions – a period now known as the Millennium Drought. These 13 consecutive years of drought, including the lowest annual inflows to storages recorded (2006/07), resulted in conditions well outside the boundaries in which the water supply systems and water sharing rules across Victoria were designed to operate. By the 2006/07 summer, many areas faced severe water shortages. These shortages were more extreme than envisaged possible when water entitlements were developed, and the effectiveness of Victoria's water management frameworks was tested.

The experience of managing water resources for all competing uses during the Millennium Drought was influenced by the complex interaction of:

- climatic conditions (that is, patterns and reliability of rainfall across the Victoria)
- physical water systems (nature of supply infrastructure and natural waterways)
- water sharing arrangements (secure water entitlements and trade)
- water planning arrangements (preparedness in the short and long term)
- demand for water for different purposes (domestic use including gardens, rural consumption including irrigation and stock, environmental water).

This report documents the challenges faced by water managers during the Millennium Drought, in particular water managers responsible for managing bulk water supply systems across Victoria. The report covers 1997 to 2015, but focuses on 2006 to 2009 when the drought hit hardest.

Despite water managers' efforts to adapt to the unprecedented conditions, water carting was required to maintain essential water supplies for several towns and rural supply systems, major infrastructure projects were brought forward, irrigation allocations were the lowest on record and the Minister for Water was required to declare water shortages and temporarily qualify rights to water because existing water sharing arrangements had failed. In many rivers across Victoria, the environment was disproportionately impacted compared to consumptive users. This occurred because most of the environmental flows were sourced from unregulated flows or spills from storage, which ceased during the drought, rather than secure entitlements that received a share of the limited water available.

The unprecedented nature of the Millennium Drought, particularly its length and severity, motivated and accelerated several responses to water scarcity, from major policy and planning initiatives (for example, sustainable water strategies) to infrastructure upgrades (for example, the Wimmera-Mallee Pipeline Project and Goulburn-Murray Water Connections Project), augmentations (for example, the Goldfields Superpipe), and improved system management. It should also be noted that a major water reform was implemented across northern Victoria in July 2007 and southern Victoria in July 2008: the unbundling of water rights from land to create water shares. This reform was unrelated to the drought, but made the water market more accessible to individuals and water corporations during its last few years.

Significant hardship was endured during the Millennium Drought, but several positive outcomes were achieved that will enable Victorian water managers to better manage water resources into the future including:

- amendments to entitlements to incorporate sharing arrangements for dry conditions
- clearer entitlements for the environment and more efficient use of environmental water
- reserve rules that reduce the likelihood of years with zero allocation (in large regulated systems)
- improved flexibility and options through measures such as trade and carryover
- streamlining of water trading options to enable water to move from low to high value uses
- creation of new and alternative sources
- a modernised and reconfigured irrigation system.

The Millennium Drought has highlighted that planning and system design cannot be based on the assumption that climate is a stationary phenomenon. While unplanned measures were necessary to respond to the unprecedented conditions, the experience of managing through the Millennium Drought has served to reinforce the relevance of Victoria's water entitlement and planning frameworks and principles.

The uncertainty surrounding future conditions means that planning needs to be based on a wide range of plausible future climate scenarios. Guidelines for urban water supply demand strategies, developed following the drought, emphasise scenario planning and adaptive management to ensure urban water supply security in the medium to long term (DSE, 2011).

This report documents the experiences of, and highlights the lessons learned by water managers across Victoria about planning and management during the Millennium Drought to assist future drought management. It provides a valuable insight into how the Victorian water entitlement and water planning frameworks, and water management arrangements more generally, have been made more robust to perform better during drought.

Victoria's water entitlement and planning frameworks (see Chapter 1)

Victoria's water entitlement and planning frameworks form the basis for how water resources are managed in Victoria. In addition to the physical nature of water systems, these frameworks influence how a water shortage is experienced in a region. Chapter 1 provides an overview of these frameworks to understand the experience of water resource managers during the Millennium Drought.

The Victorian Water Entitlement Framework provides the legal basis for how water is shared. The key elements of the framework are:

- secure entitlements – with legal tenure that is certain and protected, including bulk entitlements, environmental entitlements, water shares, licences, section 8 rights or contractual agreements to supply
- limits on water entitlements – that is, specified volumes, extraction rates and locations, diversion rules and sharing arrangements
- water allocation rules
- clear consultative processes before entitlements are changed
- ability to trade – using markets to facilitate efficient allocation of resources, giving water users the flexibility to buy and sell water.

One of the key principles of the water entitlement framework is that individual entitlement holders are responsible for managing the risks of water scarcity within their own contexts and systems.

To support and guide management of water allocated under the entitlement framework, Victoria's water planning framework comprises:

- year-to-year or short-term planning through measures such as seasonal resource determinations on rural regulated systems or drought response plans and water security outlooks in urban systems
- local planning to balance the demand of water and available supply in urban areas
- local planning to maintain and improve the health of rivers and wetlands through the development of regional river health strategies every five years
- strategic planning through the development of regional sustainable water strategies every 7 to 10 years
- long-term water resource assessments of the resource base and river health every 15 years.

Victoria's water resources 1996–2010 (see Chapter 2)

Chapter 2 presents data on the reduction in water resources available during the Millennium Drought and provides analysis and discussion, including the following key results:

- average annual rainfall from 1997 to 2009 was 13 per cent below the long-term average
- the biggest seasonal reduction in rainfall, 27 per cent below average, occurred during autumn
- drier autumns and lack of any high rainfall years or months resulted in much larger impact on run-off than expected due to the reduction in rainfall alone

- inflows to major water storages were the lowest on record in 2006/07
- Victoria's major water storages held only 26 per cent of long-term average volume by 2007.

Managing Victoria's large regulated systems (see Chapter 3)

Regulated systems were designed (through dams, weirs and other flow-regulating structures) to transform the natural variability of streamflows into a reliable supply of water for towns and irrigation. Chapter 3 describes the impact of the drought on Victoria's large regulated systems and documents the various measures taken in response.

By 2007, after the lowest recorded inflows, many of the regulated systems could no longer be operated as designed or as the entitlement rules described. Even with contingency measures in place, not enough water was available to operate all or part of many regulated systems. Between 2007 and 2010, all northern Victorian regulated systems opened the season with zero allocations.

In systems such as the northern Victorian regulated systems and the Wimmera-Mallee supply system, domestic and stock customers faced particular difficulties accessing water when there was not enough to run the delivery system. In some cases, water carting was the only option available to provide water for essential needs.

Operating the regulated systems was a complex task during these water shortages. Water corporations were expected to operate the system in an environment outside all previous planning horizons, while trying to:

- deliver essential water needs
- minimise the amount of water needed to operate the system in order to maximise allocations to users
- help users plan ahead for their water use to minimise their economic costs
- provide certainty to water entitlement holders
- operate the system fairly for all entitlement holders.

The extreme water shortages enabled Victoria's water managers to demonstrate their resourcefulness in making the small amount of water available go further and ensuring it went to those who needed it most.

In the northern Victorian irrigation systems, the Government introduced mechanisms such as carryover in 2006/07 to provide irrigators with extra flexibility in managing their water entitlements. During the drought, new reserve rules were developed to reduce the risk of starting a new season with zero allocation. Even under severe drought, once enough water was available to make a small seasonal allocation, the water markets in northern Victoria enabled individuals to adjust their allocations via trade, ensuring water could go to its highest value uses. Water markets in southern Victoria, while much smaller than in the north, were also active and enabled entitlement holders to adjust their allocations.

Some communities affected by the dry conditions benefited from major water infrastructure projects such as the Wimmera-Mallee Pipeline Project and the Shepparton Irrigation Area Modernisation Project. Progress on these projects eased the impact of the dry conditions on local communities.

With less water available for the environment during the dry years, innovative approaches were employed to use the water available for maximum ecological benefits. These included structural works to deliver environmental water more efficiently, making use of consumptive water en route to other destinations and changing the seasonal priority of environmental water needs and the delivery pattern of passing flows to achieve maximum environmental benefit.

Many modifications made to long-standing approaches during the Millennium Drought were found to provide extra flexibility for water managers and were incorporated into normal system operations where possible to help adapt towards a possible drier future.

Securing urban water supplies (see Chapter 4)

The challenges to urban water corporations varied, depending on the nature of their supply system. Only a handful of Victorian urban systems did not feel the effects of the prolonged dry spell between 1997 and 2009. Chapter 4 describes how the urban systems that were affected coped during the drought.

Many urban water corporations' first response was to reduce demand for water by imposing restrictions on residential customers and working with large industrial customers to reduce demand. By July 2007, some 457 Victorian towns were subject to restrictions. In some cases, water was carted to towns on Stage 4 restrictions to meet essential needs when no other feasible supply options were available.

In many cases, the unprecedented conditions resulted in situations where compliance with bulk entitlement obligations for urban supply would result in system failure. Where the rules in the entitlements prevented the supply of essential needs or supply priorities needed to altered, a temporarily qualification of rights to water was necessary (see Chapter 6).

Urban water corporations found that the duration and magnitude of the drought was worse than anything they had planned for in their water supply-demand strategies or drought response plans. As the dry conditions intensified, the water corporations found the water they were entitled to take under their bulk entitlements was insufficient to ensure supply to meet critical human needs of their urban communities. Furthermore, contingencies were not designed to cope with the speed at which conditions worsened and the longevity of the water shortage.

An increased interest in alternative water sources such as recycled water, desalination, stormwater and managed aquifer recharge has prompted consideration of how these sources will be allocated and accounted for within the water entitlement framework.

The lessons learned from the experience of managing through the extended drought were included in water corporations' planning processes and in their bulk entitlements through actions initiated under the regional sustainable water strategy process.

Small rural water supply systems (see Chapter 5)

Due to the lack of flow regulation on unregulated systems, water users have very little control over the amount of water available. Therefore, fewer options were available on unregulated systems for entitlement holders to manage their supplies during the Millennium Drought, as discussed in Chapter 5.

Individuals who take water from unregulated streams for irrigation, commercial and domestic and stock use are responsible for their own supply infrastructure. They do not have the benefit of large storages and interconnections with other systems to help secure their water supplies.

During the drought as the flow diminished in streams across Victoria, wherever possible licensing authorities employed progressive stages of restrictions on diversions for irrigation and commercial use. Bans were imposed in many streams to ensure enough flow remained to supply critical needs for domestic and stock and the environment.

From 2006/07 to 2009/10, licensed diverters around Victoria experienced restrictions and bans intermittently throughout each year, with some streams remaining on bans throughout the year, and for consecutive years.

Domestic and stock users across Victoria experienced significant water shortages and many users who access water under section 8 rights had to resort to carting water to maintain supplies. Carting water is an expensive and time-consuming task and as a result extensive de-stocking of land occurred during the drought where it was not financially viable to cart water for significant periods.

The drought encouraged a significant increase in groundwater extractions across Victoria as people looked for other sources of supply. Demand for construction of new groundwater bores increased sharply. Many of the 16,000 new bore construction applications received between 2006 and 2009 were for domestic and stock use in rural areas. Also, many private bores were constructed in greater Melbourne to enable residents to water their gardens while normal supply was restricted.

The Government enlarged the network of emergency water supply from 170 to about 300 points across Victoria. Landholders faced with dams that were almost empty or unable to pump from streams or access groundwater, could cart water from these emergency supply points.

Passing flows make up most environmental water in the unregulated systems, which generally stem from obligations on other users. In some unregulated systems, the passing flow rules were temporarily

qualified to alleviate stress on towns and private diverters by allowing them to divert some water when the streams were running lower than the historical passing flow requirements.

The lessons learned from managing surface and groundwater through this period will be included in improved management practices in the future. A number of improvements have already been discussed and developed with the community through the sustainable water strategy process that took place across Victoria.

Qualification of rights (see Chapter 6)

Victoria's water management arrangements put the responsibility on water entitlement holders to manage through droughts. However, in exceptional circumstances when water-sharing arrangements are no longer adequate to meet entitlement holders' basic needs, the Minister for Water can intervene to declare a water shortage and qualify rights temporarily, as detailed in Chapter 6.

Before 2006, only a handful of qualifications had been approved under the *Water Act 1989* and no clear process has been set up for doing so. In response to demands for qualifications during the Millennium Drought, the then Department of Sustainability and Environment prepared guidelines for water corporations and agencies for requesting a qualification of rights in 2008. The guidelines define when a qualification is appropriate, the priority of supply to different user groups under the qualification, and assign responsibility for reporting on the effectiveness of the qualification and paying the costs of monitoring and managing the impact of the qualification on third parties.

In many cases, rights were qualified during the drought as a stop-gap measure to ensure water corporations could continue to supply their customers' critical needs until longer-term measures to secure supplies were in place.

Towns such as Bendigo and Ballarat relied on qualifications to meet their demand even though Stage 4 water restrictions were in place. The additional water provided by the qualification was critical in supplementing supplies during the time it took to bring other contingency measures on line.

In rural areas, such as the Broken River system, qualification of rights enabled domestic and stock customers to access water for their livestock. Rights were qualified in ways that provided waterway managers with more flexibility to help reduce the impact of the drought on river health.

The preparation of all proposals to qualify rights involved consultation with major stakeholders to ensure the qualification minimised impacts on other water users and the environment. The impacts on other water users and the environment were identified and assessed and all parties were aware of their financial, monitoring and reporting responsibilities. Decisions to qualify rights were supported by scientific advice on the environmental risks involved.

The experience gained in preparing qualifications of rights across Victoria in a variety of situations allowed the qualification process to be improved. Successive qualifications take advantage of better knowledge of operating systems and managing environmental impacts under extreme dry conditions.

The lessons learned from managing through the extended drought have led to improvements in drought planning, augmenting of water systems so they can withstand long dry spells, and amendment of bulk entitlements to enable greater flexibility for water corporations and environmental managers. These lessons will help reduce the need for qualification of rights in the future.

Beyond 2010 (see Chapter 7)

The Millennium Drought of 1997 to 2009 was the most severe drought experienced in Victoria since European settlement. It brought home to water managers that the climate is not a stationary entity on which planning and system design can be based.

The drought broke in 2010, the fifth wettest year on record and resulted in severe flooding in the summer of 2010/11. Storage levels recovered although some storages in the south west did not fill. Four years of relatively stable conditions followed. However, inflows into systems in 2015/16 have again been very low and the outlook for 2016/17 is uncertain.

Victoria's water sector is well placed to manage future water shortages because of the reforms to Victoria's water entitlement regime, water supply systems and water resource planning processes that occurred. These improvements include:

- advances in our understanding of Victoria's climate variability and water availability that can be incorporated into water resource planning

- improvements in the specification of water entitlement, water markets and water conservation measures
- investment in water supply systems to modernise irrigation infrastructure to reduce losses, expand the grid to connect towns, and augment supplies by desalination, groundwater and increasing storage capacity.
- improving all aspects of the management of environmental values including increased environmental water entitlements and the establishment of an independent Victorian Environmental Water Holder.

These improvements put Victoria in a good position to face the dry conditions which started to re-emerge in 2015. However, the uncertainty surrounding future conditions means that the water planning and entitlements framework must continue to evolve to meet the water needs of the future.

Heart Morass dry 2006 *Photo: © WGCMA*

1. Victorian water entitlement and planning frameworks

Victoria's capability to deal with a range of conditions, including severe drought, is built on providing certainty and flexibility in how water is shared and managed through its water entitlement and planning frameworks. These principles have guided Victorian water management reform over the past 35 years, and their relevance were reinforced during Victoria's driest 13 years, the Millennium Drought.

The water entitlement and planning frameworks form the basis of water management in Victoria. These frameworks, along with physical water supply systems and infrastructure, are designed to ensure an acceptably reliable water supply that supports a range of uses, despite Victoria's variable rainfall. This chapter provides background to the water entitlement and planning frameworks and the tools that water managers utilise.

1.1 Supply sources and systems

Various types of water supply systems and water sources are managed under Victoria's water entitlement and planning frameworks. The specific planning mechanisms and entitlements used in a system are based on whether it is a surface water or groundwater resource, whether it is regulated or unregulated, and what the water is to be used for (irrigation, urban, environmental, commercial or rural domestic use). The design and operation of these systems and infrastructure, and the entitlements associated with them, were largely based on historical rainfall and streamflow records.

Broadly, surface water systems can be separated into regulated and unregulated systems. In regulated systems, river flows are regulated through the operation of large dams or weirs to supply water to entitlement holders. Examples in Victoria include the Murray, Goulburn and Campaspe systems, which supply irrigation, industry, rural domestic needs and urban centres.

Unregulated systems are waterways that do not have large dams or weirs regulating and capturing the water flow. Water from these systems may be supplied by pumps or other diversions to off-stream storages or directly supply a household or town storage tank. These systems remain unregulated because the flow is historically very reliable, variability is relatively low, and demand is not a significant proportion of the water available.

Groundwater systems are water reserves located beneath the earth's surface in pores and crevices of rocks and soil, known as aquifers. These areas vary in size and volume throughout Victoria and support all types of water use.

1.2 Victoria's Water Entitlement Framework

The Victorian Water Entitlement Framework is summarised in Figure 1.1. The establishment of this framework in the *Water Act 1989 (*the Act) was one of the major reforms in Victoria's water management history. The framework defines the right of individuals, companies, government and water corporations to take and use water in a system.

The framework establishes:

- **Secure entitlements** – these entitlements are equivalent to property rights, with legal tenure that is certain and protected, and known arrangements for sharing available water during dry and drought years. Secure entitlements are recognised in the Act, and considered as any of the following: bulk entitlements, environmental entitlements, water shares, licences or an agreement to supply.
- **Limits on water entitlements** – to protect the reliability of entitlements, most entitlements specify a limit on the volume issued.
- **Annual processes to allocate water to entitlements** – the framework provides the ability to restrict annual water use in response to seasonal variability. Annual use can be restricted through seasonal allocations (generally expressed as a percentage of entitlement volume), urban water restrictions or rosters, restrictions or bans on unregulated river or groundwater systems.
- **Clear consultative processes before entitlements are changed** – the Act sets out clear processes to be followed before an entitlement can be changed in order to protect the integrity of entitlements.
- **Ability to trade** – markets can be used to facilitate efficient use of water resources, giving water users the flexibility to buy and sell their water entitlements (or allocation).

The types of entitlements that exist in each water system depend on the type of system and the intended use of water. For example, each regulated system has one or more source bulk entitlements, which define the total amount that can be harvested in the system for supply to all entitlements in that system. This water is then distributed to all entitlements in the system (referred to as primary entitlements) in accordance with the allocation rules of the source bulk entitlement and the share or rules specified in each primary entitlement.

In unregulated systems, water is diverted in accordance with conditions set out in bulk entitlements, environmental entitlements and licences. These conditions often include sharing rules that control the daily volume, rate and timing available for each water user based on streamflow conditions.

Water taken from groundwater systems is usually allocated under a groundwater licence; however, it may also be allocated under a bulk entitlement for urban supply. Groundwater may be taken for domestic and stock use without a licence; however, a works licence is required to construct a bore irrespective of use.

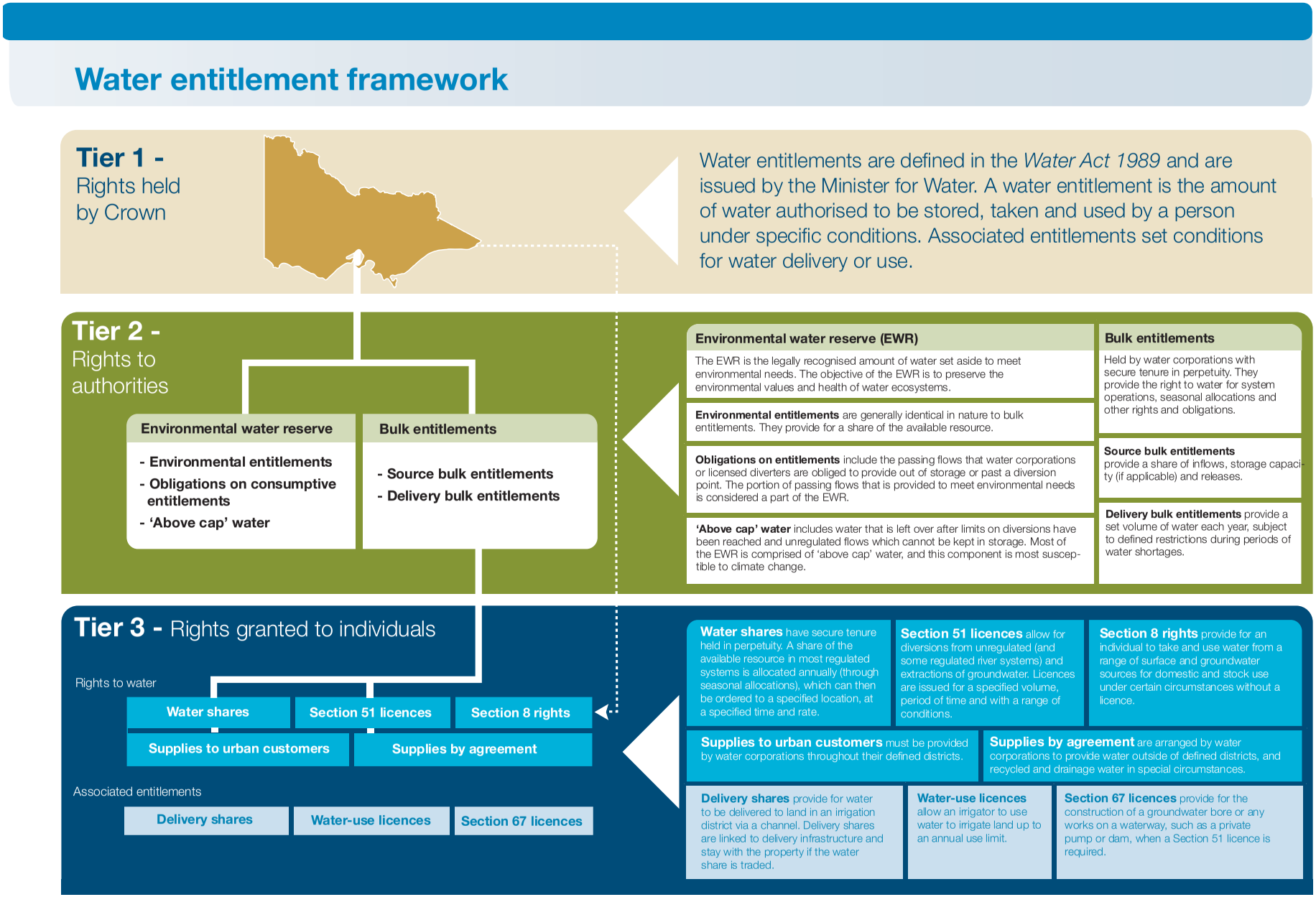
Table 1.1 lists the types of entitlement that exist in regulated and unregulated systems and includes water for urban systems as entitlements held by urban water corporations.

Most water resources in Victoria are managed under bulk water entitlements, so the following section looks at the background and development of Victoria's bulk water allocation instruments – bulk entitlements and the environmental water reserve (environmental entitlements).

Table 1.1 Types of entitlements in regulated and unregulated systems

Entitlement	Regulated system					Unregulated system			
	Rural water corporation	Urban water corporation	Environment	Irrigator and individuals	Power generating companies	Rural water corporation	Urban water corporation	Environment	Irrigators and individuals
Bulk entitlement	✓	✓	✓		✓	✓	✓	✓	
Environmental entitlement			✓					✓	
Water share	✓	✓	✓	✓					
Licence (section 51)				✓	✓	✓	✓		✓
Section 8 right				✓					✓
Supply by agreement		✓	✓	✓	✓				✓

Figure 1.1 Victorian Water Entitlement Framework (DSE, 2009)



Bulk entitlements

The first bulk entitlements were created in 1995 and clarified water management responsibilities. The entitlements directly placed the responsibility for managing water supply and demand on water corporations under all water resource conditions, and described sharing arrangements for access to a water resource.

Before this, rights to water were defined vaguely – in terms of a permit to build works to take water without reference to the amount of water that could be taken. Sometimes rights were expressed as an amount of water that could be taken, but with no reference to timing and rate of take. Often, the location the water could be taken from was not defined. The rights were not expressed in an explicit, exclusive or enforceable way, so it was not possible to establish trade. In some catchments, insufficient water was available in dry years to supply all of the rights issued. These imprecise water rights made it difficult to manage water resources equitably, especially in dry years.

Following the commencement of the Act in 1990, Victoria began to convert poorly defined rights of water corporations into better defined rights represented by bulk entitlements. The principles applied during the bulk entitlement conversion process were (DCNR, 1995):

- bulk entitlements will generally be held by water corporations with a 'retail' function
- existing legal rights will be converted
- the process of conversion will not result in new commitments
- the sum of bulk entitlements in a system will not exceed 100 per cent of the available resource at an agreed level of security
- the conversion should be fair to all claimants on the water resource and give due consideration to the environment
- a pragmatic approach will be taken to specify bulk entitlements that balance the need for complex specifications against the available time to complete the project
- an open and participatory conversion process will be used.

The bulk entitlements explicitly conferred the responsibility for managing water supply and demand on water corporations. Previously this responsibility was unclear and while water corporations generally undertook this task during good times, some wanted to hand it on to central agencies (for example, State Rivers and Water Supply and government) during droughts. With the introduction of bulk water entitlements, water corporations were required to 'accept all of the risk associated with managing within their entitlement (their share of the resource)' (DCNR, 1995: page 2). A key principle underpinning the development of bulk entitlements was that water corporations are best placed to identify and manage the risks of water scarcity within their own unique contexts and systems.

The conversion of the old rights into bulk entitlements was supported by substantial water resource modelling. Water supply system models (REALM) were developed for each large regulated water supply system to determine the amount and reliability (security) of water supplied under the old rights, and to ensure that the explicit water-sharing rules in the new bulk entitlements provided an accurate and fair conversion of the old rights. The models were based on:

- the existing infrastructure
- current operating rules and allocation policies
- the urban and rural demands assuming the 1990/91 level of development.

The models were run for the longest period possible (ranging from 30 to 100 years) depending on what historic climate and streamflow data was available. The long period of record was used to fully capture historic climatic variability including severe droughts, such as the World War II drought (1937–1945) or the drought of 1967/68. The flow-sharing rules in the bulk entitlements were specified in a way that would be applicable in a repeat of the most severe historic drought in the modelling period.

A key and reasonable assumption when developing bulk entitlements was that the climate and streamflows in the future would be similar to the past 100 years. Therefore the water-sharing rules were designed to cope with the most severe droughts experienced in the 20th century. Drought response plans for urban water corporations (see sections 1.3 and 4.3), seasonal allocations for large regulated systems (see sections 1.3 and 3.2) and restrictions on diversions in unregulated systems were expected to manage water shortages in the short term.

While arrangements for managing droughts more severe than those in the historic record were not explicitly included in the bulk entitlements, they were included in provisions of the Act. The Act allows the Minister for Water, in the event of a water shortage, to temporarily suspend the water-sharing rules (see Chapter 6).

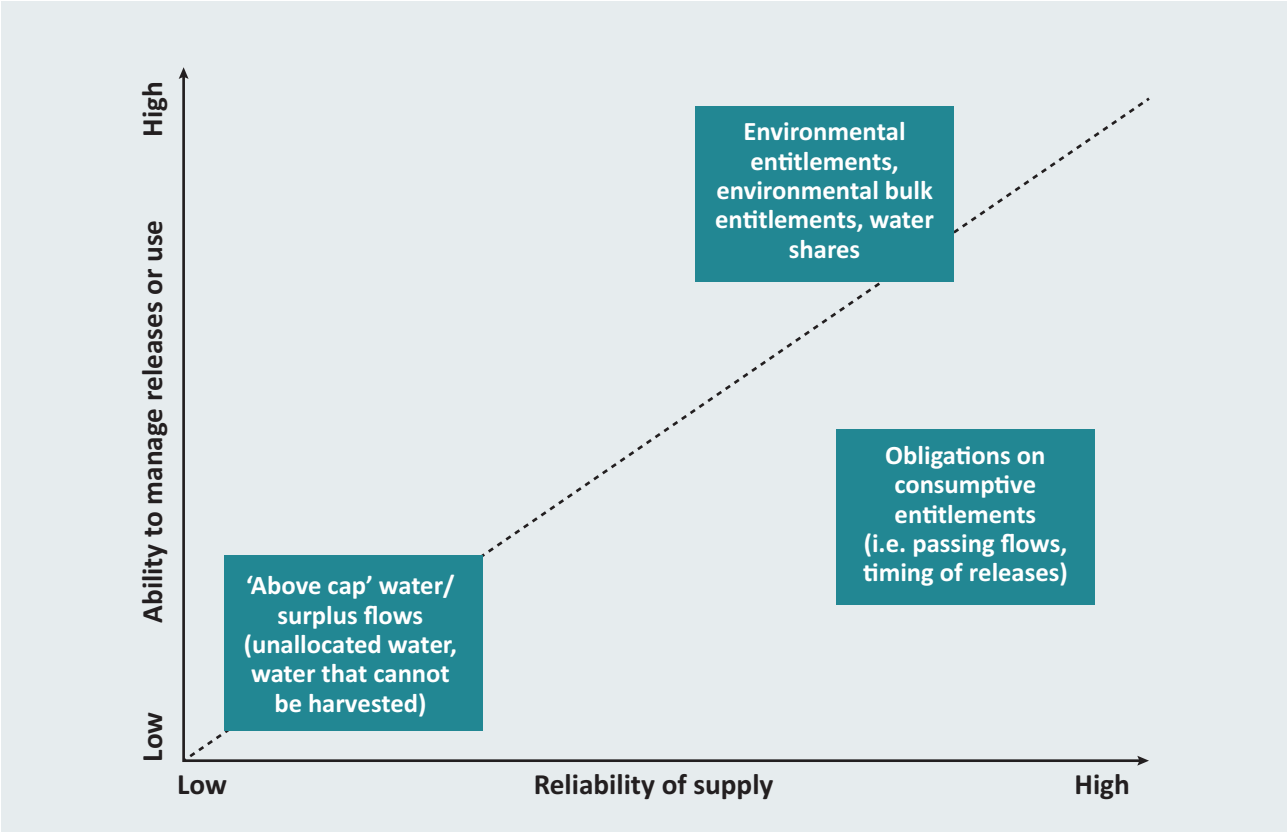
When most of the bulk entitlements were written (1990s), climate change was not widely recognised as a risk to the future reliability of water entitlements.

Environmental entitlements and the environmental water reserve (EWR)

One of the key priorities for establishing the Victorian Water Entitlement Framework in the Act was to clearly distinguish between water available to consumptive users and the environment. For the first time, the new system of entitlements enabled the creation of specific entitlements for environmental purposes.

At the time, there was little active management of water environments in most regions of Victoria and the environment generally received the water left in a system after all other water entitlements were supplied. It was recognised that the creation of entitlements for the environment would be an evolutionary process, shifting from more passive arrangements in consumptive entitlements (such as passing flows below a storage), to the creation of more sophisticated and secure environmental entitlements once more information about the priorities for active environmental water management became available (DCE, 1992). The first of these more sophisticated entitlements was created in 1999 as an environmental bulk entitlement in the River Murray system, called the *Bulk Entitlement (River Murray – Flora & Fauna) Conversion Order 1999.*

Figure 1.2 EWR – management flexibility and certainty of supply



Notes

1. Surplus flow is water in excess of the harvesting capacity of the weirs and reservoirs that spills from full storages, and greatly reduces or disappears in droughts.
2. Operational conditions include obligations such as passing flow conditions in a bulk entitlement. The bulk entitlement holder must allow a minimum flow to pass a weir, pump or storage before harvesting water from a waterway. There is little scope to manage passing flows to optimise ecological benefits because there is usually no ability (or obligation) to vary the volume and timing of passing flow. However, passing flows are less vulnerable to climate variability because they must be provided before consumptive water may be harvested.

In 2005, the Act was amended to improve distinction between consumptive entitlements and water for the environment. This amendment formally established the environmental water reserve (EWR), and created a new provision for allocating environmental entitlements (separate to bulk entitlements), with defined requirements and procedures for specifying and authorising water rights to the environment.

The EWR comprises water set aside for the environment within environmental entitlements, environmental bulk entitlements, operational conditions in consumptive bulk entitlements, and section 51 licences. The objective is to maintain the EWR to preserve the environmental values and health of water ecosystems and other uses that depend on the environmental condition of rivers.

The evolutionary process of environmental entitlements established through the initial reforms continues through the management of the EWR. Much of the water under the EWR cannot be actively managed by an environmental water manager, because it depends on operational conditions in other authorities' consumptive entitlements or is the unallocated surplus flow in a waterway (water not held under a licence, bulk entitlement or environmental entitlement). This water is sometimes known as 'above cap' water. Figure 1.2 shows the elements of the EWR and the progressive degree of management flexibility associated with each element.

Water allocated to the environment under environmental entitlements, environmental bulk entitlement or water shares is the most secure form of environmental water and can be actively and flexibly managed for the benefit of waterway health.

Since 1999 there has been a significant increase in the volume of environmental water available to be actively managed, as a result of the creation of new environmental entitlements and the environmental water purchase program.

1.3 Victoria's Water Planning Framework

To guide the management of water allocated under the entitlement framework in a range of water availability scenarios, Victoria's water planning framework incorporates:

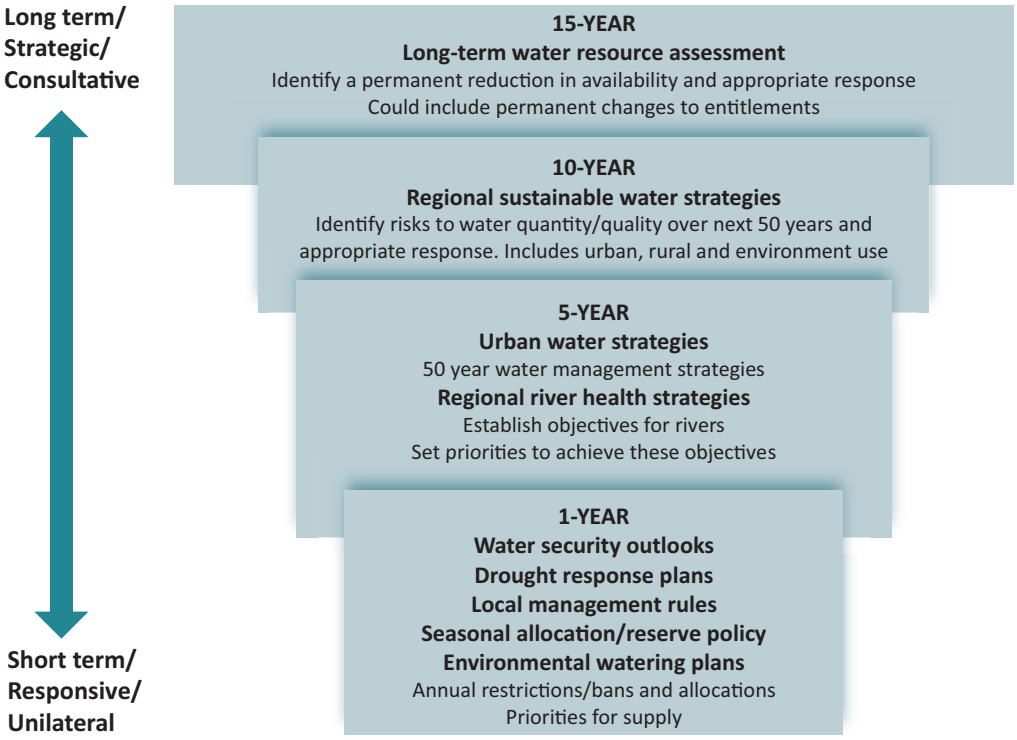
- year-to-year or short-term planning through measures such as seasonal resource determinations on rural regulated systems, and drought response plans and water security outlooks in urban systems
- local planning to balance the demand of water and available supply in our urban areas
- local planning to maintain and improve the health of rivers and wetlands through the development of regional river health strategies every five years
- strategic planning through the development of regional sustainable water strategies every 7 to 10 years
- long-term assessments of the resource base and river health every 15 years (adapted from DSE, 2011).

Responsibility for implementing various elements of the planning framework lies with water corporations or government, depending on the function of the planning process. Several elements of the planning framework were legislated in the mid-2000s, and so were incomplete when the worst conditions of the Millennium Drought hit, or did not consider conditions worse than those experienced in the past.

Urban water supply planning

In the urban supply context, water corporations are responsible for managing water resources within the conditions on their bulk entitlements, and maintaining reliable water supply services for customers. Planning tools guide actions in response to immediate or short-term events such as drought, or medium to long term water resource management requirement.

Figure 1.3 The Victorian Water Planning Framework



Short-term planning involves the preparation of drought response plans (DRPs) and emergency management plans (EMPs) and water security outlooks (WSOs). These are required in Statements of Obligations issued to urban water corporations by the Minister for Water under the *Water Industry Act 1994*.[1]

EMPs provide guidance in response to sudden and severe water shortages due to emergencies such as bushfire or terrorism.

DRPs document the contingency measures the water corporation will implement to secure urban supply during times of water scarcity. This may include the implementation of water restrictions, including a decision making framework for how and when restrictions are to be applied. As well as demand reduction measures (restrictions), DRPs may outline other contingency measures to further reduce demand or augment supplies. Before the unprecedented dry period between 2006 and 2009, many DRPs treated drought as a relatively short-term event, often based on experience of historic events, such as 1967/68. All water corporations updated the DRPs in 2011/12 to incorporate the learnings of the Millennium Drought.

WSOs are required to be published online and submitted to the Department of Environment, Land, Water and Planning (DELWP) by 1 December each year. The objective of the WSO is to provide stakeholders and the community with an annual snapshot of the current total system storage levels, recent trends in water use, a future outlook of storage positions under a range of stream flow scenarios, for each water supply system.

Based on the streamflow scenarios, water corporations are required to identify a range of short and medium term water supply measures such as:

- Using pre-existing drought reserves or alternative water sources (e.g. groundwater entitlements/ allocations)
- Purchasing water allocations on the water market
- Bringing forward augmentations previously identified.

1 **http://www.depi.vic.gov.au/water/governing-water-resources/water-corporations/water-corporations-statements-of-obligations**

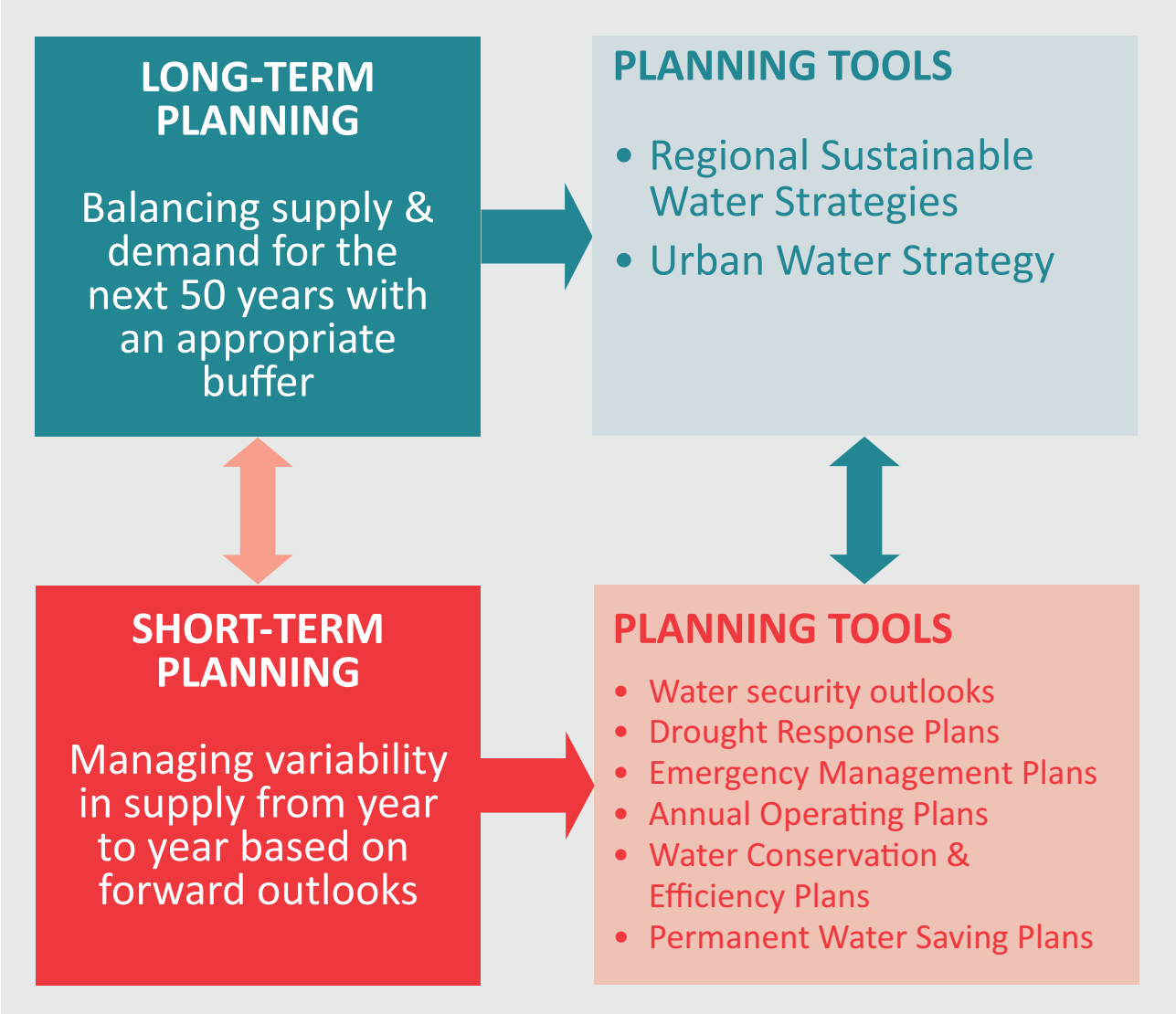
The WSO also identify demand management measures (e.g. water restrictions, water efficiency programs, community awareness measures) to maintain security of water supply in the 12 month period after 1 December each year.

Longer-term planning includes urban water strategies (UWS), or actions developed through regional sustainable water strategies.

UWSs identify the long-term supply augmentations and demand management measures that would be required to maintain an acceptable level of service (the frequency, severity and duration of water restrictions) and water supply security (ensuring the town does not run out of water) into the future, taking into account population growth and changes in demand. They forecast out to a horizon of 50 years but are updated every five years to retain relevance as a planning document.

All urban water corporations engage in extensive consultation in undertaking water supply and demand planning and drought response planning. In particular, in setting agreed levels of service with their customers, taking into account customers' ability and preparedness to pay for a greater level of water security. Further discussion of how the planning framework changed after the end of the Millennium Drought is found in Chapter 7.

Figure 1.4 Relationship between short and long-term urban supply planning



Rural water supply planning

Since the early 1990s, State and Federal water management policy has emphasised the responsibility of individuals to manage their farming practices in response to climate variability, especially drought, by recognising that those individuals are best placed to make decisions that affect their livelihoods.

On large regulated systems such as those in northern Victoria, the system operator manages most of the risk of bulk water availability and supply. However, individuals and urban water corporations must still manage within the constraints of the water available to them.

Variability of water availability from year to year is primarily managed by the size of the system storage, and through mechanisms to share available resources such as seasonal determinations and system operating rules (see Chapter 3). Regional sustainable water strategies guide management from a longer-term perspective, through the collaborative development of policies aimed at ensuring security and flexibility for stakeholders in the system.

This strategic planning focuses on ensuring stakeholders have tools available to make the most effective decisions about their water resources. Such tools include the opportunity to trade on temporary and permanent water markets, and the ability to carry over allocated water from one year to the next. Trade and carryover are water management options available to urban water corporations and environmental water managers in many large regulated supply systems across Victoria. Such options enable individuals to judge their own needs during the season, and act accordingly.

