Coliban WATER

Coliban Water Urban Water Strategy 2017

Version 1.1

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Revision History

Table 1: Revision and Distribution History of UWS 2017

Distribution	Document	Version	Revision Date1
Board of Coliban Water	Final	1.0	7 April 2017
Minister for Water	Final	1.0	7 April 2017
DELWP	Final	1.0	7 April 2017
Coliban Water website	Final	1.1	6 July 2017

Note 1: UWS to be reviewed no later than 2022.

Document Control

Table 2: Document Control

Author (Date)	Controller (Date)
Water Resources Manager (July 2017)	Water Resources Manager (July 2017)
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Schedule of Current Revisions & Proposed Amendments

Table 3: Current and Proposed Revisions to UWS 2017

Section	Sub-Section	Comments
Version 1.1	-	Minor editorial revisions.
	Part B	Additional tables added

DISCLAIMER

Figures and any values provided are indicative only and not intended to be definitive given the high degree of uncertainty associated with climate, population and demand forecasts over a 50 year timeframe. Coliban Water reserves the right to alter or update information as and when the document is revised over time.

Table of Contents

Executive Summary

Coliban Water has prepared this Urban Water Strategy (UWS) in compliance with Clause 6-1 of our Statement of Obligations 2015. The Department of Environment, Land, Water and Planning (DELWP) provided guidelines for the preparation of an UWS. A proposed future revision will include an indicative investment sequence that aims to keep supply in balance with demand. Some systems will require intervention within the next pricing submission period (July 2018 to June 2023) while some have secure supplies out to 2065.

Coliban Water faces several challenges over the next 50 years from climate change impacts on supply and a steadily increasing population. By 2040 the shortfall in supply may reach 15,300 ML across our nine water supply systems. By 2065 this potential shortfall rises to about 37,400 ML. Without intervention this magnitude of shortfall would result in unacceptable levels of water restrictions and potentially stifle economic growth.

Our *Urban Water Strategy 2017* sets out four broad strategies to address the potential shortfalls;

- Operational flexibility – to optimise the use of our current assets (infrastructure and water entitlements)
- Demand management – to maintain our customer awareness to conserve water and manage system losses
- Alternative water sources – maintain use of existing alternative water sources and investigate additional sources, and
- Supply augmentation – to connect communities via new pipelines and use the water market to secure additional entitlements and or allocation.

The policy settings that will underpin the strategies are outlined throughout the document.

The future impact of climate change is highly unpredictable. Over the long-term however it is expected to have adverse effects on water security with the supply system yields projected to decline. Yield at 2016 is estimated to be 38,094 ML but decline to 21,745 ML by 2065 under a high climate change scenario. The 'yield' is that volume of water that can maintain our Level of Service (95% reliability and no more than Stage 3 restrictions). Yield does not reflect the year-to-year variation in supply.

The annual variation in supply is partially managed through 'reserve rules' that provide for 24 months of unrestricted supply for Coliban Northern and Coliban Southern and 12 months for all other systems that are supplied external i.e. by Goulburn-Murray Water or Grampians Wimmera Mallee Water.

Demand is projected to increase over time mainly due to population growth and increased temperature. Our 2016 baseline urban demand is 28,658 ML/year which is expected to rise to 58,671 ML/year by 2065. Our rural demand is not projected to change but potentially exhibit greater seasonal variation due to hotter and drier weather during moderate or severe droughts.

The climate change projections include a number of scenarios (low, medium and high climate change). Not all scenarios are shown within the UWS. A key point to note is the use of the 'current climate baseline' defined as the period from July 1975 to June 2016 as the main scenario used for comparison purposes. The rationale for this baseline is that it is sufficiently long to include dry and wet periods and reflects the current impacts of climate change.

There is some evidence that the upper Coliban River catchment is exhibiting evidence of non-stationarity in that the runoff generated post-1997 is lower than the pre-1997 period. The climate of this post-1997 period is referred to as a 'step change' climate and has also been modelled.

Some of the less well understood impacts of climate change are elevated salinity in waterways during extended periods of low flow, and poor water quality caused by algal outbreaks during warm weather. Droughts will become more severe over time leading to potentially higher short-term shortfalls in supply. An indication of the severity of future droughts is provided in Appendix C for each system.

The severity is based on a repeat of the Millennium Drought but with a reduction in supply derived from climate models and the increased demand at 2040 and 2065.

Our proposed 'next steps' are to:

- Undertake the necessary analyses to derive an investment sequence for the next 5, 10 and 50 year time periods
- Refining a program of research (evaporation reduction) and investigations (primarily groundwater) and
- Engage with customers and stakeholders including aboriginal groups.

Detailed analysis of each of our nine systems out to 2040 and 2065 can be found in Appendix C.

Part A - Context

Overview

Coliban Water Business

Coliban Region Water Corporation (Coliban Water) is a state owned business that provides water and wastewater services to a region with a population of around 160,000 urban and rural customers across 16,500 km^2 of central and northern Victoria. The service area covers 49 towns in nine raw water supply systems. The supply systems and the respective towns are shown below:

Table 1: Supply systems and towns.

System	Towns Supplied[1]	Source Water
Campaspe	**Goornong**	Campaspe River
Coliban Northern	**Bendigo**, Axedale, Huntly, Raywood, Sebastian **Heathcote**, Tooborac	Coliban Headworks Storages, Lake Eppalock and Waranga Western Channel
Coliban Southern	**Castlemaine,** Elphinstone, Taradale, Maldon, Newstead, Harcourt, Guildford, Fryerstown **Kyneton**, Malmsbury, Tylden	Coliban Headworks Storages
Elmore	**Elmore**	Lower Campaspe Valley Groundwater Management Area
Goulburn	**Boort, Lockington, Rochester, Pyramid Hill & Serpentine** (Jarklin, Macorna, Mysia, Mitiamo Dingee)	Waranga Western Channel
Loddon	**Bridgewater**, Inglewood **Laanecoorie**, Tarnagulla, Bealiba, Dunolly	Loddon River
Murray	**Echuca** **Cohuna, Gunbower, & Leitchville**	Murray River Gunbower Creek
Trentham	**Trentham**	Spring and groundwater
Wimmera	**Korong Vale**, Wedderburn (Borung, Wychitella)	Wimmera Mallee Pipeline

Note 1: Towns show in bold indicate the location of the water treatment plant (WTP) with all following towns supplied from that WTP. Towns in (brackets) are not supplied with potable water.

Coliban System Northern (Coliban Northern) and Coliban System Southern (Coliban Southern) are interconnected and share water from the Coliban Headwork Storages. Coliban Northern also has access to water from the GMW Campaspe System (Lake Eppalock) and GMW Goulburn System (Waranga Western Channel).

Water service functions carried out by Coliban Water include:

- Water harvesting, storage, treatment and distribution
- Urban wastewater collection, treatment, re-use and disposal, including trade waste, and
- Rural water supply.

Potable Water Supply
There are 39 reservoirs and service basins to store raw water. Raw water is treated in one of our 19 water treatment plants, and distributed through 2,245 km of water mains (potable and non-potable).

Wastewater Service
The wastewater is collected through 1,904 km of sewer mains, and treated at our 16 Wastewater Treatment Plants (including two 'Build Own Operate Transfer' plants). The recycled water is distributed to be used in public open spaces through 48 km of recycled water mains. The Recycled Water Factory at Epsom is designed to produce 'Class A' recycled water. The recycled water is mainly used to irrigate public open spaces in Bendigo and for rural use.

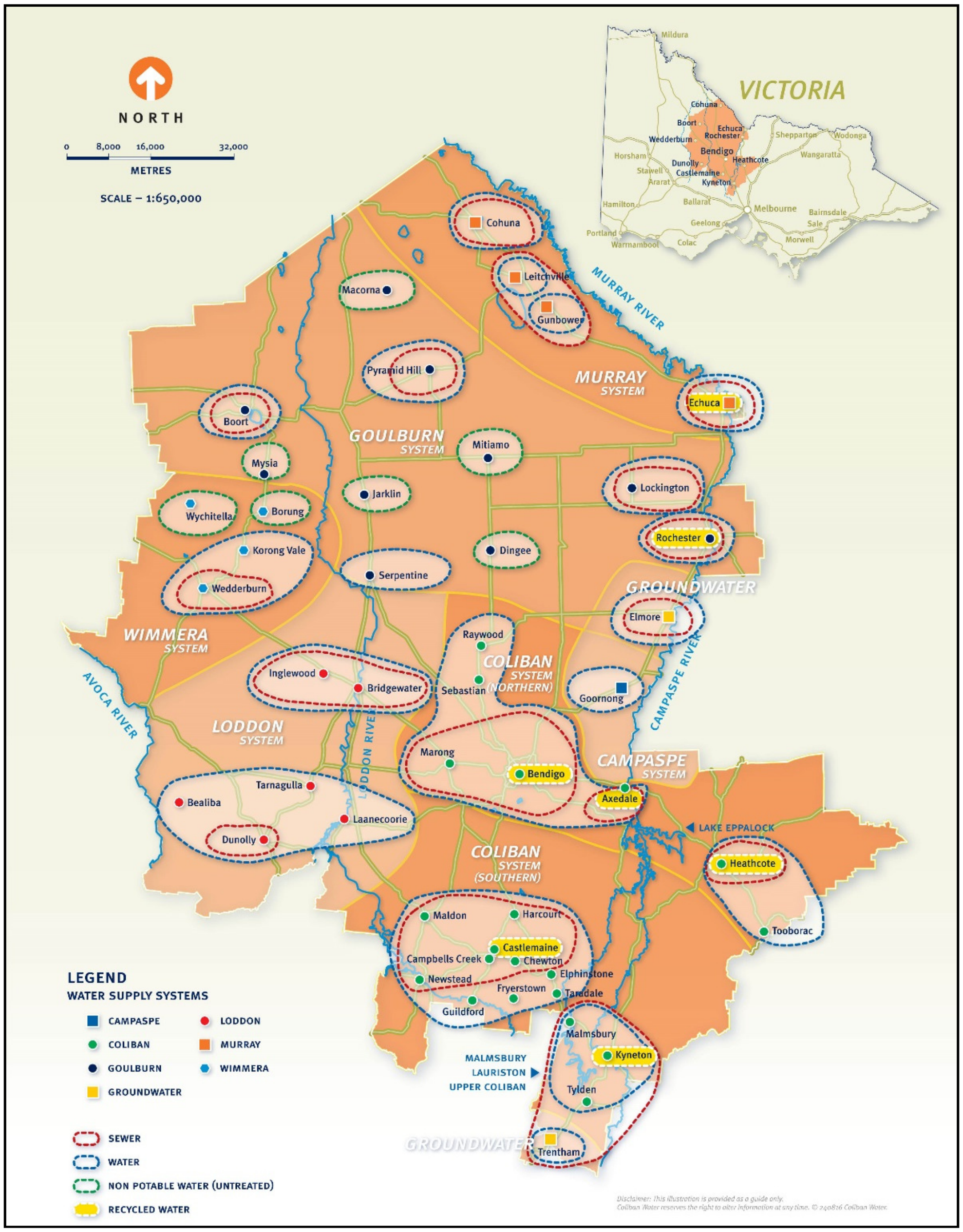

Figure 1: Map of Coliban Water region showing the water and non-potable supplies and the wastewater and recycled water systems.

Rural Water Supply
Coliban Water also services rural customers through 588 km of water distribution pipelines and open channel systems.

Geographical Context

Our raw water supply sources are spread out across Victoria from the alpine areas (GMW Murray and Goulburn Systems) to western Victoria (GWMWater Wimmera Glenelg System) in the Grampians.

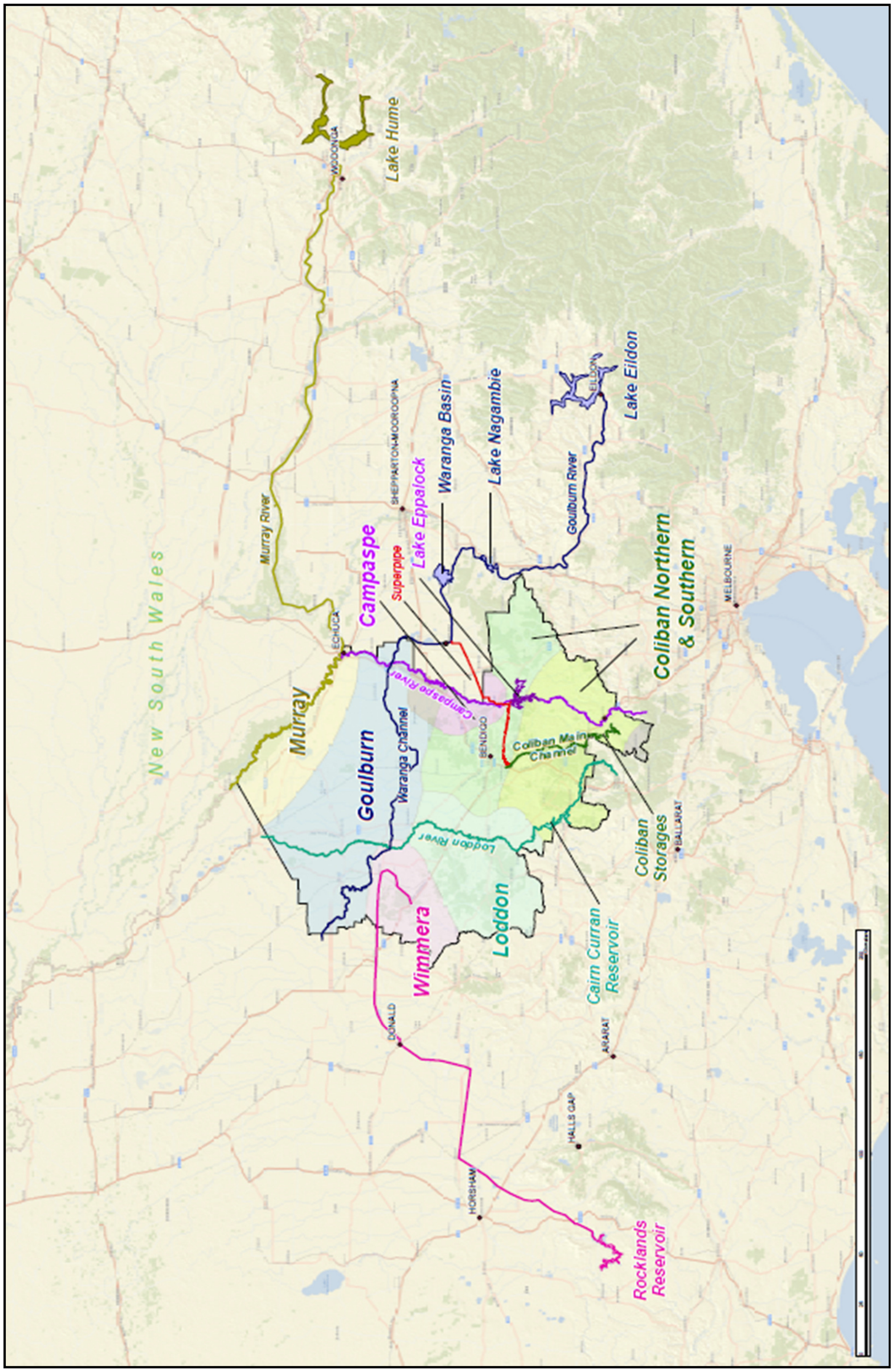

Figure 2: Raw Water Supply sources, including external supplies.

Coliban Water Systems – Aggregated Data

Coliban Water has used climate projections provided by the Department of Environment, Land, Water and Planning (DELWP) and in-house modelling to estimate demand and supply out to 2040 and 2065 under a range of climate scenarios. These are summarised below.

Table 2: Water supply and demand projections: 2040 and 2065.

System	Projection	2016 Baseline (ML/y)[1]	2040 Low to High Climate Change (ML/y)[1]	2065
Campaspe	Demand	59	84 – 90	113 – 124
	Supply	250	250 - 240	250 - 230
Coliban Northern[2]	Demand	14,887	22,182 – 24,012	33,184 – 36,129
	Supply	15,482	13,069 – 10,085	7,590 – 7,587
Coliban Southern[2]	Demand	6,964	7,969 – 8,300	8,941 – 9,478
	Supply	13,162	11,673 – 9,296	11,016 – 7,014
Elmore	Demand	125	157 – 172	189 – 213
	Supply	280	284	284
Goulburn	Demand	1,656	1,862 – 2,049	2,098 – 2,387
	Supply	2,420	2,240	2,410 - 2,100
Loddon	Demand	375	419 – 440	459 – 495
	Supply	580	520 - 480	520 - 470
Murray	Demand	4,263	5,941 - 6,791	7,778 - 9,161
	Supply	5,580	5,820 - 3,600	5,760 - 3,850
Trentham	Demand	157	231 – 262	308 – 357
	Supply	160	160 – 140	160 - 140
Wimmera	Demand	172	213 – 251	260 - 327
	Supply	180	150	140 - 70

Note 1: All volumes rounded off to the nearest 1 ML.
Note 2: Medium to High Climate Change.

Table 3: Wastewater inflow projections: 2040 and 2065.

System[1]	Location	2016 (ML/y)	2040 (ML/y)	2065 (ML/y)
Coliban Northern	Axedale	15	22	30
	Bendigo	7,227	10,169	15,066
	Heathcote	145	158	165
Coliban Southern	Castlemaine	1,139	1,506	1,867
	Kyneton Domestic	762	1,006	1,253
	Kyneton Trade Waste	269	384	447
Elmore	Elmore	20	23	26
Goulburn	Boort	93	93	93
	Lockington	28	29	30
	Pyramid Hill	43	43	43
	Rochester	219	233	252
Loddon	Bridgewater	67	73	80
	Dunolly	31	31	31
Murray	Gunbower	63	67	71
	Cohuna	269	315	369
	Echuca	1,754	2,192	2,736
Wimmera	Wedderburn	34	36	40

Note 1: Our Campaspe and Trentham systems do not have Wastewater Treatment Plants.

Source and System Reliabilities

Source Reliability

The source reliability is a high-level indication of how reliable the supply source is without the implementation of any management measures such as storage, system-interconnection with other supplies and carryover of allocation. The source reliability is calculated using the system demand and the available supply under a high climate scenario (and other scenarios). The available supply has been derived from data provided by the DELWP.

System Reliability

The system reliability is the indication of how reliable the supply system is to meet the current and future demands under the adopted levels of service when appropriate management measures are in place. The following is a graphical representation of how the system performance is impacted by the implementation of management measures.

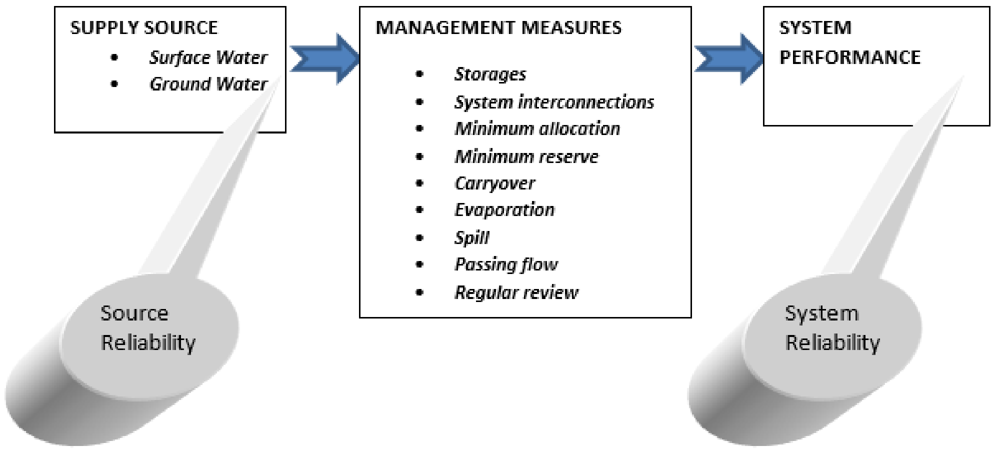

Figure 3: Relationship between 'source' reliability and 'system' reliability.

Source and system reliabilities of each system is given in table 4 below:

Table 4: Comparison of source and system reliability under different climate scenarios

System	Source Reliability (%)[1]				System Reliability (%)[1]	
	2016 Base Line	2016 Step Change	2040 High Climate Change	2065 High Climate Change	2040 High Climate Change	2065 High Climate Change
Campaspe	97	81	84	73	100	100
Coliban Northern[3]	98	89	73	33	73	33
Coliban Southern	93	79	91	73	100	95
Elmore	100	100	100	100	100	100
Goulburn (exc. Serpentine/Jarklin)	100	100	100	SF[2]	100	SF[2]
Goulburn (only Serpentine/Jarklin)	99	96	88	64	100	100
Loddon	92	56	72	47	99	85
Murray	99	94	SF[2]	SF[2]	SF[2]	SF[2]
Trentham	99	99	SF[2]	SF[2]	SF[2]	SF[2]
Wimmera	97	68	59	SF[2]	72	SF[2]

Note 1: The percentage of time when the supply and or system is capable of meeting the Level of Service obligation of Stage 3 or better.

Note 2: The maximum amount of water that may be available will not meet the projected PWSR demand. For further information refer to the relevant system in Appendix C.

Note 3: Further modelling will be undertaken to calculate the system reliability for Coliban Northern

Water Resource Management

Risks and Uncertainties – Demand and Supply

In preparing this Urban Water Strategy, it is timely to remember that despite our best efforts as a water industry, much uncertainty remains in all of our forward projections for growth in demand and the potential climate impacts on supply. The risks associated with this uncertainty are managed through the use of multiple plausible scenarios and multiple planning time frames.

The latter in particular allows future scenarios to be validated progressively and reviewed on a regular basis. These planning timeframes range from monthly resource assessment to annual, five yearly and 50 year projections (this document). The use of multiple timeframes provides the opportunity to constantly fine tune the supply – demand balance.

Policy Setting - 'Water for Victoria'

'Water for Victoria' outlines the water management opportunities and challenges facing Victoria over the coming decades. It builds on the planning framework established in *Our Water, Our Future* (DSE, 2007), while incorporating lessons from the Millennium Drought and the 2010-11 floods.

Among these lessons is a recognition that resilient and liveable cities and towns are fundamental to economic prosperity, social and environmental needs, and community identity and wellbeing. Water corporations have an essential role in supporting these outcomes through more integrated and strategic approaches to urban water service provisions and urban land use planning.

Of the actions listed in *Water for Victoria* there are some in which Coliban Water has a specific implementation role and are relevant to our Urban Water Strategy – these are identified in the table below. For other actions we may have an implementation and or support role with external agencies, or external agencies have the lead role. Rural water corporations also have specific actions and while Coliban Water is classed as an 'urban' water corporation we do have rural customers and, where relevant, will seek to be involved in those actions.

Table 5: 'Water for Victoria' Actions that impact the development of Urban Water Strategies.

Action No.	**'Water for Victorian' Action** Coliban Water's Response
2.1	**Achieve net-zero emissions in the water sector.** This will be achieved through our *Carbon and Energy Strategy*. The strategy includes a carbon reduction pledge and electricity procurement among other measures. This impacts on the assessment of options in terms of their carbon footprint.
2.2 & 2.3	**Understand and apply climate science to water management & Lead climate change adaptation across Victoria's water systems.** Coliban Water has incorporated the DELWP climate change projections into our 50 year forward planning for the Urban Water Strategy.
4.2	**Invest in rural water infrastructure.** Coliban Water is an active stakeholder in the South West Loddon Rural Pipeline Project and the feasibility study for the project to the Mitiamo stock and domestic supply system. These are current on-going projects.
5.1	**Use diverse water sources to protect public spaces.** Directly aligns with one of our key strategies of making greater use of alternative water sources.
5.2	**Better urban water planning to address key challenges.** The development of an Urban Water Strategy is the main objective of this action. This takes into account climate change, drought and alternative water sources.
5.3	**Reinvigorate water efficiency programs for Melbourne and regional Victoria.**

	Coliban Water will initiate water use efficiency programs with urban and industry customers. The action directly aligns with one of key strategies of demand management.
5.4	**Make the most of our investment in wastewater.** Incorporated into integrated water plans and addressed as part of this Urban Water Strategy.
5.7	**Represent community values and local opportunities in planning.** An engagement plan is outlined in our Urban Water Strategy. Our future participation in regional integrated water management forums will also provide an opportunity for other stakeholders to engage in water planning.
5.8	**Put integrated water management into practice.** Integrated water plans are under development for Bendigo, Castlemaine, Kyneton and Echuca. We will also participate in integrated water management forums.
10.8	**Increase Aboriginal inclusion in the water sector.** Our engagement plan has provision for an on-going collaboration with aboriginal groups. Engagement with the Dja Dja Wurrung people has commenced recently.

Role of Urban Water Strategy

Victoria's water planning framework requires the development of Urban Water Strategies by those water corporations providing urban services. It also requires the development of the Melbourne Water System Strategy covering the region serviced by the Melbourne water supply system.

The purpose of Urban Water Strategies is to identify the best mix of measures to provide water services in our towns and cities now and into the future. Urban Water Strategies have a long-term outlook of 50 years; and contain actions which:

- Consider the total water cycle, consistent with the principles of integrated urban water management;
- Support the development of resilient and liveable communities;
- Balance social, environmental and economic costs and benefits; and
- Take account of the consequences and uncertainty associated with population growth, climate change and climate variability.

Urban Water Strategies are public documents and intended to be readable by a typical customer rather than being a technical document.

Objectives of an Urban Water Strategy

Key objectives of the strategy is to ensure that water corporations undertake long term planning that:

- Ensures safe, secure, reliable and affordable water and sewerage services that meet society's long term needs;
- Encourages the sustainable use of water resources including; rainwater, storm water and recycled water and rainfall-independent supplies in ways that are efficient and fit-for-purpose, whilst ensuring that public and environmental health are protected;
- Enhances the livability, productivity, prosperity and environment of our cities and towns;
- Ensures that the water needs of environmental assets are transparently considered; and
- Provide for a transparent and rigorous decision-making process, with clear roles and responsibilities and accountabilities, which can adapt to the changing environment.

Comparison of DELWP Guidelines and Coliban Water's UWS

DELWP have provided comprehensive guidelines that apply to regional water corporations and the Melbourne bulk and retail water corporations. A comparison of the guidelines and the approach taken by Coliban Water is provided in Appendix D.

Victorian Water Management Planning Framework

Victoria has an adaptive water management framework for water resources established under legislation – primarily the *Water Act 1989*, *Water Industry Act 1994*, and associated instruments such as the Statement of Obligations (General). Water corporations have a number of responsibilities under this framework including the development of:

- Urban Water Strategies; developed every five years as required under the Statements of Obligations (General) issued to all water corporations by the Minister for Water under s4I of the Water Industry Act 1994; and
- Drought Preparedness Plans; reviewed every five years or within 12 months of either the lifting of any period of water restrictions or the augmentation of any water supply system, also as a requirement under the Statements of Obligations (General).

Water corporations also provide input to, but are not responsible for, the preparation of regional sustainable water strategies. Regional sustainable water strategies are a legislative requirement under Division 1B of the Water Act 1989 and fulfil Victoria's commitment under the National Water Initiative to carry out open, statutory-based water planning. Sustainable water strategies are prepared on a regional basis by DELWP on behalf of the Minister for Water, under the guidance of a consultative committee and an independent panel appointed by the Minister for Water.

Sustainable water strategies examine the needs of towns, industry, agriculture and the environment in a particular region over the next 50 years under a range of possible climate scenarios, and set water resource management priorities and actions. Sustainable water strategies guide the development, integration and implementation of local management plans prepared by water managers within the region, including water corporations and catchment management authorities. Water corporation's strategies are also guided by regional strategies for healthy rivers, wetlands and estuaries which establish local objectives for river systems and set priorities.

In the long-term, plans of water corporations can also be influenced by long-term water resource assessments, which are a legislative requirement under Division 1C of the *Water Act 1989*. These assessments of the resource base and river health are required to be undertaken every 15 years, with the first in 2019. The principle objective of the long-term water resources assessment is to determine whether there has been a change in water availability that has had a disproportionate impact on any class of water entitlement, or if waterway health related to flow has deteriorated.

If there has been a disproportionate impact, a review will be conducted to determine how to restore an acceptable balance. This may involve corrective action to restore a balance between water available for consumption and the environment. The *Water Act 1989* provides processes for making these adjustments. To support and enhance this adaptive water planning framework, *Water for Victoria: Discussion Paper* proposed an Integrated Water Management (IWM) planning approach to encourage the identification and implementation of integrated water servicing solutions.

The typical flow planning activities and their links to individual organisation's strategies and plans is shown below.

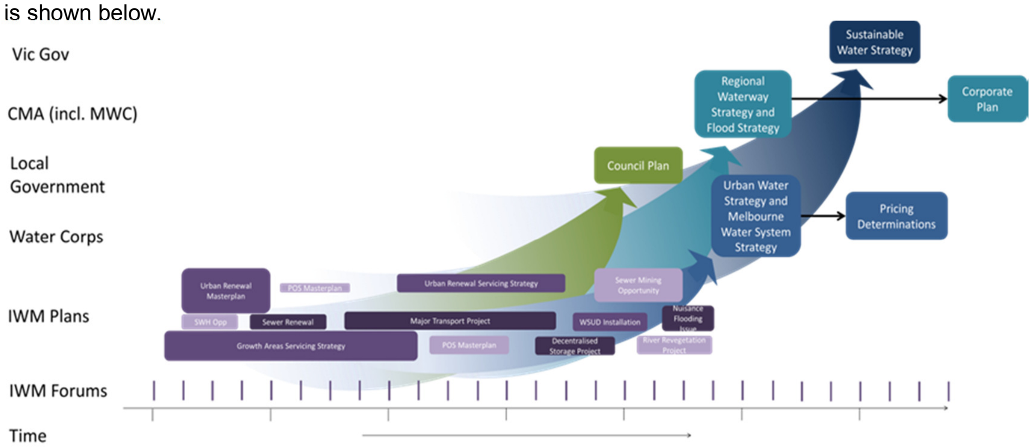

Figure 4: Victorian water management planning framework (DELWP, 2016a).

Water Sources

The Coliban Water's water supplies consist of inflows into our Coliban Headworks Storages, bulk entitlements, water shares, groundwater extraction licences and spring water flows. The combined entitlement volume of these supplies is 89,769 ML. Bendigo also has access to approximately 3,000 ML of recycled water, although the volume can vary.

A bulk entitlement of 50,260 ML applies to the Coliban Systems (Northern and Southern) and relates to raw water drawn from the Coliban Headworks Storages near Kyneton and from Lake Eppalock. Coliban Water has the right to the inflow into the Coliban Headworks Storages and to 18% of the inflow into Lake Eppalock. Water taken from our headworks storages under the bulk entitlement is for the supply of Bendigo, Heathcote, Tooborac, Castlemaine and Kyneton and their connected communities. This includes rural customers in our Coliban Systems.

Table 6: Sources of raw water.