In most unregulated systems, the licensing authority (typically a rural water corporation) is responsible for restricting water taken under licences through rostering, restrictions or bans on extraction and typically in accordance with established triggers during low-flow periods. Rostering may not result in a restriction of the extraction volume permitted from a stream or bore, but may place a condition on the timing of taking water. Licence-holders may be restricted to taking a percentage of their entitlement, or banned from extraction during low streamflow periods.

In some unregulated systems, streamflow management plans (SMPs) are developed to ensure surface water in a catchment is managed in a coordinated way, providing for the stream's environmental needs as well as an agreed, reliable and equitable water distribution between users. SMPs are developed with the local community in areas where there is significant competition for use, where flows are under stress, or where there is demand for more development. Several SMPs have been developed for unregulated waterways managed by Melbourne Water[2].

Similar plans exist for some groundwater systems. Groundwater Management Plans (GMPs) describe the resource, management objectives and specific rules for measures such as restrictions during water shortages, trade and carryover (where applicable). GMPs aim to ensure that groundwater resources are managed equitably and sustainably, and must be developed and implemented for declared water supply protection areas (WSPAs). GMPs may result in the amendment of licence conditions and/ or permanent restrictions on extraction due to a risk to the groundwater resource. The process for developing GMPs is set out in section 32 of the Act. Non statutory management plans – local management plans (LMPs) have also been adopted by water corporations in many areas for which there is no statutory management plan. These LMPs set out how the water corporation intends to manage the nominated water resources in the area dealt with in the LMP.

Individuals accessing water under private rights (domestic and stock) are responsible for their own water supply, and are not subjected to restrictions or bans. The risk of reduced water availability is borne by individuals, and if streamflows cease, individuals are responsible for carting water to their properties.

Environmental water planning

State-wide environmental planning objectives are guided by regional river health strategies, which outline the long-term direction for the management, protection and improvement of Victoria's rivers, wetlands, floodplains and estuaries. The Victorian Waterway Management Strategy was released in 2013. This new long-term strategy incorporates many of the lessons learned

2 **http://www.melbournewater.com.au/whatwedo/protectrivers/Pages/protect-rivers-creeks.aspx**

in adaptive management of environmental assets through the driest period in Victoria's records, and includes new river health policy measures such as those developed through regional sustainable water strategies.

Environmental water managers, catchment management authorities and Melbourne Water develop regional river health strategies that establish objectives for river systems and set priorities to achieve these objectives for the next five years within their respective catchments. The objectives of the river health strategies are to:

- protect priority areas of the highest community values from any decline in condition
- maintain the condition of ecologically healthy rivers
- achieve overall improvement in the condition of remaining rivers
- prevent damage from future management activities.

These strategies are developed in consultation with the community and other government agencies, and are to be reviewed every five years. The most recent regional river health strategies were developed between 2010 and 2014. In many cases, priorities under these strategies had to be adapted to deal with the prevailing dry conditions.

In the short term, annual watering plans may be prepared by environmental water managers that detail the specific uses of water planned over the year. Watering plans developed during the drought aimed to protect key pockets of the environment to provide refuges and avoid critical losses of species and irreversible damage to the environment.

The establishment of the Victorian Environmental Water Holder in 2011 has also strengthened environmental water planning frameworks through more in-depth and integrated planning mechanisms. The Victorian Environmental Water Holder works with catchment management authorities and Melbourne Water to ensure environmental water entitlements are used to achieve the best environmental outcome with the water that is available. The Victorian Environmental Water Holder is responsible for prioritising environmental watering activities in an integrated way across Victoria.

Long-term water resource planning

Long-term water resource planning is typically coordinated by the Department of Environment, Land Water and Planning on behalf of the Government, and considers the needs of all water users and the environment through consultation with stakeholders and communities.

Sustainable water strategies are a collaborative and strategic planning mechanism required under the Act since 2005 for regions across Victoria. They guide the development, integration and implementation of management plans prepared by water corporations and catchment management authorities. The process and content of the strategies is guided by the legislation, with an emphasis on consultation and review. All of Victoria's sustainable water strategies were completed by the end of 2011. The sustainable water strategies were developed over the driest period in the historic record, and so have provided a valuable mechanism for exploring options to improve water management flexibility under dry conditions, particularly in light of climate change projections.

In 2005, the Act was also amended to include a state-wide program of long-term water resource assessments. This requires the Minister for Water to undertake an assessment every 15 years to determine whether there has been a decline in the long-term availability of surface water or groundwater in each system, and whether the impacts of the decline have fallen disproportionately on the environment or consumptive users. The Act requires the first review to commence by August 2018.

1.4 Emergency measures – qualification of rights

In emergency circumstances, where water resources are so scarce that water supply systems and the sharing arrangements and contingencies defined in the entitlement and planning frameworks are no longer meeting essential needs, the Minister for Water can intervene by declaring a water shortage and qualifying rights.

The qualification of rights can overrule some or all the water-sharing arrangements in a system and replace them with new temporary water-sharing rules to ensure that essential needs are met (see Chapter 6).

1.5 Summary

In Victoria's water entitlement framework, the Government has control over water in streams and aquifers and allocates water to individuals under a set of administrative rights under the Act. These rights describe how water is shared between individual entitlement holders and the environment. The environment's water is defined within this framework, although a proportion of its water occurs in system spills that cannot be actively managed and has a low reliability of occurrence, particularly in dry conditions.

Under the water entitlement framework, entitlement holders are responsible for managing their own water supplies, including the risks to these supplies due to drought or climate variability. Entitlements to water are transferable and transfers are facilitated through water markets wherever possible.

The entitlement framework is supported by an integrated and dynamic planning framework that spans the short, medium and long terms, and tools to actively manage consumptive and environmental water entitlements.

In exceptional circumstances such as unprecedented droughts, the Minister for Water may intervene to alter water-sharing arrangements to ensure that critical human needs can be supplied when there are no other practical alternatives.

The following chapters describe the experience of entitlement holders in managing within the constraints of supply systems, and their associated entitlements and planning mechanisms, during the Millennium Drought, particularly at the bulk water level.

Moora Reservoir, 2009 *Photo: © GWM Water*

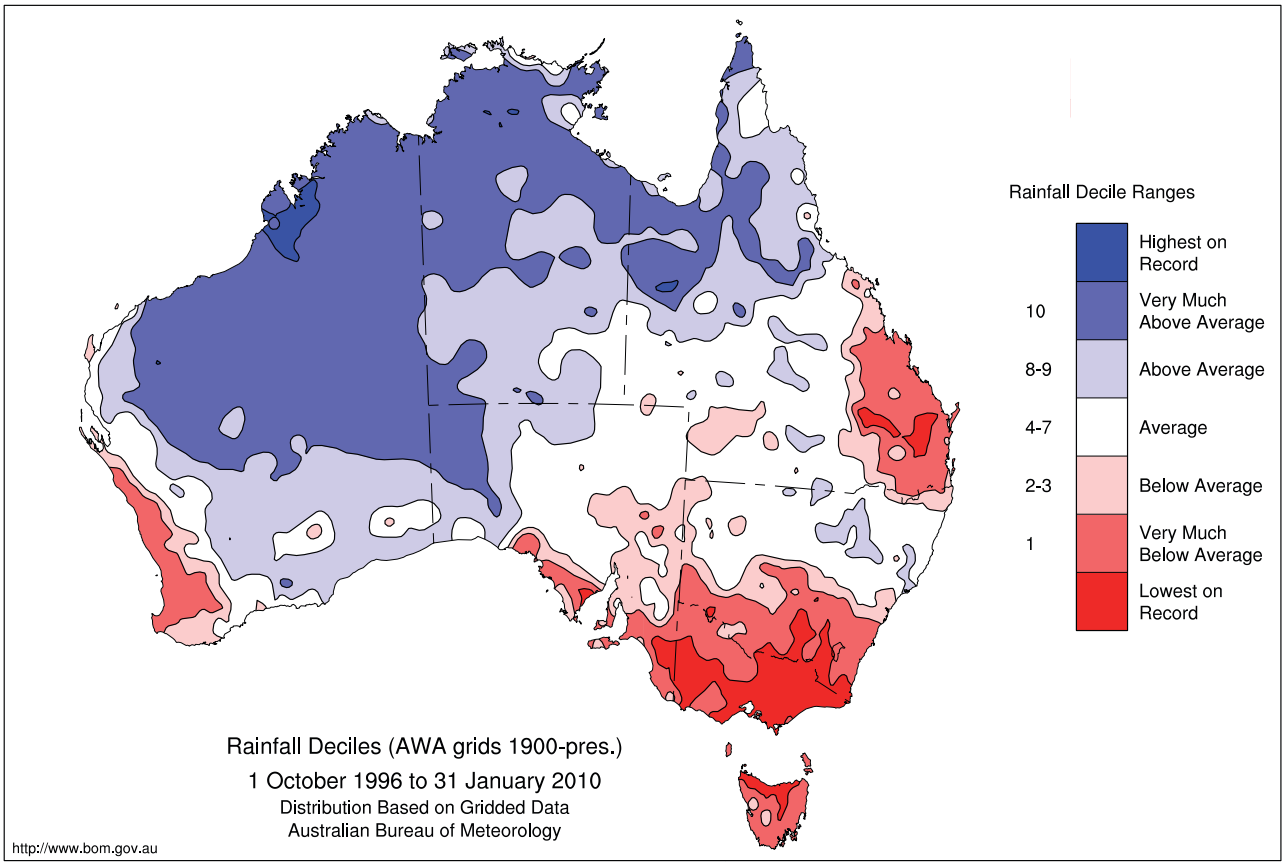
2. Victoria's water resources 1996–2010

Between late 1996 and early 2010, Victoria experienced unprecedented dry conditions that challenged fundamental assumptions underpinning drought and water resource management. This chapter provides an overview of the seasonal conditions water managers have faced during this period, and particularly 2006/07, which was the driest year on record across most of Victoria. The drought broke with major flooding in 2010/11, these weather conditions are discussed in detail in Chapter 7.

From 1 October 1996 to 31 January 2010 Victoria received rainfall which was either the lowest on record or very much below average, (see Figure 2.1) In terms of rainfall deficits, the Millennium Drought started in October 1996 although, for convenience, 1 January 1997 is generally taken as the starting date.

Between October 1996 and January 2010, more than 50 per cent of Victoria experienced the lowest 13 years and four months of rainfall on record. Rainfall for the rest of Victoria was in the very much below average category (rainfall decile 1 means that the observed totals fall in the lowest 10 per cent of historical totals for this length of time).

Figure 2.1 Australian rainfall deciles from 1 October 1996 to 31 January 2010



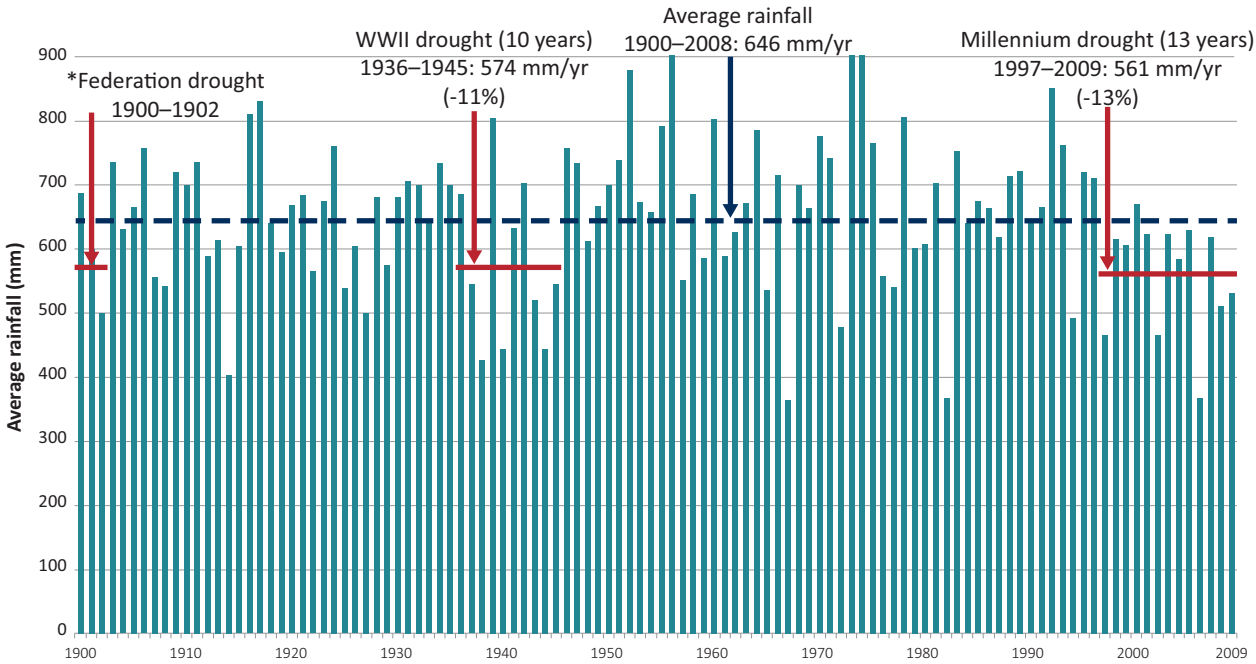
(Source: Bureau of Meteorology)

Victoria has experienced prolonged periods of below-average rainfall before (see Figure 2.2), notably in the early 1900s (the Federation Drought) and from the mid-1930s to mid-1940s (the World War II Drought). However, conditions during the Millennium Drought were more severe due to several factors.

Average annual rainfall from 1997 to 2009 was 13 per cent less than the long-term average for the full historical record from 1900. This is a slightly larger reduction than the 11 per cent reduction during the World War II drought (1936–1945). While the magnitude of the reduction in average annual rainfall over the 13 years was not very different to earlier droughts, the climate pattern was unusual in the historical context because of the length of the drought, the reduction in inter-annual rainfall variability and the shift in the seasonality of rainfall.

Expressed in this way, the reduction in annual rainfall is 15 per cent, with the biggest seasonal reductions occurring in autumn (27 per cent) and winter (14 per cent). Average autumn rainfall from 1900–1996 was 152 mm, compared with the average from 1997–2009 of 110 mm, so about half the reduction in total annual rainfall is due to reduced rainfall during autumn. In contrast, during the World War II drought, autumn rainfall was 13 per cent below average, which is consistent with overall annual rainfall reductions during this period (see Table 2.1).

Figure 2.2 Annual rainfall across Victoria – droughts compared to long-term average



* Federation drought is formally between 1895 and 1902, however rainfall data is not available prior to 1900.

Table 2.1 Rainfall reductions across Victoria in 1997–2009 compared with 1900–1996

Season	Long-term average (1900–1996) (mm)	1997–2009 average (mm)	Reduction in average rainfall (%)
Summer	122	114	6
Autumn	152	110	27
Winter	205	176	14
Spring	179	164	9
Total annual	**658**	**564**	**15**

The reduction in autumn rainfall means that the catchments were drier going into winter and spring and generated relatively less run-off from winter and spring rainfall. In addition, reduced inter-annual rainfall variability (see Figure 2.2) during the Millennium Drought meant that there were no really wet years to replenish depleted soil moisture reserves until 2010.

Along with reduced rainfall, temperatures were above average across Victoria from 1997 to 2009 (see Figure 2.3), which compounded the impact of reduced rainfall and exacerbated the drying of the landscape. Generally, as temperature rises, evaporation and water lost through evapotranspiration from vegetation increase unless it is so dry that water availability becomes a limiting factor.

Research has confirmed the severity of the Millennium Drought. As part of the South Eastern Australian Climate Initiative (SEACI), researchers compared the Millennium Drought to the World War II and Federation droughts across south-eastern Australia (a region larger than Victoria) based on an analysis of high quality rainfall records dating to 1872 (CSIRO 2010b).

This analysis showed that the Millennium Drought was more severe in terms of annual rainfall deficits than the two earlier droughts for all durations between three and twenty years. Autumn rainfall deficits were found to be more severe than the earlier droughts for all durations from one to twenty years (see Table 2.2 and Figure 2.4).

Figure 2.3 Difference in annual mean temperature from long-term average in Victoria (1910–2009)

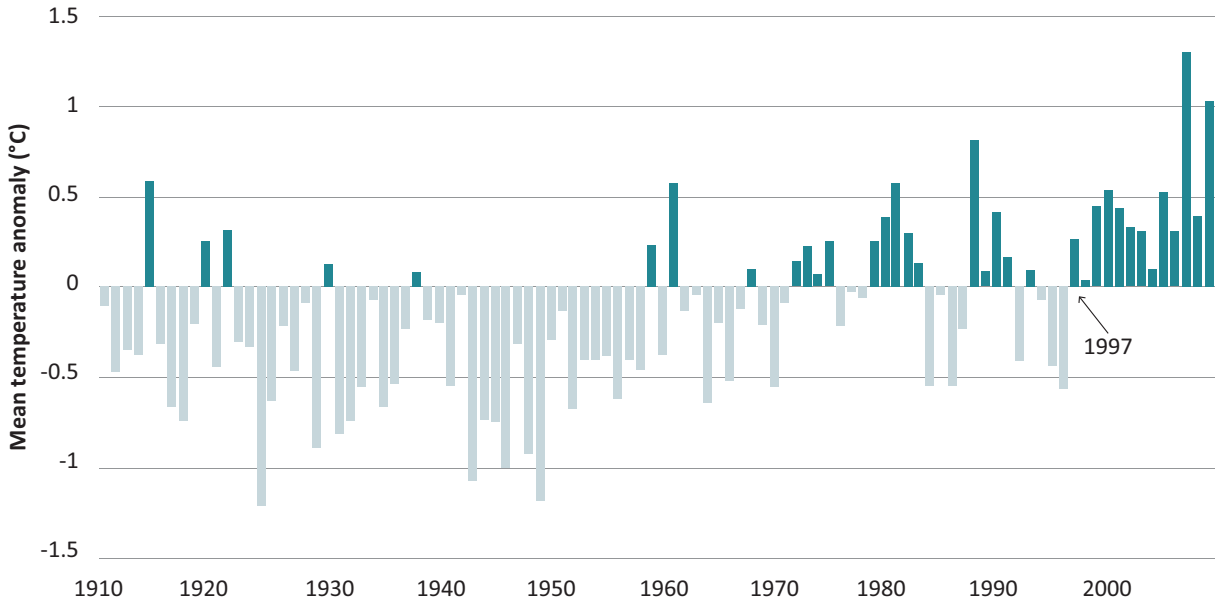
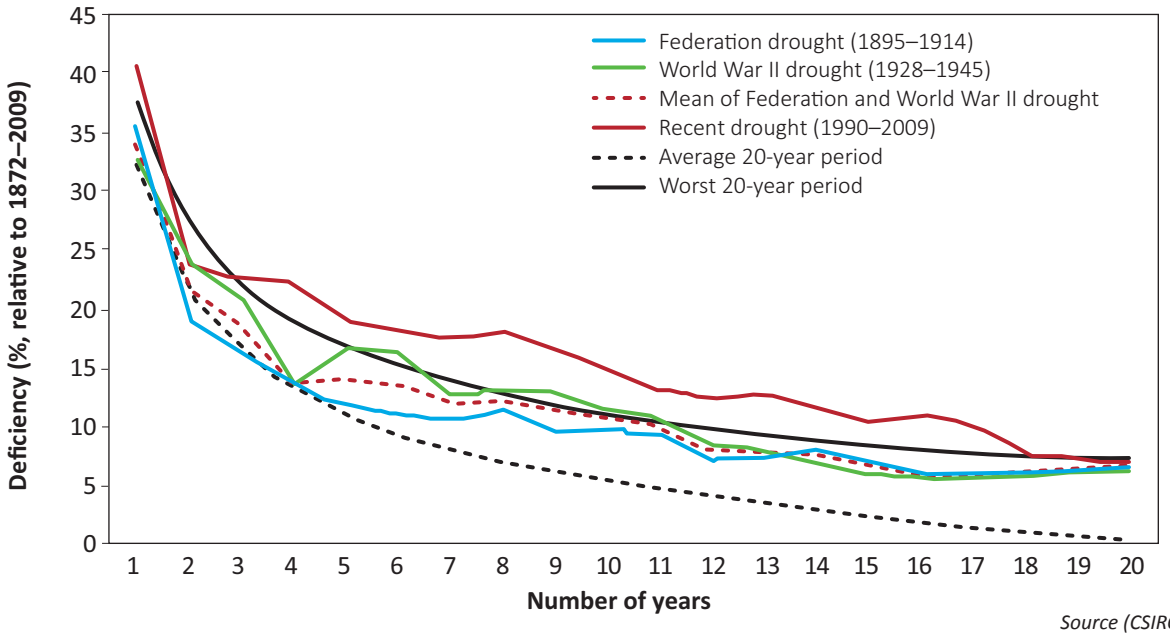


Table 2.2 South-Eastern Australian rainfall anomalies in percentage terms relative to the 1872–2009 long-term mean (adapted from CSIRO 2010b)

10- or 12-year period		Annual	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Spring (SON)
Federation drought	1897–1909	-7.7%	-20.8%	-3.1%	5.8%	-18.8%
	1895–1905	-9.4%	-7.1%	-6.1%	1.7%	-22.8%
World War II drought	1933–1945	-8.1%	-0.4%	-13.0%	-8.3%	-8.6%
	1935–1945	-10.7%	-4.9%	-11.1%	-9.2%	-16.1%
Recent drought	1997–2009	-13.0%	-9.0%	-25.5%	-11.3%	-6.5%
	1999–2009	-13.1%	-5.4%	-26.2%	-11.7%	-8.7%

Note: Annual and seasonal means are shown. Anomalies are calculated for the three droughts using the annual mean for the lowest 10-year and 12-year period within a 20-year period encompassing each drought.

Figure 2.4 Severity of Millennium Drought compared to World War II and Federation droughts



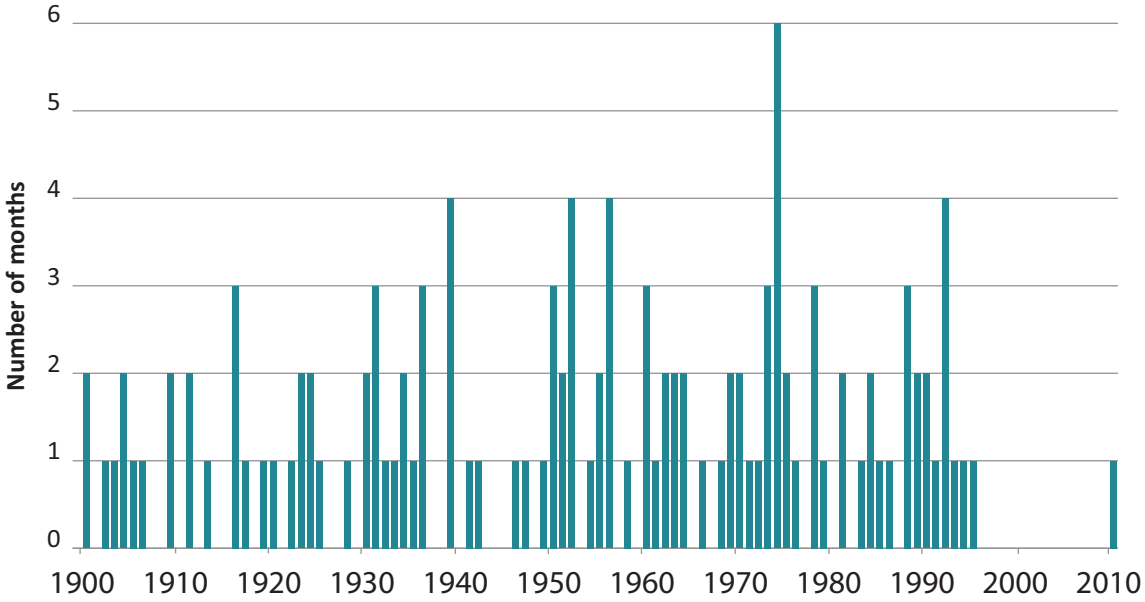
Source (CSIRO 2010b)

Note: The rainfall deficiency-duration curves are based on the annual rainfall average in the 14-station network for 20-year periods for the Millennium Drought (red line), World War II Drought (green), Federation Drought (blue), the mean of the Federation and World War 2 droughts (red dashed), the average of 20-year periods after randomisation of 138 years of data (black short-dashed) and the average of the worst 20-year periods after randomisation of 138 years of data (black long-dashed).

The research also showed that the Millennium Drought was unusual for its lack of wet years to offset the dry years, and for its lack of very wet months, with 180 consecutive months of rainfall below the 90th percentile leading up to May 2010 (see Figure 2.5).

SEACI research has indicated that these low rainfalls can be primarily linked to an intensification of the sub-tropical ridge, which is a belt of high pressure across the mid-latitudes, and that this intensification appears to be at least partly linked to global warming, although natural variability will have also played a role.

Figure 2.5 Number of months per year with rainfall above the 90th percentile (adapted from CSIRO 2010b)



Note: Data shown above from 1990 to May 2010, where percentiles are based on 20th century (1900–1999) climatology and are computed month by month.

The decline in annual rainfall, loss of high rainfall years, change in rainfall seasonality and increasing temperatures resulted in a major reduction in streamflows and inflows into major reservoirs during the Millennium Drought (see Table 2.3). This meant that the large storages, designed to hold reserves to manage through dry years, were continuously drawn down without significant replenishment. In addition, soil moisture reserves progressively depleted, contributing to lower volumes of run-off when rainfall occurred.

2006/07 was particularly severe. After 10 years of below average rainfall and declining water availability, the situation worsened across most of Victoria. Inflows to river basins and reservoirs were just 26 per cent of the long-term average, with most systems recording less than 20 per cent of the long-term average streamflow (Department of Sustainability and Environment, 2008). Increases in storage levels that normally occur in winter-spring did not eventuate.

The impact of 2006/07 was further compounded by the consecutive dry years following, resulting in inflows in Victoria from 1997 to 2009 that were the lowest ever recorded. The percentage changes in rainfall and streamflow experienced between 1997 and 2009 were greater relative to historical conditions than would have been expected under medium to high climate change projections by the middle of the century (CSIRO/Bureau of Meteorology, 2007).

Percentage changes in rainfall are expected to be amplified in terms of percentage changes in streamflows, generally by a factor of about 2 to 3.5 (Chiew, 2006). During the Millennium Drought, reductions in streamflows were much greater than expected. Research has shown that this is largely due to the nature of the changes in inter-annual variability and seasonal rainfall patterns, with some contribution from increased temperatures (Potter and Chiew, 2009).

It has also been shown that the severity of the Millennium Drought was unusual in a much longer historical context. Researchers at the University of Melbourne constructed a record of inflows into the River Murray system dating to 1783 based on a range of palaeoclimate data (Gallant and Gergis, 2011). Using a sophisticated statistical analysis, they found that the 1998 to 2008 streamflow deficit is very unlikely to occur, that is, it has an approximate 1 in 1,500 year return period.

Table 2.3 Reduction in inflows to water storages July 1997–August 2009 compared to the long-term average

Region/ river system	Average inflows GL/year	% reduction
Central Region (1996–2006)		
Bunyip	148	-41
Yarra	1,054	-29
Maribyrnong	113	-41
Werribee	102	-51
Moorabool	97	-60
Barwon	360	-34
Western Region		
Corangamite	249	-84
Otway Coast	842	-30
Hopkins	344	-40
Portland Coast	350	-56
Glenelg	681	-65
Avoca	1	-90
Wimmera	303	-77
Northern Region		
Murray	7,618	-43
Kiewa	689	-23
Ovens	1,758	-33
Broken	308	-53
Goulburn	3,363	-49
Campaspe	352	-72
Loddon	373	-74
Gippsland Region		
East Gippsland	714	-33
Snowy	2,162	-49
Tambo	298	-44
Mitchell	885	-38
Thomson	366	-43
Latrobe	847	-43
South Gippsland	912	-41
Macalister	496	-40

These conditions resulted in very low inflows to storages and created extreme water supply shortages in many regions across Victoria. For example, from 2006/07 until August 2010, storage levels in the Loddon basin remained consistently below 10 per cent.

The water shortage was further exacerbated in some areas by water-quality problems. Blue-green algal blooms and low dissolved oxygen levels in waterways increased in many systems as a result of low flows, high nutrient levels and high temperatures. Such incidents caused the deaths of fish, crayfish and other aquatic animals, and reduced the volume of clean water available for human uses. Bushfires (in 2003, 2006/07 and 2009 in particular) further reduced the availability of clean water, due to ash and sediment polluting water in burnt catchments.

Extended dry periods have been experienced in the past, notably during the Federation (1885–1902) and World War II (1936–1945) droughts. It is possible that the Millennium Drought represents another episodic dry period, as part of a broader cycle of variability. However, the Millennium Drought was more severe than other droughts in the historical record and had some characteristics that are different from earlier droughts. While research has shown possible links to global warming through the intensification of the sub-tropical ridge, as yet it is not possible to quantify the contribution of global warming to the Millennium Drought. Rainfall in 2010/11 brought welcome relief to many depleted storages (further discussed in Chapter 7), a considerable amount of uncertainty exists about future climate and, therefore water availability in Victoria.

Rain on the road, Euroa *Photo: © Bruce Cumming*

3. Managing water scarcity in Victoria's rural regulated systems

The security of water supplies in regulated systems was severely compromised by the Millennium Drought, particularly between 2006 and 2010 in the north and west of Victoria. This chapter details some of the issues faced by entitlement holders in regulated systems during the unprecedented dry conditions. It focuses on the experience of operating the regulated systems, details measures undertaken to maximise and share the available resources during this time and describes some of the lessons learned regarding water planning and management.

3.1 How Victoria's rural regulated systems operate

Large regulated systems manage the natural variability in water availability. Victoria's largest regulated systems are the Goulburn, Loddon, Murray and Campaspe systems in northern Victoria, managed by Goulburn-Murray Water[3]. In the west, Grampians Wimmera Mallee Water manages the Wimmera-Mallee system. These systems are managed to supply the needs of a wide range of customers, including the environment, urban water corporations, irrigators, industry and other rural customers. In the south of Victoria, Southern Rural Water manages the Latrobe, Werribee and Macalister systems, primarily to supply irrigators and industry. The location of these systems can be seen in Figure 3.1.

For each regulated rural system in Victoria, bulk entitlements describe the overall consumptive resource base, and establish system-wide rules for managing water resources, including the:

- total amount of water that can be harvested by the system, or in the Murray system, the total amount of water made available to Victoria
- minimum flow requirements of the regulated rivers downstream of the reservoirs (passing flows)
- primary entitlements or commitments (for example, water shares, delivery bulk entitlements and environmental entitlements) to be supplied from the water in the system[4].

The system operator (water corporation managing the supply system, sometimes known as the storage manager or resource manager) often holds an entitlement to the bulk water in the system and is responsible for overseeing the allocation of available resources to individual entitlement holders in accordance with set rules. Because of this responsibility, the system operator carries the initial risk of water availability in a given year, as it must operate the system to supply the specified entitlements. This was not an issue historically, because the system design and existing entitlements were based on the historic record of resource variability, and modelling under the historic climate showed that the full range of entitlements could be supplied in at least 95 per cent of years in most systems.

However, the unprecedented nature of conditions during the Millennium Drought meant that many operational rules did not function, even with historical dry season contingency measures in place. At times, qualifications of rights were necessary because it was impossible for the system operator to meet minimum urban, rural and domestic water needs without prioritising supply.

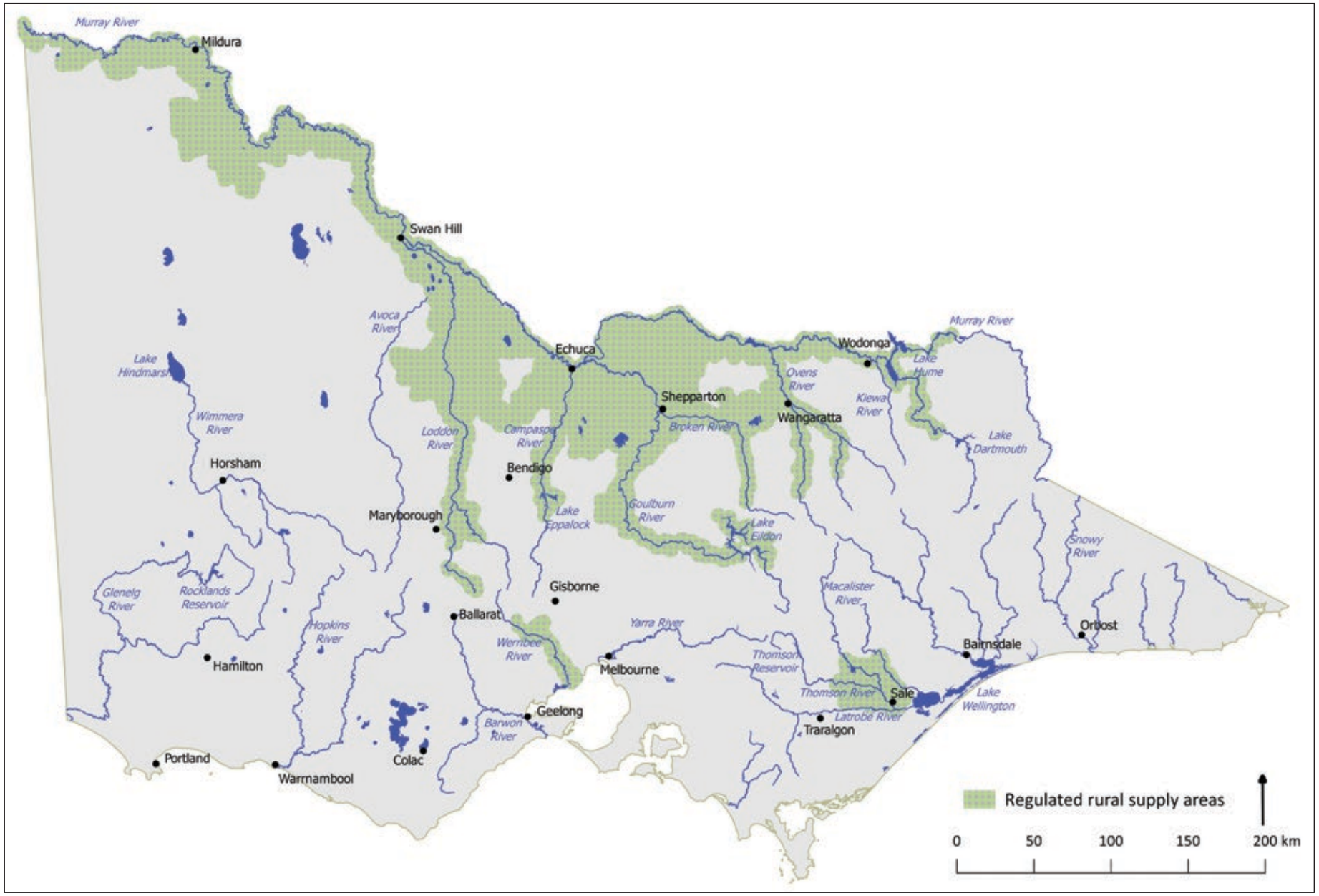
Managing the regulated systems was a complex task during these unprecedented times, when water managers were operating outside all previous planning horizons while trying to achieve the following objectives:

- deliver essential water needs
- minimise the amount of water needed to operate the system in order to maximise allocations to users
- make allocations as early in the season as possible to help water users plan and to minimise economic costs
- avoid reducing an allocation once made
- provide certainty to water entitlement holders
- operate the system fairly for all entitlement holders.

3 Lower Murray Water and Murray Darling Basin Authority are also responsible for managing designated parts of the Murray system.

4 See for example the *Bulk Entitlement (Eildon-Goulburn Weir) Conversion Order 1995.*

Figure 3.1 Victoria's regulated water supply systems



3.2 Sharing available water resources

To manage the variability of water availability from year to year, rural water corporations allocate water to primary entitlements based on the water available in the system. The process of making an allocation is known as a seasonal determination.

This process was developed as a method of sharing water available in a system equitably among entitlement holders in that system. A seasonal allocation is the proportion of an individual's entitlement volume (often expressed as a percentage) that can be supplied from the water available in the system at a given time. Allocations are made on the basis of a given priority of supply to entitlement classes, which are typically specified by reliabilities in the bulk entitlements for that system.

Seasonal determinations are made at the start of each water year based on the total water in storage in the system and a forecast of inflows during the year, minus an estimate of the total water required to operate that system over the year. Seasonal determinations are regularly revised throughout the year (often fortnightly), based on operational data to date (for example, actual deliveries, losses and inflows) and revised forecasts for the remainder of the season.

Historically, once the volume of water available exceeded the volume required to supply high-reliability entitlements and reserves for the following season, any 'leftover' water was allocated to entitlement holders as bonus water, known as 'sales water'. Before 1997, this water was often available to entitlement holders (see low-reliability water shares i.e. LRWS columns in Table 3.1). In 2007, when northern Victorian systems were unbundled and water shares were created, entitlement holders were also given an entitlement to a portion of low-reliability water shares to recognise the historic availability of this water.

The unprecedented conditions of the Millennium Drought, particularly during 2006/07 and following, resulted in several years when was not enough water to supply the full range of competing uses in the systems. As a result, several key lessons were learned about how to maximise and share available resources when conditions are dry, and ensure water is available when it is needed. These included lessons about:

- forecasting inflows under very dry conditions
- the use and allocation of system operating water
- reserving water for the following year.

The role of inflow forecasts in seasonal determinations

The process of making seasonal determinations requires assumptions to be made about inflows to the system over the coming year, generally based on what could be expected under similar conditions historically. This approach was appropriate under historical conditions, and ensured entitlement holders could access water early in the season. However, the unprecedented low inflows experienced in many river systems across south-eastern Australia during the Millennium Drought (and particularly in 2006/07), demonstrated the risk in forecasting inflows when determining allocations.

In 2006/07, inflows were much lower than previously recorded minimums, and water allocations for some water systems in New South Wales had to be reduced when the predicted inflows did not eventuate. Reducing an allocation can have severe effects on farm planning and urban supply drought contingency implementation.

In the early 2000s, when reserves were depleted following a very low-inflow year, Goulburn-Murray Water adopted a more conservative approach for forecasting inflows in northern Victorian systems for the following the year. Now, during dry years, forecast inflows are based on the rate of recession of current flows, and assume no further high-flow events will occur that season. The allocation is then increased only if more water becomes available during the season, for example, because inflows are greater or system operating water is less than forecast. In southern Victoria, Southern Rural Water adopted a similar method following the record low inflows of 2006.

Table 3.1 Historical seasonal allocations to high-reliability water shares (HRWS) and low-reliability water shares (LRWS) in northern Victorian systems

Season	Murray		Broken		Goulburn		Campaspe		Loddon		Bullarook Creek	
	HRWS	LRWS	HRWS	LRWS	HRWS	LRWS	HRWS	LRWS	HRWS	LRWS	HRWS	LRWS
1994/95	100	120	–	–	100	100	100	80	–	–	–	–
1995/96	100	100	–	–	100	50	100	100	–	–	–	–
1996/97	100	100	–	–	100	100	100	120	–	–	–	–
1997/98	100	30	100	70	100	20	100	90	–	–	100	90
1998/99	100	100	100	70	100	0	100	0	–	–	100	90
1999/00	100	90	100	70	100	0	100	0	–	–	100	90
2000/01	100	100	100	70	100	0	100	120	–	–	100	90
2001/02	100	100	100	70	100	0	100	80	–	–	100	90
2002/03	100	29	100	0	57	0	100	0	–	–	100	70
2003/04	100	0	100	70	100	0	100	0	67	0	100	77
2004/05	100	0	100	70	100	0	39	0	100	0	100	90
2005/06	100	44	100	70	100	0	31	0	100	0	100	90
2006/07	**95**	**0**	**77**	**0**	**29**	**0**	**0**	**0**	**0**	**0**	**36**	**0**
2007/08	**43**	**0**	**71**	**0**	**57**	**0**	**18**	**0**	**5**	**0**	**0**	**0**
2008/09	**35**	**0**	**0**	**0**	**33**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2009/10	**100**	**0**	**17**	**0**	**71**	**0**	**0**	**0**	**3**	**0**	**19**	**0**
2010/11	100	0	100	100	100	0	100	100	100	0	100	100
2011/12	100	0	100	100	100	0	100	100	100	0	100	100
2012/13	100	0	100	100	100	0	100	100	100	0	100	100
2013/14	100	0	100	100	100	0	100	46	100	0	100	100
2014/15	100	0	100	100	100	0	100	0	100	0	100	100
Dec 15, 2015	94	0	20	0	82	0	55	0	65	0	15	0

Source: Goulburn-Murray Water[5]

5 **http://nvrm.net.au/determinations/history**

System operating water

Historic practice in northern Victorian systems was that seasonal allocations could not be made until enough water was available to supply system operating water requirements for the entire year (see Figure 3.2).

System operating water is the water required to operate the system and includes:

- storage losses – evaporation, seepage and spills from system storage(s)
- river operating water – required to deliver water from major storages to users along the river including evaporation, seepage, passing flows and water for riparian rights in regulated rivers
- distribution system operating water – required to deliver water from the river off-take to the farm gate including evaporation, seepage, leakage, outfalls, meter error and may also include water for environmental assets that are part of the distribution system.

In the past, system operating water had not been a significant concern for system operators because most systems typically had enough inflows and storage to ensure that water needed for system operation and 100 per cent end-of-season allocation for high-reliability entitlements could be met. As a consequence, the volume of system operating water required was not often explicitly defined in the bulk entitlements, and how much that volume might vary under a range of conditions, especially dry, was not yet well understood. However, in the driest years in Victoria's records, system operating water was suddenly a very large proportion of the total water available.

Figure 3.3 shows the progression of allocations for all northern systems in 2007/08. Following the worst inflows on record in 2006/07, there was not enough water in the systems at the start of August 2007/08 to meet the system operating water needs. For the first time in recent history, the starting allocation on all northern Victorian systems was zero. Resource improvements and drought contingency measures meant that some systems were able to support allocations later in the season; however, the Bullarook and Loddon systems remained on low or zero allocations for the full season. Final allocations on all northern Victorian systems since 1994/95 can be seen in Table 3.1.

Case study 3.1 describes how the hierarchy of supply priorities for system operation was altered in northern Victoria through a collaborative planning process. A similar process was set up for the Ovens and King valleys.

The volume of water required to run a distribution system is particularly variable, depending on the volume of water allocated to entitlement holders, the pattern and timing of deliveries, and the volume delivered. Through the operation of the systems under extremely dry conditions, system operators learned that they could increase the flexibility of their operations if water needed for distributing allocations could be progressively set aside, like entitlement holders' allocation, as resources improved.

Dartmouth Dam *Photo: © Salahuddin Ahmad*

Figure 3.2 Historic allocation hierarchy for system operations and reserve rules

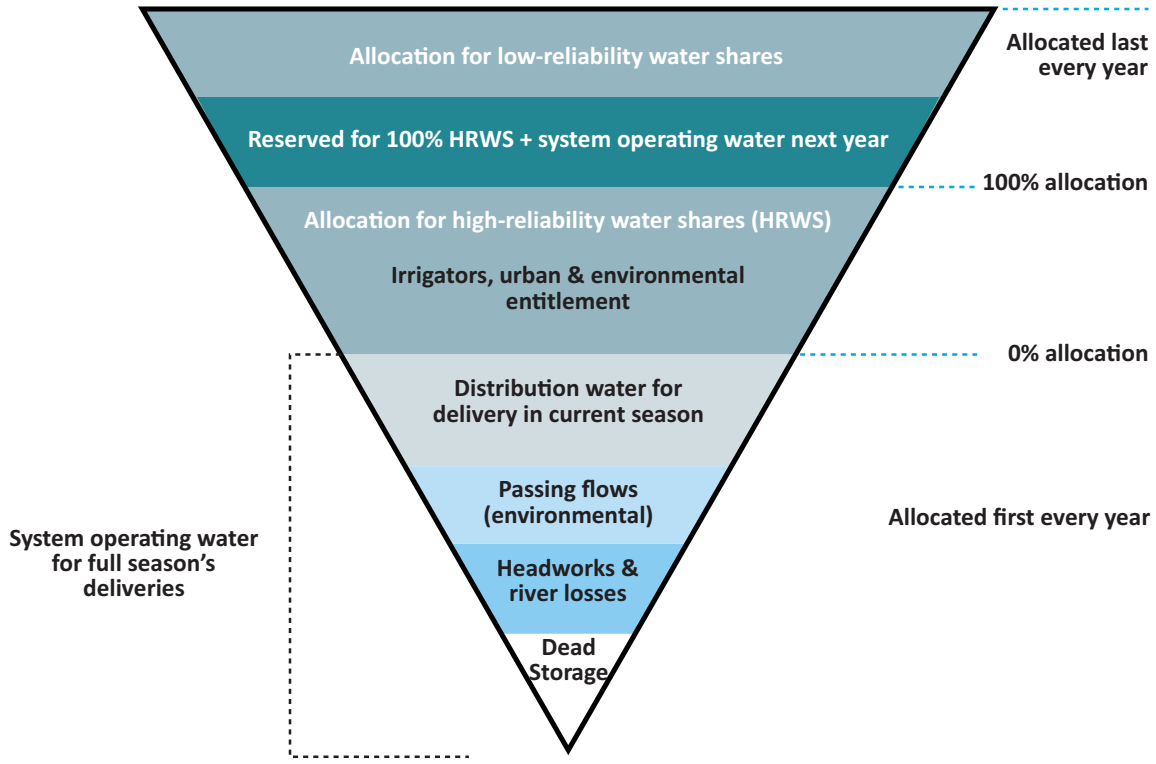
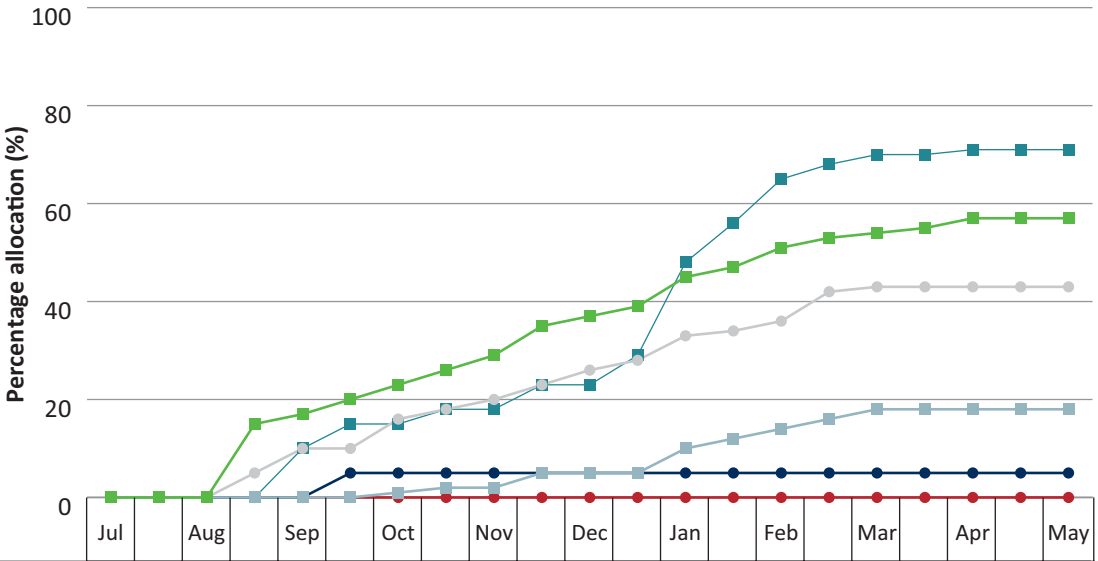


Figure 3.3 Progression of irrigation allocations in northern Victoria 2007/08



	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May
Goulburn HRWS	0	0	0	15	17	20	23	26	29	35	37	39	45	47	51	53	54	55	57	57	57
Campaspe HRWS	0	0	0	0	0	0	1	2	2	5	5	5	10	12	14	16	18	18	18	18	18
Murray HRWS	0	0	0	5	10	10	16	18	20	23	26	28	33	34	36	42	43	43	43	43	43
Broken HRWS	0	0	0	0	10	15	15	18	18	23	23	29	48	56	65	68	70	70	71	71	71
Loddon HRWS	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Bullarook HRWS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Case study 3.1: Collaborative contingency planning in northern Victoria

The Dry Inflow Contingency Planning Group (DICP) was convened for northern Victoria to help develop drought operational rules and temporary water-sharing arrangements to meet differing needs during the Millennium Drought.

The group was formed in November 2006, and was comprised of key representatives from all northern Victorian water corporations, the then Department of Sustainability and Environment, and relevant catchment management authorities.

The establishment of the group facilitated a whole-of-system, collaborative approach to examine traditional operating arrangements and address the immediate concern of low or no water availability for the coming season. The group examined a range of delivery and climate scenarios, and contributed to a better understanding and accounting of system operation.

The group identified that the first priority in a dry year was meeting essential human and stock needs. The following hierarchy of supply priorities was developed for low water availability and was endorsed by the Victorian Government:

1. dead storage and storage evaporation
2. essential human and stock water requirements and the associated system operating water to deliver this water
3. essential environmental needs
4. carryover water delivered on rivers/channels already operating to deliver essential needs
5. operating water to run whole systems (may include rostering)
6. delivery of carryover on the whole system
7. initial allocation against high-reliability water shares (HRWS)
8. return to normal volume of environmental releases (for example, resumption of normal passing flows)
9. allocations against HRWS.

Under the old system, an estimation of the full year's system operating water needed to be reserved before an allocation was made. The new hierarchy recognised that the volume of water required to run the system to supply essential needs was much less than required to run the full system. For example, if the Goulburn system was run to supply Stage 4 demand to urban centres and emergency standpipes only, the annual losses in the distribution system were estimated at 135 GL (40 GL to deliver water through the channel system and about 95 GL required to run the river under qualification) compared with up to 600 GL of system operating water needed for the delivery of full allocation for high-reliability entitlements. The rules in the bulk entitlements were qualified to give effect to this new hierarchy of supply.

Goulburn-Murray Water (as the system operator), in consultation with the DICP, developed contingency plans for operating each major system, which considered the essential needs of each user group under a range of dry inflow scenarios and the revised hierarchy of supply. Urban water corporations and environmental managers were able to use the system operating plans to prepare their own contingency plans in the event that the extremely dry conditions continued.

Evolution of reserve rules

Historically in regulated systems with significant storage, once the seasonal allocation reached 100 per cent of high-reliability entitlements, reserves were set aside in storage for the following year before any allocation for low-reliability entitlements (see Figure 3.2) This practice worked well before 2006/07 when there was generally enough water available to reach 100 per cent seasonal allocations in all systems and the volume of water available generally exceeded demand. Unused water that often remained in storage at the end of the season could be made available the following year. At the same time, rainfall could be relied on to replenish storages before the next season.

In the northern systems, the rule was justified because modelling under historic climate conditions showed that a 100 per cent allocation could be made in at least 95 per cent of years and the allocation in the worst year was more than 50 per cent. Setting aside water for the following year before allocating 100 per cent of entitlements was considered inappropriate given the high economic cost of failing to deliver high-reliability water entitlements.

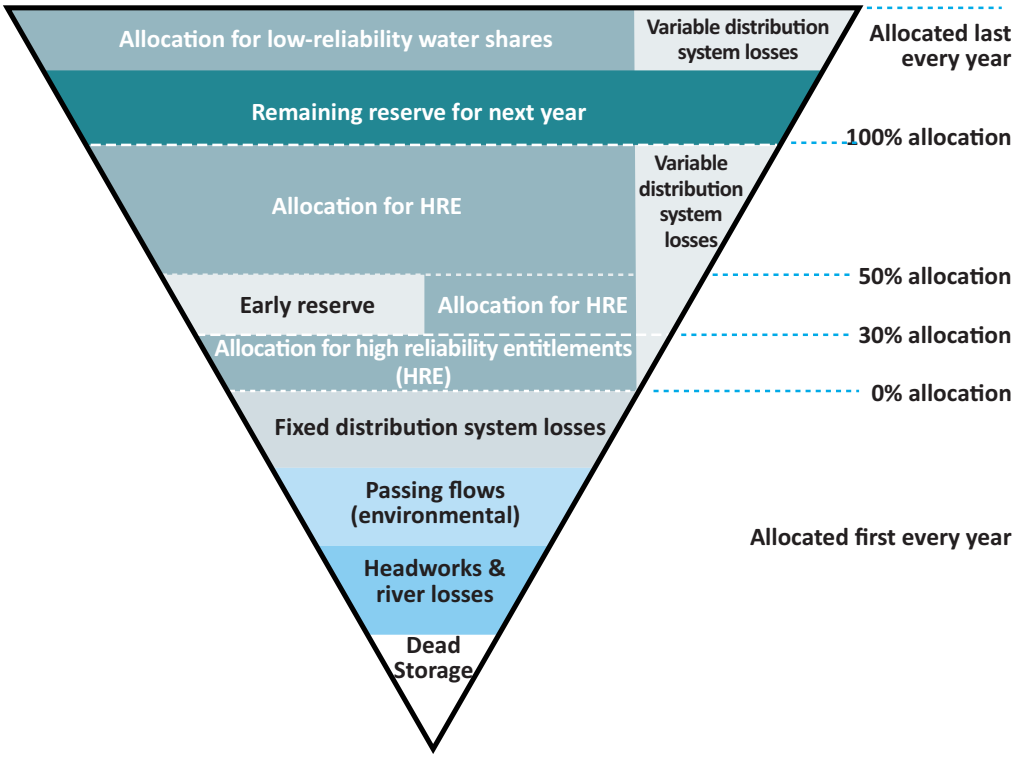
However, after consecutive years of allocations below 100 per cent following 2005/06, the expected pattern of storage recovery after an extremely dry year was no longer reliable. In several northern Victorian systems, because the allocation in 2006/07 remained below 100 per cent of high-reliability water shares, no water was reserved for 2007/08, and no reserves combined with very low winter inflows resulted in a starting allocation of zero on all systems in 2007/08.

As the dry conditions continued in the following years, it became clear that the historic reserve rules were no longer appropriate for securing resources for the following season. If the extreme dry conditions experienced between 2006 and 2009 were repeated, such a reserve rule could result in consecutive years when there is insufficient water to operate the large regulated systems in northern Victoria or supply its customers.

New reserve rules were adopted from 1 July 2010 for several systems across Victoria, including the Goulburn and the Werribee and Bacchus Marsh irrigation systems. New reserve rules were bought in for the Murray System from 1 July 2013 (see Figure 3.4).

Case study 3.2 describes the experience of operating the Goulburn system during the height of the Millennium Drought. It considers the importance of system operating water as well as the new reserve rules in light of this experience.

Figure 3.4 Allocation hierarchy for systems with new reserve rules



Case study 3.2: Water to operate the Goulburn system

Goulburn-Murray Water (GMW) is responsible for operating the Goulburn system headworks – Lake Eildon, Waranga Basin, and weirs – and distribution networks (channels) to supply urban water corporations, irrigators, and to provide passing flows for the environment.

Unlike the Murray system, where the volume for operating the irrigation system was set out in the bulk entitlement, the volume of water needed to operate the Goulburn irrigation system was not defined in the bulk entitlement. The system operating strategy before 2006/07 was based on the bulk entitlement obligations and GMW's operational experience. Following construction of major storages after the severe drought of the 1940s, and until 2002, there had always been enough Goulburn River flow each year to meet the system operating water requirements and provide at least 100 per cent allocation (end of season) to the holders of high-reliability entitlements.

The 2006/07 inflows were the worst on record, but a 29 per cent end-of-season allocation was possible on the Goulburn system because water had been set aside in the previous year once the allocation reached 100 per cent.

In late 2006/07, it became clear to GMW that if 2006/07 inflows were repeated in 2007/08, there would be insufficient water in storages to meet the system operating requirements for the following year, and make an opening allocation for high-reliability entitlements. Although such an inflow scenario would have been unprecedented, having insufficient water to operate the supply network has critical implications for all entitlement holders, and also means the water market cannot operate. Under the existing reserve rules, the 29 per cent maximum allocation in 2006/07 meant that no water was set aside for the following year.

The DICP group (see Case study 3.1) was formed to discuss the options for operating the system to minimise the amount of system operating water needed, and to ensure water was available as early as possible. It was recognised that system operations would need to be altered to ensure delivery of essential needs if extremely low inflows persisted. Dry inflow contingency plans were developed for each system to define the volume of water required to meet commitments under a range of inflow scenarios, and modified system operation plans were developed for 2007/08 to reflect the volume of water that could be delivered to entitlement holders depending on availability.

As feared, insufficient water was in storage to operate the entire water supply network for the full season at the beginning of the 2007/08 irrigation season. Consequently, the season opened with a zero allocation against irrigation entitlements. However, the dry inflow contingency plans provided a starting point for system operators to manage supplies for essential needs under a range of scenarios until resources improved. This planning process was undertaken every year between 2006/07 and 2009/10, incorporating improvements in efficiency and understanding of system operations (including better quantification of system losses).

This experience resulted in options being explored for revising the reserve rules on the Goulburn and other northern systems through the Northern Region Sustainable Water Strategy.

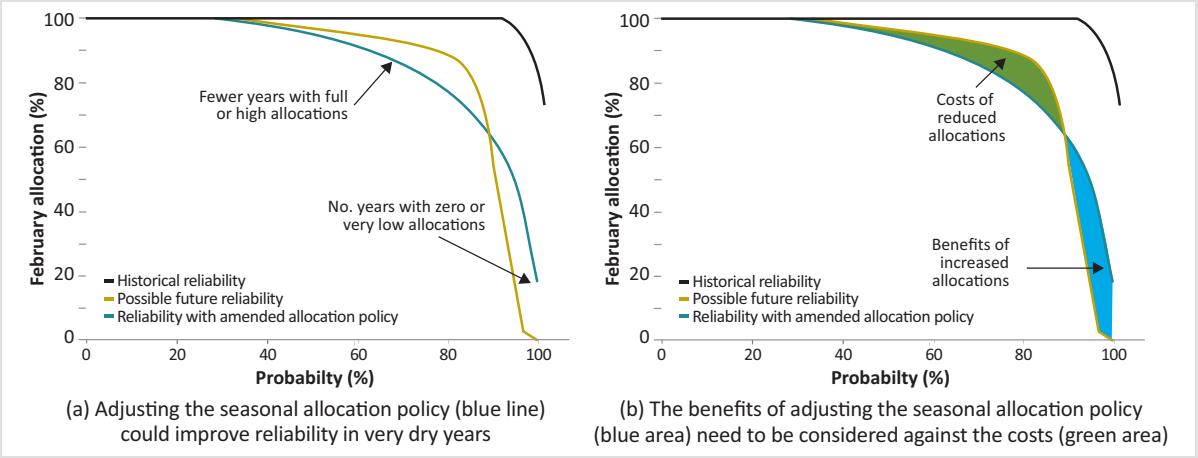
An early reserve for the Goulburn System

Action 5.1 of the Northern Region Sustainable Water Strategy committed to amending the system reserve rules for the Goulburn system. Under the new rules, when allocations against high-reliability water share (HRWS) for the current season reached 30 per cent, half of the inflows up to 340 GL were reserved for the following season. The rest of the inflows support increasing the allocation in the current season. Once the allocation reached 50 per cent, the early reserve is established and any further inflows are dedicated to increasing allocations.

The early reserve is the equivalent of a 20 per cent allocation against HRWS, plus the system operating water required to deliver that allocation. The early reserve will be used to operate the system and ensure a starting allocation in the next season.

This new policy came into effect at the beginning of the 2010/11 season, in order to reduce the risk of years with zero allocation, and improve the minimum allocation earlier in the season.

The figure below shows how Goulburn HRWS are affected by the reserve.



(a) Adjusting the seasonal allocation policy (blue line) could improve reliability in very dry years

(b) The benefits of adjusting the seasonal allocation policy (blue area) need to be considered against the costs (green area)

These early reserve rules were amended at the start of 2013/14 season when the early reserve volume was reduced. The early Goulburn reserve will continue to be set aside at the same rate once allocations reach 30 per cent but the maximum volume of the early reserve is now 270 GL. This means that setting aside water in reserve will finish early, before allocations reach 50 per cent. All further inflows then go towards achieving 100 per cent HRWS allocation.

Other methods for implementing system reserves

The type of reserve rule described above is not used for all systems. It is not appropriate for systems where the impact of reduced allocations in average or wet years is unacceptable to entitlement holders, or where storages are not designed to hold water over multiple years (that is, systems that operate on an annual basis).

In some cases, system operators have developed reserve rules based on their operational experience for each system. In some systems, for example, where bulk entitlements allow, water corporations may prioritise the development of a reserve to supply towns for a specified period, before allocating water to other customers (see Case study 3.3).

Case study 3.3: Thomson drought reserve

In the Thomson-Macalister system in southern Victoria, a different type of reserve for dry periods exists, known as the Thomson Drought Reserve. Lake Glenmaggie is the primary source of water for the Macalister Irrigation District (MID). It is a relatively small storage, due to the size of the waterway it regulates as well as the historic high reliability of rainfall and climate in the region. This meant the system was developed to operate on an annual basis, where storages empty and refill each year. Irrigators rely on a winter-spring filling period to ensure supply through summer and autumn. To provide a back-up in case of drought, the Thomson Drought Reserve was established in Thomson Reservoir (managed by Melbourne Water). Southern Rural Water is entitled to 6 per cent of the available water for MID irrigators, which is held in reserve in average or above-average conditions. If necessary in dry years, the reserve can contribute to the seasonal allocation for the MID.

Management of water shortages in the shared resources of the River Murray

Extreme water shortages were experienced in the River Murray during the Millennium Drought. The water shortages, particularly at the start of each water year, were a cause of major tension between jurisdictions because the water-sharing rules in the Murray Darling Basin Agreement had been drafted on the assumption that water supplies would always exceed the volumes that were available.

At the start of the 2006/07 water year the upper states 'advanced' water to South Australia. Providing advances requiring repayment caused three broad problems:

- 'advancing' Victorian and New South Wales water to South Australia reduced the amount of water available to those states during a period of extreme water shortage when water had a very high market value
- early allocations to water users in Victoria and New South Wales were delayed and/or reduced, imposing additional costs to those water users to the benefit South Australian water users
- allocations in South Australia were then held down whilst South Australia repaid Victoria and New South Wales, which caused political angst in South Australia.

This approach subsequently:

- provided disincentives to water users to carryover water, because the water they carried over was 'advanced' to South Australia
- undermined the operation of the water market because a political rather than a market solution was adopted.

Thomson Dam *Photo: © Melbourne Water*

These shortcomings were widely recognised and subsequently the Commonwealth *Water Act 2007* and the Basin Plan introduced a three-tier arrangement to manage extreme droughts so that critical human water needs could be supplied. The shared reserve policy on the Murray was also amended to ensure that there would be sufficient water available for operating the river assuming a repeat of the Millennium Drought.

These new arrangements are yet to be tested.

3.3 Maximising water available through system operations and infrastructure modifications

In addition to changes in the water-sharing rules, system operators implemented measures within their own systems to reduce system operating losses and maximise the amount of water available for supply to their customers, particularly irrigators, in the short and long term.

In the short term, this involved changes to the operation of channels and storages, or changes to the length of the season where water is available for delivery. Some of these measures are summarised in Table 3.2 and discussed in detail below.

While these measures were effective, they required a very high level of cooperation, goodwill and in some instances, sacrifice from individuals or all customers. For the Goulburn and Murray systems, Goulburn-Murray Water drew on the Dry Inflow Contingency Planning Group (see Case study 3.1) and its customer-based water services committees as forums to discuss and communicate such measures, and gain cooperation from its primary entitlement holders.

Table 3.2 Measures undertaken by rural water corporations to reduce system operating losses and increase supply to rural users in declared irrigation systems

Measure	Water Corporation	
	Goulburn-Murray Water	Southern Rural Water
Channel operations		
Delaying channel fills when no demand	✓	✓
Not operating parts of irrigation networks	✓	✓
Running channels at minimum levels	✓	✓
Group deliveries, strict scheduling/rostering	✓	✓
Changes to irrigation season		
Shortening season length (delivery guarantee dates)	✓	✓
Bridging allocations	✓	
Split allocations	✓	✓
Other		
Pumping dead storage	✓	✓
Permitting carryover of entitlements	✓	✓
Maximising water trading opportunities	✓	✓

Channel operations

Modifying channel operations by not filling spur channels (that is, operating only main channels), operating channels at low levels and rostering deliveries provided significant water savings, these were then used to increase allocations to entitlement holders. Rostering deliveries in regulated systems involved grouping customer orders based on the location of their service delivery point, and then delivering orders during scheduled periods. This was undertaken for the northern and southern Victorian irrigation systems.

Goulburn-Murray Water and Southern Rural Water worked very closely with their customers when reducing the number of channels operated to minimise the amount of system operating water required. In the northern Victorian systems, changes to normal channel operations and lower service levels were effectively communicated to water shareholders through system operating plans and customer committees (water services committees).[6]

Changes to irrigation season

Shortening season length

Delaying the start of the irrigation seasons reduced the amount of system operating water required. For example, in 2007/08, savings of about 130 GL of operating water were achieved by delaying the beginning of the irrigation season in the Goulburn and Murray systems until 15 September.

However, delaying the start of the irrigation season can be costly for some water users. For example, the amount of fruit set by some crops is highly dependent on adequate watering in August.

6 For more information **http://www.g-mwater.com.au/general-information/wsc**

Theoretically, allocations could be announced until 1 May however, under historic conditions the maximum allocation is normally been reached before this time. Further savings were made in 2007/08 by shortening the season by bringing forward the final allocation announcement to 15 March. Inflows that occurred after 15 March were set aside for allocation in the 2008/09 season.

However, while shortening the length of the season provided water savings, it created uncertainty for Goulburn-Murray Water customers, and meant that water may not have been available at the time of year it was needed. The following season (2008/09) Goulburn-Murray Water resolved to always try to start the season from 15 August if possible.

Additional methods for shortening the irrigation season are discussed below.

Bridging allocations

A bridging allocation is when an allocation is announced before enough water is held in storage to cover the losses for delivery of that allocation. This measure involves using some of the annual system operating water to announce a start of season allocation, so that water is available at the beginning of the season for those who might need it (for example, fruit growers in the Sunraysia Irrigation District). As more water becomes available, it is then divided between increasing the allocation and running the delivery system. This may involve other measures such as delivering over a shortened season, rostering deliveries or both.

Delivery guarantee dates

Because future inflows were uncertain, rural water corporations attempted to provide customers with some certainty by guaranteeing the delivery of allocations for a shorter period than normal. This allowed for some of the savings in system operating water to contribute to small increase in allocations.

For example, in early September 2007, Goulburn-Murray Water allocated customers in the Broken system access to 10 per cent high-reliability water shares for two months. Delivery of water was guaranteed until 31 October, and any further resource improvements would be dedicated to extending the duration of supplies and increasing the allocation. Throughout the season, low delivery rates, minor inflows and efficient operations allowed for the season to be gradually extended until almost the full season length. Allocations increased to finish at 71 per cent for high-reliability water shares at 1 April 2008.

However, while the guarantee dates were intended to provide relative certainty and assistance for irrigators, some irrigators observed that their decision-making had been altered as a result of the guarantee dates. Some irrigators were unable to take the water they required late in the season as they had taken water at the beginning of the season when they did not necessarily need it because they had feared they would not be able to access it later.

This measure has also been used in the Werribee basin, when allocations for Werribee and Bacchus Marsh Irrigation Districts were low. For example, Southern Rural Water announced a 2 per cent allocation at the beginning of 2009/10, which was guaranteed until 30 November, until resources improved to a point where delivery could be guaranteed until the end of the season.

Split allocations

Split allocations have occurred in systems where delivery of supply is restricted for some customers, based on their location on the irrigation distribution network in relation to system storages.

For example, in the Bullarook Creek system, irrigators are supplied by Newlyn Reservoir and Hepburn Lagoon. Under historic rules, all customers in the Bullarook Creek system received the same allocation. However, the situation arose where enough water was available in Newlyn Reservoir to make an allocation, but insufficient water was available in Hepburn Lagoon to deliver to customers supplied below the storage. In 2006/07, this problem was managed through a split allocation, where customers supplied from Newlyn Reservoir received a 22 per cent allocation, and no water was allocated to Hepburn Lagoon customers. While this did not benefit all customers, it enabled maximum allocation of the available water in the system to customers who could physically access the water.

Since the unbundling of water rights and the declaration of northern Victorian water systems in 2007, a split allocation is no longer possible within the declared system. No allocation was made for Bullarook Creek in 2007/08 or 2008/09, however by December 2009, Goulburn-Murray Water had enough resources in Newlyn to make an opening allocation of six per cent. Customers supplied from Hepburn Lagoon received the allocation, but were

advised that, although it could not be delivered, it could be traded to those supplied from Newlyn Reservoir.

Split allocations have also been used in southern Victoria, where under normal operating arrangements allocation announcements apply equally to all irrigators in the Macalister Irrigation District. In December 2006, a split allocation was announced for Macalister irrigators to maximise the volume supplied. An allocation of 45 per cent was made to irrigators in the Northern, Eastern and Tinamba/Riverslea areas, which could be supplied only from Lake Glenmaggie, and an allocation of 50 per cent was made for irrigators below Cowwarr Weir, who were supplied by the Thomson Dam.

Other measures

Pumping dead storage

In some of the worst periods of the Millennium Drought, water levels in several storages fell below their outlet valves. This meant that although the storages held some water, none could be released for consumptive use. It is sometimes possible to overcome this problem by pumping out the remaining water, known as dead storage. This can provide a valuable short-term benefit, but it is an expensive measure and the water pumped is effectively borrowing from the following year's supplies. This can affect the following year's allocation because the water must be replaced before the storage can be operated normally in the next year.

Goulburn-Murray Water pumped dead storage at Waranga Basin to increase supply to its customers (see Case study 3.4), while Southern Rural Water siphoned and pumped dead storage at Pykes Creek to supply irrigators in the Werribee Basin (see also case study 6.3). This measure has also been used to increase supply for urban centres (for example, Wangaratta from Lake Buffalo), and to provide environmental flows (for example, the Loddon River from Tullaroop Reservoir).

Waranga Channel *Photo: © Goulburn-Murray Water*

Case study 3.4: Pumping dead storage at Waranga Basin

Waranga Basin is a key off-river storage within the Goulburn irrigation network that contributes to irrigation and urban water supplies. About three-quarters of the basin's capacity (432,360 ML) can be delivered via gravity outlets. For three consecutive seasons between 2006 and 2009, Goulburn-Murray Water (GMW) pumped water from the basin below the normal off-take level. This had occurred only twice before, during extreme drought in 1926 and 2003.

Two temporary pump stations were installed during the 2006/07 season to enable access to 86,000 ML of water. GMW's decision to pump dead storage allowed an extra seven per cent allocation for high-reliability water share (HRWS) in the Goulburn system.

However, pumping was energy intensive and costly. For both the 2006/07 and 2007/08 irrigation seasons, the Victorian Government committed funding to meet the costs of pumping. In those two years, pumping and capital expenditure totalled more than $6.5 million. In 2008/09, the cost was borne by GMW customers (about $1.9 million), which is consistent with the policy set out in the Northern Region Sustainable Water Strategy (2009).

To avoid the need to pump in the 2009/10 season, once the allocation for HRWS in the Goulburn system was more than 30 per cent, GMW assigned half of any resource improvements to improving the allocation, and the other half to removing the need for pumping Waranga Basin and building a reserve to enable the irrigation system to run in the following year.

Further information:
http://www.g-mwater.com.au/water-resources/catchments/storages/goulburn/warangabasin

Improving system efficiency in the long term

Low water availability experience during the Millennium Drought reinforced the need for a major review of distribution systems, in particular irrigation systems, to minimise water losses in the short and long term. Infrastructure (including channels, control structures and meters) in the major irrigation areas across Victoria was generally about 50 to 80 years old and in a condition where normal maintenance and renewal could not meet the needs of modern day irrigation requirements.

In part based on the experience during the Millennium Drought, it was recognised that significant improvements in efficiency could be made by closing non-essential parts of the distribution systems, tighter delivery operation to minimise outfalls and unauthorised use, and reducing the length of the irrigation season.

While some of these projects, such as the Wimmera-Mallee Pipeline Project, were planned before the worst years of the Millennium Drought, they were imperative to maximising the volume of water available for all user groups during the Millennium Drought and into the future.

Water savings are achieved in different ways, depending on the nature of the existing supply system. Modernisation projects included measures such as pipelining (reduces leakage, seepage and evaporation), channel automation (reduces system spillage), introduction of modern metering, channel rehabilitation and lining, and channel decommissioning.

Major projects include:

- The **Northern Mallee Pipeline Project**, which began in 1994 and replaced 2,500 km of open, inefficient channels, saving an estimated 50 GL per year since its completion 2001.
- The $688 million **Wimmera-Mallee Pipeline Project**, which was designed to secure water supplies for 36 towns and about 2,300 domestic and stock customers[7]
- The **Macalister Channel Automation project** (2004), which provided up to 15 GL per year for the Macalister and lower Thomson rivers.
- The **MID2030 Strategy**, a complementary project to the Macalister Channel Automation project, which is underway and has the potential to create more than 37 GL of average water savings per year from reducing losses from existing infrastructure.
- The **Sunraysia Modernisation Project** (2013), which will provide on average 7 GL per year of environmental water.
- The $2 billion **Goulburn-Murray Water Connections Project** (formerly Northern Victoria Irrigation Renewal Project) (see Case study 3.5).

The verified water savings from modernisation projects are converted to entitlements to provide water for irrigators, towns and the environment.

Structural works to deliver environmental water more efficiently

As a result of continuing low water availability during the drought, and in particular the absence of wet years, environmental water managers increasingly considered artificial means (such as pumping) to deliver environmental water. The use of infrastructure can increase the efficiency and effectiveness of delivering environmental water in some situations. This allows environmental water managers to achieve beneficial environmental outcomes with significantly smaller volumes of water and without relying on high river flows.

For some wetlands and floodplain anabranches normally relying on overbank flows to fill them, infrastructure such as pumps and regulators were used to deliver environmental water. Several such structures have been built or are planned under the Living Murray project (for example, Lindsay Island, Hattah Lakes, Gunbower Forest). When resource availability improved in mid-2010, regulators installed at Lake Wallawalla in the Mallee region in 2006 facilitated the first major watering of the wetlands in more than 10 years.

When used appropriately, structural measures can offer an important alternative for environmental watering under a range of water availability scenarios.

7 The Wimmera-Mallee Pipeline has not replaced irrigation channels or infrastructure however, due to conditions of the past decade or more, most irrigators in the region sought to exit the industry.

Case study 3.5: Modernising the Goulburn-Murray Irrigation District – the Goulburn-Murray Water Connections Project

Since 2000, the Victorian Government has been increasing investment in modernising the irrigation distribution systems across northern Victoria. Water savings from earlier projects have been used to meet the Government's commitments to increase environmental flows through the Living Murray Initiative and the Snowy River Water Recovery Project.

The Goulburn-Murray Water Connections Project (GMW Connections Project) began in 2008, as the Northern Victorian Irrigation Renewal Project (NVIRP). In July 2012, the project was integrated into GMW as the GMW Connections Project.

The GMW Connections Project is the largest irrigation modernisation project in Victoria and aims to recover an annual average of 429 GL per year of water from the Goulburn-Murray Irrigation District (GMID). The $2 billion investment funded by the Commonwealth and Victorian governments aims to increase delivery efficiency in the GMID to at least 85 per cent, by reducing water lost historically through leaks, evaporation and other inefficiencies.

Water recovered under the GMW Connections Project will be distributed to the environment, Melbourne water retailers and irrigators. In addition to increased efficiency and recovering water, the GMW Connections Project will enable major restructuring of the irrigation system to ensure its long-term sustainability.

The restructuring involves a rationalisation of irrigation system infrastructure. The reduction in public assets is associated with on-farm adjustments including conversion to non-irrigation and significantly improved irrigation efficiency. In order to maximise the social and economic benefits of the GMW Connections Project and reduce adverse impacts on the environment, the GMW Connections Project is aligned with related on-farm and catchment management programs to recover water for the environment in the Murray-Darling Basin.

Lake Wallawalla regulator
Photo: © Lucy Alderton

Lake Wallawalla filled by pumping
Photo: © Lucy Alderton

3.4 Supplying essential needs on regulated systems

The conditions of the Millennium Drought required special measures, sometimes on an unprecedented scale, to ensure essential water needs were met. On regulated systems, significant lessons were learned about delivering water for domestic and stock customers and the environment under low water availability scenarios. Measures undertaken to secure urban water supplies are discussed in Chapter 4.

Domestic and stock supply

Since unbundling, many domestic and stock customers on the regulated water systems hold water shares with the same security as irrigators. Therefore, their water entitlement is a secure and tradable right, subject to seasonal allocation. This avoids creating a third product, which could be traded as a higher security share to irrigators.

However, because domestic and stock supply is for essential needs (household use and stock watering), the consequences are critical when not enough water is available to run a system. Most water shares for domestic and stock use are for small volumes of water (i.e. 2 ML). Therefore, even if enough water is available for a very low allocation (say, 5 per cent), that proportion of 2 ML is unlikely to be enough to meet the user's requirements.

Many domestic and stock customers can store up to five months' supply on their properties (in dams or tanks), and have additional supply available through rainwater tanks or groundwater bores. In extended dry periods, the capacity of many users to augment their supply is limited. At the time of unbundling, it was noted that the power to qualify rights under the Act may need to be used in severe droughts to ensure such users can access water.

However, it was necessary to qualify rights more frequently than anticipated, every year between 2006/07 and 2009/10 in most northern Victorian systems, to ensure domestic and stock water could be accessed. But qualifying rights is a temporary measure, and does not constitute a long-term solution if such dry conditions occurred more frequently and for long periods in the future.

Domestic and stock customers on a regulated system can be businesses or private home owners. In some cases, domestic and stock customers

Dry farm dam *Photo: © Goulburn Broken Catchment Management Authority*

can manage their own supplies through trade and carryover. However, for some small domestic holdings, this may be an unrealistic expectation, given their small volume of entitlement.

The first bulk entitlement to include provisions to prioritise water for domestic and stock use in a declared system under extreme dry conditions (when allocations are low or zero) was the *Bulk Entitlement (Bullarook System – Goulburn-Murray Water) Conversion Order 2009*. However, on systems such as the Goulburn, measures such as the new reserve rules, trade and carryover are expected to ensure enough water is available in most dry years to supply domestic and stock users, without the need to include special rules within bulk entitlements or to qualify rights.

Case study 3.6: Emergency supply to Wimmera-Mallee domestic and stock customers

Domestic and stock supply for customers connected to the Wimmera-Mallee supply system is delivered in accordance with the bulk entitlement held by Grampians-Wimmera Mallee Water (GWMWater). Before the Wimmera-Mallee Pipeline was built, water was delivered to town and domestic and stock customers' dams through a 20,000 km network of open, earth channels dating to the 1880s. The channel system was extremely inefficient, with losses of up to 85 per cent through seepage and evaporation.

The supply to domestic and stock customers' on-farm dams was not metered. In a water shortage, GWMWater could restrict customers to filling one dam per specified area (for example, one dam per 250 ha), depending on the severity of the shortage. GWMWater could reduce losses further by running only the more efficient channels.

Between 1997 and 2009, record low inflows were recorded in the Wimmera-Mallee system, with storage levels so low that not enough water was available to undertake all the normal channel runs. By January 2007, storages finished the month at 4.6 per cent of capacity. A winter channel run had been made to fill town storages only, including towns that normally received water from a summer channel run. There was not enough water to provide a summer channel run for domestic and stock supply to farms.

Most domestic and stock customers were not supplied with water from the channels. However, enough water was supplied to the town storages to provide emergency supplies for some 2,300 properties for basic domestic purposes. GWMWater carted 28,000 litres for domestic use every second month from the town storages to each rural customer not supplied by a channel, or where water in their dam had become unusable.

Customers could access additional water from urban storages for stock watering or crop spraying, provided they arranged for carting and covered the costs. Water could also be accessed by people who were not GWMWater customers (for domestic use only) under a permit system for carting.

The Wimmera-Mallee Pipeline

The Wimmera-Mallee Pipeline Project, which commenced in late 2006, proved more critical for securing water for urban and domestic and stock supplies than initially anticipated. Construction of the pipeline was completed five years ahead of schedule in 2010, due in part to the dry weather enabling construction to continue all year-round. As construction of sections of the pipeline were completed, towns and domestic and stock customers were able to receive emergency supplies via the pipeline rather than carting. The pipeline construction schedule was designed to reduce losses by minimising the number of channels run.

Managing environmental water requirements during drought

The Millennium Drought presented new challenges for the management of environmental water in Victoria. With less water available for the environment during the dry years, innovative approaches were employed to use the water available for maximum ecological benefits including:

- seasonal prioritisation of environmental water needs to achieve maximum environmental benefit
- changing the delivery pattern of passing flows
- use of consumptive water *en route*
- structural works to deliver environmental water more efficiently).

Where possible and appropriate, these approaches have been adopted into normal operations of the system where they have not affected existing water entitlements.

Some of the most important lessons about environmental water management during the drought were learned through processes for managing the impacts of qualifying rights in a waterway or system.

Seasonal prioritisation of environmental water needs – short-term management

Environmental managers had only small volumes of water available during the drought, and were forced to prioritise watering within highest priority sites. The focus shifted from improving and enhancing environmental outcomes to avoiding loss of species and catastrophic events, such as death of breeding stocks, mass fish deaths and algal blooms. Sites that provided drought refuge were given highest priority.

The then Department of Sustainability and Environment, in conjunction with catchment management authorities, developed an adaptive approach that allowed the relevant environmental manager to determine season by season where the available water was to be used to achieve the best possible long-term environmental outcomes in each system.

A list of environmental assets at risk was developed each season to help decide watering locations. Assets that provided drought refuge for fish, water birds and other animals were given highest priority (see Case study 3.7).

Complementary works and measures to enhance the benefits of environmental watering, or as alternatives when environmental watering was not an option, were also considered (for example, additional fencing to protect vegetation and drought refuges from trampling by stock). Some of this work was undertaken through drought employment programs, which were established to provide job opportunities for people such as farmers and landholders in the region whose livelihoods had been adversely affected by the Millennium Drought (NCCMA, 2008; WCMA, 2009). In dire situations, native animal populations were moved to less drought-affected areas (see Case study 3.8).

As resources improved and more water became available, assets further down the priority list were watered. In normal to wetter years, the focus is to reinstate high flows and floods to reconnect floodplains and restore environmental values that were unable to be maintained during the drought.

This adaptive approach was effective in managing through times of water shortage and is being incorporated into the future management of environmental water during all conditions.

Case study 3.7: Drought refuge and environmental watering in the Boort Wetlands

The Boort District wetlands are a collection of freshwater wetlands located on the Loddon floodplain near Boort. The system of lakes is known for its ecologically significant wetlands and birdlife, including hoary-headed grebes, red-kneed dotterels and yellow-billed spoonbills. In the past, high river flows typically filled the wetlands.

From 2003 to 2010, drought and low flows in the Loddon River meant most of the wetlands were dry. Little Lake Boort was the only wetland to retain water during this time. Due to very low water availability at the time, environmental managers focused on maintaining water in Little Lake Boort to ensure it remained a refuge for local and migratory species.

Water delivered in 2007/08 (300 ML) and 2008/09 (500 ML) was held under the Loddon River environmental water reserve bulk entitlement. In 2008/09, local community members donated a further 100 ML.

Water was gravity-fed into Little Lake Boort via Goulburn-Murray Water's irrigation channel system at the best possible time (subject to availability) to help ensure wetland productivity through summer and to maintain water levels during autumn. The wetland's water levels were kept below safe boating levels in recognition of its status as a refuge for wildlife, including threatened bird species such as bush stone curlews and grey-crowned babblers.

In 2009/10, water availability had increased sufficiently to allow watering to be extended to two other wetlands in the district – Lake Leaghur and Lake Yando. These wetlands were prioritised because they supported unique local habitat and vegetation, as well as a range of State and nationally significant birds and other wildlife. Watering objectives included maintaining vegetation and stimulating growth, avoiding loss of river red gum swamp and allowing the wetlands to continue as a drought refuge for waterbirds. The program was considered successful due to the positive response of the wetlands to these watering events.

Monitoring showed the presence of a range of birds and other wildlife, as well as marked improvements in vegetation such as cumbungi, river red gum trees and black box.

Further information: **http://www.depi.vic.gov.au/water/rivers-estuaries-and-wetlands**

Long necked turtle at Gunbower Reserve *Photo: © DELWP*

Case study 3.8: Murray hardyhead

The Murray hardyhead is a small fish native to the wetlands (both fresh and saline) of the Murray and lower Murrumbidgee river systems and to the rivers themselves.

The Murray hardyhead has a short life cycle – most adults live for only a year and the species is extremely vulnerable. Failure to breed in just one year can extinguish a population. Therefore the Millennium Drought put the species at serious risk of extinction. At this time, the Murray hardyhead remained at only three of its historical locations, and was introduced to an additional site in Victoria. These sites, where the Murray hardyhead lived, were vulnerable to drying out during the drought this meant it was vital to provide environmental water each year not only for recruitment but also for survival of the species.

Environmental water has been delivered to key Murray hardyhead sites since 2007. An additional site (Koorlong Lake) became part of the recovery program in 2009–10 when Murray hardyhead were introduced to the site. Other sites include Cardross Basin in the Mallee region and Round Lake and Woorinen North in the North Central region.

All four sites need to be regularly topped up with environmental water to maintain the depth and salinity levels that will allow the Murray hardyhead to breed.

Each year the sites received small amounts of water with the aim of keeping the fish populations alive by maintaining water quality, salinity and habitat conditions over the hot summer months and into the following year. One of the main aims is to keep water levels high enough in spring and summer to submerge the beds of water plant, Ruppia, protecting Murray hardyhead eggs laid there.

The water provided to the Murray hardyhead sites during the Millennium Drought kept the fish populations alive, and also saw successful breeding and recruitment. Monitoring showed watering maintained dissolved oxygen, turbidity, salinity and depth to acceptable levels for Murray hardyhead, which kept the populations stable. In addition, the captive breeding program at the Murray-Darling Freshwater Research Centre in Mildura successfully bred Murray hardyhead as a risk mitigation strategy.

Changing delivery pattern of passing flows

In river systems where allocations remained very low for long periods (for example, the Loddon River), bulk entitlements were qualified to prioritise the delivery of essential water needs. While the amount of water available for the environment was reduced, flexibility for the environmental flow manager was built into the qualification to allow available passing flow volumes to be delivered as a variable flow. This could occur at the discretion of the environmental flow manager once certain triggers were met.

An important reason for this change was that, under drought conditions and reduced flows, pulsed flows would provide more ecological benefits than a constant low flow rate. The environmental manager would make an assessment, based on advice from ecologists, about how long the passing flows should be held in storage until sufficient volumes were stored to release a pulsed flow. This was successful on the Loddon River in preventing the development of blackwater[8] conditions, which would lead to fish deaths (see Case study 6.6).

The variable delivery of passing flows was recognised as being beneficial under any water availability scenario. Where possible, allowing flexibility in the delivery of passing flows has since been incorporated as a permanent measure in some bulk and environmental entitlements provided it does not erode existing water entitlements.

8 Blackwater events are caused by floodwater leaching carbon from accumulated leaf litter, which typically causes discolouration of water, and low dissolved oxygen levels due to rapid breakdown of the dissolved carbon by micro-organisms. The lack of dissolved oxygen can result in the death of fish, crayfish and other aquatic animals.

Using consumptive water en route (inter-valley transfers)

In northern Victoria, the system operator and environmental managers worked together to achieve environmental benefits from the transfer of water from the Goulburn River to Sunraysia. Rather than delivering this water (known as inter-valley transfer water) to the River Murray via the Goulburn River, some water was redirected via the Waranga Western Channel and the lower Campaspe River. Lower Campaspe River flows had been low for an extended period due to the drought. The re-directed inter-valley transfers provided a much-needed boost to the river ecology of the lower Campaspe River. The extra losses incurred through the use of a less direct route to the River Murray were accounted against the environment's River Murray allocation. This allowed the environment to benefit from larger river flows while only using a relatively small volume of environmental allocation.