Supply System[1]	Volume (ML)[2]	Entitlement Type	Source of Water[5]	Storage Manager[7]
Campaspe	215 134	Bulk Entitlement (Goornong & Axedale) Bulk Entitlement (Rochester)	Campaspe River	GMW
Coliban Northern	17,440 [3] 22,709 2,828 2,591 646	Bulk Entitlement HRWS[4] LRWS[4] HRWS[4] LRWS[4]	Upper Coliban River & Lake Eppalock Goulburn Goulburn Campaspe Campaspe	Coliban Water & GMW GMW GMW GMW GMW
Coliban Southern	32,820 [3]	Bulk Entitlement	Upper Coliban River	Coliban Water
Elmore	284	Groundwater Licence	Lower Campaspe Valley Water Supply Area	GMW
Goulburn	2,420	Bulk Entitlement	Goulburn	GMW
Loddon	820 (960)[8]	Bulk Entitlement (Groundwater Licence)	Loddon Mid-Loddon Groundwater	GMW GMW
Murray	6,285 55 24	Bulk Entitlement HRWS[4] LRWS[4]	Murray Murray Murray	GMW GMW GMW
Trentham	120	Bulk Entitlement	Springs	Coliban Water

	48	Groundwater Licence	CVMS GMA[6]	GMW
Wimmera	300 ML	Bulk Entitlement	Wimmera-Mallee Pipeline	GWM Water
Total	**89,769 ML**			

Note 1: The' supply system' refers to the nine Coliban Water systems.
Note 2: 'Volume' refers to the volume of the bulk entitlement, groundwater license or volume of water shares held by Coliban Water but excludes 'stock and domestic' supplies. Coliban Water can also enter the water market to buy or sell allocation or entitlement.
Note 3: The bulk entitlement has an annual limit of 50,260 ML averaged over three years with a limit of 17,440 ML per annum from Lake Eppalock.
Note 4: HRWS: high reliability water shares, LRWS: low reliability water shares.
Note 5: Primary source is the river basin but the actual off-take may be from a storage, irrigation channel or directly from the river.
Note 6: Central Victorian Mineral Springs Groundwater Management Area.
Note 7: GMW – Goulburn-Murray Water, GWM Water – Grampians Wimmera Mallee Water.
Note 8: The 960 ML of groundwater licence is for 'stock & domestic' use only.

The raw water supply to the Coliban Region can be categorised as natural inflows to the Coliban Headworks Storages and Lake Eppalock, annual allocations provided by external bulk water providers (GMW and GWM Water), and groundwater licences.

Bendigo also has access to approximately 3,000 ML of recycled water per annum for non-potable use from the Bendigo Water Reclamation Plant and Recycled Water Factory. This water is used to supplement supply to parts of the rural network, public open spaces, school facilities and dual pipe residential systems.

Our three main storages (Upper Coliban, Lauriston and Malmsbury Reservoirs) are located near Malmsbury and Kyneton. The total volumetric capacity of the main and secondary storages is 130,151 ML.

Table 7: Coliban Water storages.

Major Storages	Water Supply System	Capacity (ML)
Upper Coliban	Coliban Southern	37,770
Lauriston	Coliban Southern	19,790
Malmsbury	Coliban Southern	12,034
Lake Eppalock[1]	Coliban Northern	54,837
Secondary Storages		
Barkers Creek	Coliban Southern (rural only)	1,690
Caledonia	Coliban Northern	214
McCay	Coliban Southern	1,360
Sandhurst	Coliban Northern	2,590
Spring Gully	Coliban Northern (rural only)	1,690
Trentham Storages	Trentham	90
	Total	**130,151**

Note 1: Goulburn-Murray Water is the storage manager, with Coliban Water holding an 18% share of the volume or inflow.

Coliban Water operates nineteen water treatment plants (WTPs) throughout the region that supply treated water to 99.8% of the total residential population. The treated water complies with the water quality standards specified in the *Safe Drinking Water Act 2003*.

Raw water is not treated for the towns of Dingee, Macorna, Mitiamo, Mysia, Jarklin, Borung and Wychitella. These towns do not have drinking (potable) water supplies. The estimated combined residential population of these seven towns is 267.

Coliban Water can also enter the water market across the southern interconnected Murray Darling Basin. During the Millennium Drought it was active in the market as a purchaser of entitlement and allocation. Over the last few years we have been active as a trader of annual allocation. The volumes sold in any given year depend on our resource position as outlined in our Annual Operating Plan.

Over the next 5 – 10 years Coliban Water anticipates acquiring of additional entitlements. By 2040 this volume needed to make up a potential shortfall is about 15,300 ML and by 2065 it could potentially be up to 37,400 ML (based on a high climate change scenario). The shortfall can be made up of lower household demand, reduced system losses, greater use of recycled water and additional supply.

Water quality is also as important as water quantity. Poor water quality has major consequences for the health of people, livestock, rivers, wetlands and aquifers. This includes rising salinity, increasing sediment and nutrient loads, changing pH and temperature level and reduced dissolved oxygen. Water quality issues (for example, blue green algal blooms) may cause short term water shortages.

Environmental flows help to maintain water quality, support flora and fauna and protect public health and safety. The community values the river for its healthy native vegetation and wildlife, scenic qualities and as a place of recreation.

Climate change means environmental flows will be reduced significantly more than water for other uses. This is because the majority of environmental flows are not provided by entitlements; they come from unregulated flows or 'above cap' water that cannot be harvested or spills from storages. Spills from storages are particularly reduced under climate change because storages on average hold less water in them and can therefore capture a greater proportion of inflows. The environment does have some entitlements. While these are less impacted by climate change, they represent a smaller proportion of the total water available for the environment (DSE, 2009).

Water Resource Planning

It is a requirement of each water business to prepare an annual forward outlook on water availability. The Coliban Water, *Annual Water Outlook 2016-17 and Annual Operating Plan 2016-17* have been prepared in accordance with guidance from DELWP.

The Annual Water Outlook (AWO) reviews the preceding year, and takes a 12 month look forward of water resource availability. The AWO also considers the outlook based on several climate scenarios. The AWO is linked to an Annual Operating Plan (AOP) which outlines the actions and recommendations for the coming year that are necessary to maintain supply.

Coupled with the Urban Water Strategy (UWS) the AWO and AOP provide guidance for water resource planning.

Being prepared for all rainfall and climate scenarios is necessary to avoid any negative impacts to water supplies. Adopting sensible policies that encourage people to use water wisely, along with supplementing supplies through system integration, will maintain services. Water restrictions were used during the Millennium Drought to maintain the supply – demand balance, however the community was negatively impacted as a result. The introduction Permanent Water Saving Rules (PWSR) in 2011 has resulted in a significant decline in per household consumption.

From when water restrictions were first introduced, compared to the peak of the drought, water consumption per connection decreased by 50% in the majority of systems as shown in Figure 5.

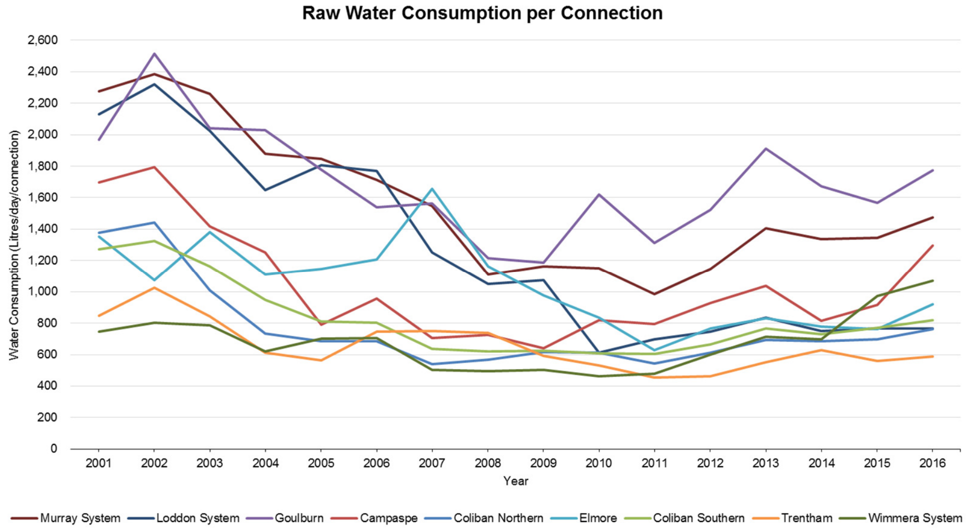

Figure 5: Water consumption per connection. (Note: Legend ordered from top to bottom in relation to 2001 consumption).

An exception to this is the Wimmera system which had the lowest consumption per connection when restrictions were announced. Reasons for this could be the fact that the farming community within that system were already conservative due to the dry landscape or that most households in this region were more self-reliant with their own water systems in place.

There was also a rise in consumption within the Elmore system during 2007 when all other systems were decreasing. This could be explained by the use of Elmore's ground water via standpipe facilities for water carting. PWSR and general water awareness have reduced water consumption to less than pre Millennium Drought levels. However that trend is beginning to be reversed.

Integrated Water Management
The Integrated Water Management Framework for Victoria (IWM) aims to help government, the water sector and the community work together to better plan and deliver solutions for water management across Victoria's towns and cities.

The framework outlines how systematic collaboration within the water sector, which includes water corporations, local government and catchment management authorities can be implemented.

Included in this framework are IWM Forums, facilitated by an independent chairperson, that will coordinate IWM planning across the forum's geographical area. IWM Forum participants will each identify opportunities to collaborate and form partnerships to deliver integrated servicing solutions and bring these to the IWM Forums for consideration.

Shared Infrastructure

Coliban Water shares pipeline infrastructure with Central Highlands Water. This includes the Goldfields Superpipe that links the Waranga Western Channel to the Lake Eppalock to Bendigo pipeline. A further pipeline links Bendigo at the Sandhurst Reservoir to the White Swan Reservoir managed by Central Highlands Water.

A 'joint venture' arrangement exists between the two water corporations to manage the infrastructure and share the costs of operation. Under the arrangement, Coliban Water is entitled to a two-thirds share of the nominal pipeline capacity of 150 ML per day i.e. Coliban Water can only pump up to 100 ML per day unless Central Highlands Water does not require its capacity share.

Table 8: Indicative augmentation dates of the Goldfields Superpipe and Lake Eppalock to Bendigo pipeline.

Demand Scenario[3,4]	Capacity at 100 ML/day	Capacity required at 2065
Average day during peak month[1]	2045	145 ML/day
Average day during peak month in dry weather[2]	2030	180 ML/day

Note 1: Our peak demand months are generally from December through to March. This includes demand from urban and rural customers and varies slightly between months and between years.

Note 2: During extended dry weather our average urban demand can increase by about 20% and our rural demand by about 50% hence the pipeline capacity needs to be able to cope with this variable demand.

Note 3: All demands are for Coliban Northern only.

Note 4: The demand scenarios ignore the operational flexibility that Coliban Water has to vary supply sources and 'smooth' out peak demand.

Regional Climate Perspective

Major Regional Climate Drivers

Our three major regional climate drivers all interact over south-eastern Australia producing a highly variable climate from year to year and over longer time periods. The major oceanic climate drivers are:

- El Niño - Southern Oscillation (ENSO),
- Indian Ocean Dipole (IOD), and
- Southern Annular Mode (SAM).

Each of these major drivers can generate dry, average or wet conditions and can interact to produce extreme events. Extreme events are likely to become more frequent under projected climate change scenarios.

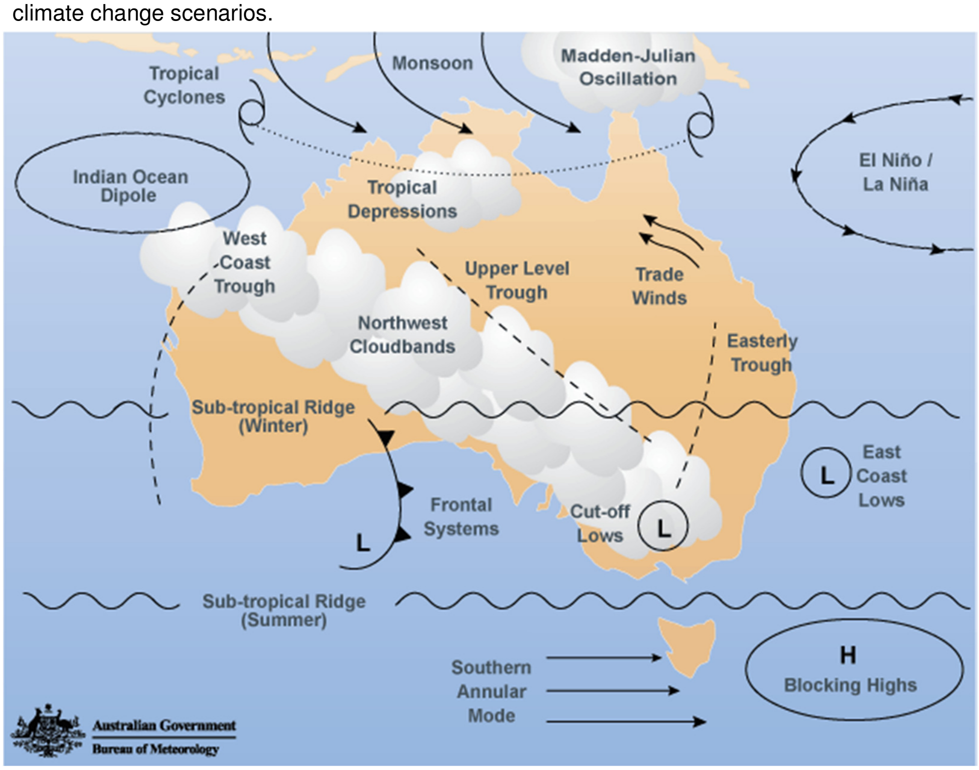

Figure 6: The major weather and climate drivers across Australia (BoM, 2010).

El Niño - Southern Oscillation (ENSO)
The Southern Oscillation Index (SOI) gives an indication of the development and intensity of El Niño or La Niña events in the Pacific Ocean. It's calculated using pressure differences between Tahiti and Darwin.

El Niño is the negative phase of the SOI, and is associated with warm ocean currents off the South American coast. El Niño refers to the extensive warming of the central and eastern tropical Pacific Ocean that leads to a major shift in weather patterns across the Pacific Ocean, with weaker low-level atmospheric winds along the equator. Across eastern Australia El Niño events are associated with increased probabilities of **drier conditions**.

ENSO has its maximum impact on rainfall and maximum temperatures in spring for south-eastern Australia, when the eastern equatorial Pacific Ocean is warm, and pressures are high across much of Australia.

El Niño dominated during the Millennium drought but the wet years of 2010-11 were very wet La Niña years with increased warm season rainfall. There is high confidence that ENSO will continue to dominate year-to-year variability in the tropical Pacific Ocean and ENSO related rainfall variability on regional scales will likely intensify (BoM, 2016). Recent studies conclude that global warming will intensify El Niño driven drying in the western equatorial Pacific Ocean, the area of northern Australia and parts of the east coast.

Indian Ocean Dipole (IOD)
The Indian Ocean Dipole (IOD) refers to the difference in sea surface temperature between two poles – a western pole in the Arabian Sea and an eastern pole in the eastern Indian Ocean. It affects the climate of Australia and surrounding countries, and has a significant contribution to rainfall variability in this region.

The IOD has been found to have the greatest impact on south-eastern Australian rainfall and maximum temperatures in winter and spring (not summer and autumn). Variations in the IOD are linked to the frequency of north-west cloud bands that bring rainfall to Australia. Positive IOD events lead to warming of waters near Africa and cooler than normal waters near Australia, reducing cloud formation near Australia and therefore less rainfall in the region. The IOD also has the potential to increase major bushfire risk.

Southern Annular Mode (SAM)
The SAM describes the north-south movement of the westerly wind belt that circulates Antarctica, dominating the middle to higher latitudes (40^0 S to 65^0 S) of the southern hemisphere. SAM acts to expand or contract these weather systems. The region of strong westerly winds is associated with cold fronts and storm activity, and heavily influences weather in southern Australia.