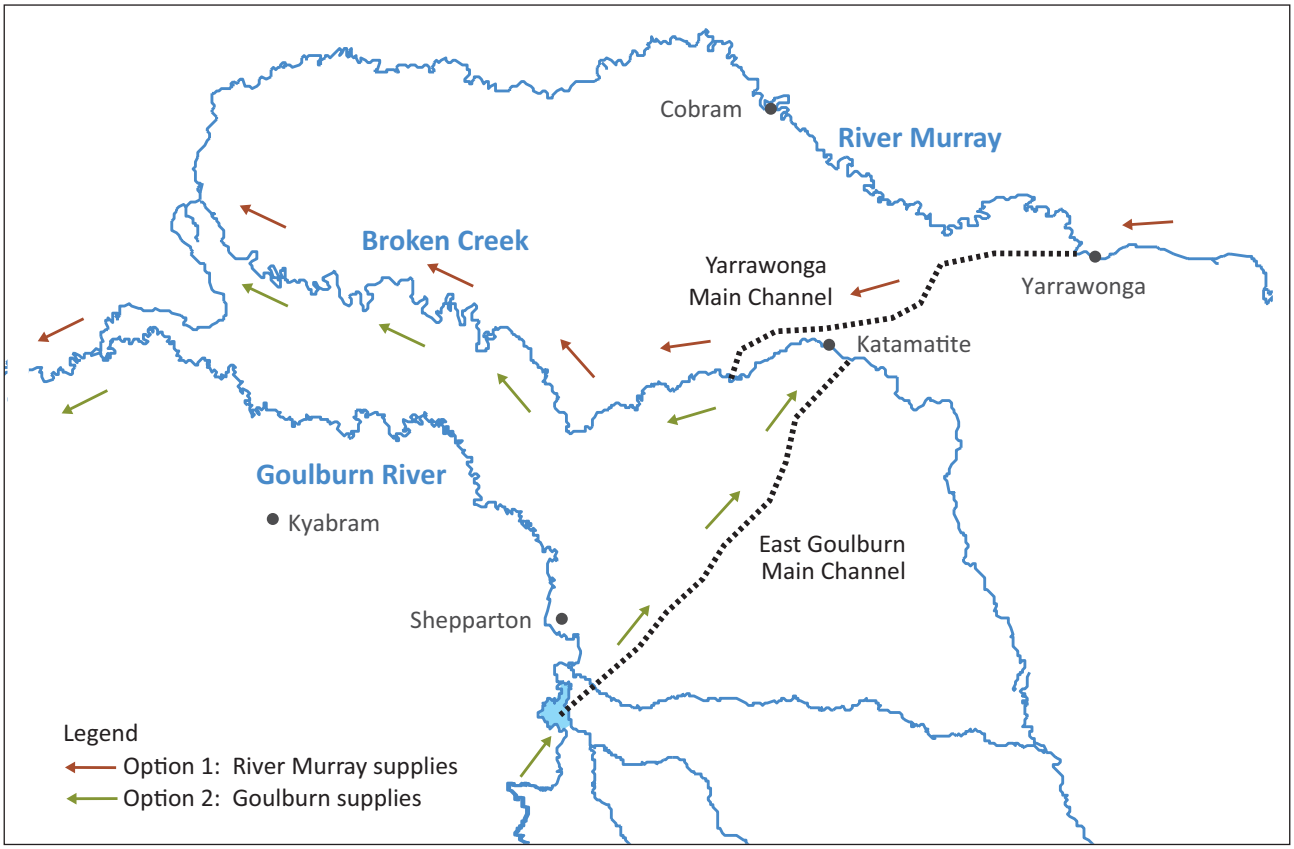
In a similar case, water was diverted from the Murray and Goulburn systems via channels to Broken Creek to provide environmental benefits (protection of Murray cod) en route to the River Murray (see Figure 3.5).

Regardless of droughts, Goulburn-Murray Water considers opportunities for providing environmental benefits from consumptive water en route in its river operations and in consultation with catchment management authorities, consistent with the outcomes of the Northern Region Sustainable Water Strategy.

Using Return Flows for environmental benefit

Return flows enables the environment to apply flows to a specified of nominated delivery point and if the water is returned to the bulk water system the water can be re-credited to the environment for use further downstream. The environment can apply for return flows if the volume returned is measured, or calculated by a method agreed with the resource manager, the water can be reused downstream within a specified timeframe, the storage manager can re-regulate the water, the volume credited does not exceed the volume which can be stored or used and the approval is consisted with any rules regarding the supply, use and accounting issued by the Minister.

Figure 3.5 Options for using consumptive water en route in the lower Broken Creek (source: DSE, 2009)



This gives the environment flexibility to better use the water resources available to them and to enable environmental water flow down the length of the river. That is environmental managers are able to use return flows at multiple sites along a river and return flows to their highest value use. For example, flows released down the Goulburn River could be used again at Gunbower Forest and flows returning to the river can be used again at another downstream site, such as Hattah Lakes, and delivered to South Australia. This has significantly reduced the amount of water recovery required to meet environmental objectives, particularly in the Murray-Darling Basin. A key priority for environmental managers is to identify opportunities for reuse.

Return flow provisions are included in the environmental entitlements held on the Murray, Goulburn and Campaspe systems.

3.5 Increasing options for entitlement holders in the medium to long term

The severity of the Millennium Drought water shortage reinforced the need for providing flexibility for entitlement holders to manage within the water available to them. Carryover was one of the most important measures introduced to improve flexibility in the longer term, and refinements of the water market and trade options also helped entitlement holders during the driest years. These measures and the lessons learned are discussed in the following sections.

Establishing carryover

Carryover was introduced in the northern Victorian systems in 2006/07 as a short-term drought contingency measure to help individuals mitigate the consequences of low starting seasonal allocations.

The carryover rules originally enabled entitlement holders to keep 30 to 50 per cent of their water allocations in storage for use in the following year, depending on the system. However, they were permitted only a total allocation (carryover water plus allocation in the following year) of 100 per cent the next year.

Carryover has since been made a permanent measure for the northern Victorian systems because it allows individuals to manage their own risks of supplies in the future, recognising that entitlement holders are best placed to judge and manage their own needs. In southern irrigation systems, carryover was temporarily introduced in the Werribee and Bacchus Marsh irrigation areas in 2005/06 and 2006/07 to enable continuity of supply between seasons in years of very low opening allocation. The practice was discontinued when the Werribee system was unbundled on 1 July 2008 and re-introduced as a permanent measure in 2014/15. Carryover does not apply in the Macalister Irrigation District because Lake Glenmaggie is relatively small and has no spare capacity to store water carried over.

Carryover for towns and the environment in northern Victorian systems was introduced through qualification of rights; however, an amendment to the *Water Act 1989* (the *Entitlements Bill 2010*) has provided the Minister administering the *Water Act 1989* with power to declare ongoing carryover rules for bulk entitlements, water shares and environmental entitlements.

Carryover rewards efficient use of water and removes the past 'use it or lose it' approach to unused allocation. However, the initial conservative rules introduced in 2007 had limited use in wet or average years, where there was a risk that entitlement holders could miss out on allocations if the water carried over plus allocation exceeded 100 per cent.

Carryover benefits for a variety of users

The opportunity to carry over allocation has been increasingly utilised by irrigators, water corporations and the environment. In the largest systems where carryover is available, the Goulburn and Murray, the carryover volumes more than doubled in the first two years (from 128 GL carried into 2007/08 and 281 GL carried into 2008/09 (see Figure 3.6 and Table 3.3) The use of carryover peaked following the floods when more than 2,500 GL was carried into 2011/12. Since then the volumes carried over each year have been decreasing as conditions have started to dry.

Carryover is particularly important for irrigators during low allocation years because, provided the system is operational, it means they can access water at the beginning of the season when allocations are low or zero. Carryover increases the options available to individuals with different needs by allowing irrigators to have water available at crucial times for their businesses. For example, sufficient water availability is important early in the season for bud set or fruit set periods for horticulturists, while dairy and cropping farmers require water during spring (DSE, 2009).

Carryover gives environmental water managers

greater flexibility to manage key environmental assets and ensure survival of aquatic plants and animals in the years of greatest water shortage. In drought years when allocations are very low, water carried over from previous years can be used to provide a minimum supply, provide baseflows in river systems and top-up drought refuges. In wet years, water carried over can be used to flood important wetlands, such as Barmah Forest and Gunbower Forest.

Carryover is also available for urban water corporations on the northern systems, which now use carryover to help manage through dry years and avoid severe water restrictions. This option should ensure essential urban supplies can be met in severe water shortages and reduce the need for Government intervention to qualify rights. The management of urban supplies is discussed in Chapter 4.

Improved carryover arrangements have expanded the time reach of the water market. No longer does the end of an irrigation season mean total uncertainty about future water availability. While new allocations will be totally dependent on storage levels and inflows, individuals can use the market during one season to set themselves up for future seasons.

Figure 3.6 Volume of water carried over on Murray and Goulburn systems between 2007 and 2015

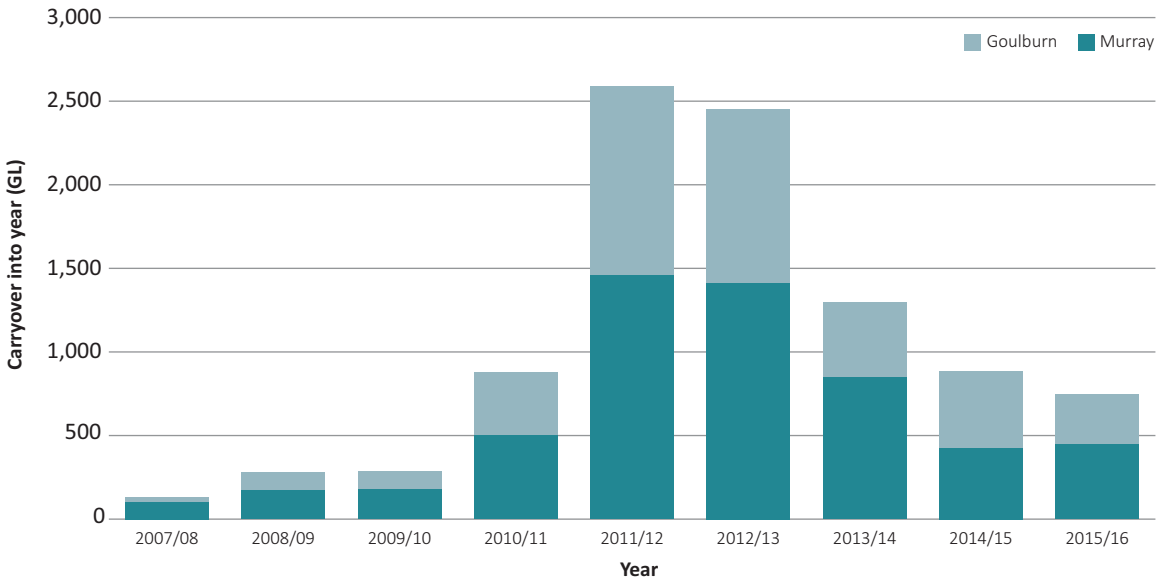


Table 3.3 Volumes of water carried over across all systems with carryover between 2007 and 2015

Year	Volume carried into each year (GL)						
	Murray	Goulburn	Campaspe	Loddon	Broken	Bullarook	Werribee
2007–2008	102	25					
2008–2009	173	103	2.5	0.8	7.6		
2009–2010	176	109	1.4	0.9	2.5		
2010–2011	500	380	1.2	1.7	4.1	0.1	
2011–2012	1,459	1,128	44	14	11	0.8	
2012–2013	1,412	1,040	43	12	10	0.7	
2013–2014	848	447	25	9.3	8.7	0.4	
2014–2015	425	456	26	8.9	7.5	0.5	4.8
2015–2016	448	298	13	6.4		0.5	6

Refinement of the carryover rules

The carryover rules have been refined a number of times since they were established. Figure 3.7 provides a timeline of carryover reform.

When the carryover rules were introduced in northern Victorian water systems in 2007, there was concern that the amount of unused water going to the reserve pool would be reduced, therefore resulting in lower allocations. As a result, the initial carryover rules were designed to limit the magnitude of this impact by restricting entitlement holders to carrying over up to 30 per cent of the volume of their entitlement.

In late 2007 an initial review was conducted, overseen by a committee comprising irrigators, industry bodies and water corporations. Public submissions were invited on a discussion paper, and the committee recommended that the initial rules remain in place. Following this review, the then Minister for Water announced in February 2008 that carryover rules would be made permanent, and extended to the Campaspe, Broken, Loddon and Bullarook systems, but would be reviewed when high-reliability allocations recovered.

In February 2009 the carryover limit was increased to 50 per cent for all systems, this was done to give individuals more flexibility to make their own risk management decisions. Following this, in March 2010 carryover rules were reviewed as part of the Northern Region Sustainable Water Strategy consultation process with independent experts, key water industry stakeholders, urban, rural and environmental
water users and the broader regional community.

The aim of the review was to overcome the limitations and maximise the flexibility and benefits of carryover. One of the key outcomes of this process was the introduction of new carryover rules for the Murray, Goulburn and Campaspe systems, including the creation of spillable water accounts to replace the original 100 per cent rule. This meant that rather than missing out on increased allocations, once allocations plus carryover reach 100 per cent of entitlement volume in a customer's allocation bank account (ABA), any further allocation volume is credited to the entitlement holder's spillable account, and will be lost only if the storages spill.

The Northern Region Sustainable Water Strategy outlined the new carryover rules for the 2010/11 season, including:

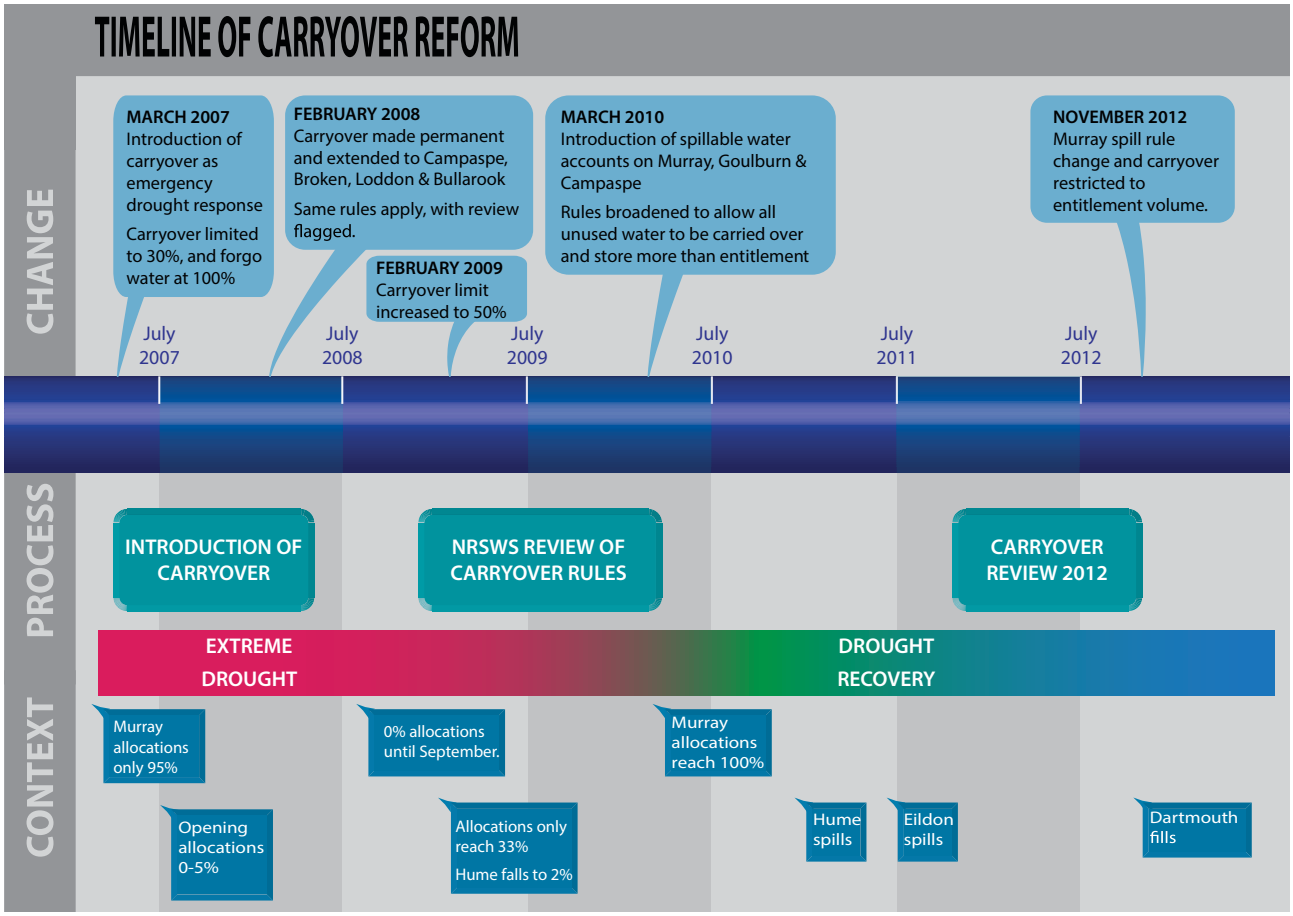
- entitlement holders can carry over any unused water in their ABA at the end of the season
- five per cent of water carried over at the end of the season will be deducted to account for evaporation losses in the following year
- where an entitlement holder has high and low-reliability water shares linked to the same ABA, water carried over will be deemed to be recorded first against low-reliability water shares, then against high-reliability shares
- carryover water, up to entitlement volume, will be available in the ABA at the start of the following season. Carryover above entitlement will be recorded as spillable water
- until the resource manager declares that the risk of the storages spilling is very low, any carryover plus allocations above 100 per cent of entitlement volume will be recorded in the entitlement-holder's spillable account, rather than being lost to the entitlement holder
- water held in a spillable account will be set aside for the entitlement holder, but unavailable for use or trade until a declaration of low spill risk is made by the then resource manager.

If the storages spilled, water in all spillable accounts spilled proportionately, up to the total volume spilled from the storages. Entitlement holders fully bore this risk of spill however, they get the benefit of having access to more storage volume than their total water shares volume when there is room available in the storage.

In 2012, a carryover review committee was formed to bring together water users and water corporations from across northern Victoria to look at how the reforms to the carryover provisions introduced in 2010 were working. This review recommended changes to the rules which were introduced in 2013 and 2014, including:

- Basing the spill rule for the Murray system on Hume Dam to reflect the fact that spills are more likely to occur in Hume Dam than Dartmouth Dam.
- Limiting carryover, so that entitlement holders cannot carry over more than their full water share volume at the end of the season.

Figure 3.7 Timeline of carryover reform



- Allowing entitlement holders to choose to return unused allocation to the communal pool at no cost.
- Introducing new limits on trading allocation between valleys to avoid the need for sudden trade suspensions.

Further information on carryover rules and the review processes can be found at the following link: **http://waterregister.vic.gov.au/water-entitlements/carryover**

Water markets and trade

In times of water scarcity, water markets provide an opportunity for participants to make their own decisions about when and whether to use water in a given year, and how much capital they want to spend on water assets (provided that there is sufficient water to operate the water supply system). Water users can buy additional water when allocations are too low to support particular uses, or generate revenue if they choose to sell part or all of their allocation. Trade is generally more active in dry conditions when seasonal allocations are low, because this is when the scarcity value of water increases (DSE 2008a). Individuals can also choose to buy or sell entitlements permanently (buy others' entitlements or sell their own).

As for any market, the water market depends on different water users having different needs for water and valuing it differently. At a given price, some people will be willing to sell and others willing to buy. These decisions are driven by the types of businesses in which individuals are involved, as well as personal and financial circumstances. The diversity of uses of water and the timing of demands for water also strengthens the market.

In Victoria (and throughout the southern Murray-Darling Basin), irrigated agricultural uses can be classified into three categories: annual cropping, dairy farming and horticulture. Annual cropping (cereals and fodder crops) is the most flexible, with croppers likely to see value in selling their water allocation when the price is attractive. Dairy farmers have some flexibility in that they can buy fodder or grain as a substitute for irrigating their own dairy pasture. Horticulturists have the least flexibility

in their use of water allocation, because of the permanent nature of their plantings, and therefore place the highest value on water. Horticulturists are likely to buy water from more flexible users when the starting allocations are low. Later in the year, dairy farmers and annual cropping farmers may also buy allocations.

A range of business drivers influences individual trade decisions between and within each of these industry sectors.

When the extreme dry conditions hit in 2006/07, water rights were in the process of being 'unbundled' from land in northern Victoria. Most water entitlements in northern Victoria were unbundled as of 1 July 2007, including water rights, domestic and stock allowances and take-and-use licences for regulated water systems managed by Goulburn-Murray Water and Lower Murray Water. In southern Victoria, water rights and diversion licences were unbundled for Southern Rural Water's Werribee/Bacchus Marsh and Thomson/Macalister systems as of 1 July 2008.[9]

Unbundling of rights proved to be timely given the dry conditions, making it easier for people to use the water market, even if it was through necessity in some cases.

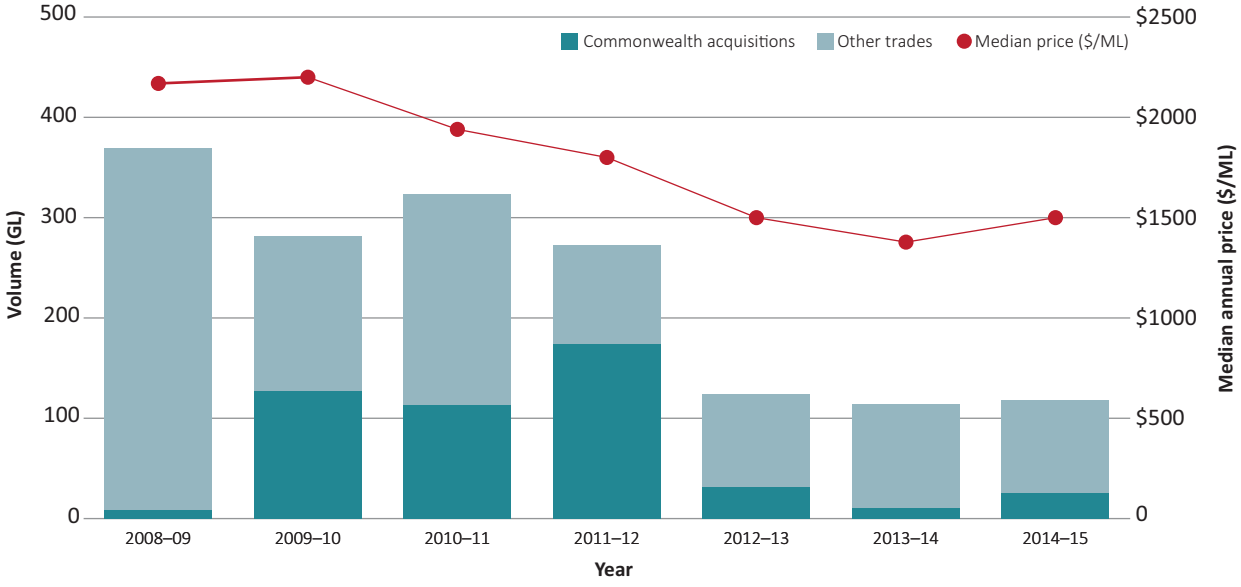
Drought has also forced increased scrutiny and rigour of trading rules and processes in response to customer queries and challenges. Examples include the management of the annual ballot for trade out of systems when trade out was limited to 4 per cent per year, and the reporting of processing times for trades against an agreed service standard.

Northern Victoria water markets

Historically the major water users in northern Victoria were irrigators who have utilised the water market heavily. During the Millennium Drought water was recovered for the environment which by July 2015 held 30 per cent of northern Victorian high-reliability entitlements. A large part of the environment's entitlement was acquired between 2009 and 2012 by the Commonwealth Government purchasing water shares from farmers who chose to sell their entitlements. Figure 3.8 shows that the price and volume of water shares transfers dropped away when the Commonwealth pulled out of the market.

From 1991 to 2009 there was a net trade of water shares out of the Torrumbarry, Central Goulburn and Murray Valley districts, and a net trade into the Lower Murray Water private diverter areas[10]. These net trade movements may reflect the retirement of salt-affected land, and a shift from mixed farming and dairy enterprises (for example, Torrumbarry) (See Figure 3.9). Since 2009 there has been continued reduction in the volumes of water shares tied to land in northern Victoria and an increase in the volumes held by water corporations,

Figure 3.8 High-reliability water share transfers in northern Victoria 2008/09 to 2014/15



9 **http://waterregister.vic.gov.au/about/water-reform-history?highlight=WyJ1bmJ1bmRsaW5nIl0=**

10 **http://www.waterregister.vic.gov.au/Public/ReportsOnTrade.aspx**

the environment and private users who have not connected their water shares to land.

While it is difficult to compare trade pre- and post-unbundling, it is evident from trade activity during the Millennium Drought that the market is an important tool in years of low water availability (see Table 3.4) (DSE, 2009). Price trends have also reflected the scarcity value of water. In 2007/08 and 2008/09 the median allocation price was over $300/ML which dropped to $20/ML in 2011/12 when Victorian and interstate allocations were high and when there was lots of carryover water available.

Higher allocations in New South Wales in the latter years of the drought increased the volume of water available on the market, providing northern Victorian irrigators, businesses and environmental managers with the option to buy water from other supply systems such as the Murrumbidgee.

Trade in Southern Victoria

In southern Victoria, although much smaller in scale, trade in the Thomson/Macalister and Werribee systems has been an important part of the irrigators' and water corporations' management responses to water shortages.

Figure 3.9 Change in high-reliability water shares linked to land, by area, 2001 to 2015

Table 3.4 Summary of annual allocation trade in Northern Victoria 2007/08 to 2014/15

Year	Total allocation trade volume (GL)[a]	Median price ($/ML)[b]	Murray seasonal allocations at 1 December
2007/08	508	$325	26%
2008/09	603	$320	24%
2009/10	758	$161	57%
2010/11	778	$33	100%
2011/12	1,152	$20	100%
2012/13	1,403	$46	100%
2013/14	1,284	$75	100%
2014/15	1,310	$123	100%

Notes:

a. Excludes trades between environmental accounts (which represent the environment moving water around for use in required areas).

b. Median annual allocation price for trading zones 1A (Greater Goulburn) and 7 (Murray below the choke) (Zero price trades have been excluded from this data set).

In the Werribee system, the ability for the market to provide opportunities for irrigators to manage their water supply risks during the drought was limited by very low allocations, the small number and volume of entitlements and difficulty of transferring water between Werribee and Bacchus Marsh irrigation areas. However, trade rules have were amended in 2009/10 to allow Werribee irrigators to buy allocation from irrigators in the Thomson/Macalister system, using the Melbourne delivery system as the transport mechanism. Although the volume of trade will be limited, it opens the door for Werribee irrigators (more impacted by drought) to take advantage of the wetter conditions of south eastern Victoria.

Case study 3.9: Unprecedented low inflows drive trade in the Latrobe Valley

As a result of record low inflows in 2006/07, entitlement holders on the Latrobe River system faced supply shortfalls. Gippsland Water, power generators and the Latrobe River irrigators were all looking to source additional water to cope with the impact of the unprecedented low inflows.

At that time the Government held 10.4 per cent of the water in Blue Rock Reservoir in the Latrobe Valley, under the Loy Yang 3/4 bench bulk entitlement and a further 35.6 per cent had not been allocated. None of this water was allocated for use.

Water users in the Latrobe system sought access to the unused water in Blue Rock Reservoir during 2006/07. The Government recognised the value of this water during times of scarcity and the need to encourage all users to pursue water-efficiency measures or other alternative supplies that may be available. The Government decided to make some of the water available through the market. By using the market, the Government sent an appropriate signal about the value of the water, which meant if users could pursue water-efficiency measures at less than the market price, they would have the incentive to do so.

The Government placed 12,000 ML of unallocated water on the market in small tranches over several weeks. The initial reserve price was $70/ML. Irrigators, Gippsland Water and the power generators all bought water at prices ranging from $70 to just over $280/ML. Proceeds from the sale were used to meet the Government's costs of storing the water.

This market-based approach worked well in sharing the available resource between users and providing some indication of the value of water in the Latrobe Valley. However, the final price was considered low and was unlikely to create much incentive for water users to pursue water-efficiency measures or alternative supplies. Faced with the prospect of a drier future, the Government believed that a stronger price signal should be sent to users seeking access to unallocated water in Blue Rock Reservoir. So it decided that a higher reserve price should be set to send strong signals about the value of that water and the need to promote sustainable water use.

While the heavy rain in June 2007 reduced the need for access to the Government's water, certain power generators again sought access during dry periods in 2008/09. In response, the power generators were advised they could buy the unallocated water on a temporary basis for $1,500/ML. No purchases were made at this price. In the meantime, storage levels have improved and power generators continue to pursue their own water-efficiency measures and alternative supplies.

In response to the Millennium Drought, the power generators have reduced water use by 5 per cent on average over the past few years. One power station has reduced its water use by 25 per cent in the past four years.

The future use of unallocated water in the Latrobe system was considered as part of the Gippsland Region Sustainable Water Strategy. In July 2013, 9 per cent of the unallocated share was converted to an environmental entitlement and the remaining 22.73 per cent was used to establish a drought reserve from which current and future entitlement holders can buy water during water shortages. In July 2014, 3.87 per cent was purchased by Gippsland Water to meet future growth needs. Government still holds the 10.4 per cent share under the Loy Yang 3/4 bulk entitlement.

Trade and the environment

The Millennium Drought reinforced the need to establish secure entitlements to water for the environment. Surplus flows to entitlements in a system were rare during this period, and in several systems, passing flow obligations in corporation entitlements were reduced due to the severity of the shortage for essential consumptive needs.

One measure for securing additional water for the environment has been through buying water shares through the water market. A large volume of water entitlements have been purchased by the Commonwealth Government in northern Victoria since 2006/07 for environmental use. The effectiveness of water markets during the Millennium Drought depended on a large pool of entitlement holders prepared to sell their allocations. Many of these entitlement holders have since sold their entitlements to the Commonwealth.

The establishment of the Victorian Environmental Water Holder in 2011 provides the opportunity for trading allocation or entitlements in regulated systems to maximise environmental benefits.

As per all entitlement holders, carryover and water trade are tools used by environmental water holders to enable environmental water to be used when and where it is most needed. Carryover and trade give environmental water holders the flexibility to mitigate against risks associated with climate variability and optimise the benefits for the environment. In some systems, carryover rules allow environmental water holders to retain unused water in storage at the end of the year, which can then be used to meet environmental watering priorities in future years.

Any decision about trading water is made independently by environmental water holders, and decisions are based on good water demand/supply analyses that allows environmental water holders to decide whether to carry over water for following years.

3.6 Summary

The extreme water shortages of the Millennium Drought enabled Victoria's water managers to demonstrate their resourcefulness in making the small amount of water available go further and ensuring it went to where it was needed most, including the environment.

Operators of large regulated water systems were able to adapt their operating rules for dry conditions to improve system efficiency and maximise allocations. This involved measures to reduce the volume of water required to operate the system and access dead storage in reservoirs.

Thomson Dam *Photo: © Melbourne Water*

In the northern Victorian irrigation systems, the Government introduced mechanisms such as carryover to provide irrigators with extra flexibility in managing their water entitlements. It also began implementing changes to the reserve rules where possible to reduce the risk of beginning a new season with zero allocation. These mechanisms were introduced through the Northern Region Sustainable Water Strategy, which was prepared during the worst years of the drought and provided a conduit for community consultation and feedback.

Once enough water was available to operate the system at the start of the season and make a small allocation, the well-established water markets in northern Victoria enabled individuals to adjust their allocations via trade, ensuring water could go to its highest value uses. Water markets in southern Victoria, while much smaller, were active in the larger regulated systems, giving entitlement holders a means of adjusting their entitlements and/or water use.

Some communities affected by the Millennium Drought benefited from major water infrastructure modernisation projects such as those in the Shepparton and Central Goulburn distribution systems, the Wimmera-Mallee Pipeline, and more recently, the Goulburn-Murray Water Connections Project. Progress on these projects during the latter years of the Millennium Drought eased the impact of the dry conditions on communities.

In the large interlinked regulated water systems of northern Victoria, the Dry Inflow Contingency Planning Group was established in 2006. Consisting of water managers from a range of interests, this group was able to coordinate the response to water shortages and ensure essential needs for water were met for consumptive and environmental use.

With less water available for the environment during the Millennium Drought, innovative approaches were employed to use the water available for maximum ecological benefits. These included structural works to deliver environmental water more efficiently, making use of consumptive water en route to other destinations, and changing the seasonal priority of environmental water needs and the delivery pattern of passing flows to achieve maximum environmental benefit.

Many of the above changes to long-standing approaches provide extra management flexibility for water managers faced with a possible drier future and have been incorporated into system operating rules and procedures and bulk entitlements.

Sheep in the Goulburn catchment *Photo: © Alison Pouliot*

4. Securing urban water supplies

This chapter describes how urban water supplies were affected by the Millennium Drought, particularly from 2006 to 2009. Urban water corporations coped with the extremely dry conditions in a number of ways, depending on their supply system design, entitlement rules, and water resource planning. This chapter describes the difficulties experienced by urban water corporations, the types of contingencies implemented to manage the dry conditions, and the lessons learned through this experience.

4.1 Urban supply systems

The Millennium Drought presented the following range of challenges to urban water corporations depending on the nature of their supply system:

- Urban corporations supplying towns from rural regulated systems receive a bulk water allocation from the system operator (for example, Goulburn-Murray Water) and the initial supply risk is borne by the system operator which must ensure enough water is available to run the system. The system operator manages water shortages and less water across the entire regulated system by limiting allocation to entitlement holders, therefore, urban corporations were required to manage supply to urban centres within very low allocations.
- Urban corporations with large storages have historically relied on the volume of water in these storages (which are designed to hold several times the region's demand) to maintain supply to urban customers until droughts break. However, these systems were not designed to cope with such prolonged dry periods as that experienced during the Millennium Drought. As a result, stored reserves were progressively drawn down without significant replenishment, and additional contingencies were required (for example, Geelong, Bendigo and Ballarat).
- Urban corporations with small storages are typically in higher rainfall areas of Victoria, supplying relatively small populations from an unregulated system. The storages operate on an annual basis where they are typically drawn down through summer and autumn, and replenished during winter and spring. During the Millennium Drought storages were drawn down to low levels and did not refill (for example, Leongatha, Sunday Creek and Apollo Bay).

Water tower, Nagambie *Photo: © Robert Mason*

4.2 Performance of urban bulk entitlements

Urban water corporations are responsible for maintaining reliable supplies to their respective urban centres within the supply arrangements set out in their bulk entitlements. Bulk entitlements set the rules on how water for urban supply may be taken. These rules were based on historical supply arrangements, streamflow records and infrastructure capacity. In many cases, the unprecedented dry conditions depleted the water resources to such an extent that there was a risk that essential town needs could not be supplied. In order to prevent this situation occurring, qualification of rights to water was often the only practicable course of action.

For towns with small storages, bulk entitlements were qualified if there was a risk that the town's essential needs could not be met and there was no practicable alternative option to supply water or reduce demand (see Case study 4.1). The qualifications allowed towns to harvest more water from the waterway by reducing the passing flow or providing a new extraction point. Where this occurred or has the potential to occur in future, urban water corporations have, or are taking steps to augment their supplies.

Case study 4.1: Maintaining supplies to South Gippsland towns

The water supplies to towns in South Gippsland from Cowes on Phillip Island to Seaspray on the 90-Mile Beach have their own small on-stream or off-stream storages. These storages typically are large enough to meet the towns' water needs from the time they stop spilling, usually in early summer, to when they start to refill the following winter. But river flows were so low in the winter and spring of 2006 that the storages did not refill. Some towns (Leongatha and Korumburra) were on Stage 4 restrictions from early July 2006 and most towns were on Stage 4 restrictions by the end of the year. During this time, water corporations implemented emergency measures to maintain a water supply to their towns.

Westernport Water was able to maintain supply to its towns (including Cowes, San Remo, Corinella, Kilcunda and Dalyston) by transferring water from South Gippsland Water's Wonthaggi system, building a pump station on the main branch of the Bass River and a pipeline to its reservoir, and developing new groundwater bores connected to the new pipeline.

South Gippsland Water (SGW) was able to maintain supply to Wonthaggi by pumping from a new off-take on the Powlett River and building a pipeline to its Lance Creek storage. SGW also investigated pumping from the disused Wonthaggi coal mines but found only water of poor quality.

SGW maintained water supply to towns serviced by the Leongatha and Korumburra systems by installing temporary pump stations on Coalition Creek and the Tarwin River west branch. The Tarwin River water was transferred to the Leongatha and Korumburra storages by reinstating a disused gravity outfall pipe and pumping in the reverse direction via staged booster pumps. Groundwater bores were drilled but only a few yielded useful volumes of water.

SGW maintained water supply to towns serviced by the Toora system by reducing passing flows on the Agnes River through a qualification of rights.

Rights were qualified to enable implementation of those contingency measures, which involved the water corporation taking more water from streams than allowed under their existing entitlements. The qualifications were justified as an emergency measure to ensure water corporations were able to supply a basic level of demand to households and avoid the closure of industry where it was a significant employer in the region.

Supply was maintained to some smaller towns (Seaspray, Loch, Poowong, Nyora and Fish Creek) by carting water. In the case of Loch, Poowong and Nyora, SGW carted water from the disused Korumburra coal mine.

Westernport Water (WW), SGW and Gippsland Water (GW) have since implemented a number of long-term solutions to secure supply to their towns if there is ever a recurrence of the dry conditions of 2006.

For example: WW secured an entitlement to the Bass River in 2009 which allows it to pump water from the Bass River into Candowie Reservoir during high flow winter months. In 2013, WW augmented the size of the reservoir, increasing it from 2263 ML to 4463 ML allowing WW to store more water in wet years and store it for dry years, and in June 2014 secured an entitlement to water from the Melbourne water supply system.

SGW has increased reliability of towns supplied from the Tarra River system through additional supply from a new groundwater bore. In June 2014, Wonthaggi (and the rest of the Lance Creek system) was connected to the Melbourne water supply system and SGW secured an entitlement to water from the Melbourne water supply system.

GW has augmented the off-stream storage at Seaspray to enable it to store sufficient water during winter and spring to supply the town in summer and autumn until streamflow increases.

The emergency contingency measures for Korumburra will be continued until the long-term solution is completed. These measures allow SGW to access more water in the winter/spring period from the Tarwin River while reducing the risk to the environment by minimising summer pumping.

The urban water corporations hold bulk entitlements and some hold water shares. Some urban bulk entitlements supplied from regulated systems are linked to seasonal allocation determinations. The security of urban water corporation's bulk entitlements differs depending on the system.

For example some urban delivery bulk entitlements in the Macalister, Loddon and Campaspe systems have a 50 per cent 'floor', which means that even when irrigation allocations are zero, towns on these systems are entitled to receive 50 per cent of their annual entitlement. In contrast, urban bulk entitlements held for the Murray system have annual allocations which are essentially identical to allocations against water shares for irrigation. This meant that when there was not enough water for an allocation at the beginning of 2007/08, it was necessary for the Minister for Water to qualify rights to water in the Murray system to ensure town supply could be delivered as a priority. Under current arrangements water corporations would be able to enter to water market to supplement supply.

The rules that allow a 50 per cent 'floor' allocation every year can place an impractical obligation on the system operator, as that volume may be more than necessary to meet essential needs. In a situation where there is not enough water in the system to run the river or meet essential domestic and stock needs, this obligation could unnecessarily restrict the capacity of the system operator to meet other entitlements.

Another issue that arose during the Millennium Drought was water corporation ability to flexibly manage water resources under their bulk entitlements. When water corporations held separate entitlements to water in the same regulated system it reduced the operational flexibility of urban water businesses to supply urban centres. Coliban Water and Goulburn Valley Water each held a number of bulk entitlements for towns supplied by the Goulburn system. These bulk entitlements specify the annual extraction volumes and daily rates at specified diversion points. These arrangements reduced the corporations' flexibility to manage their overall resource entitlement by transferring water between various supply systems to the towns where it was most needed.

The bulk entitlements were subsequently amalgamated into one flexible bulk entitlement for each water corporation. This increased management flexibility by enabling water corporations to spread the available resource more efficiently across their urban supply systems.

Korumburra water treatment *Photo: © South Gippsland Water*

4.3 Performance of drought response plans

Before drought response plans (DRPs) were introduced in the mid-1990s, urban water corporations had few contingencies in place to manage drought. Many water corporations relied on technical and financial assistance of governments to implement emergency supply measures (Moran, 2000). DRPs describe a series of measures and actions, to be implemented when the normal operations of the systems may not be sufficient to continue meeting full demand during periods of water shortages.

They are system-specific plans prepared by the water corporations that are consistent with the individual bulk entitlements, and include:

- a staged program of demand reduction/supply enhancement and associated triggers for implementing various measures, that is urban restrictions (often based on storage levels) and supply augmentation (such as groundwater bores)
- provisions for closely monitoring system status and climatic conditions (before and during drought), including the effectiveness of measures implemented
- plans for communicating measures to customers.

Like diversion licences and bulk entitlements, the planning assumptions for DRPs were based on historical streamflows, which did not include a 13-year period like the Millennium Drought.

In addition, coming on top of an already nine-year period of drought, the unprecedented dry conditions of 2006/07 were well outside the planning boundaries adopted in the DRPs. This caused a rapid worsening of the situation in 2006/07 and 2007/08 and meant that many measures outlined in the DRPs had to be implemented in quick succession within critically short timeframes. In some cases, the details and logistics of specific contingencies had not been sufficiently defined in the DRPs to allow them to be implemented at short notice.

Water corporations had typically not budgeted for the funding needed to implement contingencies. Often contractors needed to implement contingencies were already committed elsewhere on other urgent projects. For instance, sites for emergency groundwater bores had not been sufficiently scoped, nor were drillers available at short notice to do the work. Limited availability of, or access to, trucks for water carting was also an issue.

The urgency of some situations meant that there was limited time to undertake planned infrastructure works, assess water supply risks or make legislative changes to water-sharing rules specified in the bulk entitlements to allow certain drought measures.

Many corporations had to adapt their existing plans and/or develop additional contingencies to cope with the extended drought including:

- Providing exemptions from water restrictions for certain activities because many towns were not equipped socially or economically to deal with prolonged Stage 4 water restrictions
- Supporting water-saving measures (for example, changes to fixtures and appliances, such as low-flow showerheads, dual-flush toilets and water-efficient washing machines)
- Temporary pumping of dead storage to access additional water resources (see Case study 4.2)
- Installing temporary pumps on waterways to access water under lower streamflows (see Case study 4.1). Permission to divert under these conditions was granted through qualifying rights (see Chapter 6)
- Carting of water to towns on Stage 4 for critical supplies where no other supply options were feasible (see Case study 4.3)
- Applying evaporation retardants in storages to minimise evaporation losses (applied by Wannon Water at Hamilton and Glenthompson and in some storages managed by Coliban Water)
- Augmenting supply systems with groundwater (see Case studies 4.4 and 4.6)
- Increasing off-stream storages and carryover capabilities
- Augmenting alternative supplies such as recycled water (see Case study 4.5)
- Interconnecting supply systems, which involved connecting to, and buying water from regulated systems that had greater reliabilities and a functional water market.

Many of these measures required planning approvals and amendments to water corporations' bulk entitlements, or a licence application. In many instances, the opportunity was taken to ensure

the bulk entitlement amendment improved the flexibility of the water corporation to manage under dry conditions (for example, specifying alternative diversion points under dry conditions).

Adapting to uncertainty:

A key action outlined in the regional sustainable water strategies involves updating drought response plans to reflect a range of climate scenarios, including a 'worst case' continuation of the low inflows of 1997 to 2007). For example, Action 8.1 of the Northern Region Sustainable Water Strategy states: Drought response plans will be updated to:

- examine the responsiveness to a range of water availability scenarios, including a continuation of recent low inflows
- incorporate all the necessary contingencies to augment supplies and further reduce demand to address or manage supply shortfalls
- ensure adequate consideration of the lead times involved in implementing contingency actions
- incorporate recent system augmentations and operational changes
- provide specific guidance on when restrictions will be eased or lifted.

The drought response plans were updated by the water corporations in 2011/12 to address the above points.

4.4 Demand management

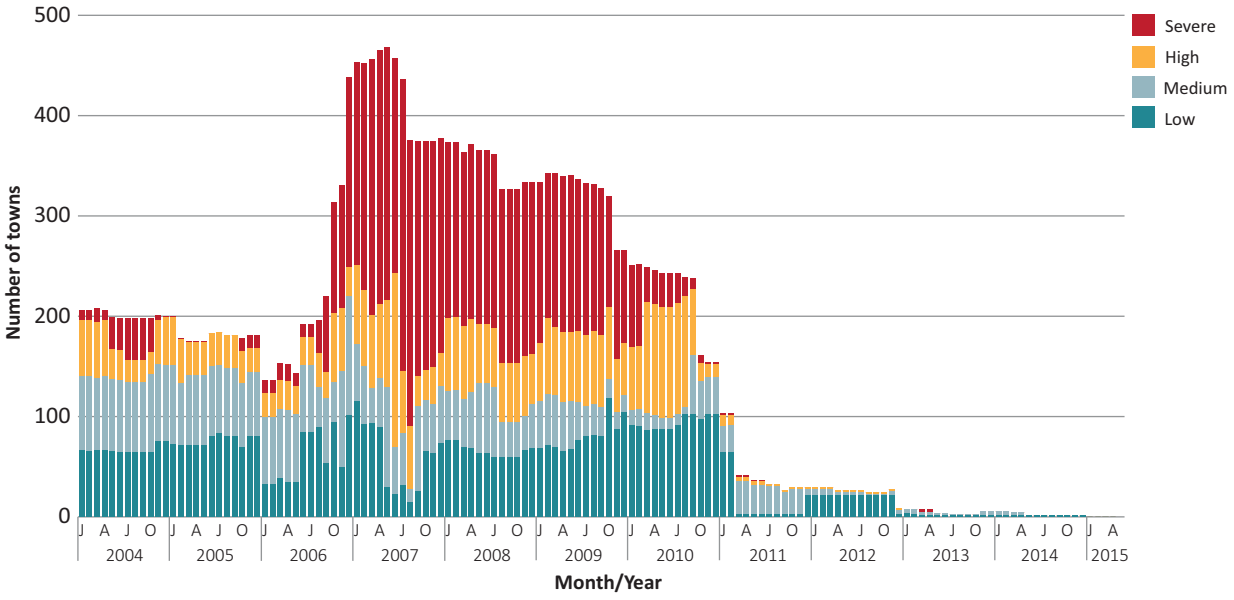
Water restrictions have been used historically by urban water corporations to curb demand during times of water scarcity. By November 2006, the number of Victorian towns on urban water restrictions had doubled compared with the previous year. The unprecedented low inflows of 2006/07 meant that towns quickly progressed through more severe restriction levels where triggers in DRPs were associated with rapidly deteriorating storage levels (see Case study 4.3).

By the beginning of July 2007, a total of 457 Victorian towns were subject to water restrictions. Coupled with the extended dry conditions since 1997, some towns were on severe levels of restriction for long periods, with considerable impacts on communities.

In 2005, the Victorian Uniform Drought Water Restriction Guidelines (Victorian Water Industry Association, 2005) were developed to provide a four-stage restriction policy that describes water-use activities permitted under each restriction level across Victoria. Water corporations can tailor the restrictions under each stage to suit local conditions. Previously, each region had determined its own rules and levels, which meant the number of stages and the associated restriction provisions were different depending on the region or town.

It was never envisaged that towns would be on severe restrictions for long periods. The highest level of restriction, Stage 4, was found to be very harsh on communities, particularly when they were

Figure 4.1 Number of Victorian towns on water restrictions and the severity of restrictions (January 2004 to May 2015)



in place for long periods. For example, residents of Ballarat and district were on Stage 4 restrictions for almost three years. Stage 4 restrictions ban outdoor use entirely, including (DSE, 2010a):

- watering public, residential or commercial gardens and lawns
- watering sports fields
- washing vehicles with water (excluding windows, mirrors and lights)
- washing building facades/windows with water
- filling new swimming pools, ponds or lakes.

While individuals generally appreciated the need to restrict water use within their own homes and went to great efforts to do so, the impact of the strict restrictions was felt at a broader level. In some communities, long periods under such severe restrictions caused the death of significant trees in parks, compromised the survival of some businesses (such as carwashes and nurseries), and led to the closure of sports fields.

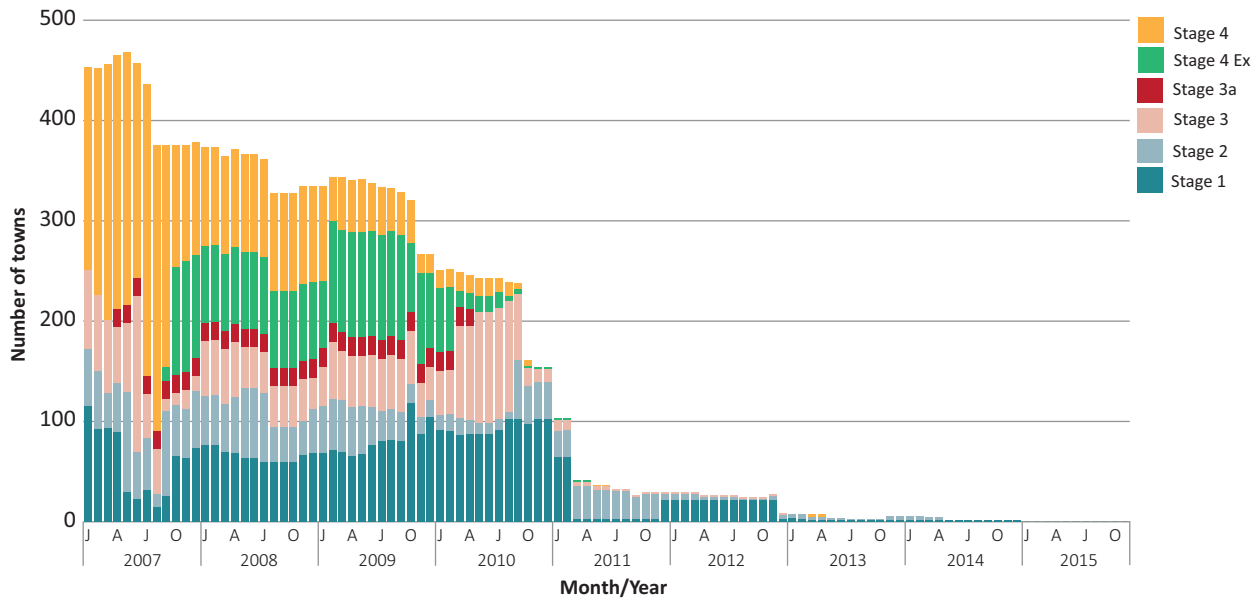
In spring 2007, many water corporations began introducing exemptions in response to improving water resources. For example, exemptions permitted watering of some sports fields and two hours' garden watering per week at certain times. This became a new restriction level known as Stage 4 with exemptions (Stage 4ex). The introduction of Stage 4ex can be seen in Figure 4.2. In most instances, exemptions were found to have little measurable impact on the demand for water resources; however, they were important in ensuring the survival of parks and for community morale.

During the height of the Millennium Drought in 2007 and 2008, other initiatives, such as drought relief funding for community sport and recreation, helped maintain sporting grounds in towns that were subject to Stage 3 restrictions or higher.

In 2011, the then Department of Sustainability and Environment, in conjunction with VicWater, reviewed the Victorian Uniform Drought Water Restriction Guidelines and permanent water savings rules.

Many Victorians were extremely successful in reducing their overall water use in response to urban water restrictions, recognising the seriousness of the dry conditions. In several communities across Victoria, the reductions in water consumption were over and above the level the restrictions were designed to achieve, due largely to additional voluntary measures many people undertook. As a result, a significant number of people may have permanently adjusted their water use in and outside the home, by converting to more water-efficient appliances, installing greywater systems or rainwater tanks to supplement supply, or changing the garden to more drought-tolerant plants.

Figure 4.2 Water restriction levels (post uniform drought restriction guidelines in 2007)



The extended period in which many Victorians were subject to water restrictions and the permanent adjustment of water use behaviours may have implications for the effectiveness of restrictions in future. This is known as 'demand hardening' where demand-management measures have been so effective that the potential for future short-term water savings is reduced.

Many urban water corporations have acknowledged that it may be necessary to gain a better understanding of potential future water consumption patterns if demand management measures are to be included in future drought contingency planning.

Urban water conservation measures

Another key element of reducing water demand included programs to encourage more permanent behaviour change and water savings through rebates, incentives and community education programs. These programs, led by water corporations and the Victorian and local government, focused on reducing water consumption in households. These programs aimed to help communities adjust their consumption in response to water restrictions, by identifying areas in the home where water use is generally highest, and offering options and alternatives to reduce potable water. For example, all Victorian water corporations offered customers the option to exchange their old, inefficient showerhead for a free water-efficient showerhead.

Rebate programs provided financial incentives for individuals to buy water-efficient appliances and a variety of household fixtures and products. For example, through the Water Smart Gardens and Homes Rebate Scheme, individuals could receive rebates for purchases such as:

- rainwater tanks
- dual-flush toilets
- water-efficient showerheads
- connecting a toilet to a rainwater tank
- installing a permanent greywater system
- hot water recirculators
- other small household goods that promote water efficiency (including garden mulch, shower and garden tap timers, tap flow reduction devices, compost bins).

In addition to other voluntary measures undertaken by individuals, the Water Smart rebate scheme is estimated to have saved about 2.4 GL per year between 2003 and 2008 (DSE, 2010a).

Non-residential consumers (industry, some local councils) also provided incentives to identify areas to reduce water use and adopt alternatives if appropriate. Between 2007 and 2010 non-residential urban consumers were encouraged to develop Water Management Action Plans (waterMAPs) with their local water corporation to demonstrate how they would improve their water use efficiency over time.

A waterMAP helped eligible non-residential water customers across Victoria:

- assess their water use
- identify inefficiencies and opportunities for water savings
- prepare an action plan to implement water conservation activities
- report annually on the implementation of water conservation activities.

Between 2007 and 2010, waterMAP customers saved about 17 GL, and approximately 1,750 customers had waterMAPs in place (DSE, 2010d).

Local government authorities, as the caretakers of many important public facilities such as parks or sporting fields, were also supported by water corporations and the Victorian Government to prepare sustainable water use plans. These plans identify where the council uses water, how much is used, and identifies opportunities and actions to reduce consumption. The plans also helped identify opportunities to receive funding to implement stormwater and recycled water initiatives through Smart Water Fund projects or the Stormwater and Urban Recycling Fund.

4.5 Supply augmentation measures (short and long term)

In response to continuing drought, many corporations had to implement measures to increase water supplies. Such measures involved improvements to the efficiency or capacity of existing water delivery infrastructure, connecting to existing systems, or accessing new water sources.

In some cases, urban water corporations were required to implement measures that were not part of their short or long-term planning. In other cases, the drought has accelerated the implementation of long-term supply augmentation measures. Examples include the Goldfields Superpipe (see Case study 4.10) and the Wimmera-Mallee Pipeline (see Case study 3.5). The following sections outline some measures undertaken to secure urban supply.

Emergency measures

Where water shortages were extreme, temporary emergency measures were required in some situations. For example, several urban water corporations across Victoria had to cart water by truck (see Case studies 4.1 and 4.3), pump dead storage (see Case study 4.2), install emergency groundwater bores (see Case study 4.4) or temporary pumps on waterways and build pipelines to convey the water. These measures can be very expensive. Many have been used in past droughts; however, they are not effective for all systems. For example, carting to supply even a medium-size town would be logistically and financially prohibitive due to the volume of water necessary (and the number of tankers required).

In some cases, the emergency measures resulted in improvements or augmentations that would benefit the system into the future (see Case study 4.3).

Case study 4.2: Buying time for Wangaratta

North East Water's supply for Wangaratta was severely compromised in 2006/07, as a result of extremely low flows in the Ovens River and into the supply headworks. The situation deteriorated rapidly when the typically highly reliable spring streamflow did not eventuate.

Goulburn-Murray Water advised North East Water in early January 2007 that Wangaratta's demand under Stage 4 restrictions could not be met without pumping dead storage in Lake Buffalo. This measure provided a small, temporary increase to the volume of water available, buying time while other contingencies were implemented. The Lake Buffalo pumps were installed by early March, but could guarantee supply only until mid-April.

In the meantime, emergency groundwater bores were being drilled. Fortunately, rainfall in late March resulted in improvements in flow in the Ovens River and timely inflows to the storage, averting the potential financial and logistical problem of having to cart in large volumes of water to supply Wangaratta. Groundwater is now available as a permanent contingency supply for Wangaratta.

Lake Buffalo empty *Photo: © Alison Pouliot*

Case study 4.3: Water carting for Broadford, Sunday Creek system

Gouldburn Valley Water's (GVW) Sunday Creek system supplies Kilmore, Broadford, Wandong, Heathcote Junction and the surrounding area. The Sunday Creek Reservoir is the major water storage for the system, with a capacity of 1,700 ML supplemented by some smaller storages (for example Hollowback, which has a capacity of 110 ML). The system experienced extreme water shortages several times during the Millennium Drought, with towns being on severe water restrictions for long periods.

As a result of extremely low winter and spring rainfall in 2006, the situation deteriorated very quickly moving into summer. Towns supplied by the Sunday Creek system progressed rapidly through restriction levels as storage levels fell, shifting from Stage 1 to 4 between November 2006 and February 2007. By the end of March 2007, the volume of water available in all storages (Sunday Creek, Hollowback, Kilmore No. 3 and Broadford No. 3) was 231 ML. As a result, GVW had to use a range of measures, both emergency and long term, to secure supply to the towns.

During 2007/08, GVW resorted to carting water from Seymour to supply Broadford, resulting in costs of more than $2.5 million to supply 252 ML (GVW, 2009). Additional infrastructure was required to enable the carted water to be unloaded from the tankers at the Broadford treatment plant. Carting to Broadford enabled the remaining water in Sunday Creek Reservoir to supply Kilmore and Wandong/Heathcote Junction. From July 2007 to December 2008, GVW also pumped water from Wallan to supply Kilmore under agreement with Yarra Valley Water. Wallan is supplied from the Melbourne system and GVW was able to use the pipeline that formerly supplied Wallan from the Sunday Creek system.

GVW completed a pump station on the Goulburn River at Tallarook and a pipeline in December 2008, capable of supplying up to 12 ML per day to Broadford. This enabled an easing of restrictions to Stage 2 in early January 2009, allowing the remaining water in the system to be supplied to Kilmore and Wandong/Heathcote Junction residents (GVW, 2009). A temporary pump station was also constructed at the Broadford storage, to allow up to 3 ML to be pumped into Sunday Creek Reservoir if necessary.

Alternative supply sources

When existing supply systems could not provide adequate supplies, water corporations looked to alternative sources of potable water (such as groundwater and desalination) or non-potable substitutes (such as recycled water and stormwater). The role of alternative supply projects such as stormwater capture and reuse, managed aquifer recharge, and desalination in reducing the demand on potable water sources has increased since the start of the Millennium Drought.

Groundwater

The use of groundwater as an alternative water source to supplement surface water supplies has been increasingly important since 2006/07. Groundwater was used as an emergency supply in several regions (see Case studies 4.1 and 4.5) and, in some cases, groundwater supplies were also augmented to meet the long-term supply needs of an urban system (see Case study 4.4).

Since 2006/07, several urban water corporations have targeted groundwater as an additional measure to augment diminishing surface water supplies. Successful supplies (and entitlement volumes) brought on line include:

- Central Highlands Water: Ballarat (3,000 ML), Daylesford (273 ML), Maryborough (1,200 ML)
- North East Water: Wangaratta (200 ML) (see Case study 4.2)
- Barwon Water: Geelong (7,000 ML) (see Case study 4.4)
- Westernport Water: Corinella (490 ML)
- South Gippsland Water: Leongatha (715 ML), Yarram (214 ML)
- East Gippsland Water: Bairnsdale (120 ML)
- Grampians Wimmera-Mallee Water: Horsham (800 ML).

In 2009/10, about 75 towns across Victoria relied on groundwater for primary or supplementary water supply. At this time, urban groundwater use accounted for about 5.5 per cent of total groundwater use in Victoria in 2009/10.

Case study 4.4: Alternative supplies and interconnections for greater Geelong

Barwon Water customers in Geelong and the surrounding region were on high levels of water restrictions between 2006 and 2010, with storage levels consistently below 35 per cent.

In response to the surface water shortage, existing groundwater supplies at the Barwon Downs borefield were upgraded, and were able to provide more than half of Geelong's water supplies for several years (Barwon Water, 2007; 2008; 2009).

In addition, Barwon Water has completed three major projects that have increased the security of Geelong's supplies to meet future growth and manage the risks from climate variability or change:

- The Northern Water (treatment) Plant, completed in April 2013, to provide 2000 megalitres of recycled water for major industry
- The Anglesea borefield project, which has been contributing to Geelong's supply since late October 2009
- The Melbourne-Geelong Pipeline, completed in early 2013, allows Barwon Water access to the Melbourne supply system.

Case study 4.5: Bushfires and floods create emergency in Mitchell basin

The availability of water supplies in the Mitchell basin during 2006/07 was impacted by several events that affected surface water quantity and quality. Inflows during that year were about one-quarter of the long-term average, and would have been worse without an extremely heavy storm in the last three days of the year (DSE, 2008a).

Severe and widespread bushfires during summer placed pressure on dwindling water resources, as river flows declined rapidly at the same time as increased volumes were required for firefighting, drawing storages to very low levels.

In December 2006, a temporary qualification of rights to water was put in place for one month to reduce passing flows in the Mitchell River and allow East Gippsland Water (EGW) to pump more water if needed to manage the fire risk in the Bairnsdale area and secure supply to Bairnsdale and surrounding towns.

A few months after the bushfires, torrential rainfall in the catchment washed ash, charcoal, silt, nutrients and other flood debris into rivers and wetlands, compromising environmental values and water supply. Floodwaters caused a major break in the pipeline serving the Lindenow area.

At that time, Bairnsdale's supply from the Mitchell River was not treated (apart from settling and chlorination), so EGW urgently needed to acquire portable treatment units and built temporary clarification basins to treat the river water. Two farm bores were also used and a number of emergency bores were drilled into a largely untapped aquifer at Woodglen to provide an alternative source of clean water.

By March 2007, all EGW customers in the Mitchell supply system were on Stage 4 restrictions to conserve water until sufficient volumes of potable water could be produced. Without groundwater, EGW would have struggled to supply its demand, even with the highest level of restrictions in place.

Recycled water

The decrease in water availability has encouraged non-potable supplies for fit-for-purpose uses. As the volume of wastewater treated has increased, recycled water is being increasingly used around Victoria for watering sporting fields, golf courses, industry and horticulture. This reduces pressure on waterways because much of the potable water formerly supplied for these purposes was sourced from rivers and creeks. It also enables more potable water to be retained for domestic use.

However, recycled water is not currently recognised under the Victorian Water Entitlement Framework and so cannot be held under a bulk water entitlement. Owners of treatment plants maintain ownership of the recycled water product, and are free to use, sell or discharge it to waterways (within regulatory constraints). Private contractual arrangements have typically governed the supply of recycled water at a retail level, usually directly from a water corporation's treatment plant to individuals (for example, the Werribee recycled water scheme for irrigators). This arrangement has been considered adequate in the past due to the relatively low number of recycled water users, notwithstanding any regulatory issues that may exist. However, as recycled water use is likely to increase, and may become a substantial resource during dry periods, such arrangements may pose a barrier to efficient allocation (see Case study 6.2). There is a recognised need to review these arrangements.

Case study 4.6: Recycled water in Campaspe basin

In the Campaspe basin, recycled water provided Coliban Water (CW) with an alternative source to supplement potable water for fit-for-purpose uses, and enabled agriculture in areas where there was no surface water available for irrigation. The recycled water, was delivered to customers from the Bendigo water treatment plant, and can be temporarily stored in the Spring Gully Reservoir.

The recycled water allowed the City of Greater Bendigo to keep parks and sports fields green without using potable water, consistent with Stage 4 restrictions. The recycled water was also used for laundry services and to water school grounds.

Since 2008/09, CW has been able to supply a small part of its rural system with recycled water for irrigation purposes. Irrigators on CW's rural system faced significant hardship during the drought, with consecutive years of inflows about one-quarter of the long-term average, and low or zero allocations. The volume of recycled water provided to eligible customers was the equivalent of a 40 per cent allocation.

Coliban Water purple piping *Photo: © Coliban Water*

Case study 4.7: How recreation returned to Lake Wendouree

Ballarat's iconic Lake Wendouree faced extreme water shortages during the Millennium Drought, affecting several highly valued community activities and attractions. This prompted the City of Ballarat and Central Highlands Water to begin seeking alternative sources of water to supply the lake from 2003. In 2006, the lake dried up altogether for the first time since 1946.

The City of Ballarat and Central Highlands Water investigated using groundwater, recycled water and stormwater to supply the lake. In 2006, the $7 million Lake Wendouree water supply project began, funded by the City of Ballarat, Central Highlands Water and the Victorian Government. The project included the construction of works and agreements to supply a combination of Class A recycled water and stormwater to the lake. It also included arrangements for excess water to water public assets.

High rainfall in January 2011 and stormwater diversions resulted in the lake filling for the first time in many years, and recreational activities such as canoeing, rowing, sailing and fishing (following restocking) recommenced. The option to use stormwater and recycled water means that supply for the lake is secure without having to use potable water to maintain water levels.

Sources and further information:

http://www.ballarat.vic.gov.au/lae/lakes/lake-wendouree.aspx **http://www.chw.net.au/**

Sailing on Lake Wendouree *Photo: © DELWP*

Stormwater

Harvesting stormwater for fit-for-purpose supply has gained increased interest in recent years. This recognises the benefits of intercepting significant volumes of stormwater that runs off paved urban surfaces to substitute for potable water supplies, as well as improving the quality of water discharging into waterways and bays. During droughts, opportunistic harvesting and treatment of stormwater could provide an important source for outdoor watering and maintaining green space, lakes and waterways in urban areas (see Case study 4.7).

The water entitlement framework was extended to include the take and use of stormwater by an individual from drainage works of an authority (primarily Melbourne Water) and waterways via a licence. The Act also provides for authorities (water corporations) to hold bulk entitlements to 'water, other than recycled water' from the works of an authority. This definition can be interpreted to include stormwater and desalinated water.

However, the process to quantify and allocate stormwater is not straightforward, due to the complex nature of stormwater as a resource.

Stormwater availability is variable, and may contribute directly and/or indirectly to flows in waterways and bulk water supplies. Therefore any allocation of the resource must take into account the impacts on existing entitlement holders and the environment, which may be difficult to define in some cases. Significant water quality issues from an environmental and human health perspective also should be considered.

While the licensing framework now extends to the take and use of stormwater from drainage works of an authority (as defined in the Act) and waterways, it does not regulate access from local council drainage systems, catchment dams or harvesting on private property.

There is a recognised need to clarify arrangements by which people can harvest and use stormwater from all sources, including how stormwater from drains and private property should be managed.

Despite the challenges associated with allocating stormwater entitlements, significant benefits can be made through the capture, treatment and use of stormwater from potable water substitution and urban waterway health perspectives.

Desalination

Following years of drought, developing a 'rainfall independent' source of water such as the Victorian Desalination Plant (VDP) was considered a reliable option for augmenting Melbourne's future water supply. Desalinated water is a manufactured 'product' like recycled water, and is therefore easily quantifiable.

Water produced for Melbourne from the VDP is owned by the Melbourne water retailers under source bulk entitlements. These entitlements provide the right to take and store water for the Melbourne supply system. The Minister for Water is responsible for placing water orders from the VDP on advice of Melbourne Water and the three Melbourne retailers.

Managed aquifer recharge (MAR)

Several water corporations have expressed interest in managed aquifer recharge as a way of storing excess water for use during drier periods. East Gippsland Water undertook a trial near Woodglen Reservoir, Bairnsdale, where water diverted from the Mitchell River was injected into an aquifer and subsequently recovered. Such an arrangement could allow East Gippsland Water to store water in the aquifer that is diverted from the river during winter, for extraction in summer when river flows are lower. This may also contribute to improving reliability for irrigators over summer (see DSE, 2010c). A number of smaller trials have been undertaken at a local scale, for watering sports fields and other smaller-scale uses.

In addition to the technical challenges of MAR (for example, see Dillon and Molloy, 2006; EPA Victoria, 2009), licensing and allocation issues have to be addressed. The then Department of Sustainability and Environment, worked with Environment Protection Authority Victoria, the then Department of Health and licensing authorities, to develop guidelines for the efficient assessment and approval of MAR schemes. This includes determining the licensing process in accordance with the Act. An approval to 'dispose' the water in an aquifer (recharge) (section 76) is required, as well as a bore construction licence (section 67) and a take-and-use licence (section 51). In determining the allocated volume, the characteristics of the aquifer are taken into account. If the aquifer is unconfined, up to 80 per cent of the volume injected will be allocated as the licence volume to account for losses. If the

aquifer is confined, up to 100 per cent of the injected volume is allocated.

Increasing off-stream storage and carryover capabilities

In streams with relatively reliable winter flows, urban water corporations were able to offset the reduction in their summer diversions with an increase in winter diversions. This requires sufficient off-stream storage capacity that can be drawn down to meet urban demands over summer and until river flows increase again in the following winter and spring.

In some cases, water corporations had to construct new off-stream storages or enlarge existing ones to provide sufficient capacity. Depending of the size of their existing storage and supply configurations, some water corporations could implement this contingency almost immediately. Others required significant lead time for planning, design and construction.

In an emergency water shortage, a water corporation's ability to increase its winter diversions was enabled through qualifications of rights, which temporarily altered the water-sharing arrangements for the waterway. A permanent increase in diversions requires an amendment to a corporation's bulk water entitlement.

Case study 4.8: Winter diversions to meet east Gippsland demand

East Gippsland Water (EGW) was granted an amendment to its Bairnsdale bulk entitlement in 2010 allowing it to harvest up to an additional 3,306 ML/year from the Mitchell River during the winter and spring. The increased diversions and progressive increases of its off-stream storage capacity and delivery infrastructure will help EGW meet increasing demand from future population growth in towns supplied off this system.

In June 2010, EGW completed a new water treatment plant for the Bairnsdale system and a 715 ML off-stream storage. These works allow EGW to utilise a larger proportion of its Mitchell River bulk entitlement.

The increase in entitlement volume on the Mitchell River was offset by EGW surrendering its Tambo River and Nicholson River bulk entitlements, which combined had an equivalent volume of entitlement. For this reason, there was no increase in total consumptive entitlement volume from the Gippsland Lakes basin.

Case study 4.9: Connections work for north-east towns

During 2006/07, streamflows in the Ovens basin were 11 per cent of the long-term average. Town supplies from some small unregulated catchments that had been highly reliable in the past were compromised.

For example, Bright and Wandiligong are supplied under bulk entitlements from the Bakers Gully and Ovens River catchments, while Porepunkah is supplied under an entitlement from the Buckland River catchment. In order to increase the short-term and long-term supply security of these towns, North East Water constructed a pipeline from Bright to Porepunkah in 2007. The connection between the two unregulated systems allows water to be transferred between the town supplies as necessary; for example, if streamflows in one catchment are worse than the others, or affected by water quality issues.

However, in such small systems, additional projects can be required to secure the long-term supply. In the Bright system, North East Water constructed drought relief bores as an alternative supply in case of future water shortage. It also constructed a 520 megalitre off-river storage at Freeburgh to enable water to be harvested and stored during wetter periods for use during dry times. This provides a more secure and reliable water supply for Bright, Wandiligong and Porepunkah.

The Water Grid

Increasing the connections between water systems was a key drought response. Interconnected systems can provide greater reliability of supply by allowing water to be moved around Victoria to where it is needed most, and can increase flexibility in balancing water supply and demand (DSE, 2010b). Case study 4.9 is an example of small supply systems being connected to increase supply options during water shortages.

Many of Victoria's water systems are already connected through a network of rivers, channels, pipes and storages. Projects undertaken during the drought further linked water systems across Victoria through the construction of connections and pipelines. In some cases, these connections have enabled water corporations in unregulated systems to access regulated water systems that have a water market and carryover rules to manage water shortages (see Case study 4.10).

The Wimmera-Mallee Pipeline, the North-South Pipeline and the Northern Mallee Pipeline are among other projects that are part of a network of almost 10,000 kilometres of pipeline that can deliver water to areas where it is most needed during times of scarcity.

Case study 4.10: Superpipe delivers a more reliable water supply to Ballarat and Bendigo

The Goldfields Superpipe was a crucial contingency for maintaining a water supply to some large regional cities and towns during the Millennium Drought. Following unprecedented low river flows in 2006, the Superpipe was constructed between February 2007 and May 2008 to deliver up to 18 GL of potable water a year to Ballarat and up to 20 GL a year to Bendigo. Without the Superpipe, Bendigo and Ballarat would have faced grave water shortages, and longer periods of severe water restrictions.

The first 46.5 kilometres of the Goldfields Superpipe is owned by Coliban Water (CW) and connects the Waranga Western Channel near Colbinabbin with Lake Eppalock, from where water is piped to Bendigo's Sandhurst Reservoir. The next 87 kilometres is owned by Central Highlands Water (CHW) and runs from near the Sandhurst Reservoir to the White Swan Reservoir, to supply Ballarat.

The Superpipe has been capable of supplying water to Bendigo since September 2007 and to Ballarat since May 2008. As well as providing relief during water shortages, this connection gives CHW and CW the flexibility to manage their water resources to meet the future challenges of drought, climate change and population growth. It allows them to buy water to manage water restriction levels and/or meet essential needs, and also allows them to carry over water for future years, and reduce the reliance of these cities on qualification of rights to secure supply during extreme water shortages.

In May 2007, Bendigo's major storage levels had fallen to 5.6 per cent (7,158 ML). Since the Superpipe was commissioned, CW has purchased 25,632 ML of high-reliability water entitlements on the Goulburn system to secure essential needs for Bendigo and surrounding towns.

Bendigo had been subject to severe Stage 4 restrictions since September 2006. The Superpipe enabled CW to stop the decline in storage levels and ease water restrictions to Stage 3 at the beginning of 2009. Water from the Superpipe is capable of providing up to 90 per cent of supply for Bendigo and surrounding towns. During the drought, CW was able to reserve the water available in the Coliban system storages to supply essential needs for Kyneton and Castlemaine (which are not connected to the Superpipe).

Just before the Superpipe was commissioned, Ballarat's major storages reached an all-time low of about 7 per cent capacity (4,376 ML). More than 22,000 ML of water was delivered to Ballarat in the two years after the Superpipe was commissioned in May 2008. CHW was able to reduce restrictions for Ballarat and district to Stage 3 at the beginning of 2010, after being on severe Stage 4 restrictions since November 2006. By May 2010, Ballarat's storages held more than two years' worth of supply in reserve.

Lake Eppalock empty 2007

Lake Eppalock 23% capacity 2010 *Photos: © GMW*

Non-structural measures: market and carryover

Urban water corporations were able to enter the water market in Victoria to source water for their customers, avoiding the need for government intervention to ensure that essential needs were met. Cities and towns that are embedded in irrigation areas (such as Shepparton and Mildura) have been involved in the water market for some time, albeit in different ways. In the past, Goulburn Valley Water has been a seller of annual allocation as its entitlement caters for future population growth, while Lower Murray Water has been buying water to build up its entitlement to supply Mildura as it grows.

Bendigo and Ballarat entered the market to support the use of the Goldfields Superpipe (see Case study 4.10). The market was essential to enable Bendigo and Ballarat to have security of supply, and yet their involvement in the market has been relatively modest. The Melbourne water system is also connected to the Goulburn water system via the North-South Pipeline (which connects the Goulburn River to Sugarloaf Reservoir). There are rules in place under the Melbourne urban retailers' Statement of Obligations which define the parameters under which water can be transferred via the North-South Pipeline.

In addition to market opportunities, the ability to carry over unused water at the end of the season in some regulated systems is an important tool for managing in dry periods. This option can assist urban water corporations to avoid long periods of severe water restrictions, particularly in the northern regulated systems.

Adapting to uncertainty:

The Western Region (Action 3.13) and Gippsland Region (Action 4.5) sustainable water strategies include actions to encourage fit-for-purpose use of alternative water supplies to meet future water needs where there are overall benefits to the local communities. Some examples of alternative supplies include stormwater, greywater and recycled water.

4.6 Summary

Only a handful of Victorian urban systems did not feel the effects of the prolonged dry spell between 1997 and 2009. Urban water corporations' first response was to reduce demand for water by imposing restrictions on residential customers and working with large industrial customers and communities to reduce demand. By beginning of July 2007, a total of 457 Victorian towns were subject to restrictions.

Urban water corporations found that the duration and magnitude of the dry spell was worse than anything they had planned for through their water supply-demand strategies or their drought response plans. When they did their projections as the dry conditions intensified, the corporations found the water they were entitled to take was insufficient to ensure supply of critical human needs of their urban communities.

The urban systems affected coped with the dry conditions in a variety of ways, depending on whether their water was supplied from a large regulated system, they had their own large storages or small storages filled from streams with dependable flow.

Seven Creeks during the Millennium Drought. *Photo: © Alison Pouliot*

Several large projects were initiated with a long-term view of securing rural and urban communities' water supplies. For example, the Goldfields Superpipe allowed Ballarat and Bendigo to access water from the Goulburn system; the North-South Pipeline connected Melbourne to the Goulburn system; the Kilmore-Broadford system was also connected to the Goulburn system; and a number of towns, including Sunbury, Melton and Bacchus Marsh, were connected to the Melbourne system. Construction of the Victorian Desalination Plant began with the aim of providing longer-term water supply security for Melbourne.

Other large projects such as the Wimmera-Mallee Pipeline aim to provide more secure supplies for rural and urban use through improving water delivery efficiency. Urban water corporations with towns connected to the large regulated supply systems were able to use water markets to boost their water holdings.

The water shortages encouraged water corporations to look at using alternative supplies such as recycled water or stormwater as a substitute for potable water for fit-for-purpose applications such as industry, agriculture, and watering parks and gardens and sporting fields, and several major recycling projects were initiated. The increased interest in alternative sources of water has prompted consideration of how these sources will be allocated and accounted for in the water entitlement framework.

Urban water corporations that did not have access to large regulated systems or the Melbourne system augmented their water supplies where they could. Typically this involved drilling groundwater bores, pumping out dead storage and building pumps and pipelines to tap more reliable streams. Some small towns resorted to carting water by truck.

In order to reduce the risk of cities and towns not being able to supply their customers' critical needs while the longer-term measures to secure supplies were being implemented, rights to take water were temporarily qualified as an emergency contingency measure.

The lessons learned from the experience of managing through the extended dry period are being included in the water corporations' planning processes, in their bulk entitlements and through actions initiated in regional sustainable water strategies.

5. Small rural supply systems

This chapter discusses the issues arising from management of water supplies from unregulated waterways and groundwater during the Millennium Drought. The chapter focuses on water supplies for commercial, irrigation and private use in these systems, and the difficulties of actively managing environmental water on unregulated waterways. A more detailed discussion of the issues for urban supplies can be found in Chapter 4.

Unregulated systems are waterways without large weirs or dams capturing and regulating the flow. From a water supply perspective, the management of unregulated waterways is particularly challenging during drought, because without large storages intercepting flows, entitlement holders rely on a consistent flow in the waterway. Many water corporations and landholders build off-stream storages to ensure continuity of supply during low river flows.

While conditions were generally drier across Victoria from late 1996 to mid-2010, entitlement holders on unregulated streams faced particular hardship from 2006 to mid-2010. During this time, streamflows were often below trigger levels for diversion, and waterways ceased to flow for extended periods in some systems (for example, the upper Ovens River).

In some regions, groundwater users faced reduced water availability due to reduced recharge from low rainfall. In other areas, groundwater has maintained reliable supplies or proven an excellent back-up resource when surface water supplies have failed. The prolonged drought has provided valuable lessons that will feed into future policy and management procedures for Victoria's groundwater.

In unregulated waterways and groundwater systems, water can be taken under:

- bulk entitlements for urban corporations (see Chapter 1)
- take-and-use licences (section 51 of the Act), issued to landholders (or sometimes urban corporations) for commercial and irrigation use and under agreed arrangements
- private rights (section 8 of the Act) for domestic and stock use.

Drought affected livestock *Photo: © Alison Pouliot*

Licences and bulk entitlements protect water for the environment by limiting extractions in unregulated river and groundwater systems, but there are limited opportunities to actively manage this water to achieve environmental benefits.

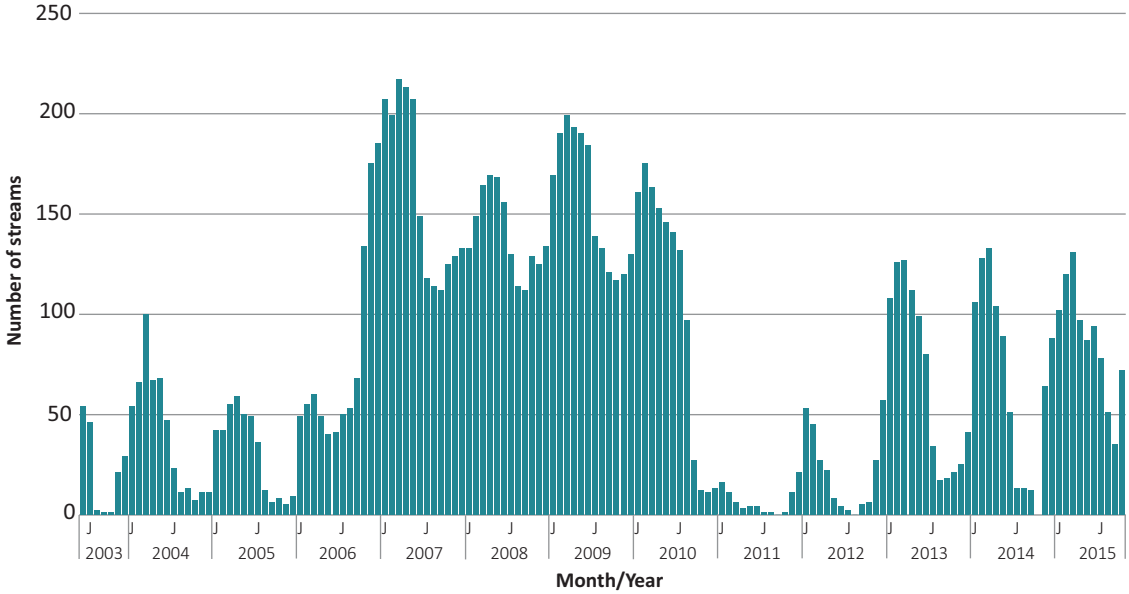
Under extreme dry conditions, diversions from unregulated waterways for critical urban supply typically takes priority over other uses, through qualification of rights or restrictions or bans on licensed diverters. After water is diverted for urban supply, the remaining passing flows are dedicated to maintaining minimum environmental flows and ensuring water is available for essential domestic and stock use. Water for commercial and irrigation use is the most often and severely restricted.

5.1 Licences on unregulated streams

Licensed diverters may pump water for irrigation or commercial purposes directly from unregulated waterways, in accordance with section 51 of the *Water Act 1989*. This water is not managed under a bulk entitlement. Instead, the Minister for Water delegates management of section 51 licences to rural water corporations. Conditions on section 51 licences document water-sharing arrangements or a central location of water-sharing arrangements, such as details of rosters or restrictions, if the flow in the waterway drops below a specified trigger level.

Under severe conditions, rural water corporations can ban diversions for commercial and irrigation use. However, diversion for essential needs (such as domestic and stock use) can still occur if water is available. The implementation of restrictions and bans can vary within days, depending on whether the streamflow at a specified point is above or below its trigger level. However, restrictions and bans generally occur more often during summer and autumn and are calculated on a seven-day rolling average. These restrictions generally determine when a licence-holder may take water, rather

Figure 5.1 Total number of streams on restrictions or bans (2003–2015)



Note: Data for the above figure was supplied by water corporations

than the volume of water permitted to be taken. However this does not extend to qualifications on unregulated streams.

Between 2006/07 and 2010, licensed diverters around Victoria regularly experienced restrictions and bans. At the end of March 2007, the total number of streams and lakes across Victoria on restrictions or bans peaked at 217, compared with 60 at the end of March 2006. The total number of streams on restriction remained high between 2006 and 2009. Figure 5.1 provides a comparison of the number of Victorian streams on restrictions or bans every year since 2004/05.

This was particularly difficult for licence-holders who relied on diverting water during summer. Other licence-holders who diverted water during winter into off-stream storages, for use in the summer months, were less impacted by summer bans. However, even these diverters were impacted when some streams remained on bans throughout the year, and in some instances for several years. Private diverters in the upper Wimmera River faced irrigation bans between 1999 and mid-2010.

Long-term restrictions and bans due to dry conditions can have a significant impact on farm businesses. For example, if restrictions are in place during critical stages of the growing cycle, loss of vegetables or other plantings may occur. In future, such impacts may be mitigated through the inclusion of off-stream storages (such as tanks) or by changing cropping practices (for example, planting more winter crops instead of summer crops). There is also potential for improving water markets in unregulated surface water systems across Victoria, which would provide further options to help farmers and communities manage through droughts.

Adapting to uncertainty:

Improving opportunities for water trading in unregulated river and groundwater systems

The Western Region (Action 3.12) and Gippsland Region (Action 4.2) sustainable water strategies have committed actions to improve trading options and flexibility for licence-holders in unregulated river and groundwater systems.

Actions under the strategies include:

- implementing a market development and education program to inform water users and the broader community about trade, how it works, and its benefits
- the potential development of system-based trading rules that provide greater potential to trade while minimising risks to other users and the environment
- ensuring a risk-based approach to water trading approval processes
- amendments to the current Policies for Managing (section 51) Take-and-Use Licences to allow low-risk, limited-term transfers or leases of section 51 licences.

5.2 Section 8 private rights (unregulated domestic and stock supply)

Section 8 of the *Water Act 1989* describes the rights of individuals to take and use water from surface and groundwater sources for domestic and stock purposes free of charge (see Figure 5.2). In 2008/09, water diverted under section 8 rights was estimated to be 5 per cent of the total consumptive surface water diverted in Victoria.

Water taken under section 8 private rights is limited by the definition of domestic and stock use in the Act. Domestic and stock use is defined as the use of water for household purposes, watering of animals kept as pets, watering of cattle and other stock, watering of land for fire prevention purposes (limited to certain sources), and irrigation of a kitchen garden. A kitchen garden is further defined as a garden used solely in connection with a dwelling; and its size varies depending on when the land was alienated from the Crown and whether the garden is irrigated by surface water, groundwater or both. The volume of supply is usually limited by the hydraulic arrangements at the diversion point.

However, if works are required to take water for domestic and stock use from a waterway with Crown frontage or from groundwater, a section 67 works licence is required.

There is no reliability of supply attached to water taken under section 8 rights; users must manage their own supply and risk in light of reduced water availability, and sometimes the risk of other users on the system. As a result, water corporations place a high priority on managing waterways to maintain supply for domestic and stock users.

Figure 5.2 Section 8 private rights for domestic and stock water use (Source: DSE 2009)

1. Rainfall capture on roof
Individuals have the right to capture rain that falls on a roof.

2. Groundwater extraction
An occupier of land can take domestic and stock water without the need for a Section 51 licence. A Section 67 licence may be required for more construction.