Positive SAM events result in a contraction of normal westerly winds towards Antarctica, meaning higher pressures over southern Australia and restricted penetration of cold fronts inland. During autumn and winter, positive SAM events result in fewer storm systems and less rainfall across the southern regions of Australia. However, positive SAM phases during spring and summer can increase rainfall over eastern Australia. Climate change is expected to increase the positive phase of SAM. The SAM is driven primarily by atmospheric dynamics that have a lifespan of approximately two weeks so has received limited research attention for predictability of seasonal climate.

The positive trend is attributed to ozone depletion and increased concentrations in greenhouse gases (BoM, 2016). While ozone levels are expected to recover in the future, greenhouse gas increases will dominated changes in the phases of SAM.

Sub-Tropical Ridge (STR) and the Hadley Cell
The sub-tropical ridge (STR) is an extensive belt of high pressure that encircles the entire globe at the middle latitudes. The position of the STR varies seasonally, allowing cold fronts to pass over south-eastern Australia in winter but pushing them south in the summer. The STR has been found to intensify with an increase in global surface temperature. STR strengthening can account for up to 80% of observed rainfall decline across south-eastern Australia.

The Hadley Cell is the process by which heat from the sun, which falls mainly in the tropics, is transported from the equatorial zones to higher latitudes in the atmosphere. In Figure 7 the Hadley Cell is shown as the central element to the meridional circulation. There is a Hadley Cell in both hemispheres.

Figure 7 also shows regions of high and low atmospheric pressure (H and L); the relationship between the intensity of the Sub-Tropical Ridge (red) and an 11-year rolling average global surface temperature (black) (E); the relationship between annual rainfall and the intensity of the Sub-Tropical Ridge (F); and the April-July rainfall deciles from 1986-2015 (G). The southern edge of the tropics has expanded toward the south pole (shown as 'A' in Figure 7) along with the descending arm of the Hadley Cell.

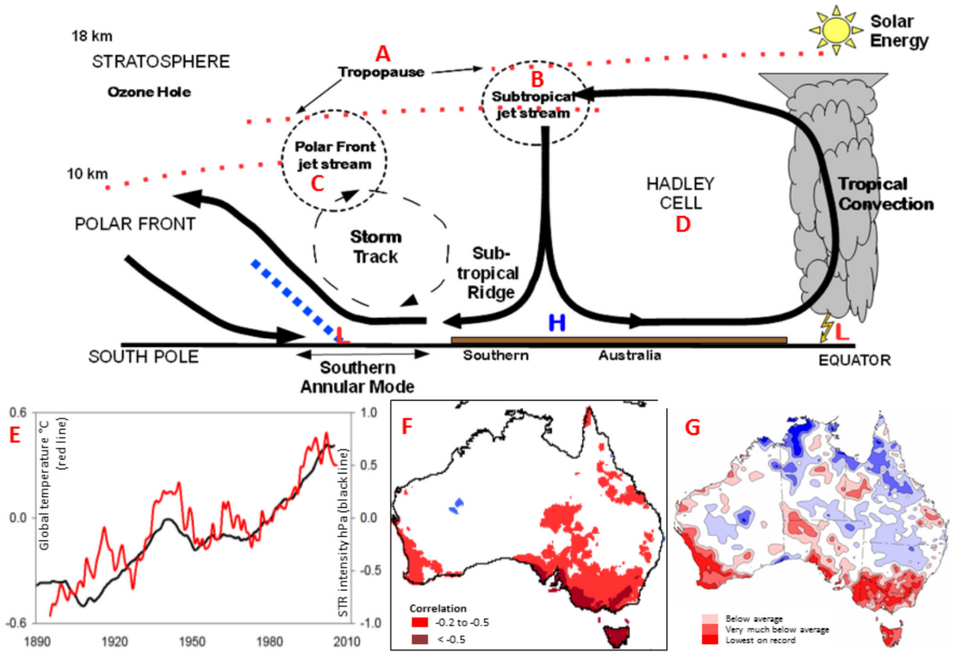

Figure 7: Interaction of the Hadley Cell with the Sub-Tropical Ridge and Southern Annual Mode (BoM, 2016).

The Hadley Cell has been expanding at a rate of around 50 km per decade since the late 1970s, and at around 65 km per decade in the Australian region. The expansion of the Hadley Cell has led to changes in the STR that are associated with declines in winter rainfall in Victoria. The Hadley Cell expansion is at least partly due to anthropogenic ('man made') climate change, so the cool-season rainfall decline is expected to continue into the future.

Other Influences

Natural Variability: While the major climate drivers influence the Victorian climate they do not account for all of the year-to-year variability. A large part (around 80%) remains random and hence unpredictable from a climate perspective and is referred to as 'the weather noise' (BoM, 2016). Soil moisture, runoff and streamflow are all difficult to simulate hence projections are more uncertain.

The relationship between increased greenhouse gas concentrations and increased temperatures is well understood and monotonic i.e. if one parameter increases so does the other. However the impacts of increased temperatures on rainfall, on runoff and streamflow are harder to predict and cannot be modelled with great certainty (Stafford-Smith *et al*, 2011).

Inter-decadal Pacific Oscillation (IPO): The IPO is similar to El Niño in that it relates to changes in sea surface temperatures in the Pacific Ocean but at a broader scale geographically and on a non-regular timescale of many decades. The IPO typically takes 15 – 30 years to shift between warm and cold phases (BoM, 2016). There is currently no method available to predict these shifts.

The Climate Challenge Ahead

The *Coliban Water Urban Water Strategy 2017* is drafted in the context of the challenges presented by the year-on-year variation in rainfall and runoff, and climate change; and the multi-year climatic variations leading to acute and severe water shortages (droughts). North of the Great Dividing Range we experience a warmer climate with greater variation in day and night time temperatures than coastal areas. Rainfall variability is also greater nearly all year around (BoM, 2016).

Mention is made of the extensive flooding during 2010-11 (wettest year on record). The Coliban Headworks Storages experienced inflows totaling 119,136 ML during this period. This high inflow year was preceded only four years earlier by the lowest on record during 2006-07 when only 3,090 ML was recorded. This is nearly a 40 fold variation in inflows in less than five years.

From an operational perspective there is no single measure that defines the change from a [nuisance] water shortage and a moderate to severe water shortage - what most people would recognise as a drought.

In early 2015, CSIRO and the Bureau of Meteorology released a significant report on the 'climate challenge ahead' (CSIRO & BoM, 2015). The text that follows draws heavily on the projections from that report along with the confidence ratings.

In that report, the authors put forward the concept of an index that relates only to rainfall as a measure of drought – the 'standardised precipitation index' (SPI). The index considers cumulative variations from average rainfall on a month by month basis based on the mean (average) annual rainfall. Variations between +1 or -1 standard deviations from the mean are regarded as 'normal'. Any index below -1 standard deviation is regarded as a moderate drought. The figure below shows the SPI for Coliban Water based on rainfall data from Malmsbury Reservoir.

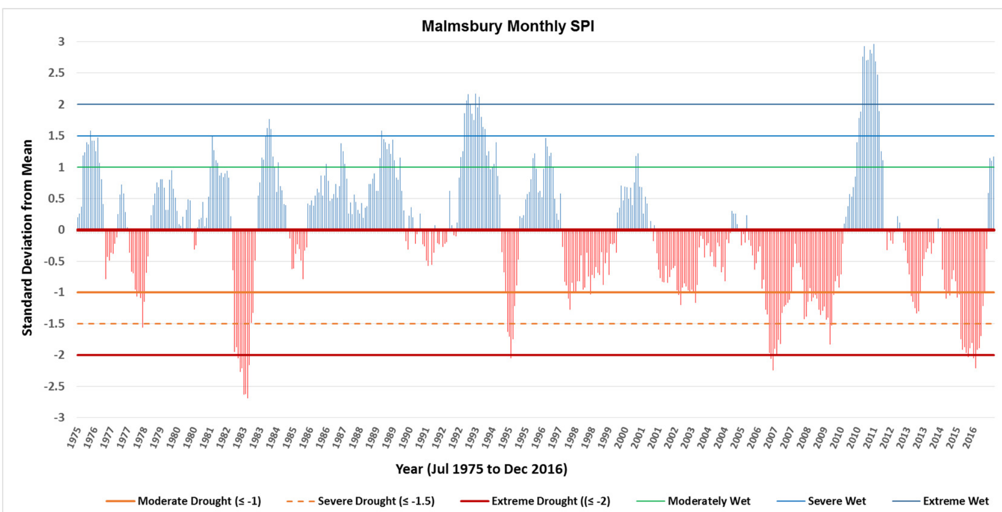

Figure 8: SPI graphic from July 1975 to December 2016.

Climate Baselines

Throughout the Urban Water Strategy several climate baselines are referred to. The baselines serve as a basis of comparison between different possible futures given the high uncertainty of 50-year forward projections. The baselines are outlined in guidance material provided by (DELWP 2016a). After the Millennium Drought it is recognised that our climate has been affected by climate change and that the management of water resources needs to reflect this (BoM, 2016).

Historical Climate

On-going climate change implies that the climate is non-stationary i.e. dynamic rather than static. Therefore the use of the historical record is not recommended for the purposes of climate change projections. The rationale is that the historical climate is not a reliable guide to the future. The impacts of climate change have been most pronounced since the 1950s, and hence the historical record would not adequately reflect this impact.

The historical record has not been used in any projections and has only been provided by DELWP for comparison purposes. The use of the 'current climate' or 'post-1997' ('step change) as baselines is recommended.

Current Climate Baseline (1975 – 2016)

The 'current climate' baseline refers to the period July 1975 to June 2016 and is used as the basis of comparison. The period is regarded as representative of the current climate in that there have been periods of above and below average rainfall. The period is sufficiently long to be representative and recent enough to have been directly affected by increased greenhouse gas emissions.

The CSIRO and BoM (2015) have recommended a period of at least 30-40 years. Some previous analyses by Coliban Water have used a slightly shorter period of 1975 to 2014 as these were carried out before the release of DELWP guidelines in 2016.

Table 9: Climate change projections, 2040 and 2065 under medium climate change.

River Basin[1,3]	Temperature Change (^{0}C)		Change in Potential Evapo-Transpiration[2]	
	2040	2065	2040	2065
Campaspe	+1.3	+2.4	+4.7%	+7.8%
Loddon	+1.3	+2.4	+4.6%	+7.7%
Lower Murray	+1.5	+2.5	+4.5%	+7.6%
Wimmera	+1.3	+2.3	+4.2%	+7.1%
Victoria	+1.3	+2.3	+4.5%	+7.4%

Note 1: The Goulburn River basin has been excluded as the majority of runoff occurs in the alpine region of Victoria and is not representative of the climate our Goulburn System customers will encounter.

Note 2: All projections are based on modelling provided by DELWP (Table 9, Appendix A) (DELWP, December 2016).

Note 3: Coliban Water region spans these three river basins and the Wimmera region.

Post-1997 Baseline (1997 – 2016) ('Step Change')

The baseline is also referred to as the 'step change' baseline. The 'post-1997' baseline reflects the post Millennium Drought period. DELWP have recommended the period 1997 to 2016. Coliban Water has also used the period 1996 to 2014 in some analyses as these were carried out prior to the release of the DELWP guidelines in 2016.

The rationale for using the post-1997 baseline is that there is evidence that in some parts of Australia there appears to have been a shift in climate patterns that may or may not be permanent. Where the shift may impact negatively on supply, then as a precautionary measure, it is prudent to take this potential change into account.

Climate Change Baseline (2040 and 2065)

DELWP have undertaken modelling on behalf of the water corporations (see 'climate change projections' below). The model outputs provide estimates of various climate parameters out to 2040 and 2065. The outputs are provided for low, medium, and high climate change projections. The 2040 and 2065 projections are compared to the current climate and post-1997 baselines to determine the likely period in which action(s) may need to be taken to maintain supply in balance with demand.

Table 10: Projected rainfall in 2040 and 2065 resulting from climate change.

River Basin	Ave (mm)	Climate Change Scenarios[1,2]					
		2040[3]			2065[3]		
		low	medium	high	low	medium	high
Campaspe	596	2.4%	-2.2%	**-15.2%**	2.6%	-6.1%	**-23.2%**
Goulburn	767	3.9%	-2.5%	**-13.6%**	2.4%	-4.0%	**-20.7%**
Loddon	459	2.5%	-2.8%	**-14.3%**	3.2%	-5.6%	**-22.9%**
Lower Murray	394	7.3%	-3.8%	**-15.0%**	9.1%	-2.3%	**-19.1%**
Wimmera	394	2.0%	-3.7%	**-13.3%**	3.9%	-5.9%	**-22.3%**
Victoria	643	2.4%	-3.6%	**-10.4%**	2.7%	-4.7%	**-19.4%**

Note 1: All projections are based on modelling provided by DELWP (DELWP, December 2016).
Note 2: Changes in rainfall are not directly related to a change in allocations.
Note 3: The three climate change projections are based on greenhouse gas emission scenarios. Low being in the bottom 10% (10th percentile), medium being the mid-point of projections (50th percentile), and high being the top 10% (90th percentile).

Table 11: Projected runoff in 2040 and 2065 resulting from climate change

River Basin	Ave (mm)	Climate Change Scenarios					
		2040			2065		
		low	medium	high	low	medium	high
Campaspe	64	+10.5%	-12.3%	-37.1%	+1.0%	-20.7%	-57.0%
Goulburn	182	+9.9%	-9.5%	-29.1%	+1.3%	-13.7%	-41.9%
Loddon	24	+12.4%	-7.4%	-36.6%	+6.9%	-17.6%	-57.6%
Lower Murray	13	+32.8%	-4.6%	-37.5%	+27.1%	-11.4%	-47.0%
Wimmera	21	+12.1%	-6.5%	-32.3%	+12.3%	-14.4%	-53.1%
Victoria	93	+8.7%	-8.5%	-24.7%	+1.5%	-15.9%	-43.8%

Note 1: All projections are based on modelling provided by DELWP (DELWP, December 2016).
Note 2: Projected runoff is typically underestimated by Global Climate Models. The decline in runoff is generally a factor of 2-3 greater than percentage decline in rainfall.
Note 3: Changes in runoff are not directly related to a change in allocations.
Note 4: The three climate change projections are based on greenhouse gas emission scenarios. Low being in the bottom 10% (10th percentile), medium being the mid-point of projections (50th percentile), and high being the top 10% (90th percentile).

The global climate models use various greenhouse gas emission scenarios to make projections i.e. low, medium and high. These scenarios are referred to in the literature as 'Representative Concentration Pathways' (RCP). RCP8.5 is regarded as a 'business as usual' scenario and represents a high greenhouse gas emission pathway (BoM, 2016). RCP4.5 is a lower emission scenario that could be achieved if significant greenhouse gas reduction measures are put in place.

Climate Scenarios used for the Urban Water Strategy

In the assessment of climate related demand increases and supply decreases Coliban Water will use a number of scenarios to outline a range of projections. No single projection is necessarily more valid than any other. The projections used include:

- Current climate baseline (1975 – 2016)
- Post-1997 ('step-change') (1997 – 2016)
- Climate change (low, medium, and high), 2040, and
- Climate change (low, medium, and high), 2065.

Not all scenarios are used in every comparison or analysis. However, Coliban Water will take a conservative approach to water resource planning.

‘High Climate Change’

Coliban Water will adopt the ‘high climate change’ scenario as the basis of comparison between systems and in estimating the magnitude of potential shortfalls in supply out to 2040 and 2065.

Climate Change Implications for Coliban Water

Estimating future water availability under a changed climate involves three main components: global climate modelling; downscaling global and regional climate models to the catchment area of interest; and hydrological modelling (Chiew & Prosser, 2011; Chiew *et al.*, 2011).

Coliban Water has relied on modelling undertaken by the DELWP for the majority of supply related climate and population projections. Simple models have been developed in-house to relate increases in temperature and decreases in rainfall to changes in demand, and potential increases in evaporative losses.

‘Climate Forecast’

More blue skies and sunshine, but less rain when it’s needed
Coliban Water will face multiple challenges as the climate of southern Australia continues to warm up. The key challenge is that the already variable annual rainfall will continue to decline during the time of year when rainfall and streamflow is traditionally most reliable i.e. late autumn and winter and into spring (the cool months). The net moisture deficit will lead to increased demand from customers at times when water resources (volumes in storage and allocations) will be lower.

Higher temperature and low humidity will exacerbate the potential imbalance between supply and demand. The strategies outlined aim to minimise the risk of a reduction in the level of service.

Some of the specific climatic challenges are outlined below, however local climate is not fully predicable at any timescale (BoM, 2016).

Decline in cool season rainfall in southern Australia (high confidence)
Rainfall during the cooler months (winter and spring) has declined in southern Australia. This decline is linked to changes in atmospheric circulation in the southern hemisphere “… that are influenced by increasing [concentrations of] greenhouse gases …” (CSIRO & BoM, 2015). The crucial change is that winter storm fronts are moving further south and hence less rain falls over southern Australia.

To date there appears to be no long-term trend in total annual rainfall but there is considerable variability between decades. However if the year is split into two seasons then warm season rainfall has increased by about 31%, but cool season rainfall has declined by about 37% over the last 30 years (BoM, 2016). This trend has accelerated during the second half of the 20th century to become statistically significant. The decline in cool season rainfall was strongly evident during the Millennium Drought and more pronounced in northern Victoria.

Decline in Rainfall – Implications for Coliban Water

In southern Australia it is the cooler months that generate the bulk of the runoff into storages. A drier catchment mean less runoff and hence overall yield declines. A single year of decline does not represent a great risk, but a multi-year decline increases the risk of an operational and/or meteorological drought. This makes establishing a baseline rainfall and inflow for comparison purposes difficult given the significant variation experienced between 2006-07 (3.1 GL inflow) and 2010-11 (119.1 GL inflow).

Coliban Water will base projections on the ‘current climate’ baseline with a high climate change scenario acknowledging that we may be experiencing a ‘step change’ in rainfall and inflow similar to that in the southwest of Western Australia.

Note: Global climate models tend to underestimate the decline in rainfall (BoM, 2016). Hence the need for a precautionary approach to modelling supply.

The Southern Annular Mode (SAM) has trended toward a positive state since the late 1950s and may have contributed to the decline in cool season rainfall (BoM, 2016). But in the short-term, up to about 2030, there is high confidence that natural climate variability will remain the main driver of changes in rainfall (BoM, 2016).

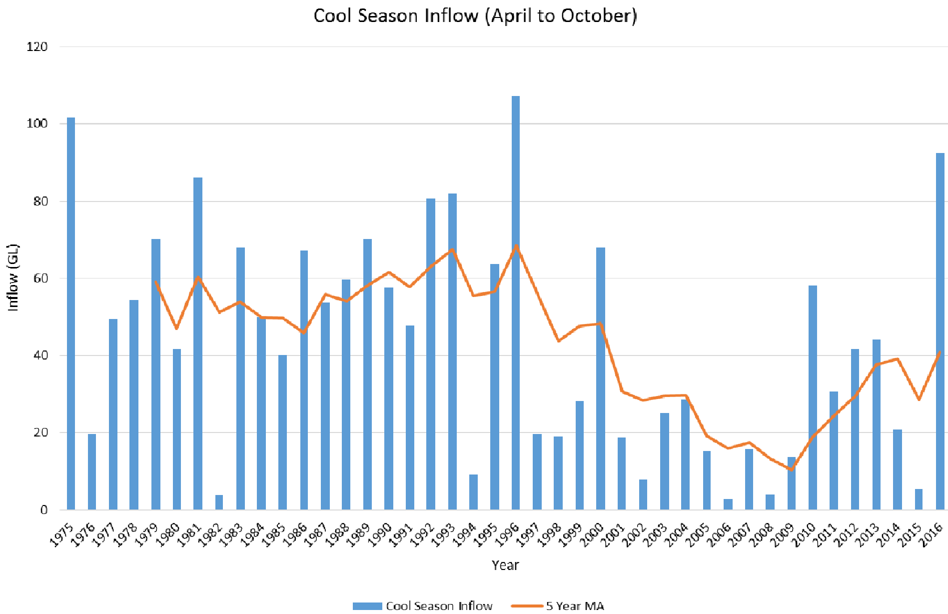

Figure 9: Cool season inflow (April – October) from July 1975 to June 2016 with 5 year moving average.

Decline in runoff (medium confidence)
The amount of runoff at any given time is impacted by numerous factors such as rainfall, temperature, solar radiation, relative humidity, soil moisture, and potential evapotranspiration. Soil moisture, runoff and the subsequent streamflow are difficult to simulate in models. Hence a conservative approach is adopted in water resource planning to ensure that supply is not over-estimated.

Decline in Runoff – Implications for Coliban Water
Based on the current climate baseline our median inflow is 48.1 GL per annum. When the post-1997 climate is taken into account this volume reduces to 23 GL per annum (Note: Coliban Water has used July 1997 to June 2016 data for this latter estimate). The implications over the longer term are: - Less raw water will be transferred to Coliban Northern (Bendigo) and that system will become more reliant on pumping from Lake Eppalock or the Waranga Western Channel, - Our Coliban Headworks Storages will spill less frequently with potential negative effects on the Coliban River downstream of Malmsbury Reservoir, - The catchment response to rainfall, especially after long dry periods will become less predictable, and - Annual allocations from external bulk water suppliers (GMW and GWM Water) will decline.

The amount of annual runoff together with demand affects the volume held in storage at reservoirs. For Victoria and the southern Murray Darling Basin, Lake Hume and Lake Eildon are major storages for urban populations and irrigated horticulture. Table 11 provides an indication about how average storage volumes may change over time.

Table 12: Change in average storage volume for Lake Eildon and Lake Hume under different climate scenarios.

Climate Scenario	Ave. Monthly Volume[1] (ML)	Change in Volume[2]
Lake Eildon (Goulburn)		
Current Climate Baseline	1,937,922	N/A
Post-1997 Baseline	1,289,037	-33.5%
High Climate Change at 2040	1,112,693	-42.6%
High Climate Change at 2065	776,374	-60.0%
Lake Hume (Murray)[3]		
Current Climate Baseline	1,734,983	N/A
Post-1997 Baseline	1,153,441	-33.5%
High Climate Change at 2040	1,081,164	-37.7%
High Climate Change at 2065	663,302	-61.8%

Note 1: *The average monthly volume in storage was calculated from modelling provided by DELWP and is based on a 120 year record with appropriate scaling for each climate scenario.*

Note 2: *Only 'high' climate change scenario has been used for these comparisons for 2040 and 2065. The current climate and post-1997 baselines do not have projections for these future years.*

Note 3: *The Lake Hume data excludes inflow from Dartmouth Dam.*

Coliban Water has undertaken an analysis of the rainfall-runoff relationship of the upper Coliban River catchment to determine if there has been a 'step change' in this relationship (Figure 10). The analysis compares the catchment behaviour post-Millennium Drought to the period beforehand. If the catchment response were unchanged then all three lines would closely align, however the post-1996 line in the figure is lower indicating a reduced response to annual rainfall (see text box 'Decline in Runoff'). The modelling is based on the research of *Saft et al (2015).*

Saft's research indicates that long droughts are likely to change the rainfall-runoff relationship in catchments that are "more arid, larger, flatter and less forested". These four factors suggest that the rainfall response is most likely driven by internal catchment processes (Saft *et al*, 2015).

Note that the pre and post drought time periods differs from that used by DELWP.

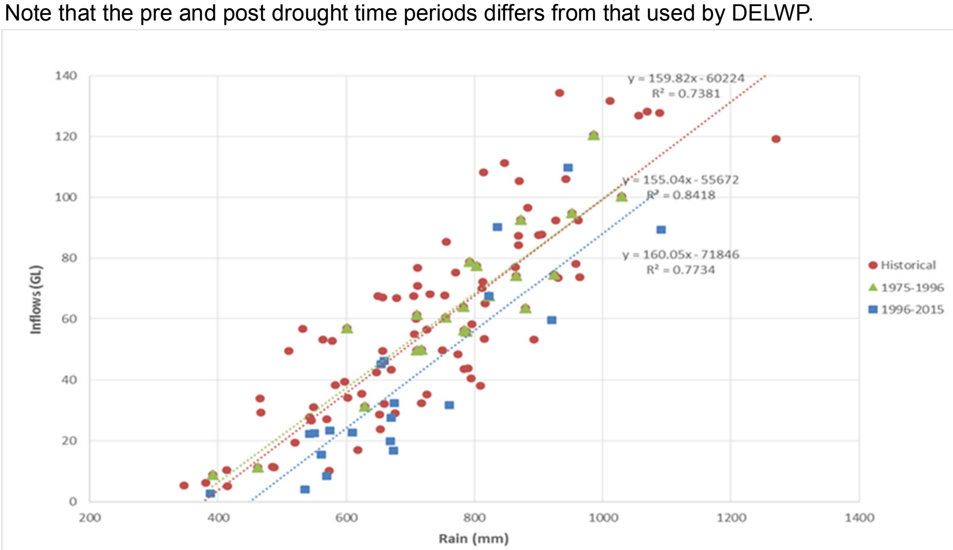

Figure 10: Annual rainfall-runoff correlation for the three time periods; historical (1892 to 2015); pre Millennium Drought (1970 to 1996); and post Millennium Drought (1996 to 2015).

Greater frequency and longer times in drought (medium confidence in southern Australia)
Droughts can be characterised by duration and severity. For southern Australia there is medium confidence that both duration and frequency of extreme drought will increase under RCP8.5 (BoM, 2016). Elsewhere in Australia there is only low to medium confidence in this projection. The change in the pattern of drought is linked directly to the overall lower rainfall.

Lower rainfall has led to a corresponding decline in annual streamflow which is primarily driven by a decline in cool season rainfall (BoM, 2016). The trend is not uniform across Victoria and away from the alpine areas, is likely to be more influenced by the characteristics of the catchment.

Future Droughts - Implication for Coliban Water

When a drought arises, water corporations may be faced with higher demand from customers because of the warmer dry weather. Lower volumes in storage and dry catchments that generate reduced runoff will exacerbate this risk. Drought risk management strategies accordingly need to be sufficiently robust to cope with a sustained water shortage over many years.

Coliban Water will endeavor to be operationally ready to deal with water shortages with the appropriate strategies in place to cope with extended periods of low or very low water availability.

More frequent and hotter days (very high confidence)
Australia's average temperature has warmed 0.9^0 C since 1910. The average temperature is projected to rise an additional 0.6 - 1.3^0 C by 2030 under a moderate climate change scenario. The greatest impact will be felt through an increase in the number of hot days (i.e. days above 35^0 C). For Victoria the warming trend has been averaging 0.06^0 C per decade between 1911 and 2014 (BoM, 2016). However over the last 30 years this trend has increased up to 0.63^0 C per decade for warm season maximum temperature.

Hot Weather - Implications for Coliban Water

From a water resource management point of view, catchments will be drier in spring and summer, and plants will transpire a greater proportion of available soil moisture. This will result in decreased base flow to rivers and streams. Peak demand for water from customers and irrigators will increase and water authorities will need to invest to ensure continuity of supply. During droughts, demand may rise further but supply could be constrained.

Warmer weather and dry vegetation also increase the risk of fire which can impact on demand for firefighting, water quality with ash entering storages, and reduced yields from the catchment as vegetation recovers.

Coliban Water will need to investigate options to reduce peak daily demand.

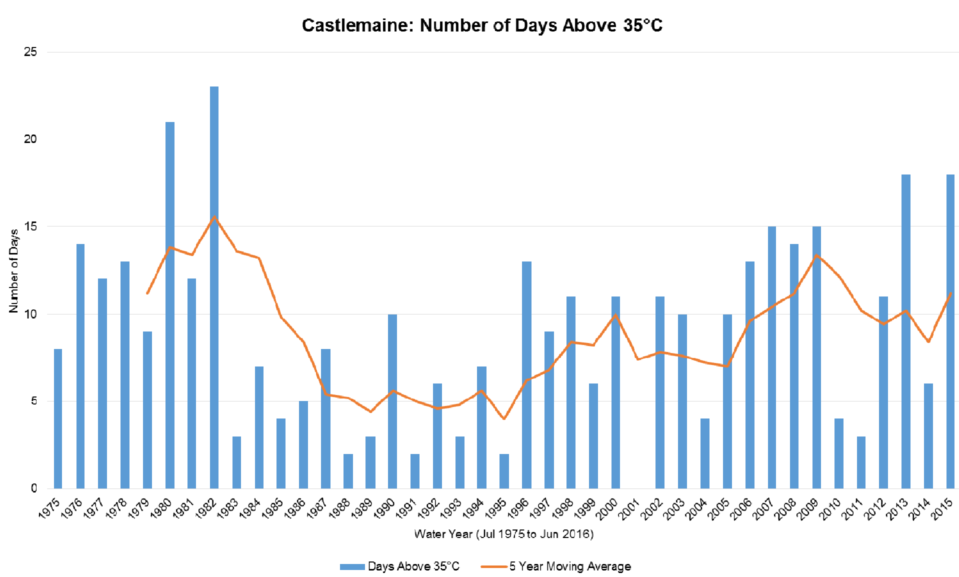

Figure 11: Number of days >35^0 C for Castlemaine, 1975 – 2015 (Water Year).

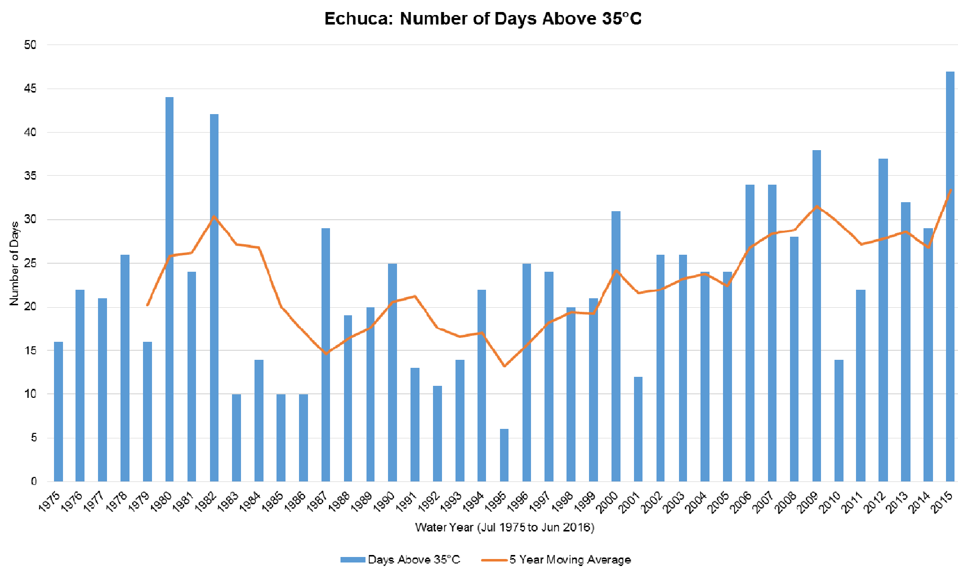

Figure 12: Number of days >35⁰ C for Echuca, 1975 – 2015 (Water Year).

Toward the end of the 21st century the projected global warming is highest under RCP8.5 with a median increase of 4⁰ C above the 1986 – 2005 temperature during the warm season for both maximum and minimum temperatures (BoM, 2016). The corresponding cool season increase is 3.5⁰ C.

High evaporation rates (high confidence)
Hot weather exacerbates existing high evaporation rates from storages. There is a high degree of confidence that in future there will be a decline in relative humidity, and higher potential evaporation. These conditions will also lead to a decline in available soil moisture, which in turn reduces runoff (medium confidence, BoM 2016). The increases are expected to be larger during the winter months.