3. Domestic and stock dams
An occupier of land has the right to collect water that occurs or flows on land for domestic and stock purposes. A Section 67 works licence is required if the dam falls within a prescribed class of dam, such as hazardous or on a waterway.

4. Public rights (at the waterway)
The public has the right to take and use water from publicly accessible waterways (e.g. for camping, cultural purposes or watering of droving stock).

5. Riparian rights (at the waterway)
An occupier who has a licence to a Crown frontage leasehold has the right to access water for stock at the waterway without a licence.

6. Waterway diversions
An occupier of land adjacent to a waterway (up to the bed and banks) can take water for domestic and stock purposes without the need for a Section 51 licence. A Section 67 licence may be required for pump installation.

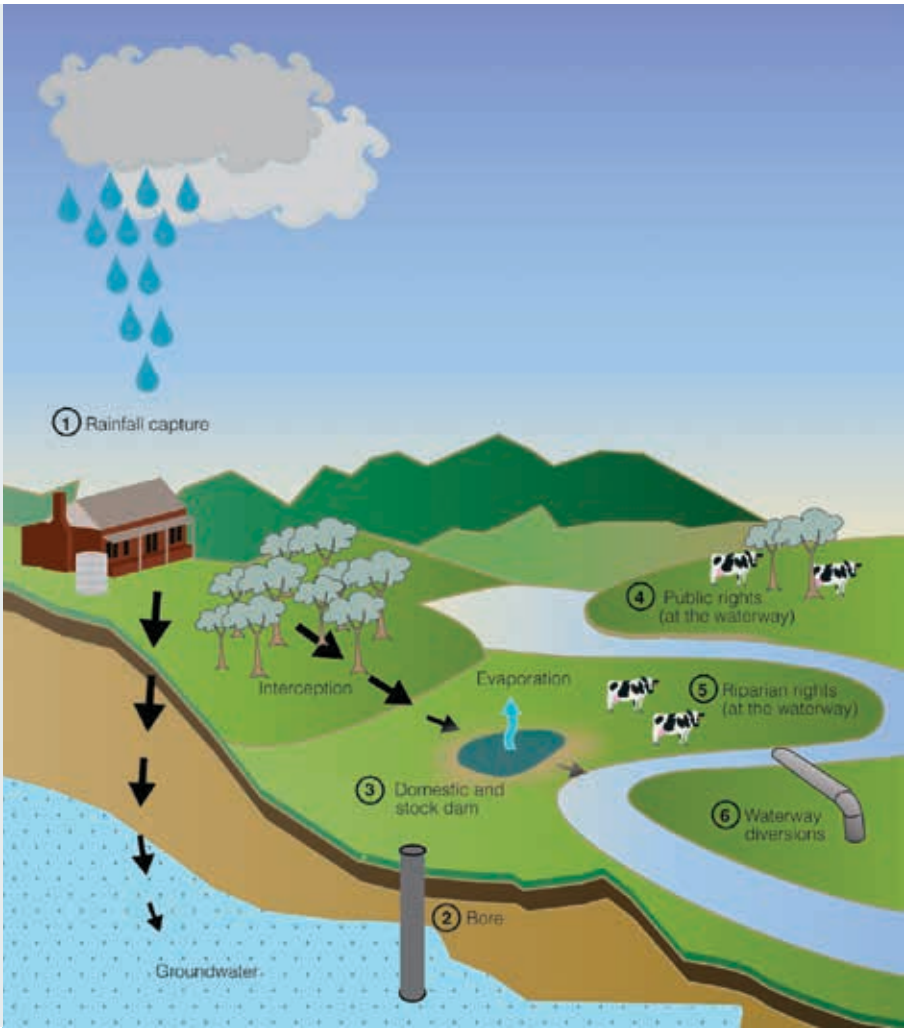
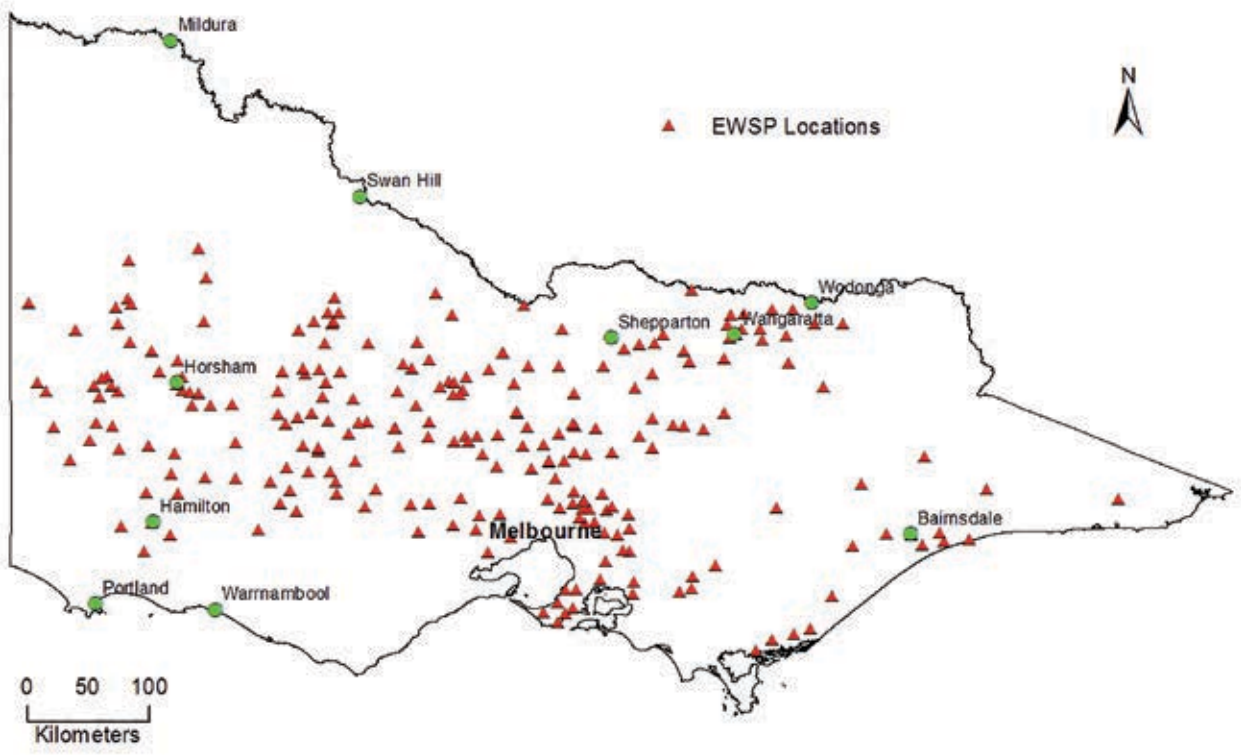


Figure 5.3 Emergency water supply point network



Water taken in accordance with section 8 rights for domestic and stock purposes is not restricted, because it is considered a small volume of water that is typically used for essential needs. Despite this, under severe dry conditions, if a waterway ceases to flow, a dam dries out, a water tank is emptied, groundwater supply is drawn down or poor water quality prevents use, domestic and stock users can be left in a critical situation.

Such incidents were common for many domestic and stock users in 2006/07. In response to the consequent hardship, the Victorian Government funded and coordinated the establishment of a network of emergency water supply points for water carting. The supply points consisted of a combination of municipal drought relief bores, urban surface water standpipes and surface extraction points on channels or streams. Access to these supply points was managed by local councils (municipal bores) and urban and rural water corporations (standpipes connected to urban and rural supply systems and waterways).

Victoria's emergency water supply network was upgraded and extended over the period 2006/07 to 2009/10 to meet the needs of water users. There are about 300 emergency water supply points across Victoria compared with 170 emergency water supply points pre-2006. Figure 5.3 shows the location of the emergency water supply points across Victoria.[11]

Government funding was used to upgrade the existing emergency water supply point network, and to add new supply points where necessary. The program, coordinated by the then Department of Sustainability and Environment, was initiated in 2006 and completed in April 2010.

The program was managed by:

- a working group that approved proposals and oversaw the program implementation
- local steering groups (one each for Southern Rural Water, Grampians Wimmera Mallee Water and Goulburn-Murray Water) that reviewed supply points, identified needs, proposed sites and oversaw works approved by the working group.

11 Updated information on supply points locations is available at: **http://www.depi.vic.gov.au/water/rural-water-and-irrigation/on-farm-and-emergency-water-supplies**

Proposals were submitted by each local steering group for approval by the working group. The program funded works on 211 sites involving 34 councils at a cost of almost $5 million and was well supported by local communities.

Carting water is an expensive and time-consuming task. Domestic and stock users have to pay for water to be carted to their property from emergency supply points. The aim of the emergency water supply points program has been to ensure that landholders did not have to travel more than 20 kilometres to access emergency supplies in the most drought-affected areas, thereby reducing the need and cost of water carting for individuals.

Some water corporations have standpipe connections to the reticulated water supply system. In small regional towns, provision of emergency supplies can result in problems such as traffic congestion around standpipes and depletion of town supplies where this is the source of the emergency water. For example, at Mansfield so many outsiders reportedly accessed the emergency water supply that the security of the town's supply was compromised.

5.3 Groundwater supplies and use during drought

Groundwater has been an important source of water for individuals and urban water corporations around Victoria for many years and interest surged in it during the Millennium Drought. Groundwater was an important resource during the drought, as a primary resource and as a supplementary supply option.

The availability of groundwater resources for consumptive use is not uniformly distributed across Victoria. The varying hydrology affects groundwater quality and the yield of aquifers. In some regions of Victoria, groundwater is a major contributor of water supplies – for example, in western Victoria, groundwater accounts for 52 per cent of water use (DSE, 2010b).

Many towns in the south-west of Victoria rely solely on groundwater supplies for drinking water. Towns such as Portland, Port Fairy and Heywood were protected from the impacts of the extreme dry conditions of 2006/07 due to the nature and extent of the Dilwyn aquifer from which their supply is sourced. These towns were not affected by water restrictions and will have a reliable supply beyond

Farm land, Goldfields region *Photo: © James Lauritz*

2055, regardless of climate change impacts (DSE, 2010b).

In other regions, groundwater is used by urban water corporations and individuals as a supplementary supply option. For example, in parts of northern Victoria, some licence-holders use groundwater as a back-up resource when surface water supplies are restricted. Many urban regional water corporations' drought response plans include groundwater as a back-up supply for their towns (see Chapter 4).

Total groundwater use across Victoria increased during the particularly dry year of 2006/07, representing a 160 GL increase on the previous year (see Table 5.1). Groundwater extraction increased by about 30 per cent in the deeper aquifers of northern Victoria compared to other years. In the Shepparton groundwater management area, groundwater use was about 85 per cent higher, increasing from about 60 GL per year to 110 GL per year. This was generally in response to reduced surface water allocations for irrigation.

Groundwater levels in these areas are managed in accordance with the relevant groundwater management plan.

Table 5.1 Total estimated annual groundwater use in Victoria

Year	Total estimated use (licence + domestic and stock) (GL)
2003/04	422
2004/05	401
2005/06	366
2006/07	526
2007/08	464
2008/09	449
2009/10	438
2010/11	221
2011/12	316
2012/13	370
2013/14	327

Note: Data compiled from Victorian Water Accounts (formerly State Water Reports).

In addition to increased use of groundwater by existing entitlement holders, there was increased interest in groundwater from individuals and water corporations, who wanted to supplement their water supplies. Groundwater was viewed by many as a ready source that could be accessed at short notice. A significant increase in groundwater licence applications included more than 16,000 bore construction licence applications between 2006 and 2010 (DSE, 2010b).

As a result of this increased interest, there was a sharp rise in groundwater exploration and drilling activity, with varying degrees of success. The complexity of the groundwater resource and the lead times required for assessment and drilling were often underestimated. Assessing the extent and reliability of a groundwater resource, particularly where proposals for large volumes of extraction are concerned (for example, for urban supplies), is difficult and expensive due to the lack of point source data and the specialised expertise and modelling required. In some cases, the groundwater resource did not prove as extensive or as easily accessible as initially assumed. In other instances, access to groundwater played a crucial role in securing water supplies for towns (for example, Horsham) and individuals.

A number of private bores were constructed for domestic and stock use in rural areas, and in urban areas for fit-for-purpose use. In Melbourne, many private bores were constructed to water gardens and lay fields in order to avoid water restrictions. Domestic and stock groundwater use is estimated to account for 18 per cent of total groundwater use in Victoria in 2009/10, compared to about 9 per cent of total groundwater use in 2006/07.[12]

Impacts

The response of groundwater systems to different climatic conditions, as well as rates and volumes of extraction, varies across Victoria. During the Millennium Drought, groundwater supply was affected in areas where users pump from shallow aquifer systems with limited storage that rely on rainfall for recharge. In contrast, in some deeper, confined aquifers, it could be a number of years before a reduction in recharge affects groundwater availability.

12 **Note**: the magnitude of the increase could also be related to improved methods for estimating domestic and stock water use.

In some cases, groundwater access was heavily restricted due to reduced availability, overuse or threat of saline intrusion in coastal areas. For example, in the Werribee basin, access to water in the Deutgam WSPA was qualified by the Minister for Water for more than two years to prevent saline intrusion into the aquifer, as a result of increased reliance on the resource and very little recharge. These restrictions were progressively lifted after 2010 as rain recharged the aquifer.

There is some concern about the link between the exposure of acid-sulphate soils and falling groundwater levels as a result of extraction. Potential acid-sulphate soils exist in many areas of Victoria as layers of iron sulphide are present beneath the surface, and do not cause harm if they remain under water (DPI, 2003). However, if oxidised, they produce large volumes of acid and very low pH levels (DPI, 2003). If re-wetted and leached from the soil, other harmful metals can be mobilised in addition to the acid.

While acid-sulphate soils are naturally occurring, disturbance can result in environmental degradation and water quality issues, with potentially significant impacts on infrastructure, land use, and waterway and estuarine health, including the death of aquatic organisms (DPI, 2003). The link between groundwater extraction and acid-sulphate soils remains unclear. The threat of exposure extends beyond groundwater to risks from the drying of streambeds and wetlands or long periods of reduced flows followed by flooding.

But there were also been positive effects of reduced groundwater levels in some areas. For example, in the Shepparton GMA, increased groundwater extraction and reduced surface water irrigation during the drought led to reduced recharge and deepening of the water table, which helped to achieve the region's salinity management objectives.

Lessons learned

The significant increase in interest in groundwater resources revealed the complexity of resource assessment and the increasing community focus on issues associated with groundwater management. Overall, the experiences during the Millennium Drought contributed valuable information to inform future groundwater management arrangements.

Some water corporations found that accessing groundwater was not as simple as initially envisaged, from a technical, scientific and also licensing perspective. Several corporations found the licensing regime challenging, because they had not understood the resource cap and the need to ensure new entitlements did not adversely impact other users or the environment. Increased public awareness of groundwater issues has resulted in greater public scrutiny of licence applications. Existing licence-holders and private users are more likely to challenge new licence applications which they consider could put their own groundwater supplies at risk.

The significant increase in interest in bore construction licences proved challenging for the licensing authorities[13] from a resourcing perspective. Initially, some of these authorities did not have the capacity to consider the number of groundwater licence applications being submitted. The unexpected severity of the water shortage meant that applicants expected their licence applications to be processed quickly in order to access groundwater as soon as possible and maintain their water supplies. However, their expectations were often not met because the ratio of staff to applications was low, and/or significant time was required to properly consider requests.

The need to improve information on groundwater was reinforced by the experience of managing groundwater through the drought. There has been a significant improvement in groundwater metering in the past decade, and some bore records stretch back over 30 years. Since 2005, all new bores for irrigation and commercial purposes must be metered, and there is a requirement to install meters on existing bores extracting more than 20 ML/year. In southern Victoria this limit is 10 ML/year.

The increase in availability of groundwater information has enabled more sophisticated appraisal of the resource, including targeted programs for drilling bores for consumptive use and monitoring. In some areas, such as in the Campaspe Deep Lead Water Supply Protection Area, improved

13 The Victorian licensing authorities for groundwater are Southern Rural Water, Goulburn-Murray Water and Wimmera-Mallee Water. They each have a Ministerial delegation to licence groundwater use in accordance with the *Water Act 1989*.

quality of information about the resource enabled water managers to permit increased extraction without causing the impacts previously predicted.

The increased understanding of Victorian groundwater systems and improved data availability provides momentum for developing more sophisticated groundwater management arrangements. Information gathered as part of monitoring, licensing and metering of groundwater in Victoria will continue to improve understanding of demand, the characteristics of the resource and changes over time.

Current arrangements for groundwater management focus on those areas Victoria where groundwater use is most intensive. With interest in groundwater use increasing, and recognising that groundwater systems behave differently (for example, some are very responsive to rainfall or its lack thereof, while levels in others have remained relatively stable to date), a new State-wide framework was proposed in the sustainable water strategies.

Adapting to uncertainty:

Chapter 3 of the *Gippsland Region Sustainable Water Strategy* and Chapter 4 of the *Western Region Sustainable Water Strategy* outlined a focus on ensuring management of whole groundwater systems, and adapting to changes in availability of groundwater, including annual processes for temporarily limiting extraction (such as allocations or restrictions).

Additional actions included increased monitoring and metering to gain information about the behaviour of groundwater systems and their interaction with surface water, as well as the flexibility to adapt management approaches as new information becomes available. Management options for entitlement holders, such as trade or carryover, could be introduced in many regions to help users manage supplies within caps (called permissible consumptive volumes) and during dry periods.

5.4 Managing environmental water on unregulated systems

In an unregulated waterway, environmental flow managers typically can't manage water for the environment actively, because flows depend largely on natural inflow conditions and on entitlement holders' extraction.

Passing flows make up most environmental water in unregulated systems, and generally stem from obligations on other users. Passing flows are the minimum amount of flow in the waterway before any diversions under a bulk entitlement or section 51 licence are allowed.

Bulk entitlements stipulate passing flow rules to maintain environmental flows and provide for downstream users. Access to water under diversion licences is based on a series of rules relating to instantaneous streamflows, diversion rates and volume limits (rather than a share of a storage capacity for example). The rules permitting diversion are typically based on trigger levels associated with the volume or level of streamflows in the waterway. For example, if streamflows fall below a specified trigger level, diversion is not permitted. Water accessed for domestic and stock use (under section 8 rights or, in some cases, a licence) is not subject to restrictions, because it is a statutory right and is usually a relatively small volume.

Passing flow requirements were typically based on historical conditions that did not envisage an extended sequence of extremely dry years of the kind experienced during the Millennium Drought.

In some unregulated systems, the passing flow rules were temporarily qualified to alleviate stress on towns and private diverters by allowing them to divert some water when the streams were running lower than the historical passing flow requirements. For example, in 2006 passing flows in the Delatite River were reduced via a qualification of rights to allow Goulburn Valley Water to pump additional water to supply Mansfield's urban demand under Stage 4 restrictions. Similarly, in 2007, several qualifications were necessary to allow South Gippsland Water to pump additional water from waterways, such as the Powlett, Agnes and Tarwin rivers, to supply towns under Stage 4 restrictions. Consultation and ecological risk assessments were undertaken before passing flows were qualified.

Markets in unregulated systems are still emerging and it is unlikely that water markets will provide the same opportunities for active management of environmental water as in regulated systems.

Adapting to uncertainty:

The *Northern Region Sustainable Water Strategy* contained several actions to improve management of water use in unregulated systems, including:

- Better monitoring of usage and growth in domestic and stock use [Action 4.1]
- Determining what constitutes a 'reasonable' maximum volume for stock and domestic use [Action 4.2]
- Ministerial guidelines for licensing unregulated and groundwater supplies [Action 4.4]
- Standard conditions for section 51 and 67 licences and improved records of licence information [Action 4.5]
- Limiting entitlement volumes in unregulated river systems [Action 4.10], accounting for authorised but unlicensed use in unregulated systems
- Developing appropriate restriction policies to manage seasonal variability in unregulated river and groundwater systems through local management rules and management plans [Actions 4.6, 4.7 and 4.12]
- Amending urban bulk entitlements for unregulated systems to allow additional water extraction to off-stream storages during wet periods (provided a number of conditions are met to demonstrate need and protect other users in the system and the environment) [Action 4.17].

5.5 Summary

Individuals who take water from unregulated streams for irrigation, commercial and domestic and stock use are responsible for their own supply infrastructure. They do not have the benefit of large storages and interconnections with other systems to help secure their water supplies.

During the Millennium Drought, as flows diminished in streams across Victoria, licensing authorities introduced progressive stages of restrictions on diversions for irrigation and commercial use, wherever possible. Bans were imposed in many streams to ensure sufficient flow remained in streams to supply critical domestic and stock and environmental needs.

The water shortage encouraged a significant increase in groundwater extractions across Victoria as people looked for other sources of supply. There was a big jump in demand for construction of new groundwater bores. The increase in extractions raised concerns about increased pressure on groundwater supplies since 2006, particularly outside intensively managed areas.

During the drought, the Government enlarged the network of emergency water supply points from 170 to 300 points across Victoria. Landholders faced with dams that were almost empty or who were unable to pump from streams or access groundwater, could cart water from these emergency supply points.

The lessons learned from managing surface and groundwater through this period will be included in improved management practices in the future. These improvements were further developed and discussed with the community through the sustainable water strategy process.

6. Qualifying rights to water

This chapter discusses the lessons learned throughout the Millennium Drought from the qualification of rights to water. This chapter describes when and why qualifications were used, and how they were adapted to achieve better outcomes for all parties. Many of the lessons learned have subsequently been formalised, so there should be a reduced need for future qualifications.

6.1 Translating legislation into practice – key principles

Victoria's water management arrangements place responsibility for managing through drought onto water corporations and other entitlement holders. However, in extreme circumstances, where water resources are so scarce that existing sharing arrangements are no longer adequate to supply all needs, the *Water Act 1989* (the Act) enables the Minister for Water to intervene by declaring a water shortage, qualifying rights and declaring new temporary rules for how water must be used to meet essential needs. This process is known as a qualification of rights.

Due to the unprecedented severity of the Millennium Drought, the Minister for Water qualified rights to water in many systems across Victoria between 2006 and 2010. This was the first time it had been necessary to use this power so extensively.

The temporary water shortage may be the result of a drought more severe than anticipated in a drought response plan, a water quality incident, catastrophic failure of infrastructure, or another unforeseen event.

Section 33AAA of the Act states that:

1. *If the Minister declares under this section that a water shortage exists in an area or water system, he or she may temporarily qualify any rights to water whether or not they relate to the same area or water system.*
2. *The Minister may declare that a water shortage exists in an area or water system if he or she is of the opinion that the volume or quality of water available in the area or system to satisfy any rights to water (whether or not they relate to that area or water system) is or will shortly be inadequate for any reason.*
3. *Before making a qualification to rights to water under subsection (1) the Minister must notify the Minister responsible for administering the Agricultural and Veterinary Chemicals (Control of Use) Act 1992.*

Broken catchment during the Millennium Drought *Photo: © Alison Pouliot*

This provision provides non-prescriptive, enabling powers to the Minister. For example, the definition of what constitutes a water shortage and the powers to declare new temporary water-sharing rules are broad. Such enabling powers are for managing unforeseen extreme events, where the appropriate response will need to be determined on a case-by-case basis. Prescriptive provisions could result in legislative restrictions that hinder timely responses in an emergency.

However, because the powers are enabling it was necessary to develop administrative principles and processes to implement the provisions. The following principles were developed to underpin the qualification of rights process:

1. Qualifications are to be implemented only when all other reasonable contingency measures have been exhausted, including purchase of water allocation on the market
2. Under a qualification, water is allocated according to a hierarchy of supply priorities (see below)
3. The beneficiaries of the qualification pay to manage and mitigate the impact of the qualification on those parties whose rights are affected.

The hierarchy of supply priorities is:

- water for towns under severe water restrictions (Stage 4)
- essential domestic and stock supply for rural customers
- essential commercial and industrial use, such as power generation
- water for critical environmental needs, such as to maintain drought refuges
- water for firefighting.

Guidelines for water corporations were issued by the then Department of Sustainability and Environment in March 2008, to ensure that future qualification of rights processes build on the lessons learned from the early experience. The guidelines outline the procedure to be followed when a water corporation requests a qualification of rights for surface water, including the proponent's responsibility to identify and manage the qualification's impact on other water users and the environment. Lessons learned from implementing qualifications in Victorian systems between 2006 and 2010 have being incorporated into the guidelines which were reviewed and re-issued in 2014.

Cattle at feeder *Photo: © Alison Pouliot*

The proponent's responsibility to identify and manage the impact of a qualification has been incorporated into the Act through the *Water Amendment (Entitlements) Bill 2010*, proclaimed in June 2010. This Bill included an amendment to Division 4, Section 33 of the Act – Minister's powers to qualify rights. Under the amendment, a new section (Section 33AAD) was added to enable the Minister to impose conditions, duties and costs on the holder of a bulk entitlement that is qualified.

Despite being necessary to manage unforeseen extreme events, qualifying rights remains an inherently controversial action. By the very act of qualifying rights, the Government is reallocating water from one use to another and is unavoidably 'picking winners and losers'. The incentives for entitlement holders to manage their own risks are also weakened. Qualification of rights is therefore used only as a last resort under extreme circumstances.

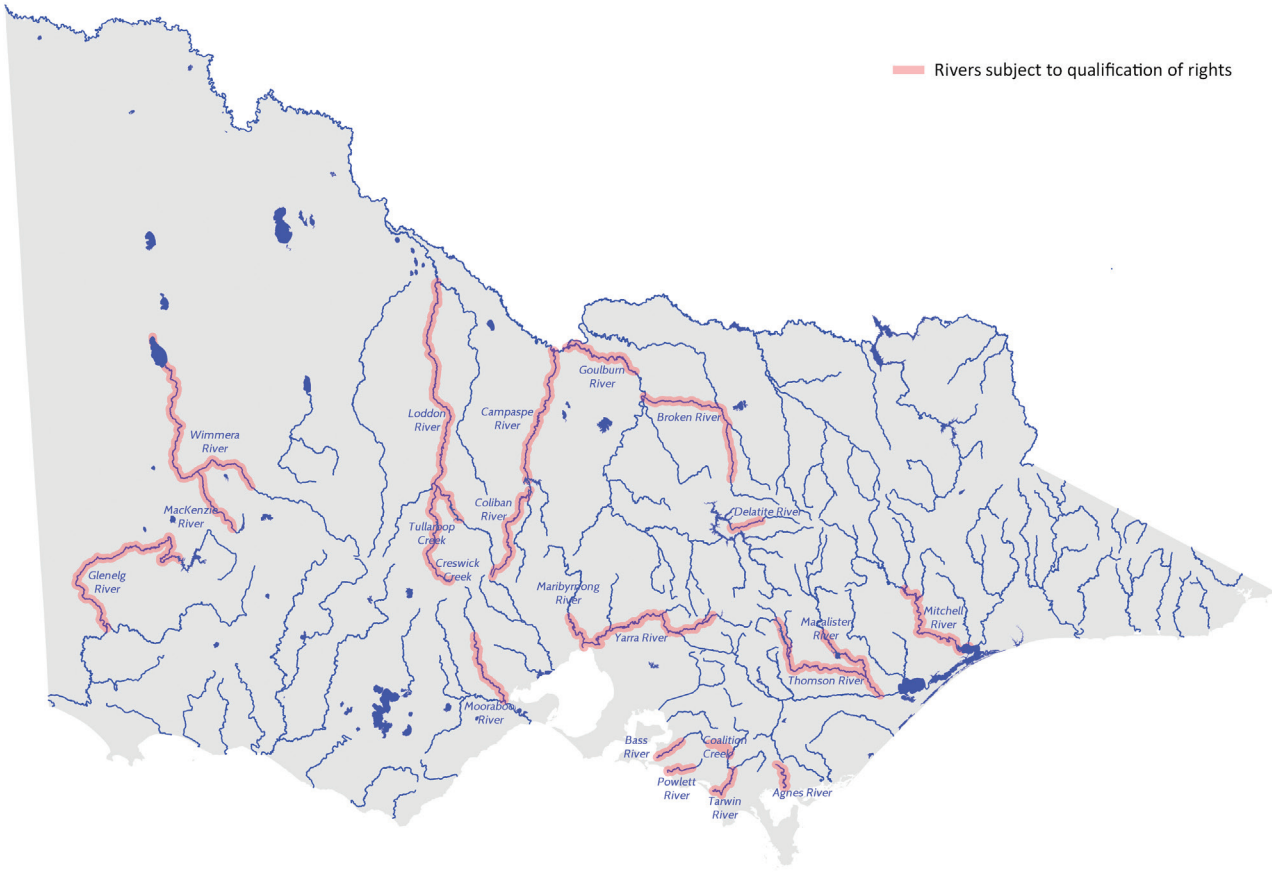
6.2 Implementation of qualifications since 2006

There had been little experience of declaring water shortages and qualifying rights under Section 33AAA of the Act before 2006/07. During that year, temporary qualifications were imposed 28 times in 12 river basins (DSE, 2008a). Without qualifications to rights in place, the impact of water shortages on communities would have been more severe and their associated costs even higher.

Qualifications of rights are undertaken on a case by case basis because each system, its users and associated entitlements are unique, and the measures required to maintain supply must be tailored to the specific conditions of the water shortage. This section provides an overview of the types of measures implemented under qualifications of rights during the Millennium Drought.

Figure 6.1 shows the Victorian rivers that were the subject of a qualification of rights during the Millennium Drought (highlighted in red).

Figure 6.1 Rivers subject to qualification of rights



Typically, a water corporation initiates the qualification of rights process by alerting the Minister that conditions have or will become so severe that they will not be able to meet their supply obligations with their existing drought contingencies in place.

Representatives of the stakeholders affected by a qualification of rights, including water corporations, catchment management authorities and the Department of Environment, Land, Water and Planning work together to negotiate the terms of the qualification and how the impacts will be mitigated. Due to the nature of the measure as an emergency response, most qualification processes occur under critically short timeframes in which difficult decisions that affect the rights of water users must be made.

Generally, qualifications of rights are made when necessary to alter water-sharing arrangements specified in system entitlements. Measures introduced through qualifications on surface water supply systems enable water corporations to prioritise essential urban and rural needs, and provided time for additional contingencies (such as supply augmentation measures) to be completed.

Towns such as Bendigo and Ballarat relied on qualifications during the Millennium Drought to meet their demand even though Stage 4 water restrictions were in place. The additional water was critical to supplement their water supplies during the time it took to bring other more permanent system augmentation measures on line. In rural areas, qualification of rights enabled domestic and stock customers on regulated systems to access water for their homes and livestock. Where possible, rights were also qualified to provide waterway managers with more flexibility to help reduce the impact of the drought on river health.

In several cases, particularly in some of the larger supply systems, the severity and length of the water shortage resulted in rights being qualified for consecutive years (for example, northern Victorian regulated systems such as the Loddon, Campaspe and Goulburn; the Melbourne supply system).

In unregulated systems, qualifications were often used to temporarily alter the water extraction rules outlined in a bulk entitlement of an urban water corporation. Generally, qualifications of rights in these systems were used to:

- reduce passing flow requirements to give the water corporation a greater share of the flow
- extend or alter the timing of pumping or diversion
- establish a new diversion point.

(See examples in Case study 6.1).

In regulated systems, other measures were possible due to the level of control storage operators have over the system. For example, on the northern Victorian regulated systems, many measures discussed in Chapter 3 (such as priority of supply and carryover) were enabled via qualifications on bulk entitlements. Qualifications in the northern Victorian systems were coordinated through the Dry Inflow Contingency Planning Group (see Chapter 3) in consultation with relevant stakeholders. As relationships between agencies matured and understanding of system operations improved, the rules of qualifications were written to maximise efficiency in the supply and use of water, and to ensure mutual benefits.

Wimmera River *Photo: © DEDJTR*

Case study 6.1: Qualification of rights in the Goulburn system 2009/10

Rights in the Goulburn system were qualified every year between 2007 and 2010. The terms of the qualification, these were adjusted each year as more was learned about system efficiency and operations under extremely dry conditions. When the system was re-qualified in 2009/10, water managers were able to incorporate more sophisticated triggers for resuming normal water-sharing rules.

The 2009/10 year began with a zero allocation and with storages holding just 14.3 per cent of capacity. The qualification ensured water corporations could supply essential domestic and stock needs while reserves remained extremely low.

Consistent with carryover provisions in place for water shares, the qualification also allowed urban water corporations to carry over up to 50 per cent of their unused entitlement from the previous year, minus losses. This was crucial for maintaining town supplies at the beginning of the year when allocations were low.

To help build reserves to meet essential needs, the qualification suspended Goulburn-Murray Water's (GMW) obligation to supply the East and West Loddon Waterworks District (which typically incurs high losses) while allocations were zero, and reduced passing flows in the Goulburn River while allocations were less than 10 per cent.

While supplies were suspended, customers in the East and West Loddon Waterworks District could access water from emergency supply points on nearby operating channels. Supplies resumed on 15 September 2009, when the first allocation was announced.

By 1 October 2009, Goulburn system reserves had recovered sufficiently to announce a 30 per cent seasonal allocation, at which time water users were allocated water consistent with their entitlements.

The environmental impacts of the temporarily reduced passing flows could be managed in two ways:

- By the potential use of 20,000 ML remaining in the Goulburn Water Quality Reserve to address possible water quality risks in the river system
- When allocations reached 1 per cent, passing flows could be reinstated or withheld in storage and released by the Goulburn Broken Catchment Management Authority (GBCMA) to best meet the needs of a recovering river system.

A scientific panel report on the ecological implications of the qualification was prepared before the start of the water year, and provided guidance on objectives for environmental water releases. In partnership with GMW, GBCMA directed these water releases to supplement baseflows in the Goulburn River and to top up flows generated from high rainfall to mimic the pattern of natural flushing. Some 818 ML was released from the water quality reserve in 2009/10 to improve water quality in lower Broken Creek.

Case study 6.2: Different access for Coliban customers

The Millennium Drought resulted in increased demand for recycled water, for example via the Werribee Recycled Water Scheme (Werribee Irrigation District) and the Bendigo Recycled Water Project (Coliban Rural System). Customers in these systems relied on their relevant water corporation to provide access to the recycled water schemes.

However, because recycled water could not be legally recognised as a bulk water supply under a bulk entitlement, this reduced the ability of the water corporation to share the benefits of the schemes to all customers. It meant that the Minister for Water had to qualify rights between July 2008 and June 2011 to allow Coliban Water to announce emergency allocations to certain customers who could not access water from the Bendigo Recycled Water Project.

Coliban Water's bulk entitlement required it to consider all rural system customer demands in calculating seasonal allocations. Without the additional recycled water supply, there was not enough surface water available to make an allocation. The qualification enabled Coliban Water to supply the equivalent of a 30 per cent allocation to significant commercial operators on the Coliban Rural System who could not receive the recycled water. This maintained business viability for these users in a system where there is no ability to manage through low water allocations via carryover or trade.

Qualifications to groundwater rights were made to increase and restrict access to groundwater in different locations. In the Campaspe Deep Lead water supply protection area (WSPA), rights to groundwater were qualified to increase access to 65 per cent of the users' licenced volume in response to reduced water availability. Before the qualification, groundwater allocations had been limited via a groundwater management plan to 50 per cent of entitlement volume. Another groundwater qualification in the Deutgam WSPA (in the Werribee basin) banned use, including domestic and stock (with a few exemptions for minor but essential commercial uses), in order to protect the groundwater resource from impacts such as saline intrusion, and to allow groundwater levels to recover.

Qualifications of rights were also made to allow water to be used in areas outside the specification of the entitlement (see Case study 6.2). This sometimes involved transfers between corporations, or between the entitlements of a corporation. Case study 6.3, which covers the transfer of water to the Werribee system from Gippsland, represents an example of the integrated use of legislative instruments (qualification of rights) and infrastructure to provide water in an emergency. While transfer between the Thomson system and the Werribee system was conceived as an emergency response to supply irrigation water, the initial transfer led to the introduction of rules to permit regular trading of small volumes between systems.

Coliban water pipe *Photo: © Coliban Water*

Ballarat Botanical Gardens *Photo: © Peter Dunphy*

Case study 6.3: Moving water between systems

Southern Rural Water (SRW) supplies water to the Werribee Irrigation District (WID) and Bacchus Marsh Irrigation District (BMID) in the Werribee basin, as well as the Macalister Irrigation District (MID) in the Thomson-Macalister basin.

The availability of water resources in the Werribee basin declined substantially during the Millennium Drought. When the extreme dry period of 2006/07 hit Victoria, rainfall and inflows in the Werribee basin had already been well below average for several years.

Irrigation in the Werribee and Bacchus Marsh districts is primarily for vegetable crops and horticulture, which typically require water supplies to be available all year round. Between July 2003 and June 2010, storage levels in the Werribee basin averaged 15 per cent (about 10,500 ML). Drought measures used to increase supply for irrigators included short-term and long-term responses, such as:

- recycled water (WID only) from 2005
- carryover of allocation
- pumping dead storage in Pykes Creek Reservoir
- BMID access to unallocated water in Lake Merrimu Reservoir
- access to the Thomson Drought Reserve via urban supply systems
- groundwater
- trade

In November 2006, BMID and WID irrigators had a 10 per cent allocation. WID irrigators had access to recycled water but needed more low salinity water to improve the quality of water supplied. BMID irrigators had no access to recycled water. Two measures to improve supply to WID and BMID irrigators required qualifications.

Accessing water from the Macalister Irrigation District

Starting in 2006/07 and for the next two years, SRW transferred water from its Thomson-Macalister irrigators' drought reserve in the Thomson Reservoir to WID and BMID irrigators. A qualification of rights was necessary to allow SRW to supply WID/BMID irrigators with water taken under the Thomson/Macalister bulk entitlement. Each year, the transfer was supported by SRW's Macalister Irrigation District customer consultative committee.

The transfer involved collaboration between SRW, Western Water, Melbourne Water, City West Water, the then Department of Sustainability and Environment and irrigators from both basins.

Water was delivered to the Werribee main channel via City West Water's supply system and the Thomson water was delivered through Melbourne Water and City West Water supply infrastructure. The Thomson water was to be bought by individual WID irrigators to dilute the high salinity recycled water and to increase water available to irrigators who had elected not to join the recycled water scheme.

To deliver the water in 2006/07 to the BMID irrigators, 1,000 ML of Thomson Reservoir water was exchanged for 1,000 ML of Western Water's water stored in Lake Merrimu. Western Water pumped the water from Lake Merrimu to SRW's irrigation channels via the Bacchus Marsh urban supply system. Even though Lake Merrimu was low, Western Water had an alternative supply from the Melbourne system. An arrangement was made for Western Water to carry over any unused water (for more than one water year). In 2007/08 and 2008/09, Western Water pumped the water directly from the Melbourne system before supplying to SRW's irrigation channels via the Bacchus Marsh urban supply system.

Case study 6.3 continued overleaf

Case study 6.3: Moving water between systems continued

Accessing unallocated water in Lake Merrimu during the Millennium Drought

Entitlement holders in Lake Merrimu have a share of the storage capacity and the inflows to the storage, as defined in their respective bulk entitlements. Western Water's share is 60 per cent of storage capacity and 70 per cent of inflows, SRW's share is 20 per cent of storage capacity and 10 per cent of inflows, the Victorian Environmental Water Holder's share is 10 per cent of inflows, and there is an unallocated share of 20 per cent of storage capacity and 10 per cent of inflows.

In 2006/07, SRW's Werribee bulk entitlement was qualified to provide access to 1,200 ML held in the unallocated share of Merrimu at the time.

6.3 Managing the impact of qualification of rights

When considering the impacts of qualifying rights in a system, it is often difficult to distinguish between the impacts of a qualification and of prolonged drought. Negotiation between the affected parties when developing the terms of the qualification is the key to managing the impacts within the broader context of a water shortage.

In many cases where rights on a system are qualified, all water users feel some impact of the water shortage and the change to normal sharing arrangements as a result of restrictions on use, prioritisation of other uses, low or zero allocations and subsequent commercial effects. However, the environment is often affected disproportionately as a result of drought and qualification. This is because a lot of the environmental water comes from unregulated flow or system spills, which are usually non-existent during drought, or provisions in supply entitlements that are partly or completely reallocated for essential consumptive use.

Ovens River, Bright *Photo: © Tasha Kiely*

A key principle in the qualification guidelines is the requirement that the beneficiaries must assess the impacts of the qualification on other water users, including the environment, and pay the cost of the water that they receive or the cost of managing the impacts of the qualification on other users.

Where the water being sought was a defined volume, an agreed price could be paid, typically based on an equivalent market value. Where the volume was not well defined, such as a reduction of passing flows, the beneficiary was required to:

- assess the impact of its proposal on the environment
- demonstrate that the critical need of its customers outweighed this impact
- develop a plan to mitigate and monitor this impact
- develop a recovery plan for the affected environment
- review the success of this plan at the end of the qualification, or annually if the qualification went for more than one year.

The following sections describe how these impacts were assessed, managed and paid for, and the lessons learned in this process.

Identifying potential impacts

In a water corporation's initial submissions seeking a qualification of rights, they are required to assess the impact of the qualification on other water users (such as irrigators and domestic and stock users) and the environment.

Environmental considerations are addressed in several ways, and with varying degrees of thoroughness depending on the risks involved. Assessments might include one or more of the following:

- an environmental impact assessment undertaken by the water corporation
- an environmental impact assessment undertaken by independent experts, which could include special consideration of threatened species
- a letter of endorsement from the environmental water manager

Generally, water corporations work collaboratively with the relevant catchment management authorities, the Department Environment, Land, Water and Planning and other relevant stakeholders to consider the risks to the environment and other users.

Where third parties are affected by a qualification of rights (such as domestic and stock diverters and the environment), arrangements to mitigate impacts are to be put in place. For example, during the Millennium Drought, Central Highlands Water carted water to domestic and stock users below Tullaroop Reservoir when passing flows from the storage were suspended under a qualification of rights to provide extra water for Maryborough and district. Central Highlands Water carted enough water for in-house use, provided that water was stored in a tank to reduce evaporation.

Costs to manage and mitigate the impact

The principle of beneficiary pays in the qualification of rights process has been appropriate in most instances, but the approach becomes less straightforward under extended dry conditions. Often there is not a clear separation between the beneficiary and those being impacted. For example, rural communities who live, value and rely on their environment are impacted by the drought, impacted by very low water allocations, urban water restrictions, and also by the deterioration of wetlands and rivers.

In the 2007/08 season, when the first large-scale qualification of rights occurred in northern Victoria, the terms of the qualifications often reduced the volume of environmental water to meet essential needs. In some cases, environmental water was qualified to provide an irrigation allocation, in which case it was appropriate for the rural water corporation to bear the costs of identifying and managing the impacts.

When the environment's Thomson Reservoir entitlement was qualified to increase supply for Melbourne, the urban water corporations benefiting from the reduction in passing flows made a financial contribution based on the nominal market value of the environment's water (see Case study 6.4).

However, as dry conditions continue, it can become increasingly difficult to determine how much of the impact on the environment is caused by the qualification activity, and how much was due to prolonged drought.

During the Millennium Drought as more was learned about the operation of systems in dry years and collaborative relationships between stakeholders matured, the qualification instruments became more sophisticated, and arrangements that provided mutual benefits were achieved. Impacts could be offset by improved flexibility and management arrangements, thereby negating the need for the beneficiaries to pay in some instances.

Monitoring and managing environmental impacts

A key part of the qualification process includes actions to identify and manage environmental risks in a qualified system. The Department Environment, Land, Water and Planning, water corporations and catchment management authorities work together to determine ways to best mitigate the impacts of reduced environmental water availability. Independent expert advice on the risks and impacts of the qualifications on the river systems may also be used to inform the process.

An independent scientific panel was convened in late 2007 for the review of all the northern system qualifications. The panel identified priority environmental sites for the protection of key species and areas of high ecological value and provided advice on the risks and impacts of the qualifications on the river systems (for example, see case study 6.1).

Similar independent scientific panels were also established to provide advice on the management of environmental values during very low flows on the larger regulated supply systems in southern Victoria (see Case study 6.5).

The work of the panels increased understanding of system performance and priorities under very low inflow conditions. Amendments to several qualifications were made on the basis of the panels' advice.

In northern Victoria, the independent scientific panel was reconvened every year the systems were qualified to review the management options for mitigating the risk associated with the qualifications.

Case study 6.4: Beneficiary pays on the Thomson

During the drought qualifications of rights in the Thomson basin meant environmental water was retained in Thomson Reservoir to supplement Melbourne's water supplies and mitigate the risk of Melbourne entering Stage 4 restrictions before the desalination plant was completed.

Under the beneficiary pays principle, Yarra Valley Water, City West Water, South East Water and Western Water were required to buy the environment's Thomson Reservoir entitlement at the average market rate for water in the Macalister Irrigation District. Funds received through the program were paid to the West Gippsland Catchment Management Authority (WGCMA) to be used for environmental management activities on the Thomson River. The objectives of this program were to:

- monitor the impacts of the qualification to inform emergency management decisions
- undertake complementary river health activities within the Thomson River basin to contribute to the long-term health and resilience of the system
- investigate opportunities to enhance the long-term health and resilience of the Thomson River

Offset projects identified for 2009/10 included:

- monitor the impact and inform emergency management under the qualification of rights
- modify the Cowwarr Weir fish ladder to improve the passage of small-bodied fish
- enhance the habitat in the Old Thomson River at the Rainbow Creek confluence to provide a preferential migratory pathway for fish passage to the upper Thomson River
- enhance the habitat of priority fish refuges in the Thomson River

WGCMA's impact assessment found that no additional environmental impacts were found to have occurred in the Thomson River as a result of the qualification.

The Melbourne retail water corporations' annual reports on the effectiveness of the qualification stated that about 13,000 ML of water was retained in Thomson Reservoir during 2009/10 as a result of the qualification. This is equivalent to about two weeks' of water supply for Melbourne.

Adaptive management plans for environmental flows were created based on the advice of the panels. These plans:

- address the recommendations in the scientific panel report
- outline how the identified priorities will be monitored
- identify actions that will be taken based on monitoring results
- identify who would bear the cost of each action, based on the principle of beneficiary pays.

6.4 Reviewing and refining the qualification process

A key aspect of the qualifications process was the application of the lessons learned to each new qualification or amendment. This was particularly important for systems where qualifications were required for a long period. An adaptive approach was undertaken to periodically revise the qualifications to reflect the increased understanding of system performance and environmental management under extremely dry conditions. As experience was gained,qualifications were created or amended to

Case study 6.5: Yarra River – environmental risk assessment

In 2007, the Minister for Water qualified rights in the Yarra River to delay the introduction of previously legislated, new environmental flows and retain more water in storage to boost Melbourne's dwindling drinking water supplies. The Yarra qualification of rights provides an example of a comprehensive due diligence process. It included an environmental risk assessment to understand the potential impacts on key environmental values.

This assessment acknowledged that the prolonged drought conditions represented a substantial risk to the health of native fish populations in the Yarra River. It examined the incremental risk represented by additional water extraction under a qualification of rights and found that the key environmental values potentially at risk were the Australian grayling and Macquarie perch — two native fish species listed as vulnerable and endangered under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999.*

In the short term, these species were at risk from the prolonged low flows, which could lead to poor water quality in pools and fish kills. In the longer term, the flows that trigger fish spawning could be reduced, leading to a decline in fish populations, and a risk of losing a species from the Yarra system.

Melbourne Water, the then Department of Sustainability and Environment and the Environment Protection Authority Victoria developed a monitoring program and contingency measures. In one measure, water quality parameters (such as dissolved oxygen) were monitored and, if triggers were reached, specific volumes of water were released into the river to improve the water quality and protect the Australian grayling and Macquarie perch. These measures are part of the Environmental Emergency Contingency Plan and Drought Monitoring Program prepared for the Yarra River.

In September 2009, after protracted low flows, spring rain caused flooding in the Yarra River, triggering a rule in the qualification of rights designed to protect high-flow events and create favourable conditions for spawning of Macquarie perch. When the flow trigger of greater than 2,000 ML/day at Yarra Glen gauging station was reached, no pumping was allowed for seven days. This management action has helped to protect the long-term viability of native fish populations in the Yarra River.

All aspects of the qualification of rights were reported weekly on Melbourne Water's website, including volumes of water harvested, compliance with qualification of rights rules for harvesting, water-quality risk status and any emergency actions undertaken to mitigate environmental risks. Melbourne Water also provided an annual assessment on the impacts of the qualification of rights on the health of the Yarra River.

A key lesson learned from the Yarra River qualification of rights was that regular review of the monitoring program and management plan was necessary to manage the ecological risks. Adjustments may include the location and frequency of monitoring, frequency of in-stream habitat surveys, and adjusting management responses to triggers as new information arises.

provide the maximum flexibility for stakeholders to manage within the new sharing arrangements and constraints of low water availability.

For example, the first qualifications of rights made in northern Victoria reflected the assumption that the extreme conditions would not continue in the longer term. While provisions were made to identify and protect critical environmental sites, some triggers for returning environmental flows assumed a return to 'normal' conditions.

By 2008/09, northern Victorian systems had not recovered as initially hoped, and the irrigation season began once more with zero allocations on all systems. Without the qualifications in place in the previous year, all systems would have experienced difficulty supplying even essential needs, and some may have failed. Yet it was also clear that some adjustments to the qualifications were needed to ensure there was enough flexibility in the arrangements for environmental managers to manage the impacts of consecutive dry years under qualification.

One of the most significant lessons learned was that the environmental water manager could manage risks to the environment most effectively when given the flexibility to control the timing and volume of releases, subject to the water availability and delivery capacity (see Case study 6.6).

For some regulated systems in northern Victoria, the qualification allowed passing flows to be suspended. Water that would have been released as a continuous passing flow was retained in storage. In some systems, the system operator was able to use some of this water to supply essential needs. An account for the water that would have been released was established, termed a Withheld Passing Flow account. In this way, a record was kept of the water 'owed' to the environment, and this water could be repaid once the resource base improved.

Instead of a simple qualification which, for example, reinstated passing flow obligations once a set storage-level trigger was reached, environmental water managers were given the ability to release the water in the Withheld Passing Flow account to meet environmental needs. This gave environmental water mangers the flexibility to choose the best possible flow regime under the conditions at that time. Flexibility was further increased by allowing the water in the account to be carried over for use in subsequent years.

The qualifications were written to manage water during extreme shortage, and so there were times when unintended consequences arose when conditions improved slightly. For example, the build-up of Withheld Flows Accounts for passing flows was a potential barrier to returning to normal water-sharing arrangements when the terms of a qualification required the storage operator to have the full volume of water in the account available in storage before announcing an allocation. Case study 6.7 provides an example of where this occurred. Overall, once the arrangements were refined, the Withheld Flows Accounts proved a valuable tool for managing the environmental impacts of drought and qualifications.

Ovens River *Photo: © Alison Pouliot*

Case study 6.6: Special rules protect Loddon environment

At the end of the 2006/07 water year, storage levels in the Loddon system were less than 10 per cent. On 1 July 2007, the Acting Minister for Water qualified the rights to water on the Loddon water system to require that passing flows below Loddon Weir be withheld in storage until such time as there was adequate water to declare a 1 per cent allocation against irrigation water entitlements.

On 16 January 2008, sufficient water was in storage to trigger the restoration of the passing flows. When Goulburn-Murray Water (GMW) informed the environmental flow manager, North Central Catchment Management Authority (NCCMA), of its intention to restore flow, NCCMA was concerned that the reinstatement of low passing flows could do more environmental harm than good given conditions in the river at that time. There was a high risk that the planned release would mobilise a pulse of stagnant 'blackwater,' leading to fish deaths.

NCCMA proposed that the passing flows be held back until autumn rain freshened the river, creating suitable conditions for the resumption of passing flows. GMW and NCCMA, with the support of the then Department of Sustainability and Environment, sought an amendment to the qualification of rights to implement special operating rules to increase the flexibility to manage environmental water. These rules established a temporary account for retaining the passing flows in storage until conditions were suitable for environmental releases.

Case study 6.7: Withholding passing flows in the Campaspe system

Under the Campaspe system qualification, Goulburn-Murray Water (GMW) was permitted to withhold passing flows (that would normally be provided in the Campaspe River below Lake Eppalock) to meet essential needs. Under these arrangements, a record of the flows that would otherwise have been passed was kept in the Eppalock Withheld Passing Flow account. Once essential needs were met, 1,000 ML was available from this account for use by the waterway manager.

However, under the terms of the qualification, GMW was required to have the full amount of the water in the Withheld Passing Flow account in storage before an irrigation allocation could be made (despite only 1,000 ML being available for use for the environment). This meant that if the water in storage was not sufficient to cover the full return of the volume of water held in the Eppalock Passing Flow account, no irrigation allocation could be made, and no further water could be made available to the environment. These terms benefited neither the environment nor irrigators.

In 2010, the qualification was amended to make half the volume in the Withheld Passing Flow account available to the waterway manager at a 1 per cent allocation, and all the water available at a 5 per cent allocation. The new terms provided dual benefits, with water able to be accessed earlier than it would have been under the previous arrangements.

The annual review of the northern Victorian qualifications was undertaken near the end of the 2009/10 season. Several amendments were made to recognise changes to legislation, supply augmentation measures that had been implemented and improved water resource availability.

While water availability around Victoria remained below average, the water supply situation improved significantly at the end of the 2009/10 season compared to the previous three years. Moving into the 2010/11 season, the northern Victorian system qualifications were left largely intact to maintain management flexibility provided for environmental flow managers during the extreme drought years.

For example, for the 2010/11 amended Campaspe system qualification, no additional water was set aside for urban water corporations. Central Highlands Water's access to its bulk entitlement volume from Tullaroop Reservoir on the Loddon system was qualified, and the obligation on GMW to supply Central Highlands' entitlement was removed until essential domestic and stock and environmental needs in Tullaroop Creek could be met.

6.5 Reducing the need to qualify rights in future

Unforeseen and unprecedented circumstances may arise in the future that warrant qualification of rights, but infrastructure and policy measures have been implemented across Victoria to ensure that water corporations are equipped to manage through a range of water availability scenarios, including a repeat of the Millennium Drought. These measures will contribute to reducing the need to qualify rights in the future. Further continual improvements of water supply system infrastructure, understanding of climate and environmental conditions, entitlements and planning framework and environmental management will mitigate the need for future qualifications.

For example, the reliance of some urban water corporations on a qualification of rights throughout the Millennium Drought provided the motivation to improve the robustness of their planning and/or augment their water supply systems to reduce the risk of severe restrictions for their customers in future, and by association, avoid the need for future qualifications.

While most qualifications proved successful in avoiding catastrophic system failure, there were a number of impacts that water managers are committed to avoiding in future. When rights were qualified and water reassigned for essential uses:

- rights to water were changed and their security undermined
- reductions in passing flows reduced water available for the environment to benefit other water users
- uncertainty was created as rights were qualified and terms of the qualifications were renegotiated each year as the drought progressed.

Yet positively, more was learned about how to operate the systems efficiently, including the management and delivery of environmental water under low-flow conditions. Many important lessons about sharing water under extreme conditions were learned through the qualification process.

In many cases, because of the collaborative nature of the development of qualification provisions, stakeholders themselves were able to devise new sharing arrangements within a system, which were tested by the conditions. Often, the new arrangements put in place through the qualification proved successful in avoiding catastrophic water shortages, while at the same time meeting the essential needs of water users and managing severe environmental impacts under low water availability.

Several measures introduced through the qualification processes increased the flexibility of water managers to operate under very low inflow conditions. These measures have mostly been incorporated into operating arrangements and/or entitlement provisions where appropriate and will reduce the need to qualify rights in the future.

Case study 6.8: Emergency plan for towns on the Maribyrnong

Like the Werribee basin (see Case study 6.3), the water shortage in the Maribyrnong basin was long and severe. At 1 July 2009, Rosslynne Reservoir held just 3.1 per cent of capacity, or 734 ML.

The qualification of rights on the Maribyrnong system reduced passing flows below Rosslynne Reservoir to maintain water in storage for emergency supplies to towns such as Gisborne, Macedon, Riddells Creek and Sunbury, and for any potential environmental emergencies in Jacksons Creek and Maribyrnong River. Without the qualification, there was a significant risk that Rosslynne Reservoir would be emptied to meet passing flow requirements.

To manage emergency environmental releases from Rosslynne Reservoir, SRW, Melbourne Water and Western Water executed the Maribyrnong Environmental Emergency Contingency Plan and Monitoring Program (MEECP). Releases in 2009/10 targeted specific river water quality parameters at Settlement Road, Salesian College and at Gisborne Botanical Gardens consistent with the MEECP. No water was released for irrigation or diverted for emergency urban supplies.

The qualification expired on 30 June 2010. However, the low flow-sharing arrangements established through the qualification were formalised through an amendment to SRW's Maribyrnong bulk entitlement.

Adapting to uncertainty:

Action 4.18 of the Northern Region Sustainable Water Strategy states: 'Where distribution system operating water is clearly intended for environmental benefit, it will be quantified in bulk entitlements and converted to environmental entitlements to provide the environmental manager with increased flexibility. Where possible, passing flows will be redefined to better share the future risk of climate changes, provided there are no undue third party impacts.'

Future qualification of rights may avoid linking return of environmental water (held by the environmental flow manager) to an allocation level trigger (which is the decision of the rural water business). Instead, it may be preferable to link the return of environmental water to inflows and/or volumes held in storage.

6.6 Summary

Victoria's water management arrangements put the responsibility on water entitlement holders to manage their own risks and water supplies through droughts. However, in exceptional circumstances when water-sharing arrangements are no longer adequate to meet entitlement holders' basic needs, the Minister can intervene to declare a water shortage and qualify rights.

Before 2006, only a handful of qualifications had been approved. These dealt with the transitional arrangements agreed when the River Murray bulk entitlements were implemented and also to ensure towns supplied from the River Murray had access to sufficient water if there were low allocations at the start of the season.

In many cases, rights were qualified as a stop-gap measure to ensure water corporations could continue to supply their customers' critical needs until longer-term measures to secure supplies were in place.

During the Millennium Drought the then Department of Sustainability and Environment prepared guidelines for water corporations and agencies requesting a qualification of rights. The guidelines explain when a qualification is appropriate, define the priority of supply to different user groups under the qualification, and assign responsibility for reporting on the effectiveness of the qualification and paying the costs of monitoring and managing the impact of the qualification on third parties.

The preparation of all proposals to qualify rights involved consultation with major stakeholders to ensure the qualification was tailored to minimise impacts on other water users and the environment; the impacts on other water users and the environment were identified and assessed; and all parties were aware of their financial, monitoring and reporting responsibilities.

Because of the interconnected nature of systems in northern Victoria, qualifications of rights were coordinated through the Dry Inflow Contingency Planning Group, which ensured that all stakeholders were involved in preparing the qualifications. The decisions were supported by an independent scientific panel, which reviewed all qualifications and advised on environmental risks associated with qualifying rights and on priority of sites for protection of ecological values.

The accumulated experience of recent years has increased understanding by all stakeholders of how to balance various essential needs in the qualified water supply systems. Stakeholders developed a greater understanding and appreciation of other priorities and supply challenges. Greater mutual understanding has increased cooperation between the parties, and stakeholders worked together to deliver multiple-benefit outcomes. This cooperation has extended to activities beyond the qualification process.

By mid-October 2010, only three qualifications for surface water remained. Their primary purpose was to improve the environmental management of the rivers when flows were low.

The experience gained in preparing qualifications of rights across Victoria in different situations allowed the qualification process to be improved. Successive qualifications take advantage of better knowledge of operating systems and managing environmental impacts under extreme dry conditions.

Some lessons learned from the qualifications have been used as a foundation for more permanent arrangements, and planning and management arrangements for individual water corporations. This includes improvements to water corporations' drought planning, augmenting of water systems so they can better withstand long dry spells, and amendment of bulk entitlements to enable greater flexibility for water corporations and environmental managers. All this has reduced the need for qualifications of rights in future dry periods.

7. Beyond 2010

As described in Chapter 2, the Millennium Drought of 1997 to 2009 was the most severe drought experienced in Victoria since European settlement. It came to an end in 2010, which was the fifth wettest year on record resulting in severe flooding in the summer of 2010–11.

The experience of managing water resources for all competing uses during the Millennium Drought was influenced by the complex interaction of:

- climatic conditions (patterns and reliability of rainfall across Victoria)
- physical water systems (nature of supply infrastructure and natural waterways)
- water-sharing arrangements (secure water entitlements and trade)
- water planning arrangements (preparedness in the short and long term)
- demand for water for different purposes (domestic use including gardens, rural consumption including irrigation and stock and environmental water).

The Millennium Drought drove home to water managers that climate is not a stationary entity on which planning and system design can be based. While unplanned contingencies were necessary to respond to the unprecedented conditions, the experience of managing through the drought served to reinforce the relevance of Victoria's water entitlement and planning frameworks and strengthened approaches to managing the uncertainty of future water resource conditions.

These improvements put Victoria in a good position to face the dry conditions which started to re-emerge in 2015. However, the uncertainty surrounding future conditions means that the water planning and entitlements framework must continue to evolve to meet the water needs of the future.

Inflows into systems in 2015/16 have been very low and the outlook for 2016/17 is uncertain, and storage volumes are significantly lower than in 2014/15 although still substantially higher than the lowest levels experienced during the Millennium Drought. This final chapter provides a summary of what has occurred in Victoria since the beginning of 2010. It provides an analysis of the conditions in 2015/16, and summarises the lessons learned. These lessons ensure that Victoria has a secure yet flexible water management regime that is robust in the face of uncertain future conditions.

7.1 The floods – 2010/11

In stark contrast to 1997–2009, 2010 was the fifth wettest year on record in Victoria and the summer of 2010/11 was the wettest in Victoria since records began. Almost two-thirds of Victoria received rainfall totals very much above the long-term average. The State-wide average rainfall total for 2010/11 was more than double the long-term average and more than 25 per cent greater than the previous record high, set 100 years ago in 1910/11.

Although Victoria experienced several relatively wet months early in 2010, most of the rain was recorded in the second half of the year. This was because 2010 began with El Niño conditions in the Pacific, followed by a rapid transition to La Niña during autumn. The cycle of El Niño and La Niña events accounts for much of the variability in Australia's climate. This cycle is connected with the atmospheric phenomenon called the El Niño Southern Oscillation (ENSO), which involves a major seesaw of air pressure, ocean temperatures and rainfall patterns between the Australian/Indonesian region and the eastern Pacific.

Persistent wet conditions in the second half of 2010 were driven by record warmth in the tropical waters around northern Australia. The strong La Niña event in the Pacific Ocean was coupled with warm sea-surface temperatures off the north-west coast of Australia (a negative Indian Ocean Dipole event) and these warm conditions in the eastern Indian Ocean created conditions conducive to the formation of north-west cloudbands. Together, these events resulted in tropical moisture being brought into Victoria, with more frequent low pressure systems as well as much cloudier and more humid conditions than usual. This led to above-average rainfall across Victoria particularly in regions north of the Great Dividing Range.

The La Niña event was one of the strongest ever observed and was the principal cause of the high rainfalls over spring and summer. The last time such a strong La Niña event occurred was in 1973/74.

Significant rainfall in September and November 2010 as well as January 2011 brought widespread flooding

across large areas of north, central and western Victoria. The floods during January 2011 were the worst on record for catchments in the west and north-west of Victoria, with some areas recording three to four times the January average rainfall.

La Niña conditions during 2010/11 also brought welcome improvements to streamflows and storages across Victoria (see Figiure 7.1). However, even though the floods of 2010/11 marked an abrupt end to the Millennium Drought, it took time for storages to recover, restrictions to be lowered and users to experience a similar level of service.

The 2010/11 La Niña event passed its peak by March 2011 and decayed over autumn. Neutral conditions were firmly established by mid-2011. After four years of relatively stable condition, in July 2015 the Bureau of Meteorology (BOM) escalated the ENSO status again to an El Niño event. This season's El Niño event has been ranked the third strongest El Niño event in the last 50 years, and it likely to persist well into 2016.

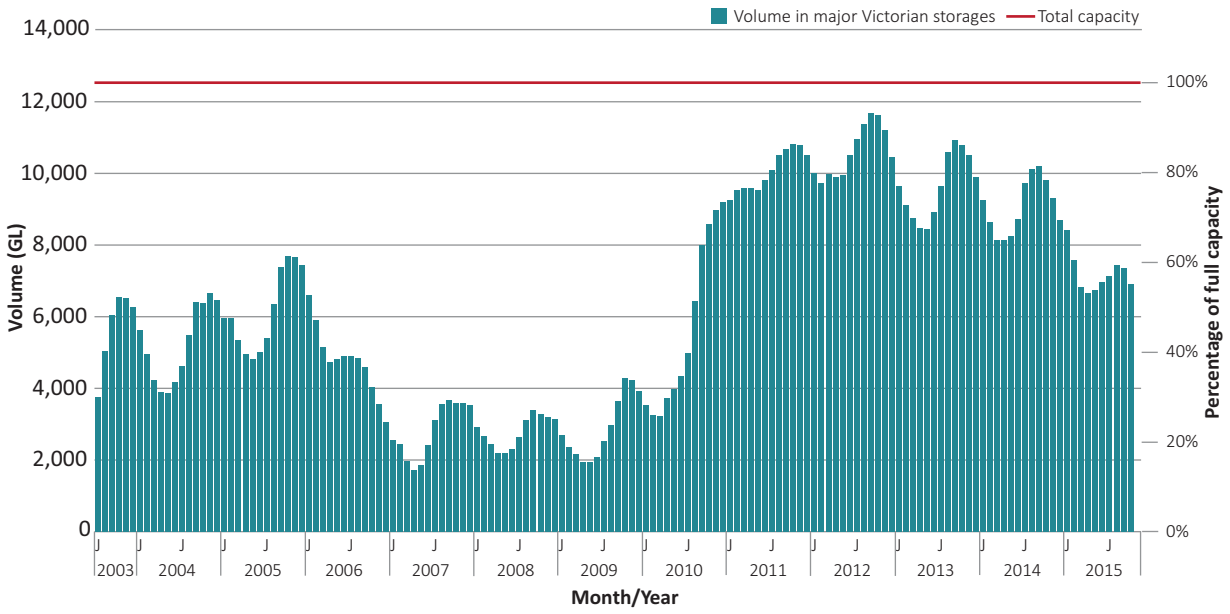
Climate change projections for south-eastern Australia indicate generally drier and hotter conditions on average in coming years (IPCC, 2007; Hennessy et al., 2008; CSIRO, 2007; CSIRO, 2010). This has implications for water resource availability that go beyond reduced inflows. For example, with drier and hotter conditions, bushfires are likely to become more frequent, intense and extensive, which can affect water quality and quantity in the short and longer term. In addition, drier and hotter conditions may mean that water demand for some uses, such as crop watering or evaporative air cooling systems, may increase.

Overall, there is significant uncertainty about the future climate and how it will impact water resources across Victoria. Given the changes in the major climate drivers that have been seen over the past 15 years and climate change projections, the medium to longer-term outlook is for generally drier and warmer conditions, possibly punctuated by very wet years and/or events. In order to reduce the risk of future uncertainty, all plausible future climate scenarios should be considered in planning and managing Victoria's water resources.

7.2 Statewide streamflow and reservoir levels since 2010

During the drought Victoria's storage levels fell to unprecedented levels and with no meaningful winter or spring inflows they stayed low (see Figure 7.1) Storage levels substantially recovered in 2010/11, although some storages, notably in the south west of Victoria, did not fill. As can be seen from Figure 7.1 storage levels have been decreasing since 2010/11 but not to the levels experienced during the worst years of the drought.

Figure 7.1 Volume of water in Victoria's major storages, July 2003 to November 2015



The declining trends in Victoria's major groundwater systems were also reversed in 2010/11 across many parts of Victoria.

Total Victorian annual streamflows during the Millennium Drought were persistently less than the long-term average flows (see Table 7.1). Flows were less than 50 per cent of the long term average over the four years from 2006/07 to 2009/10. Flows exceeded long-term averages between 2010 and 2012, but have been below average since then.

Storage volume of major water supply systems in Victoria at the end of December 2015, expressed as the percent of the maximum storage volumes are show in Figure 7.2. It can be seen that streamflow trends and storage volumes have again started to fall. Storage volumes in the west of Victoria are lower than the east. Storages also are generally lower in the north than the south of Victoria.

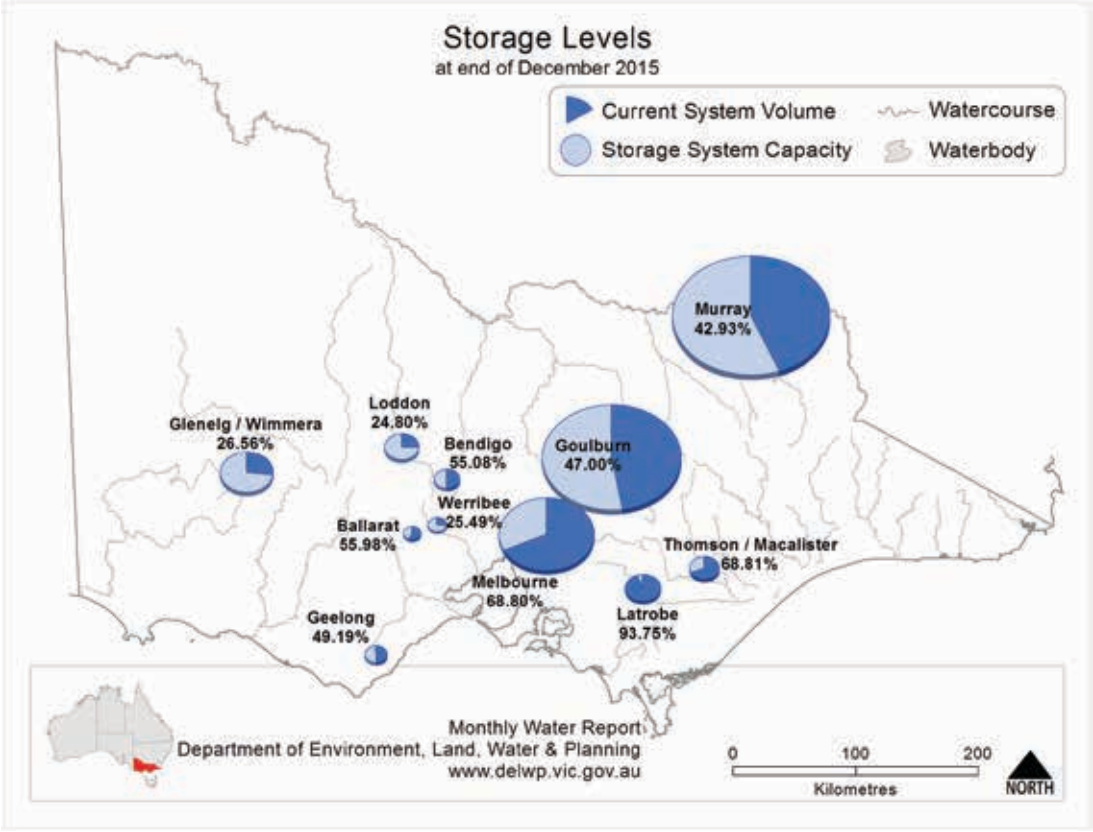
Table 7.1 Total Victorian streamflow compared with long-term average, 2003–04 to 2013–14

Source: Table 1-2, Victorian Water Accounts 2013–14 [Note: DELWP advised that 2014–15 data are not yet available]

Year	Streamflow (ML)	Percentage of long-term average
2003–04	16,848,300	65%
2004–05	17,015,900	65%
2005–06	15,296,700	59%
2006–07	7,091,100	27%
2007–08	11,070,600	42%
2008–09	8,239,800	32%
2009–10	13,132,100	50%
2010–11	45,714,200	175%
2011–12*	32,501,756	124%
2012–13	21,185,276	81%
2013–14	19,850,362	76%

* The total 2011–12 streamflow differs from the value of 32,182,195 ML reported in the 2011–12 Victorian Water Accounts due to updated data for the Murray, Broken and Goulburn basins.

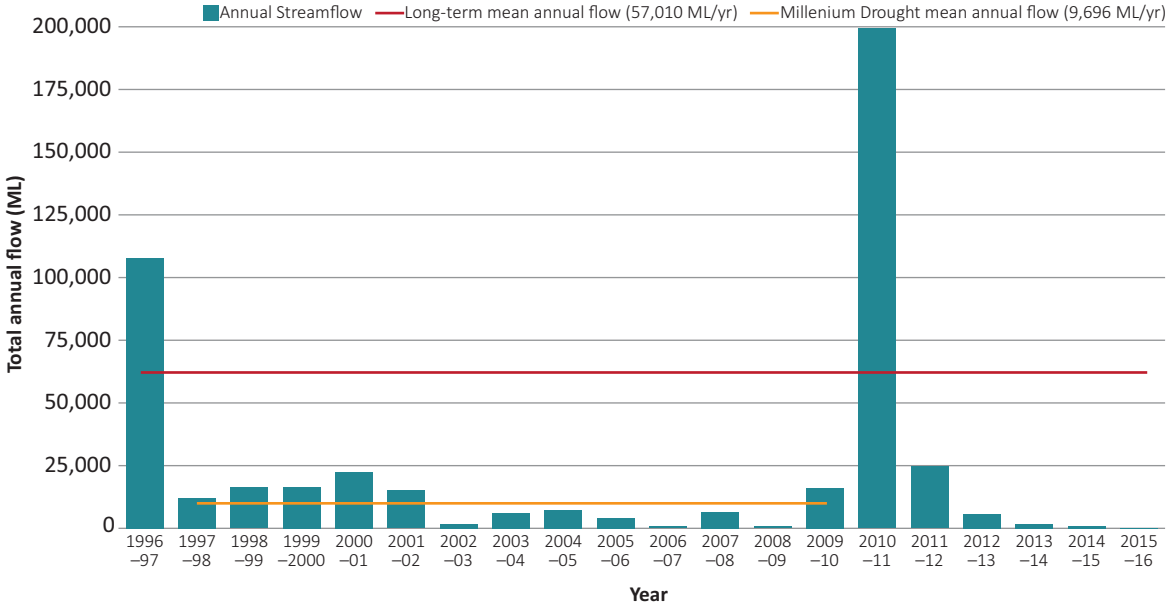
Figure 7.2 Levels in major Victorian water supply systems, December 2015



An analysis of streamflows in different parts of Victoria shows that flows since 2012–13 have been substantially below average in the north west of Victoria (e.g. flows in the Wimmera River at Glynwylln (see Figure 7.3) have fallen to Millennium Drought levels and were close to zero in 2014–15).

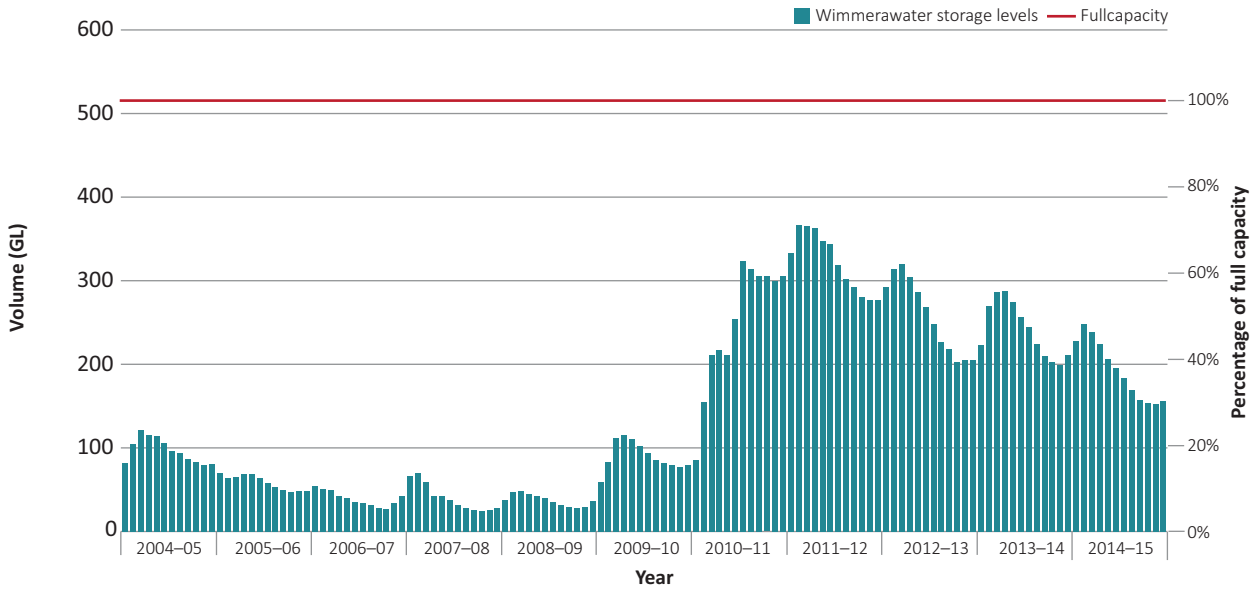
The volume of water in storages in the major Glenelg-Wimmera water supply system fell to extremely low levels during the Millennium Drought (see Figure 7.4). Storage levels recovered with the floods of 2010–11, but did not completely fill. Storage levels persistently declined since 2011–12 because of the very low inflows and as at December 2015 were about 25 per cent full. Despite very low levels, the volume held is comfortably greater than the lowest levels experienced during the drought.

Figure 7.3 Annual streamflow in the Wimmera River at Glynwylln



Source: Data for site number 415206 from the Victorian Measurement information system http://data.water.vic.gov.au/monitoring.htm

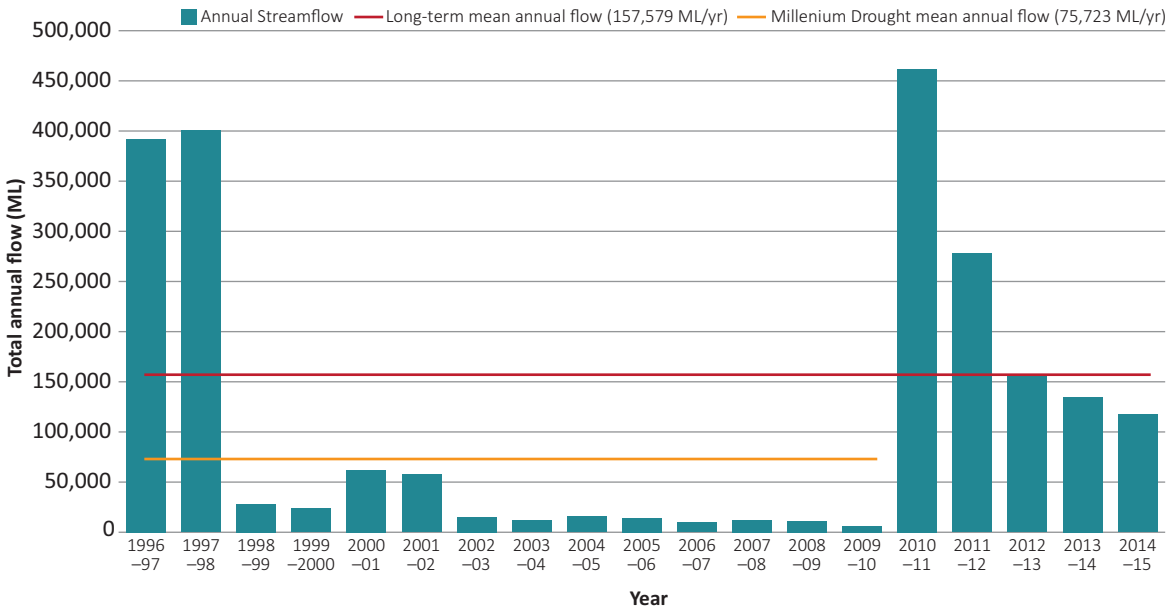
Figure 7.4 Volume in Glenelg-Wimmera major storages, 1 July 2004 to 30 June 2015



Streamflows towards the east of Victoria have been stronger. Figure 7.5 shows that flows in the Campaspe River at Rochester, although on a downward trend and below average over the last two years, remain well above those experienced during the Millennium Drought.

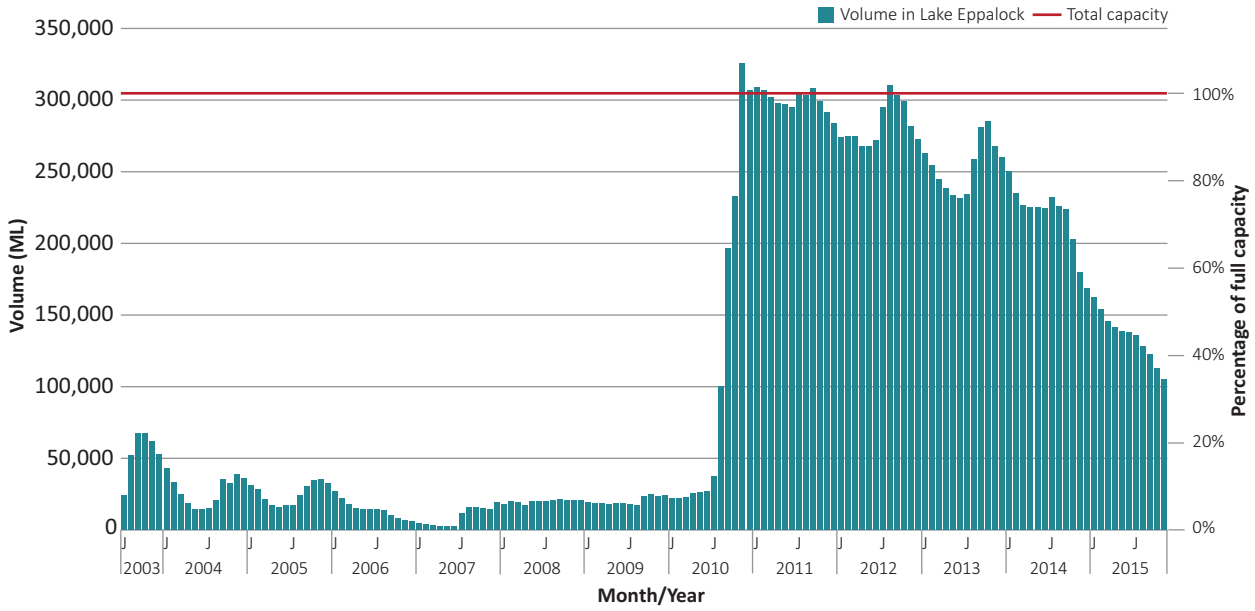
In the Campaspe system, the volume of water in Lake Eppalock fell to extremely low levels during the Millennium Drought. It filled with the floods of 2010–11 but storage levels have fallen since then due to extremely low inflows (see Figure 7.6). This has been especially marked in 2015 when there was effectively no inflow from February to June 2015 and over winter 2015, the total inflow to Lake Eppalock was about 0.7 per cent of the long-term average. However, as at 30 November 2015, lake levels were still well above the lowest experienced during the Millennium Drought.

Figure 7.5 Annual streamflow in the Campaspe River at Rochester



Source: Data for site number 406202 from the Victorian Measurement information system http://data.water.vic.gov.au/monitoring.htm

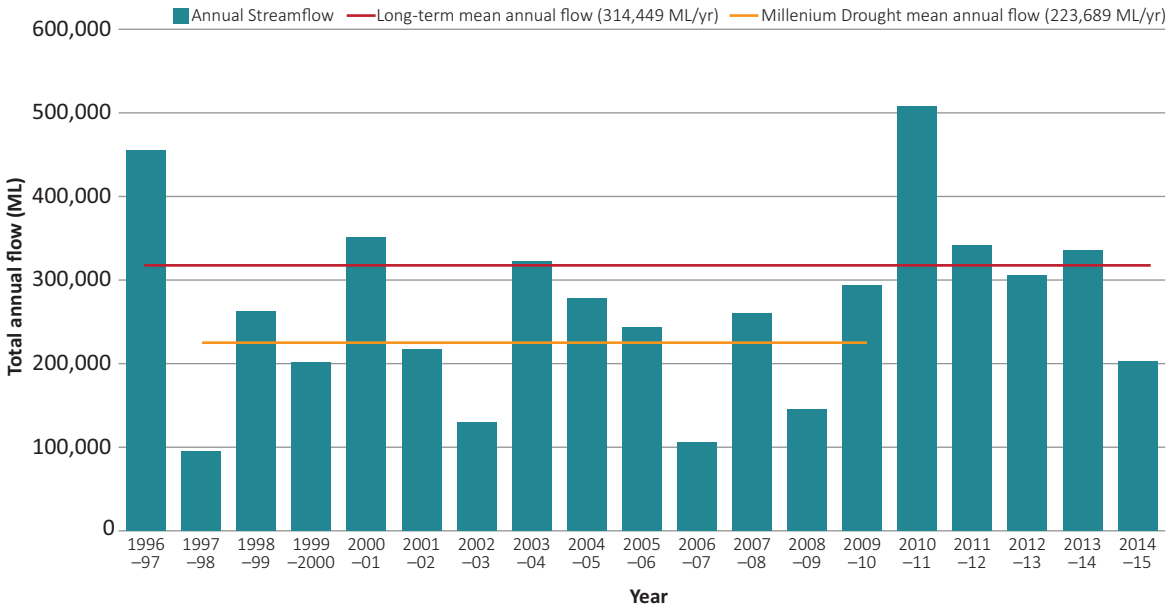
Figure 7.6 Volume in Lake Eppalock, 1 July 2003 to 30 November 2015



Further east in the Goulburn catchment, streamflows have been stronger. Figure 7.7 shows that flows in the Goulburn River above Lake Eildon were about average post the 2010–11 floods, but dropped away markedly in 2014–15 and low flows have again being experienced in the first half of the 2015–16 water year.

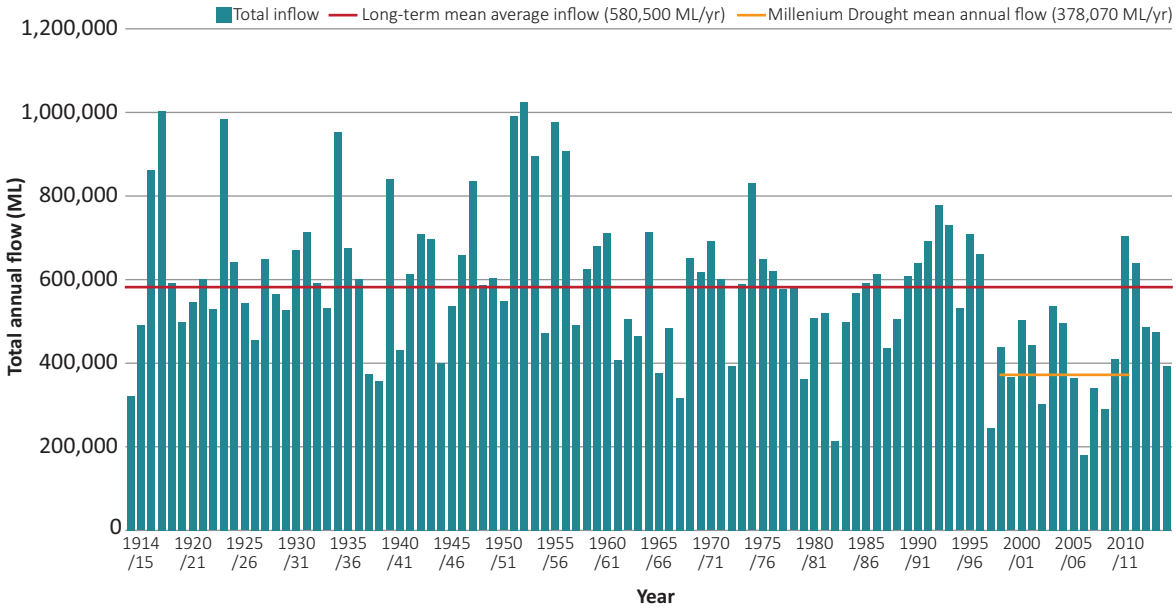
Annual inflows to Melbourne's major storages (see Figure 7.8) have been less than 80 per cent of the long-term average since 2012–13. Inflows have exceeded the average flows during the Millennium Drought.