Evaporation - Implications for Coliban Water

Annual evaporation from our major storages is our largest, system operating loss. Increased losses will exacerbate decreased inflows and potentially higher demand.

Options need to be identified that are capable of reducing evaporative losses.

Estimates provided by DELWP indicate that under a high climate change scenario potential evaporation rates may increase by around 10% in northern Victoria. Also we are likely to experience harsher fire weather (high confidence, BoM 2016).

Extreme rain events more intense (high confidence)
Extreme rain events do not of themselves present an increased risk of water shortages provided major storages and service basins cope adequately with the inflow. The critical implication is that there needs to be capacity to receive any sudden inflow, and that water corporations can respond quickly to changing circumstances. There is high confidence in the modelling that the frequency of heavy rainfall events will increase into the future (BoM, 2016).

Extreme Weather - Implications for Coliban Water

The economic benefit and potential demand reduction achieved from on-site harvesting of rain water, and / or storm water becomes more favourable when replenishment occurs during periods of high demand i.e. summer months.

Mean sea level pressure increase (high confidence)
Changes in rainfall will be driven by changes in atmospheric circulation. Mean sea level pressure (MSLP) is projected to increase during the cool season driven by an increase in the strength of the sub-tropical ridge (STR). A southward shift of the STR is predicted which is consistent with observations over the last 30 years. Climate models tend to underestimate the rainfall response

to changes in the position and intensity of the STR and hence may underestimate the decline in cool season rainfall.

Figure 13 shows the influence of a high pressure system forcing ‘lows’ closer to the Antarctic coastline. The interaction between these cold fronts in the Southern Ocean and ‘highs’ typically generates rainfall over southern Australia. In this instance the majority of the rain falls on the ocean. Climate models are consistent in predicting a southerly shift and strengthening of the STR (BoM, 2016). Any intensification of the STR is expected to be associated with a reduction in rainfall.

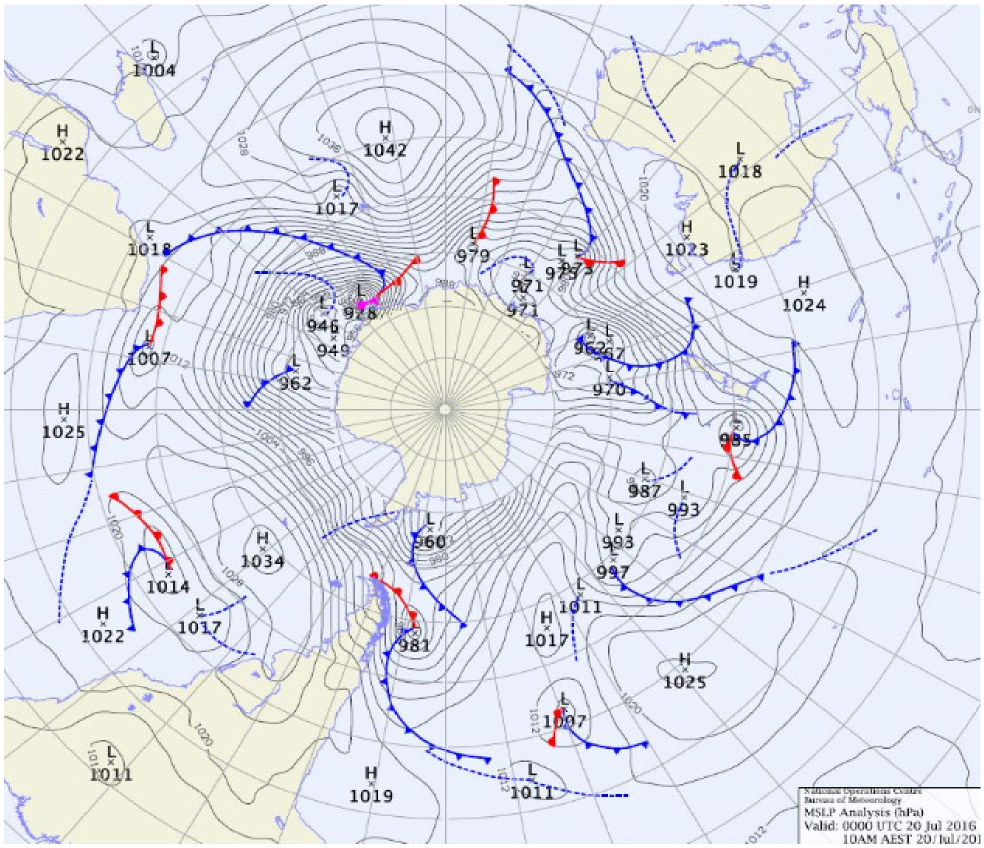

Figure 13: Mean sea level pressure over the southern hemisphere with cold fronts ‘pushed’ closer to the Antarctic coastline by a ‘high’, 20 July 2016 (BoM).

Impact of the Millennium Drought 1996 – 2009

Climate Impact on Rainfall and Inflow

The dry weather conditions that persisted during the Millennium Drought resulted in significant reductions to inflows and water allocations.

The critically low raw water position in Coliban Southern during 2005 and 2006 accelerated the construction of the Goldfields Superpipe, completed in August 2007. The Goldfields Superpipe connects Coliban Northern with the GMW Goulburn system. Rainfall was below average in most years from 1996 to 2009.

The average annual rainfall from 1891 to 1996 at Malmsbury (representing rainfall at our main catchment storages) is 741 mm. From 2001 to 2009 the average rainfall was only 590 mm, a decline of around 20%. This latter period represents the longest contiguous period of below average rainfall during the drought.

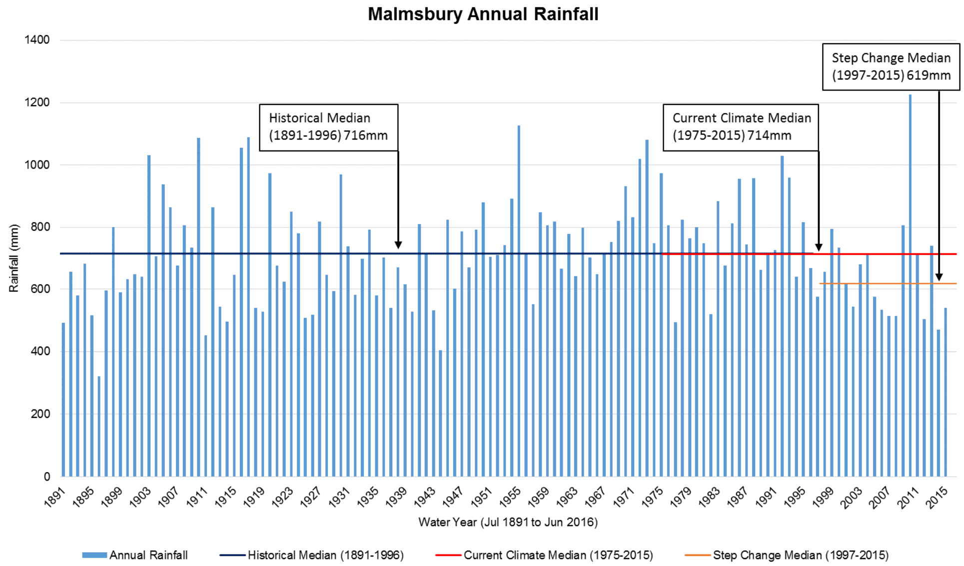

Figure 14: Malmsbury Annual Rainfall, 1891 – 2015 (July - June). Historical median up to 1996 is 716 mm, current climate median is 714 mm, and post-1997 is 619 mm (about a 10% decline). All values rounded off to the nearest mm.

During the Millennium Drought, declines in autumn rainfall were pronounced and the dryness of the catchments leading into the winter months resulted in dramatic reductions in inflows into our storages.

Previously the long-term average annual inflow to the Coliban storages was 62,300 ML. However, the average inflows between 1997 and 2009 declined by 61% to 24,413 ML with a low of 3,000 ML in 2006-07 with the storage levels falling to 6% of capacity in mid-2007.

Median Inflow

Our current climate estimate of annual median inflow is 48,100 ML. The median is preferred to 'averege' where data is variable as it provides a better indicator of probability i.e. 50% of inflows are likely to be higher and 50% are likely to be lower. Hence the data has no bias toward extreme events.

At the other extreme, very high inflows were received in 2010 with all storages filling by November and major floods occurring downstream of Lake Eppalock in late 2010 and again in early 2011.

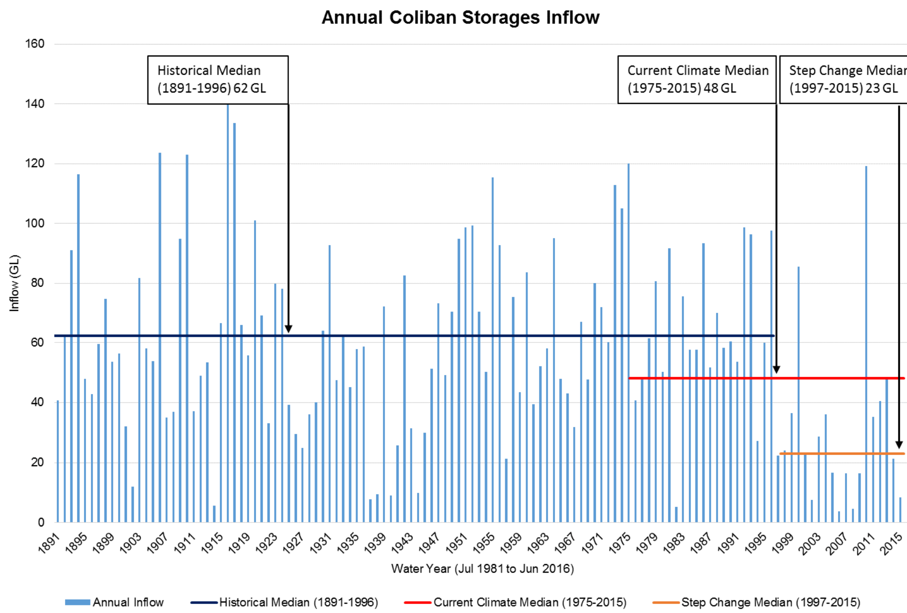

Figure 15: Annual inflows (July – June) into Coliban Headworks Storages showing median historical (62.3 GL), current climate (48.1 GL/a), and post-1997 (23.0 GL/a).

'Operational Drought' in Action

Water restrictions were first introduced in the Wimmera System in December 1999 followed by all others systems in October-November 2002. Water restrictions had a major influence on managing system demand. The most severe restrictions of Stage 3 and Stage 4 were in force for seven to eight years in Coliban Northern and Coliban Southern, and the Wimmera System.

The annual demand for raw water ranged from 54,000 ML in 2001-02 in a year of unrestricted urban supply (pre-PWSR) and 100% rural allocation, to a low of 19,800 ML in 2010-11 in a year of extremely high rainfall.

Supply to Coliban Water rural customers was also restricted in the nine years since 2001-02 with allocations less than 100%. Zero allocations were provided in three years. Annual rural water demand ranged from 17,800 ML in 2001-02 (100% allocation year) to a minimum of 2,500 ML in 2006-07 (emergency supply).

The Millennium Drought presented Coliban Water with a severe test of its capacity to cope with a sustained shortage of raw water supply. Depending on the supply system there were:

- Reductions in inflows into the main storages that affected Bendigo, Castlemaine and Kyneton, their connected communities, and rural customers;
- Sustained low allocations in supply systems not managed by Coliban Water within the Campaspe, Goulburn, Loddon, Murray and Wimmera systems (see Table 6);
- Issues with very poor water quality caused by high salinity and cyanobacteria (aka blue-green algae); and
- Limited opportunities to draw on a diversity of raw water sources for each supply system.

The limited capacity to access a wider range of water sources for Coliban Northern was addressed through a program of infrastructure works, and the purchase of water shares and allocation. The legacy is greater resilience to drought but with a higher annual operational cost. It also provides greater security for Coliban Southern by allowing the largest demand centre of Bendigo to access multiple raw water sources.

Table 13: Variation in restriction level and duration across each system during 1997-2009

Supply System	Range of Restriction Level1	Duration
Campaspe	Unrestricted to Stage 4	96 months
Coliban Northern	Unrestricted to Stage 4	99 months
Coliban Southern	Unrestricted to Stage 4	104 months
Elmore	Unrestricted to Stage 2	89 months
Goulburn	Unrestricted to Stage 4	89 months
Loddon	Unrestricted to Stage 4	96 months
Murray	Unrestricted to Stage 4	93 months
Trentham	Unrestricted to Stage 2	53 months
Wimmera[2]	Unrestricted to Stage 4	138 months

Note 1: Unrestricted demand is pre-PWSR and represents a higher level of demand than currently experienced (PWSR adjusted demand).

Note 2: During the Millennium Drought the Wimmera System was converted from an 'open channel' supply to a pressurised pipeline supply via the construction of the Wimmera Mallee Pipeline.

The figure below highlights the pattern of demand based on the restriction level. This pattern is typical of the reductions in demand experienced in other systems during the Millennium Drought.

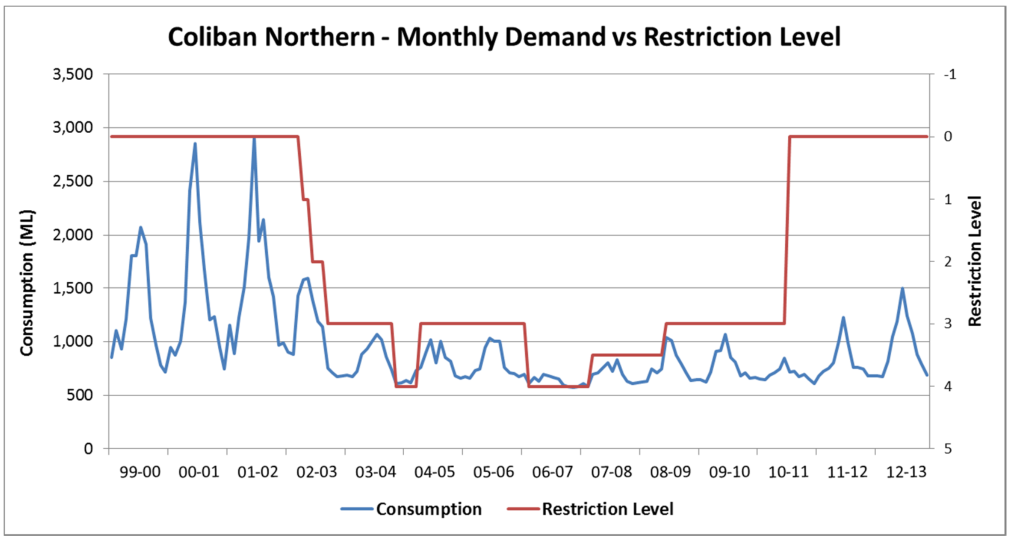

Figure 16: Reduction in demand for the Coliban System Northern based on the restriction level during the Millennium Drought 1997-2009.

Drought Related Expenditure

During the Millennium Drought Coliban Water expended around $218 million on infrastructure and water purchases (entitlements and allocation). Of the total expenditure, $67 million was from Government grants with the balance financed by Coliban Water. Central Highlands Water was also a joint venture partner for part of the major capital works, and for the augmentation of the Lake Eppalock pump station.

During the Millennium Drought intangible water assets (water shares and allocation) were acquired from the water market at the prices prevailing at the time – typically at or around the peak of the market. Coliban Water utilised a number of mechanisms to secure these assets at this critical time.

Table 14: Expenditure on major infrastructure and water assets attributable to the Millennium Drought.

Drought Related Expenditure	Capital Cost
Colbinabbin Pump Station & Goldfields Superpipe[1]	$90 million
Augmentation of Lake Eppalock Pump Station[3]	$18 million
Recycled Water Factory, Epsom	$47 million
Entitlement Purchases[2] (~23 GL)	$54 million
Allocation Purchases (~25 GL)	$9 million
Total	**$218 million**

Note 1: Joint Venture between Coliban Water and Central Highlands Water.
Note 2: Includes purchases of water shares (high and low reliability).
Note 3: Augmentation was paid for by Central Highlands Water. However Coliban Water also derives a benefit.

Other Drought Related Financial Impacts

The borrowings by Coliban Water to fund the capital infrastructure have an on-going financial legacy through increased operating costs to the business for:

- Interest payments of around $11 million per annum, and
- Additional operation and maintenance costs for the infrastructure of $1 - 3 million per annum.

During the drought there was also a net reduction in revenue of around $10 million per annum as increasingly severe restrictions were imposed and the sales of water declined. This has impacted on the prices being charged.

There were broader community and economic impacts across the region through expenditure on alternative water sources (e.g. greywater), loss of sporting opportunities, loss of gardens and the garden supplies industry. The simple 'take home message' is that droughts, in particular severe or extended droughts are expensive.

PART B – PROJECTIONS TO 2040 & 2065

This section of the UWS details the projections of future demands and future water availability. Our customer population is forecast to more than double over the 50 year timeframe of the UWS. Our major towns of Bendigo, Echuca, Castlemaine and Kyneton are centres of significant population growth. Future demands for water services will be further amplified as household demand increases with a projected drier and hotter climate.

The extent and impact of climate change on our water resources to date has been substantial during the past 20 years with record low inflow into our storages and record low allocations against bulk entitlements and water shares. Some of the water resources supplying our urban and rural communities are near or already at their sustainable limits. Climate change will further reduce rainfall and available water supply, and increase the frequency and severity of droughts. We face significant challenges in meeting future demands for water services and maintaining acceptable levels of service with declining supply from our current water sources.

These two fundamental quantities of demand and water availability have been analysed using in-house modelling to forecast the sustainable water supply of each system under a range of climate change scenarios out to 2040 and 2065.

System Yield

The 'sustainable supply', referred to as the **system yield**, is the average annual volume of water that can be sustained and supplied each and every year subject to complying with levels of water security afforded to our customers. It determines the volume of water that can be reliably supplied over time. The actual amount of water available in any given year can vary considerably so the yield typically represents more of an average based on the demand at the time.

The system yield further determines the timing when a water supply system fails to provide satisfactory performance in meeting acceptable levels of service. It also determines the extent of additional water resource and or infrastructure augmentation needed to ensure our water supply systems remain resilient to the challenges of growth and climate change.

Demand Projections

The current baseline demand for the region is 28,658 ML. The baseline demand comprises the PWSR supply to the urban systems and the demand assuming 100% rural allocation.

Table 15: Baseline demand for each supply system.

Water Supply System	Baseline Demand (ML/y)		
	Urban	Rural[1]	Total
Campaspe	59		59
Coliban Northern	11,173	3,714	14,887
Coliban Southern	2,855	4,109	6,964
Elmore	125		125
Goulburn	1,656		1,656
Loddon	375		375
Murray	4,263		4,263
Trentham	157		157
Wimmera	172		172
Total	**20,835**	**7,823**	**28,658**

Note 1: Rural demand is typically only about 50% of licence volume in an average year. In a dry or wet year it can be up to 50% higher or lower respectively.

Urban demand currently accounts for approximately 73% of all raw water use. Our two largest water supply systems of Coliban Northern and Coliban Southern account for two-thirds of this total.

Rural demand accounts for about 27% of all water use and comprises water deliveries to rural licence-holders supplied via open channels and rural pipelines, and the water losses incurred through channel seepage and evaporation at rural water storages.

Even though there has been high population growth, the Coliban Region has experienced a 45% reduction in demand over the past 15 years from a high demand of 54,000 ML in 2001-02 in a year of unrestricted urban supply and 100% rural allocation and associated high channel losses. The reduction in demand can be contributed to:

- The adoption of PWSR that delivered a significant saving in demand of 20% to 25% compared to the unrestricted supply years of the late 1990s and early 2000s
- Reconfiguration and modernisation of a major rural channel section involving the piping of inefficient rural open channels
- Changes to the way customers use water that have been largely influenced by education programs, changes to water pricing, grey-water reuse, changes to garden and lawn areas, and efficiency improvements in household appliances; and
- Ongoing efficiency improvements to water distribution systems with action including the replacement of old, fragile and leaking mains.

Urban Water Demand Projections

The 2017 current baseline PWSR annual urban demand (the baseline PWSR demand) used in the projections is 20,780 ML.

Urban water demand comprises customer water consumption and non-revenue water losses incurred through leakage and pipeline bursts, fire hydrant use and the flushing of mains to maintain general pipeline health. Other water losses also comprise evaporation at service basins, losses incurred in transfer of urban water in open channels and major transfer pipelines and the operational water required to backwash and clean the treatment plant filters and membranes.

The baseline demand is the estimated demand for raw water in a year of average annual rainfall; for Bendigo the average annual rainfall since 1975 is 534 mm. Some recent actual annual demands have been marginally greater than the baseline demand but these have occurred in years of low rainfall where demand for water is greater due to the drier conditions.

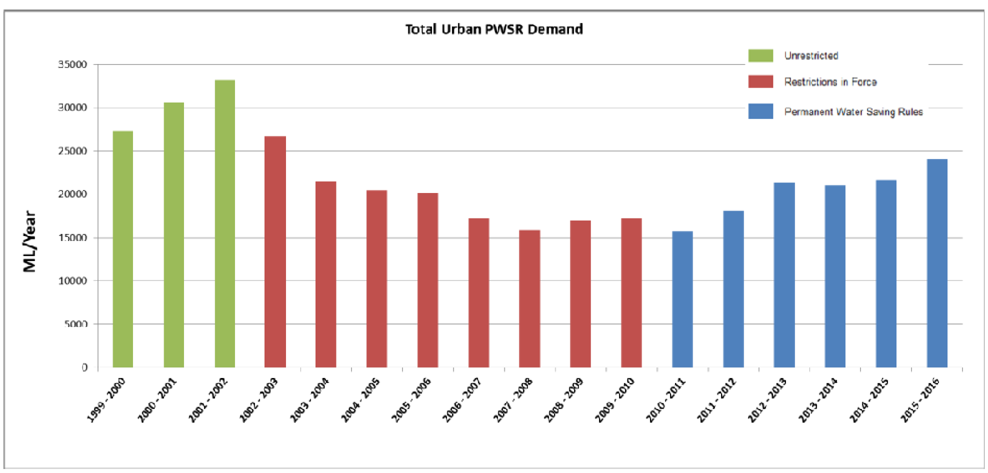

Figure 17: Demand pattern under 'unrestricted conditions', during restriction and with PWSR in place from 1999 to 2016.

The baseline PWSR demand was determined separately for each town and system, based on the actual PWSR demands over the past five years and taking into account actual rainfall.

The general approach taken to forecasting future raw water demands was to adopt the baseline PWSR demands and then project forward using growth in water connections.

However, because of the wide variation in the water consumptive demands of our end users, that vary considerably from residential to industrial and from commercial to public open space, connections were segmented so that demands could be analysed under the following four sectors:

- Residential
- Commercial & Industrial
- Community Infrastructure & Public Open Space
- Other non-residential

The above sector-based approach to forecasting future urban demands provided considerable rigour with attention given to the distinct differences in sector demand and growth.

This approach of forecasting future demands using current sector demands and projecting forward using the sector growth provided our baseline demand into the future. The baseline demand due to population growth is estimated to increase from 28,658 ML to 49,600 ML by year 2065.

The growth in water connections is the primary driver of increases in water demand. Water connections are forecast to grow from the current 73,000 to 153,500 by the year 2065; i.e. more than doubling over the next 50 years.

The growth in water connections has been based on actual growth trends and the most recent data available of household and population projections contained in *Victoria in Future 2016* (VIF2016) that covers the period 2011 to 2051 for Victoria and major regions. This is the official State government projection of population and household trends.

Victoria remains the fastest-growing State in the country with its population and households expected to more than double in the next 35 years; strong household and population growth is forecast in the Coliban region and particularly in the Bendigo area given its status as a major regional centre. The last decade has seen the residential population of the City of Greater Bendigo (CoGB) increase from 92,000 to 108,500 and the VIF2016 data projects that the CoGB will continue grow at a strong rate of 1.7% per annum.

Connection growth rates are slightly greater than population growth due to the declining number of persons per household. Coliban Northern, with its high growth rate, is projected to grow from 47,325 to 109,781 connections by 2065.

Table 16: Estimated growth in water connections by system out to 2040 and 2065.

Estimated Growth in Water Connections				
Water Supply System	**Growth (%/a)**	**2016**	**2040**	**2065**
Campaspe	0.90	175	219	267
Coliban Northern	1.74	47,325	70,850	109,781
Coliban Southern	1.19	10,946	15,317	19,638
Elmore	0.64	438	513	591
Goulburn	0.21	2,724	2,854	3,029
Loddon	0.24	1,364	1,440	1,528
Murray	1.10	8,773	11.200	14,206
Trentham	1.67	595	954	1,327
Wimmera	0.33	659	700	779
Total	**1.5**	**72,999**	**104,047**	**151,146**

Residential household connections are forecast to grow at 1.5% per annum with strong growth also in connections for new commercial and industrial developments. Potential additional new developments as identified by local knowledge have been incorporated into the expected water connection growth rates and demands.

Table 17: Estimated growth in water connections by customer sector out to 2040 and 2065.

Estimated Growth in Water Connections				
Customer Sector	**Growth (%/a)**	**2016**	**2040**	**2065**
Residential	1.52	66,227	95,787	140,730
Commercial & Industrial	1.35	4,848	6,033	7,738
Community Infrastructure and Public Open Space	0.95	1,138	1,396	1,786
Other Non-Residential	0.72	786	831	891
Total	**1.50**	**72,999**	**104,047**	**151,146**

Growth in Water Connections

Customer connections are projected to more than double over the planning timeframe of the Urban Water Strategy out to 2065. This will create significant challenges in meeting the increased demands placed on our water and wastewater infrastructure and water resources.

Besides growth in connections, other drivers of demand were considered in the demand forecasts:

- Consumer consumptive behaviour
- Climate change, and
- System operational efficiencies and non-revenue water.

Consumers have delivered significant saving in demands (20-25%) in the way they use water compared to the unrestricted supply years of the early 2000s. The removal of water restrictions in 2010 after the Millennium Drought has seen little to 'no bounce-back' to the pre-drought demands and demonstrates a continuation of water conservation measures within the community.

However, further reductions in demand due to changes in 'customer consumptive behaviour' on top of the already significant changes to water use, may result in an under-estimation of the likely future demands. Further, the challenges a growing population and the impacts of climate change could easily be underestimated.

Accordingly, no further reductions in demand due to behavioural changes are provided in the analysis of future demands. Nevertheless, in-house modelling incorporates the ability to analyse the sensitivity of possible future changes in customer behaviour on the estimates of demand and system yield.

The impact of our future climate will severely impact demand. The potential impact of climate change on demand has been analysed using temperature, rainfall and evapotranspiration projections provided in the *Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria* (DELWP, December 2016).

Our recent demands have been impacted by weather. Variations in actual demand over the past five years strongly correlate with prevailing rainfall and temperature. A drier and hotter future climate will push up the demand for water while increases in evaporation will see greater loss of water through evaporation at our reservoirs and storage basins. Table 18 shows the estimated changes to rainfall, temperature and evapotranspiration in the Campaspe River Basin with a medium change in climate.

Table 18: Relative future climate impacts within the Campaspe River Basin

Change Relative to the Current Climate Baseline Due to Medium Climate Change		
Campaspe River Basin	**2040**	**2065**
Average Annual Rainfall	-2.2%	-6.1%
Temperature Change	+1.3^0 C	+2.4^0 C
Potential Evapotranspiration	+4.7%	+7.8%
Estimated Impact on Water Demand	+14.0%	+17.0%

Even medium change in climate is estimated to add considerately to our regional demand by 14% to 17% over and above the baseline. By 2040 this scenario is estimated to add 4,750 ML to regional demand and 8,640 ML to demand by 2065.

A high climate change brings even more severe impacts. Demand is estimated to increase by 18% or 6,500 ML by 2040 and by 22% or 11,600 ML by 2065.

Wastewater Demand Projections

The growth in connections is projected to only increase with respect to residential connections except for the larger urban centres. The sewer connections for the larger urban centres are assumed to increase in proportion to population growth.

Table 19: Estimated growth in wastewater connections by system out to 2040 and 2065.

Estimated Growth in Wastewater Connections			
Wastewater System	**2016**	**2040**	**2065**
Coliban Northern	44,432	66,725	103,663
Coliban Southern	8,986	12,599	16,186
Elmore	380	447	517
Goulburn	2,294	2,412	2,570
Loddon	937	1,000	1,074
Murray	8,064	10,388	13,267
Wimmera	446	482	552
Total	**66,089**	**94,933**	**139,056**

Table 20: Estimated growth in wastewater connections by customer sector out to 2040 and 2065.

Estimated Growth in Wastewater Connections			
Customer Sector	**2016**	**2040**	**2065**
Residential	60,353	87,793	129,874
Commercial & Industrial	4,763	5,945	7,641
Community Infrastructure and Public Open Space	817	1,026	1,349
Other Non-Residential	156	171	192
Total	**66,089**	**94,933**	**139,056**

Rural Raw Water Demand Projections

The Coliban Rural system supplies stock and domestic water to 1,374 licence holders (30 June 2016) with entitlements of 10,600 ML held in Coliban Northern and Coliban Southern.

The baseline rural demand is 7,800 ML of which 3,700 ML is demand in the Coliban Northern system and 4,100 ML in the Coliban Southern system.

The rural demand is based on the analysis of actual rural demands since 2008. It comprises the delivery or take-up of allocations and the operational channel losses such as channel leakage and evaporation in a year of 100% allocation and average annual rainfall.

Climate has a profound impact on rural demand. In dry years, the rural demand can be as much as 11,700 ML or 50% greater than the baseline demand while in wet years the rural demand can be a low as 2,700 ML or 50% of the baseline rural demand. Rural demand is forecast to remain relatively unchanged over the timeframe of the UWS except that there may be more dry years in the future which impacts on the average demand over time.

Modernisation and piping of sections of the open channel system as well as urban encroachment and the surrendering of licences has resulted in a gradual and sustained shrinkage of the rural area and declining rural demand over the past 30 years. Further reconfiguration and piping of the open channel system is likely over the timeframe of the UWS that will again reduce operational water losses and demands. However, this will be offset by increased demands that come with a hotter and drier climate and also the likely increase in water trading, and with it the greater take-up of future available allocations. There are potential savings in rural demand due to efficiency measures but these will be partially offset by potential increased take-up in rural demand due to water trading.

Table 21: Potential changes in rural demand under a range of climate scenarios.

Climate Scenario	Rural Demand (ML)
Baseline, Medium and Low Climate Change	7,823
Dry – High Climate Change	11,735
Wet	3,912

Rural Demand

No change is expected in the rural demand for raw water (including losses) over the timeframe of the UWS with rural demands to continue to range from 7,800 ML in an average rainfall year to 11,700 ML in a dry year. However there may be a trend toward higher average demand over time. Note: The rural raw water demand is higher than entitlement volume because it includes an allowance for channel losses.

Total Regional Raw Water Demand

The total projected system and regional demands are shown in Table 22 and Figure 18. The baseline demand due to growth is estimated to increase from 28,658 ML to 46,817 ML by year 2065. The increase in demand is due to the growth in urban demand that is forecast to increase by 1.4% per annum from 20,780 ML to 41,800 ML.