Figure 7.7 Annual streamflow in the Goulburn River at Dohertys



Source: Data for site number 405219 from the Victorian Measurement information system http://data.water.vic.gov.au/monitoring.htm

Figure 7.8 Annual inflows to Melbourne's main harvesting reservoirs (Maroondah, O'Shannassy, Upper Yarra and Thomson Reservoirs)



The lower than average inflows have resulted in water levels in Melbourne's storages ranging between about 70 per cent to 85 per cent. The Melbourne system was 70.6 per cent full at 10 December 2015, substantially above the lowest storage level (29 per cent) experienced in the depths of the Millennium Drought in 2008–09 (see Figure 7.9). Storage levels are likely to fall below 70 per cent this summer.

Gippsland streamflows have been similar to those into Melbourne storages, with flows over the last three years being below the long term average, but above the average experience during the Millennium Drought (see Figure 7.10). Droughts in southeast Victoria are generally shorter and less severe than in northwest Victoria, but still have considerable impacts as they occur in areas which expect, and plan for, regular rainfall.

Figure 7.9 Volume in Melbourne Water Corporation storages, 1 July 2004 to 30 June 2015

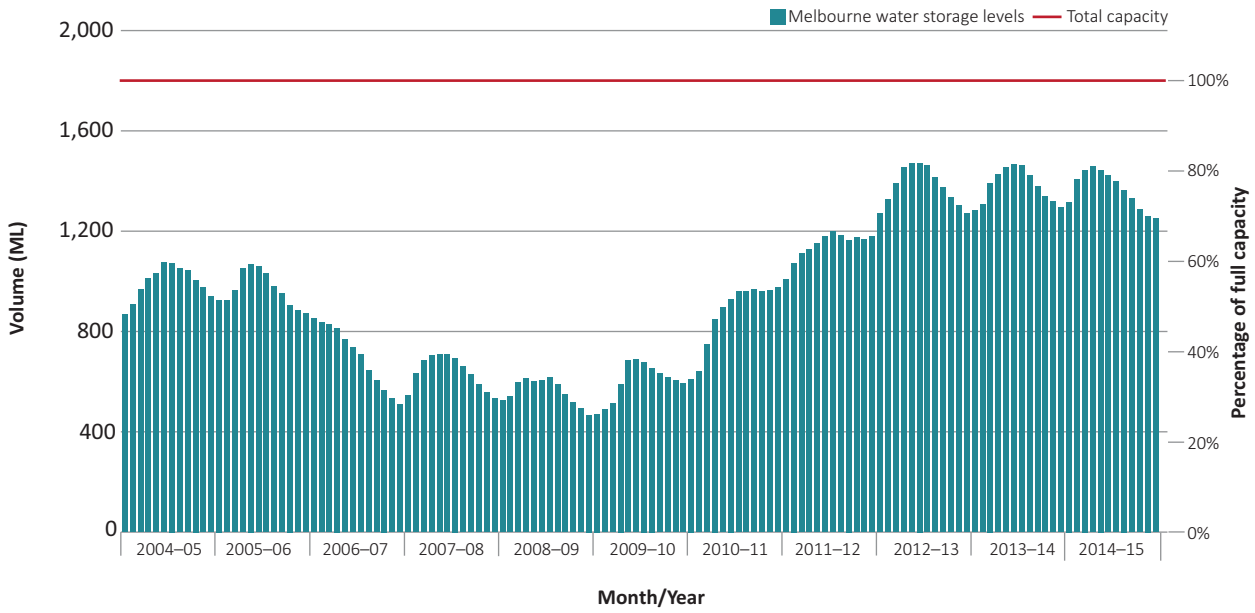
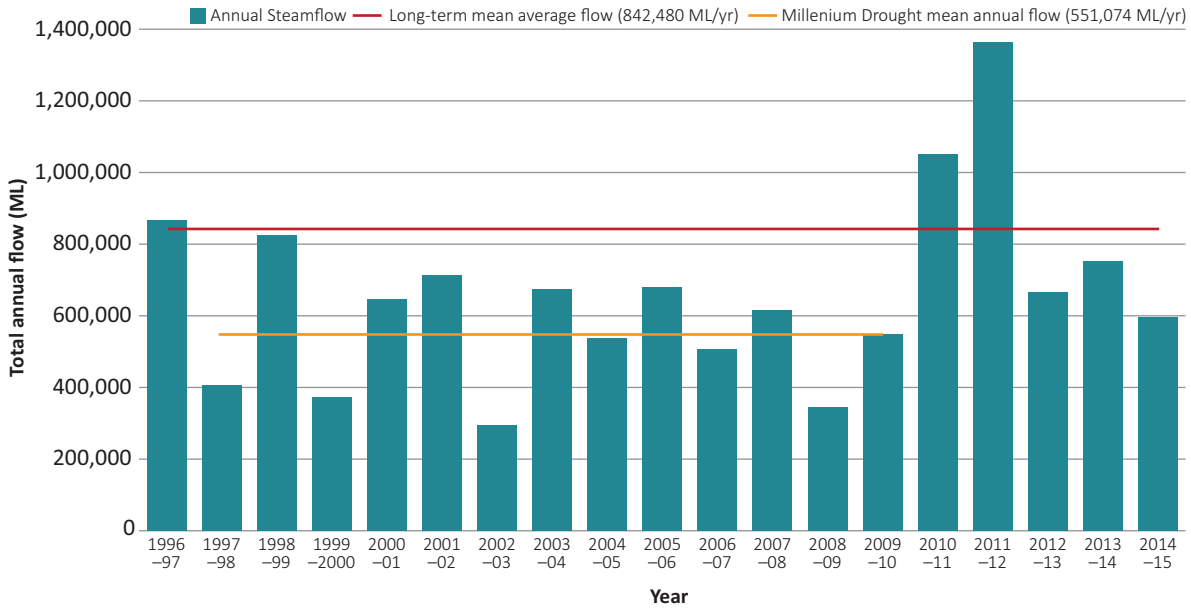


Figure 7.10 Annual streamflow in the Mitchell River at Glenaladale



Source: Data for site number 224203 from the Victorian Measurement information system http://data.water.vic.gov.au/monitoring.htm

7.3 State-wide water resources available since 2010

In July 2007 there were 32 towns on water restrictions, with no towns on Stage 4. By June 2012 there were 26 towns on some level of restriction and this dropped to three towns in June 2013. The last town to come off restrictions was Harrow in December 2014.

On 16 November 2010, northern Victorian allocations reached 100 per cent for high-reliability water shares on all systems for the first irrigation season in 10 years. Low-reliability allocations were also announced on the Campaspe, Broken and Bullarook systems. As a result of good inflows and low demand during the 2010/11 season, the 2011/12 season opened with high-reliability allocations for all northern systems for the first time since 2002/03. Since then the Murray and Goulburn systems have reached 100 per cent high-reliability water shares each year until 2015/16, but have not received any allocation against low-reliability water shares.

Allocations for Werribee and Bacchus Marsh irrigators in 2010/11 opened at 6 per cent allocation for high-reliability water shares and reached 100 per cent on 30 November 2010. By the end of the 2010/11 season there was also a 55 per cent allocation for low-reliability water shares. The 2011/12 season opened with a full allocation for high-reliability shares. Since 2011/12 allocations have decreased, and although both districts have received an opening allocation each year, allocations only reached 70 per cent high-reliability water shares in 2014/15. In 2015/16 up to December 2015, allocations for high-reliability water shares were only 15 per cent. If current dry conditions continue there will be no opening allocation in 2016/17.

Only three temporary qualifications of rights to surface water remained in place in two river basins by mid-October 2010. These qualifications were in the Campaspe and Loddon systems, and were kept in place to maintain flexibility in the delivery of environmental water, to retain access to environmental water held under the terms of the qualification and to support an allocation on the Coliban rural system. At the end of June 2011, all qualifications to surface water expired, and none have been used since then.

Groundwater levels in many areas have increased as a result of the wet conditions. For example in the Deutgam water supply protection area, groundwater levels recovered by more than two metres in 2010 due to increased recharge and the removal of restrictions.

Wide spread bans and rosters for taking and using water from unregulated streams were experienced during the Millennium Drought. These restrictions were most significant from 2006 until 2010 when many bans stayed in place for years rather being lifted in the winter and spring months. Nearly all bans were lifted by October 2011. Since 2013 the number of streams on rosters and bans has again increased with the number or rivers on bans since 2013 exceeding the number of rivers on bans during the early years of the Millennium Drought.

7.4 Reforms coming out of the drought

There were many hard lessons learned during the Millennium Drought. The Victorian water sector came through the drought with an improved capacity to manage future dry conditions.

Improvements included:

1. advances in our understanding of Victoria's climate variability and water availability that are incorporated into water resource planning
2. improvements in the specification of water entitlements so they work better during extreme water shortages
3. improvements to water markets
4. improved water conservation in urban areas
5. investment in water supply systems to:
    a. modernise domestic and stock and irrigation systems to reduce inefficient system losses
    b. expand the water grid to connect towns to reliable water supplies
    c. augment water supplies by accessing groundwater, increasing storage capacity and investment in the Victorian Desalination Project
6. the establishment of standpipes to support people in dryland areas that need to cart water

7. reform to all aspects of the management of the environmental values of our waterways including greatly increased water entitlements and allocations

Improvements to these reforms have continued to be made post the Millennium Drought and are discussed further in the following sections.

1. Improved understanding of our climate

Prior to 2006 water resource planning assumed that the past 100 years of rainfall and stream flow records represented best practice for water resource planning. However, the nature and causes of climate variability and change in south-eastern Australia was poorly understood. Gaining a better understanding became an urgent priority with the onset of the Millennium Drought and growing concern that the severity of the drought was at least partly caused by climate change.

Victoria became a lead partner in the Southeast Climate Change Initiative (SEACI), a cooperative research project conducted by the Bureau of Meteorology and the CSIRO. Victoria, the Murray Darling Basin Authority and the Commonwealth Government provided funding of $16.5 million over the six years from 2006 to 2012.

SEACI provided a better understanding for the main drivers of the climate in south eastern Australia, including the impact of global warming. Outcomes from SEACI investigations suggest that:

- the Millennium Drought was:
  - unusual in an historical context in terms of its extent, severity, duration and seasonality, hence it was not surprising that water management processes were challenged
  - associated with trends in global atmosphere circulation that are partly linked to anthropogenic influences (i.e. linked to climate change)
- the observed trends in climate are projected to continue – in particular, the southward movement of cool season 'storms' is expected to continue
- rainfall and runoff projections show a generally drier and warmer future, but there is considerable uncertainty around the timing and magnitude of impacts.

SEACI has improved:

- the understanding of the key influences on seasonal and inter-annual rainfall variability
- dynamic and statistical forecasting schemes
- the understanding of changes in the rainfall runoff relationship under drier and warmer conditions

The Commonwealth Government and the Murray Darling Basin Authority withdrew funding from SEACI in 2012. However, important climate work has continued through a revamped program called the Victorian Climate Initiative (VicCI).

The VicCI program aims to resolve some of the key challenges remaining after SEACI. Its research, which is focused on climate variability, predictability and change, will:

- improve predictions of water availability in the short term (seasonal to inter-annual time scales), which have the potential to inform drought response strategies and outlooks for urban supplies, and processes for seasonal determinations for rural supplies and risks of spill for irrigation systems
- underpin an improved assessment of the risks to water resources and supplies from changes in climate over the medium to longer term, based on improved understanding of the climate system and its representation by climate models.

Improvements in our understanding are being incorporated into Victoria's water planning processes discussed in later sections. The most substantial change has been to no longer rely on the past 100 years of water resource data to estimate future water availability.

2. Improved water entitlement regime

The drought tested Victoria's entitlement regime because in some cases the water-sharing rules within the entitlements did not contemplate the very low levels of water availability experienced. In simple terms they did not provide rules for sharing the last megalitre of water. They did not include rules to specify how the water required to deliver water to distant end users would be rationed. Nor did they include rules for pumping water from below the off-take of reservoirs (the dead storage) that created a water deficit for the following year.

As a result of these practical deficiencies, improvements to legislation and bulk and environmental entitlements have been made including:

- explicitly defining how water shall be shared under very dry conditions
- more explicitly defining water allocations for conveyance water in headworks and distribution systems in declared systems
- amending rules to build reserves for the following year in bulk supply systems to reduce the risk that water carried over cannot be delivered
- amending rules to provide more operational flexibility to the Victorian Environmental Water Holder to enable them to manage drought refuges better
- implementing policies to mitigate environmental damage when environmental flows are reduced as a result of the qualification of rights under section 33AAD of the *Water Act, 1989*.

3. Improved water markets

During the Millennium Drought water markets played a vital part in mitigating economic damage that would have otherwise caused even higher economic costs. Urban water corporations also used the market to meet their customers' essential needs in many Victorian cities and towns. It was far better for all water users for towns to purchase water at a fair market value from people who had decided to sell, rather than the alternative of governments stepping in to take water off some users to give to the towns to ensure the towns did not run out of water.

Active water markets occurred in:

- regulated systems across northern Victoria
- irrigation systems in southern Victoria (i.e. Macalister, Werribee and Bacchus Marsh)
- some larger groundwater aquifers used for irrigation.

Markets were less effective in small water supply systems where there were limited numbers of potential sellers and buyers. However limited trading still occurred in these smaller systems.

Building on the unbundling of water rights and introduction of the Victorian Water Register, further improvements have been progressively made to water markets following the Millennium Drought. These include:

- the inclusion of all surface and groundwater take and use licences on the register and their associated works licences in 2014
- progressive enhancements in the Victorian Water Register and water trading processes to:
  - speed up transaction time
  - enable paperless electronic transfers
  - provide improved price information to the market
- the expansion of interstate trading in the Murray basin
- rule changes to enable towns to buy water on the temporary and permanent market to supply critical water needs and protect community assets such as ovals, golf courses, bowling greens and parks.

4. Improved water conservation measures

The water sector, with government and community support, made significant investments in water conservation measures including:

- introduction of permanent water saving rules (i.e. bans on the hosing down of footpaths and the use of sprinklers in the middle of the day)
- enhanced water efficiency labelling of household appliances such as washing machines and dishwashers
- shower head swap schemes to replace water inefficient shower heads with water efficient shower heads
- improvements in the water efficiency of dual flush toilets
- the use of purple pipes in new subdivisions to enable potable substitution
- trialling of local stormwater and wastewater harvesting schemes to enable these alternative water sources to supply non-potable uses
- increased use of drought tolerant plants in private and public gardens.

Customers that were successful in reducing their water consumption benefited through lower water bills because of the variable component of their water tariffs. In some parts of Victoria, rising block tariffs ensured that high water users faced higher charges, reinforcing the rewards of water conservation.

Water conservation programs can only be successful if they are understood and supported by the community. Major efforts were made by all water corporations to provide information about the current water resource position and outlook, the likelihood of water restrictions, and the actions customers and the local community could take to conserve water. Water corporations also provided additional information on their water bills so each household could compare their water use to the average use of comparable households and to target consumption levels.

Communication messages were tailored to the local needs. In Melbourne the three metropolitan water corporations and Western Water collaborated and funded a single communication campaign with a single spokesperson.

The Victorian Government supported, and where necessary coordinated, the communication programs of the water corporations.

The benefits of the water conservation technologies and measures introduced during the Millennium Drought continue today with ongoing growth in the number of water efficient appliances in households.

5. Investment in water supply systems

5(a). Reduce losses in domestic and stock and irrigation delivery systems

The Victorian and Commonwealth governments, water corporations and rural water users have made significant investments in improving the efficiency of irrigation distribution systems and stock and domestic pipelines. Water savings as a result of improved efficiency have been made available to the environment, irrigators and water corporations. Major projects continuing in 2015/16 include the Goulburn-Murray Water Connections Project (429 GL LTCE), Macalister Irrigation District 2030 Project (12.3 GL LTCE), Sunraysia Modernisation Project (7 GL LTCE) and the Victorian Farm Water Program (59.5 GL LTCE to date).

5(b). Expanding the water grid

Victoria's water grid was rapidly and urgently expanded during the Millennium Drought in response to the very real prospect of towns running out of water (see chapter 4). Connections completed since 2010 include:

- Geelong to the Melbourne system
- Phillip Island to the Melbourne system
- Wonthaggi to the Melbourne system.

Further the Victorian Government is looking at opportunities to extend Victoria's water grid to cover more of regional Victoria. This includes an extension to the Wimmera Mallee Pipeline and supporting the business case development and Stage 1 construction of the South West Loddon Rural Water Supply.

In urban areas, a number of water corporations are investigating localised infrastructure upgrades where required to secure water supplies. These include South Gippsland Water and its long-term planning to improve the reliability of supply to Korumburra through opportunities presented by the water grid.

5(c). Augment water supplies by accessing groundwater, increasing storage capacity and investment in alternative water sources.

Water corporations made substantial investments to bolster supplies and improve the security and resilience of their supply systems during the Millennium Drought. As well as connections to the water grid, water corporations have secured towns water supplies through accessing groundwater, augmenting storages and investment in alternative water sources. Many towns have access to more than one source of water which improves their security, and many water corporations have also enabled large users to access alternative water sources and reduce the impact on town supplies.

In the Melbourne system, the Victorian Desalination Project (VDP) was completed in 2012 and provides an additional rainfall independent source of water capable of supplying up to 150 billion litres a year. This is around one third of Melbourne's annual water consumption. Desalination provides an insurance policy against future dry conditions by supplementing Melbourne's existing catchment supplies. The project is a public-private partnership with a $3.5 billion capital cost between the

State Government and AquaSure, the company contracted to finance, design, construct, operate and maintain the project for 30 years. When the VDP is operational, desalinated water can enter the Melbourne network directly at Berwick, or Cardinia Reservoir. It can also be transferred through Silvan Reservoir to the broader Melbourne water network, depending on storage levels.

6. Water carting to assist people in dryland areas

During the Millennium Drought the standpipe network was expanded dramatically to assist landholders living in dryland areas that are not serviced by public water supply systems (see Chapter 5 for further details). However currently some areas are suffering from drought conditions where this water infrastructure is not currently available. The Victorian Government is further investing in standpipes to increase water security for landholders in these regions. This includes the construction of additional 14 standpipes in the Grampians Wimmera Mallee district which has been suffering from dry conditions.

7. Improved management of the environmental values of our waterways

In addition to steadily increasing volume of environmental water a key change to environmental managements since 2010 has been the establishment of the Victorian Environmental Water Holder. The Victorian Environmental Water Holder was established on 1 July 2011 and has been running as an independent statutory body responsible for holding and managing Victoria's environmental water entitlements since then. The Victorian Environmental Water Holder's planning and use of this environmental watering is critical in ensuring Victoria's rivers, wetlands and floodplains continue to maintain and improve the environmental benefits communities value most.

The Victorian Environmental Water Holder works closely with the Commonwealth Environmental Water Holder to enable and manage large scale environmental watering events in Northern Victoria. Further it works with waterway managers in the catchment management authorities to plan and prioritise watering actions. Each year the Victorian Environmental Water Holder publishes a seasonal watering plan based on seasonal watering proposals prepared by each waterway manager. It regularly reports on the implementation of the plan and progress against objectives. As allocations are made to environmental water entitlements, and water is actually available for use, the Victorian Environmental Water Holder releases seasonal watering statements to communicate its decisions throughout the year. Planning for varying climatic conditions is included in this process included planning for drought years.

Between 2012 and 2015 the Victorian Environmental Water Holder has delivered between 430,000 ML and 800,000 ML of environmental water per annum. This has supported scores of river reaches and wetlands across the state, and has delivered shared

Channel Lining, Central Goulburn channel *Photo: © GMW Connections*

benefits for the environment and the community. The outcomes and achievements of the Victorian Environmental Water Holder's environmental watering can be read in the consecutive reports 'Reflections – environmental watering in Victoria' found at:
http://www.vewh.vic.gov.au/news-and-resources/resource-library/annual-watering-booklets.

7.5 Planning for future water shortages

A core business function of water corporations is to undertake planning to ensure that they can supply the future needs of their customers, taking into account the possible future supply and demand for water. Corporations prepared water supply demand strategies (WSDSs) for this purpose. These plans were prepared as a requirement of the Statement of Obligations issued by the Minister and in accordance with Guidelines for Development of a Water Supply Demand Strategy issued in 2011.

Among other things the Guidelines required the water corporations to base their planning on a range of future climate scenarios and to incorporate the lessons of the Millennium Drought.

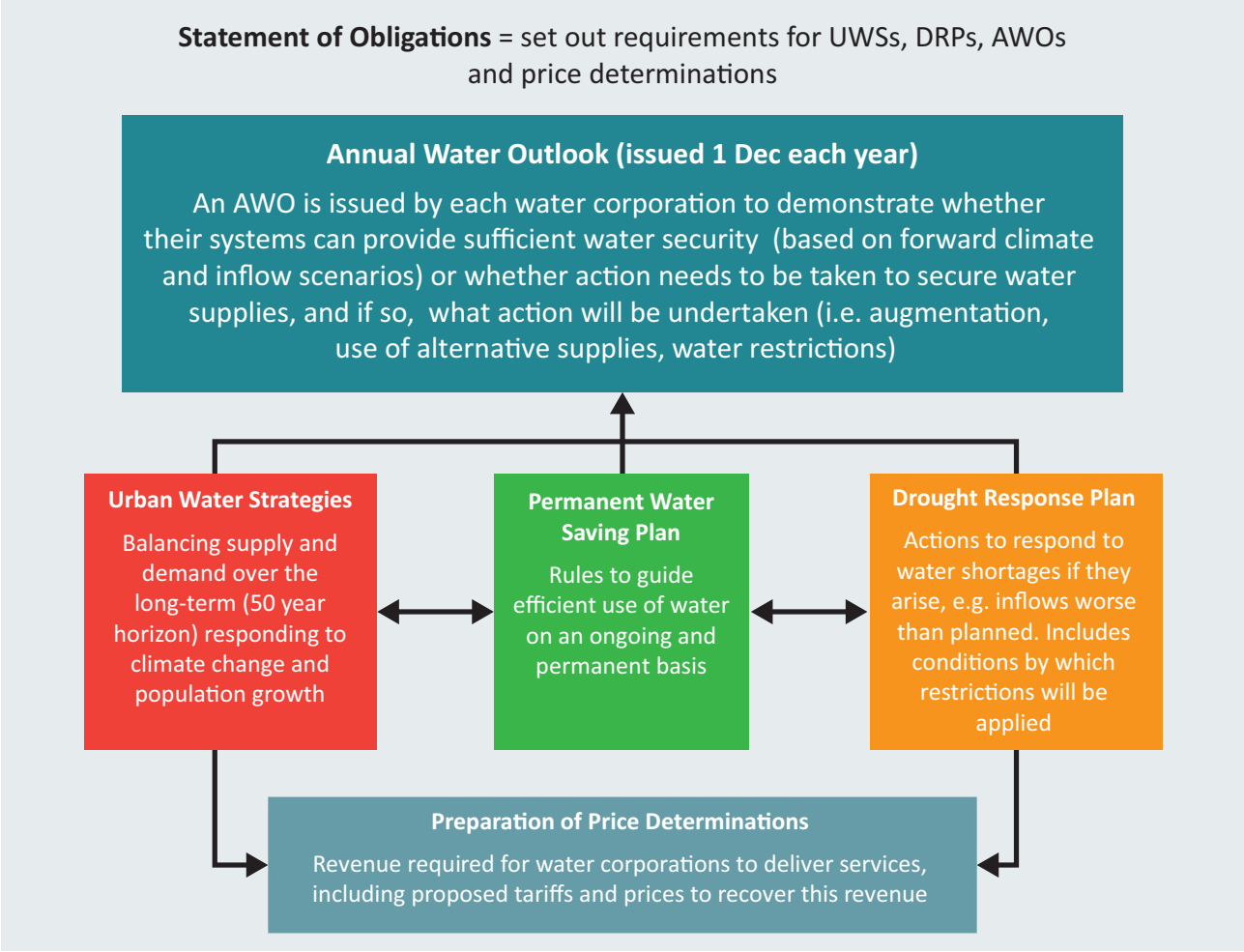
The Guidelines required long-term planning to be linked with short-term planning and drought response plans (see Figure 7.11). Each water corporation's WSDS was signed off by their Board of Directors and was published (except for Melbourne). Copies of the water supply demand strategies were provided to the government for information rather than approval.

These arrangements placed the responsibility and accountability for managing water shortages firmly with the water corporations rather than the government.

Victoria's current water planning processes are described in detail in Chapter 1 of the Report. In summary, water corporations are required to:

- not plan on the basis of historic streamflow patterns and droughts as they do not provide a sound basis for the future

Figure 7.11 Victoria's framework for planning

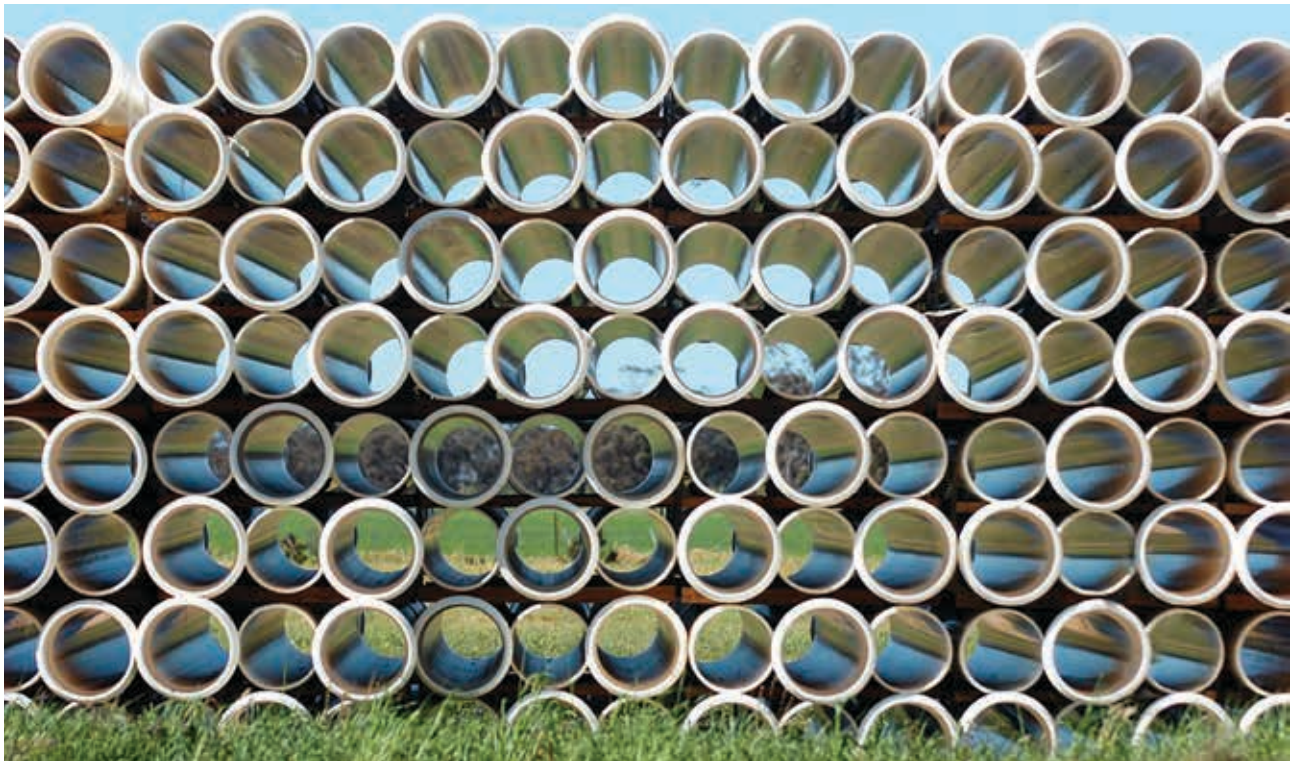


- adopt a scenario approach for planning using a range of climate change and demand scenarios
- evaluate a range of water management options
- establish storage triggers to initiate action to implement the next best option
- prepare a drought response plan to guide the implementation of water restrictions
- develop urban water strategies to ensure that the planning assumptions are appropriate
- prepare a seasonal water outlook (using wet, average and drought inflow scenarios) in December each year to evaluate whether to trigger long term augmentation options or the drought response plan.

These improvements, along with policy reforms and infrastructure investment, will contribute to reducing the need to qualify rights in the future. However, unforeseen and unprecedented circumstances may arise in the future that warrant qualification of rights. Consequently, the Minister for Water has retained emergency powers to declare that a water shortage exists and qualify rights to water in the event a water supply system experiences a drought more severe than the Millennium Drought in the future. As discussed in Chapter 6, the lessons learned from implementing qualifications in Victorian surface water systems between 2006 and 2010 have being incorporated into the Guidelines for water corporations, which were reviewed and re-issued in 2014. The proponent's responsibility to identify and manage the impact of a qualification was also incorporated into the Act through the Water Amendment (Entitlements) Bill 2010, proclaimed in June 2010. This Bill added a new section (Section 33AAD) to enable the Minister to impose conditions, duties and costs on the holder of a bulk entitlement that is benefiting.

7.6 The future

The Millennium Drought and 2010 floods tested water managers and users. This resulted in significant reforms and improvements to the planning and entitlements framework. This puts Victoria in a good position to face the dry conditions which started to emerge in 2015. However, uncertainty surrounding future conditions means that planning and entitlement framework must continue evolve in order to meet Victoria's water needs in the future. This will be addressed through the development of the Victorian Water Plan.



Pipe stack pile, WMPP Construction *Photo: © GWM Water*

8. Glossary

Above-cap water: Water that is left over after the upper limits on diversions have been reached. It also includes unregulated flows which cannot be kept in storage.

Act: *The Water Act 1989 (Victoria).*

Adaptive management: Systematic process of continually improving management policies and practices in response to change.

Allocation Bank Account: Allocations made throughout the irrigation season are credited to the allocation bank account (ABA) of each water shareholder. The balance of an ABA is the amount of water available to the owner of the associated water share for the current season.

Aquifer: A layer of underground sediments which holds groundwater or allows water to flow through it.

Basin (river basin): The area of land which a river and its tributaries drain. In the Victorian Water Accounts, river basins are consistent with those defined by the Australian Water Resource Council (AWRC). The exception is the Murray basin which, for the purposes of this report, includes the Upper Murray basin as defined by AWRC and areas in Victoria supplied from the River Murray downstream of Lake Hume. See also 'river basin'.

Bulk entitlement: The right to water held by water corporations and other authorities defined in the *Water Act 1989*. The bulk entitlement defines the amount of water in a river or storage to which an authority is entitled and the conditions under which it may be taken.

Bulk entitlement conversion order: The statutory instrument used to issue a bulk entitlement under the provisions of section 47 of the *Water Act 1989* where the entitlement holder had a long standing legal right to water in a waterway.

Carryover: Allows entitlement holders to retain ownership of unused water into the following season (according to specified rules).

Catchment: An area of land where run-off from rainfall goes into a river system.

Catchment management authorities (CMAs): Statutory bodies established under the *Catchment and Land Protection Act 1994*. CMAs have responsibilities under the C*atchment and Land Protection Act 1994* and the *Water Act 1989* which include river health, regional and catchment planning and coordination, and waterway, floodplain, salinity and water quality management.

Climate change: An extended period (typically decades or longer) where there is a statistically significant change to the expected characteristics (averages and/or variability) of a region's climate.

Consumptive entitlement: A water entitlement that permits the holder to use the water taken under the entitlement for the purposes of consumption.

Consumptive use: Water that is provided for all human uses (i.e. non-environmental uses).

Critical human needs: The amount of water required to supply Stage 4 restricted demand in urban areas, supply domestic and stock needs and operate the distribution system to deliver that water.

Dead storage: Water in a storage that is below the lowest constructed outlet.

Declared Water Systems: A water system that has been declared in accordance with section 6A of the *Water Act 1989*. Water rights and take-and-use licences in declared water systems have been converted into water shares, delivery shares and a water-use licence.

Delivery bulk entitlement: Provides a set volume of water each year to the entitlement holder, subject to defined rules for restricting supply during periods of water shortages.

Delivery share: An entitlement to have water delivered to land in an irrigation district and a share of the available channel capacity in a delivery system. It is linked to land and stays with the property if the water share is traded away.

Desalination: Removing salt from water sources, normally for drinking purposes.

Distribution system operating water: Water used to operate the irrigation distribution system from river off-take to the farm gate, including evaporation, seepage, leakage, outfalls and meter error (see also System operating water).

Diversions: The removal of water from a waterway.

Drought response plans (DRPs): Used by urban water corporations to manage water shortages, including implementation of water restrictions.

Environmental (bulk) entitlement: A water entitlement held by the Minister for the Environment that permits the use of water in a river or storage for a purpose that benefits the environment.

Environmental flow: The streamflow required to maintain appropriate environmental conditions in a waterway.

Environmental flow regime: The timing, frequency, duration and magnitude of flows for the environment.

Environmental manager: The government agency such as the Department of Environment, Land, Water and Planning or a catchment management authority responsible for environmental outcomes for a relevant waterway.

Environmental water reserve (EWR): The share of water resources set aside to maintain the environmental values of a water system and other water services that are dependent on the environmental condition of the system.

Fit-for-purpose: A description of water requiring no further treatment for its intended use.

Fresh: A small and short peak in flow in a waterway; a 'flush' of water through a waterway.

Gigalitre (GL): One thousand megalitres.

Greywater: Household water that has not been contaminated by toilet discharge, and can be reused for non-drinking purposes. Typically includes water from bathtubs, dishwashing machines and clothes washing machines.

Groundwater: All subsurface water, generally occupying the pores and crevices of rock and soil.

Groundwater management area (GMA): A GMU where groundwater resources of a suitable quality for irrigation, commercial or domestic and stock use have been developed (or have the potential to be developed) and warrant careful management.

Groundwater management unit (GMU): A discrete area – such as a groundwater management area (GMA), a water supply protection area (WSPA) or an unincorporated area – identifying an aquifer or group of aquifers.

Groundwater management plan: A management plan prepared for a water supply protection area to manage the groundwater resources of the area.

Headworks: Large dams, weirs and associated works used for the harvest and supply of water.

High-reliability water share (HRWS): A legally recognised secure entitlement to a defined share of water as governed by the water-sharing rules.

Hydrological modelling: Simplified, conceptual representations of a part of the hydrologic cycle, used primarily for prediction of water behaviour within catchments and associated water supply systems.

Inflows: Water flowing into a storage.

In-stream: The component of a river within the river channel, including pools, riffles, woody debris, the river bank and benches.

Irrigation district: An area declared under the *Water Act 1989* supplied with water by channels and pipelines used mainly for irrigation purposes.

Licensing authority: Administers the diversion of water from unregulated waterways and the extraction of groundwater on behalf of the Minister for Water.

Low-reliability water share (LRWS): A water share with a relatively low reliability of supply. In northern Victoria, these shares are allocated from the available water once there is enough water to meet higher-reliability water shares in the current year, and, with minimum inflows, to meet higher-reliability water shares in the following year.

Megalitre (ML): One million litres.

Millennium Drought: The drought period that occurred in Victoria (and other parts of south-eastern Australia) from 1997 to 2009.

Order (ordering of water): The advance notification given to the storage operator by individual entitlement holders to enable the storage operator to regulate water flows so that all entitlement holders' water needs can be delivered at the agreed time.

Passing flows: Flows that must be allowed to pass a dam or weir before water can be harvested for later use.

Permanent trade: Transfer of ownership of a bulk entitlement, water share or licence.

Permissible consumptive volume (PCV): The total amount of water that can be taken in a water management area under a Ministerial declaration. PCVs can apply to surface water, groundwater or both.

Qualification of rights: A temporary water shortage response under section 33AAA of the Act, when the Minister of Water declares a water shortage and qualifies existing water entitlements to reallocate water to priority uses.

Recharge (to groundwater): The process where water moves downward from surface water to groundwater due to rainfall infiltration or seepage/ leakage.

Recycled water: Water derived from sewerage systems or industry processes which is treated to a standard that is appropriate for its intended use. Regulated system: Systems where the flow of the river is regulated through the operation of large dams or weirs.

Reliability of supply: The frequency with which water that has been allocated under a water entitlement is expected to be supplied in full.

Reservoir: Natural or artificial dam or lake used for the storage and regulation of water.

Reserve rules: Rules that govern the balance between water allocated to entitlement holders in a given year and water kept in reserve for the following year.

Residential use: Water use in private housing.

Reticulation: The network of pipelines or channels used to deliver water to end users.

Return flows: The portion of an allocation that the entitlement holder returns to the bulk supply system.

River: Large stream of water flowing to sea or lake or marsh or another river.

River operating water: Water used to operate regulated rivers (in accordance with bulk entitlements) and deliver water to off-take points for distribution systems, including evaporation, seepage and water to provide passing flows for riparian rights and maintain environmental and other assets.

Run-off: Precipitation or rainfall that flows from a catchment into streams, lakes, rivers or reservoirs.

Seasonal allocation: The volume of water available to an entitlement holder for a water year, as determined by the relevant water corporation and often expressed as a percentage of the entitlement volume. Sometimes shortened to 'allocation'.

Seasonal determination: The process by which a seasonal allocation is made consistent with requirements of the Act and any rules in the relevant bulk entitlement.

Small catchment dam: A farm dam that is filled from its own catchment and is not located on a waterway. This includes small catchment dams used for domestic and stock purposes which are not required to be licensed and dams used for commercial and irrigation use, which are now required to be registered (under the W*ater Act 1989*).

Source bulk entitlement: A type of bulk entitlement held by water corporations to provide a share of inflows, storage capacity (if applicable) and releases.

Spillable water account: An accounting method for managing carryover ensuring entitlement holders lose their carryover only when storages spill.

Stranded assets: Distribution infrastructure left with too few customers to pay for its maintenance when water entitlements delivered by that asset are traded to other systems.

Streamflow management plan: A management plan prepared to manage the surface water resources of the area.

Storage losses: Water lost from storages through evaporation, seepage and spills.

Storage manager: Water corporation managing water storages; may be appointed under section 122ZK of the Act where water in the storage is shared between entitlement holders.

Stormwater: Untreated rainfall run-off from urban areas; the net increase in run-off and decrease in groundwater recharge resulting from the introduction of impervious surfaces such as roofs and roads within urban development.

Sustainable diversion limit: The upper limit on winter-fill diversions within an unregulated river sub-catchment, beyond which there is an unacceptable risk to the environment.

Surface water: Freshwater found above ground in rivers, wetlands and storages.

System operating water: Water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits (see also Storage losses, distribution system operating water, river operating water).

System operator: The water corporation responsible for operating water storages and other infrastructure as specified in the relevant instrument of appointment and bulk entitlement(s) for that water system.

Temporary trade: Transfer of a seasonal allocation.

Unbundling: Separation of water rights or take-and-use licences into a water share, delivery share and a water-use licence.

Unregulated system: A river system that does not contain any dams or major diversion weirs which control the flow of water in the river, and all groundwater sources.

Urban Water Strategy: Strategies prepared by water corporations with urban supply districts. These strategies consider all aspects of the urban water cycle across a 50 year planning horizon and must be consistent with the guiding principles of the Statement of Obligations and any relevant Sustainable Water Strategy.

Water corporations: Government organisations charged with supplying water to urban and rural water users. They administer the diversion of water from waterways and the extraction of groundwater. Formerly known as water authorities.

Water entitlement: The volume of water authorised to be taken and used (or stored) by an individual, water corporation or other authority. Water entitlements include bulk entitlements, environmental entitlements, water shares, surface water and groundwater licences.

Water market: Market in which the trade of entitlements and allocations is allowed under certain conditions.

Water plans: Outline the services water corporations will deliver over a three-year regulatory period and the prices they will charge.

Water right: Previously rights to water held by irrigators. As a result of unbundling, these have now been separated into a water share, delivery share and water-use licence.

Water shares: A legally recognised, secure share of the water available to be taken from a water system that can be traded permanently or leased.

Water supply protection area (WSPA): An area declared under the *Water Act 1989* to protect the groundwater and/or surface water resources in the area. Once an area has been declared, a water management plan is prepared.

Waterway: *The Water Act 1989* defines a waterway as a river, creek, stream, watercourse and a natural channel where water regularly flows, whether or not the flow is continuous.

Water-use licence: A licence which authorises use of water on a specific parcel of land (see also Winter-fill licence).

Wetlands: Inland, standing, shallow bodies of water, which may be permanent or temporary, fresh or saline.

Winter-fill licence: A licence that permits the taking of water from a waterway during the winter months (normally between 1 July and 31 October).

Works licence: A licence that authorises the construction, alteration, operation, removal or decommissioning of any works on a waterway, a bore or a dam belonging to a prescribed class of dams.

Yield: The quantity of water that a storage, water supply system or aquifer produces.

Landsborough valley *Photo: © DELWP*

9. Acronyms

ABA allocation bank account

ASR aquifer storage and recovery

BE bulk entitlement

BMID Bacchus Marsh Irrigation District

BOM Bureau of Meteorology

CEWH Commonwealth Environmental Water Holder

CMA catchment management authority

CSIRO Commonwealth Scientific and Industrial Research Organisation

CW Coliban Water

DELWP Department of Environment, Land, Water and Planning

DICP Dry Inflow Contingency Planning Group

DSE Department of Sustainability and Environment

DRP Drought Response Plan

EGW East Gippsland Water

ENSO El Niño Southern Oscillation

EWR environmental water reserve

GBCMA Goulburn Broken Catchment Management Authority

GL gigalitre

GMA groundwater management area

GMID Goulburn-Murray Irrigation District

GMU groundwater management unit

GMW Goulburn-Murray Water Corporation

GVW Goulburn Valley Water

GW Gippsland Water

GWMW Grampians Wimmera Mallee Water

HRWS high-reliability water share

LRWS low-reliability water share

LTCE Long term cap equivalent

MAR Managed aquifer recharge

MDB Murray-Darling Basin

MID Macalister Irrigation District

ML megalitre

NVIRP Northern Victoria Irrigation Renewal Project

PCV permissible consumptive volume

REALM Resource Allocation Models

SAM Southern Annular Mode

SEACI South East Australia Climate Initiative

SGW South Gippsland Water

SRW Gippsland and Southern Rural Water Corporation

SWS sustainable water strategy

VEWH Victorian Environmental Water Holder

WaterMAP water management action plan

WGCMA West Gippsland Catchment Management Authority

WID Werribee Irrigation District

WSDS water supply demand strategy

WSPA water supply protection area

WW Westernport Water

Thomson Dam *Photo: © Melbourne Water*

10. References and Further Resources

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Useful links

Bureau of Meteorology	**http://www.bom.gov.au** **http://www.bom.gov.au/jsp/awap/** **http://www.bom.gov.au/climate/change/**
Catchment management authorities	**http://www.vic.gov.au/environment-water/water/catchments.html**
CSIRO Climate Adaptation	**http://www.csiro.au/org/ClimateAdaptationFlagship.html** **http://www.climatechangeinaustralia.gov.au/en/**
Department of Environment, Land, Water and Planning – Water Website	**http://www.delwp.vic.gov.au/water** **http://www.depi.vic.gov.au/water/water-resource-reporting**
Indian Ocean Climate Initiative	**http://www.ioci.org.au/**
GMW Connections Project	**http://www.gmwconnectionsproject.com.au/**
South East Australian Climate Initiative	**http://www.seaci.org/**
Victorian Environmental Water Holder	**http://www.vewh.vic.gov.au**
Water Act 1989	**http://www.austlii.edu.au/au/legis/vic/consol_act/wa198983/**
Water corporation websites	**http://www.depi.vic.gov.au/water/governing-water-resources/water-corporations**
Water Register	**http://www.waterregister.vic.gov.au/Default.aspx** **http://waterregister.vic.gov.au/water-trading/trade-reports**

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