Medium climate change is forecast to increase demand to 55,693 ML by year 2065 with urban demand forecast to increase by 1.8% per annum from 20,835 ML to 39,291 ML.

High climate change is forecast to increase demand to 58,670 ML by year 2065 with urban demand forecast to increase by 1.9% per annum from 20,835 ML to 50,847 ML. The drier and hotter high climate change is forecast to increase the rural demand from the baseline of around 7,800 ML to over 11,700 ML.

Table 22: Comparison of demand under medium and high climate change at 2040 and 2065.

Water Supply System	2016 Baseline Demand	2040 Demand (ML)			2065 Demand (ML)		
		Baseline	Medium	High	Baseline	Medium	High
Campaspe	59	74	88	90	93	120	124
Coliban Northern (urban)	11,173	16,747	19,214	20,298	26,048	30,786	32,415
Coliban Southern (urban)	2,855	3,527	3,997	4,191	4,173	5,071	5,369
Coliban Northern (rural)	3,714	3,714	3,714	3,714	3,714	3,714	3,714
Coliban Southern (rural)	4,109	4,109	4,109	4,109	4,109	4,109	4,109
Elmore	125	141	162	172	156	199	213
Goulburn	1,656	1,699	1,958	2,049	1,754	2,212	2,387
Loddon	375	384	429	440	391	477	495
Murray	4,263	5,129	6,458	6,791	6,207	8,389	9,161
Trentham	157	215	242	262	271	330	357
Wimmera	172	181	231	251	197	286	327
Total	**28,658**	**35,915**	**40,306**	**42,366**	**46,817**	**55,693**	**58,670**

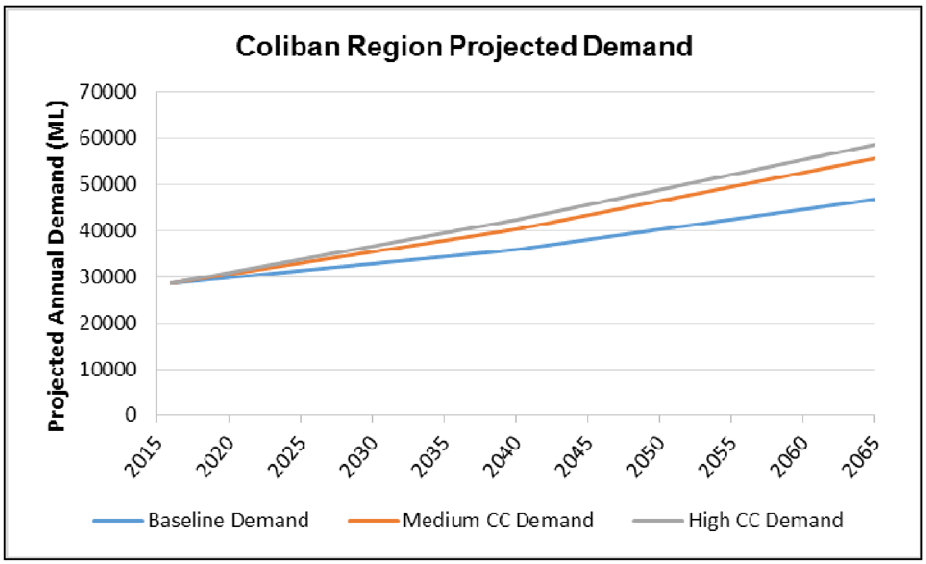

Figure 18: Projected demand to 2065 under medium and high climate change scenarios.

Projections of Raw Water Availability

The sources of water supplying the Coliban Region are:

- Inflows into major catchment storages in the Campaspe River Basin
- Annual allocations under Bulk Entitlement and water shares
- Groundwater supply; and
- Recycled water.

Our sources of water will all be impacted by climate change. In accordance with the *Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria* (DELWP, December 2016), Coliban Water has assessed the impact of climate change on water availability for the various possible climate change scenarios of:

- Current climate baseline experienced from 1975 to date, and the future plausible climate scenarios of medium and high climate change as developed by the CSIRO and based on climate projections; and
- A 'step-change' climate scenario that captures recent seasonal changes in rainfall in the post-1997 period to date that are not fully captured in the above current, medium and high climate change scenarios.

The impacts of climate change on water availability were assessed to determine the level of vulnerability of our sources of water to climate change as shown by the extent in decline in water availability over the timeframe of the UWS. The variability of future supplies was also assessed to determine the potential impact on supply from one year to the next and the potential and severity of three, five and 10 consecutive dry years.

The recent impact of climate change on our water resources has been substantial as experienced in the past 20 years with record low inflow to our storages and record low allocations against bulk entitlements and water shares. Some of the water resources supplying our urban and rural communities are near or already at their sustainable limits. Climate change will further reduce rainfall and available water supply and increase the frequency and severity of droughts. Extended dry periods with reducing water volumes will severely challenge our water supply systems to meet the growing demand for water services.

Projections of Inflows to Major Catchment Storages in the Campaspe River Basin

Our major catchment storages are the three Coliban Headworks Storages and an 18% share of the capacity of Lake Eppalock.

The Coliban Headwork Storages comprise the Upper Coliban, Lauriston and Malmsbury Reservoirs located south of Malmsbury. These reservoirs are the sole source of supply to the Coliban Southern but can also transfer water via the Coliban Main Channel to Coliban Northern. The storages have a combined capacity of 69,594 ML and an historical annual median inflow of around 62,300 ML. The current climate annual median inflow since 1975 is 48,100 ML, a 33% reduction over the historical inflow.

Coliban Water's 18% share of Lake Eppalock comprises a capacity of 54,837 ML and a historical annual inflow of 28,700 ML (based on the 18% share of inflow). The baseline annual inflow since 1975 is 26,400 ML, an 8% reduction on historical inflow. Lake Eppalock supplies Coliban Northern. The Goldfields Superpipe has the capability to transfer water from Lake Eppalock to Coliban Northern but currently there is no interlinking connection with Coliban Southern.

Table 20 shows the projected impact of climate change on the water available from inflows to the Coliban Headworks Storages and Lake Eppalock as modelled by the CSIRO.

Inflows are extremely vulnerable to climate change. A continuation of the post-1997 is projected to result in a 63% reduction compared to historical inflows. A high climate change scenario is projected to reduce average historical inflows by 61% to 33,200 ML by year 2065. Such average annual inflows are approximately only half of the projected Coliban System demands in 2065 under a high climate change scenario. To compound the severity of this supply shortfall, is the loss to evaporation of inflow water held in storage and the obligation to release inflow for downstream environmental purposes.

The variability of inflow from year to year creates challenges in the way water resources are stored and managed. The inflows can vary from one year to another by a ratio of 50 to one where an extreme dry year could potentially be followed by a flood year.

Long-term drought sequences present serious threats to the viability and liveability of our communities. High climate change is projected to see potentially more severe droughts where the driest 5 and 10 year inflow could average as little as 5,800 ML per annum and 12,200 ML per annum respectively. Supplies at this level would be sufficient to meet only 5% to 20% of water demands for periods up to 10 years in duration.

Table 23: Variation in Campaspe River Basin under a range of climate scenarios.

Parameter	Climate Scenario			2040		2065	
	Historic	Baseline Climate[1]	Post 1997	Medium	High	Medium	High
Average Inflow (ML/a)	85,900	77,300	37,500	67,800	48,600	61,300	33,200
Forecast Reduced Supply	0%	10%	56%	21%	43%	29%	61%
Maximum Inflow	222,200	218,900	218,900	192,000	137,700	173,600	94,100
Minimum Inflow	4,200	4,200	1,600	3,700	2,700	3,300	1,800
Variability in Supply	50:1	50:1	140:1	50:1	50:1	50:1	50:1
Short Term Dry Periods							
Lowest Consecutive 3 year Average Annual Inflow (ML/a)	9,700	9,700	8,600	8,500	6,100	7,700	4,200
Longer-term Drought Period							
Lowest Consecutive 5 year Average Annual Inflow (ML/a)	13,500	13,500	10,700	11,800	8,500	10,700	5,800
Lowest Consecutive 10 year Average Annual Inflow (ML/a)	28,400	28,400	17,900	24,900	17,900	22,600	12,200

Note 1: Current climate baseline for the period July 1975 to June 2016.

Variability in Supply

Our supply systems will need to have substantial operational flexibility in order to smooth out the potential variation in supply from year to year.

Allocation Projections against Bulk Entitlements and Water Shares

Bulk Entitlements and water shares for the GMW Campaspe, Goulburn, Loddon, Murray and GWMWater Wimmera water supply systems have a total entitlement of 38,585 ML. The historical average annual allocation is 95% or 36,700 ML. Table 29 shows the projected impact of climate change on water allocations.

Allocations are vulnerable to climate change. A continuation of the post-1997 change in climate is projected to result in a 14% reduction to historical allocations. A high climate change scenario is projected to reduce average historical allocations by 31% to 25,500 ML by 2065.

There is a high variability in annual allocations where allocations can currently vary by a factor 3 to 1 from one year to another and this will escalate to a factor of 11:1 under high climate change at year 2065 where an allocation of 37,800 ML might be received in one year followed by a year of only 3,600 ML.

Long-term drought periods are projected to reduce annual allocations to 15,200 ML per year over a ten year period and also reduce allocations to as low as 7,200 ML per year in a shorter-term three year drought. This is a 60% to 80% reduction to the full allocation volumes that could conceivably continue for up to 10 consecutive years.

Table 24: Impacts of climate change on annual allocations under a range of scenarios.

Parameter	Climate Scenario			2040		2065	
	Historic	Baseline Climate[1]	Post 1997	Medium	High	Medium	High
Average Allocation (ML/y)	36,700	35,700	31,400	34,500	30,200	33,700	25,500
Forecast Reduction in Supply	0%	3%	14%	6%	18%	8%	31%
Maximum Total Allocation ML	38,600	38,600	38,600	38,600	38,600	38,600	37,800
Minimum Total Allocation ML	13,000	13,000	7,200	12,000	5,100	10,700	3,600
Variability in Supply	3:1	3:1	5:1	3:1	8:1	4:1	11:1
Short Term Dry Periods							
Lowest Consecutive 3 Year Average Annual Allocation	17,200	17,300	17,000	13,400	8,400	11,800	7,200
Longer-term Drought Period							
Lowest Consecutive 5 Year Average Annual Allocation	21,500	21,500	21,200	17,700	12,400	16,100	10,500
Lowest Consecutive 10 Year Average Annual Allocation	27,700	27,700	24,500	24,700	18,800	23,000	15,200

Note 1: Current climate baseline for the period July 1975 to June 2016.

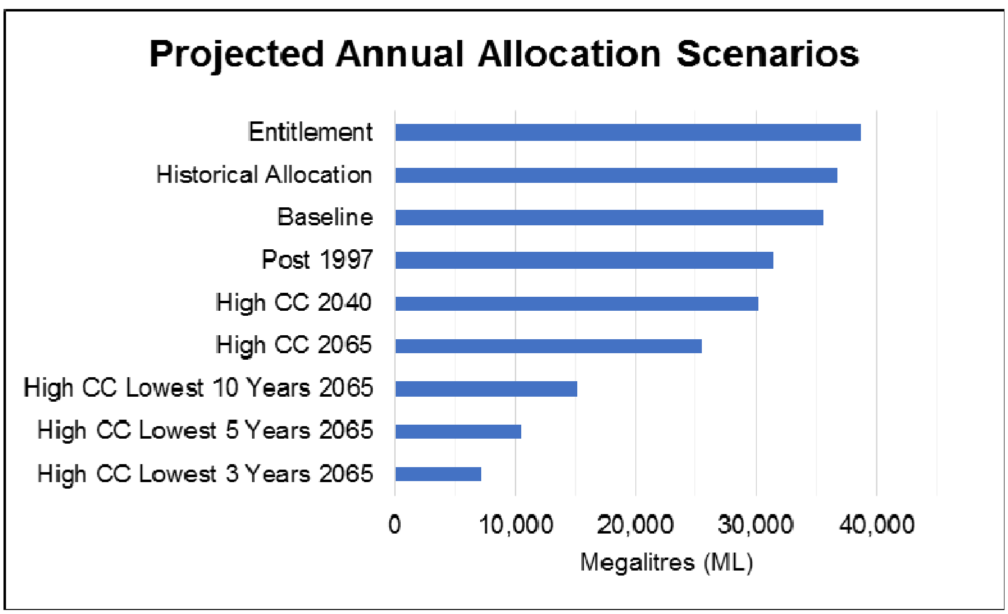

Figure 19: Indicative allocation volume under different climate scenarios compared to entitlement volume (Y-axis).

Projections of Groundwater Allocations

Groundwater Supplies in Elmore and Trentham

Elmore has a 284 ML licence while Trentham has a 120 ML spring water Bulk Entitlement and ground water licences of 48 ML.

The Elmore groundwater system is a deep lead aquifer and is not expected to respond to changes in climate over the 50 year timeframe of the UWS; or if it does the change will be gradual allowing adequate time to manage. The average annual water allocation in recent years is of the order of 90% with a low allocation of 65% in 2009 and again in 2010. However, recent amendments to the Catchment Management Plan (October 2012) indicate that the minimum allocation is projected to be 75%.

The projected water availability of the Elmore groundwater system is forecast to remain unchanged and could be increased very marginally with the projected minimum allocation.

The Trentham spring water and groundwater extraction system is situated in fractured rock and is likely to be impacted to some extent by climate change. However, a sophisticated model of this complex groundwater and spring-water system is currently not available to accurately assess the impacts of climate change. It will be some time in the future before an accurate assessment can be made of the likely impacts of climate change.

A desk-top review carried out in the early 2000s of the Trentham system set the maximum allocation of spring-water tentatively at 120 ML over a rolling three-year period and a minimum allocation of 84 ML.

Coliban Water will look to undertake the development of a groundwater model of the Trentham springs that includes our two bores. With Trentham's high growth rate this system will need to be well understood before embarking on future supply augmentation projects.

Ground Water Supplies
Groundwater supplies are less likely to be impacted by the effect of a changing climate over time. However shallower unconfined aquifers such as that at Trentham will be more vulnerable to short-term dry periods.

Projection of Available Recycled Water

The Bendigo Recycled Water Factory (RWF) can supply approximately 3,000 ML per year of recycled water for non-potable use. The recycled water can be used to supplement supply to the rural sector, public open spaces, school facilities and dual pipe residential systems.

Recycled water is a real option in partially offsetting the growing demand on future dwindling raw water supplies. The future extent of recycled water use is discussed in the section on 'Options and Evaluation'.

Vulnerability to Climate Change
Our water resource availability is highly vulnerable to climate change. There is the potential for significant declines in raw water availability and as water resource managers we must plan and be prepared for the worst case scenarios of post-1997 climate ('step-change') as well as medium and high climate change.

Supply Projections

The current available system yield to the Coliban Region is estimated at 38,094 ML. The system yield is the average annual volume of water that can be sustained and supplied each and every year subject to the levels of service and the operational rules that are specific to our water supply systems.

The current yield is marginally greater than the current estimated regional demand of 28,658 ML. Our water supply systems are considered to be capable of meeting the current baseline demands while satisfying levels of service obligations.

This section of the UWS outlines our approach and methodology to forecasting the system yields over the next 50 years. Computer modelling has been used in the forecasting.

The computer modelling uses the demand projections, and the projections of available supply, as undertaken by the CSIRO and provided as part of the DELWP Guidelines, and as outlined in the above “Projections of Raw Water Availability”, to forecast the supply yield for each of our nine water supply systems.

The analysis determines for each climate scenario:

- System yield
- Supply reliability
- Frequency of restrictions
- Severity of restrictions, and
- Additional water needed to meet the level of service obligation.

Computer modelling enables the complexities and operational rules to be incorporated in the analysis of system yield. The water available to our water supply systems is subject to various system constraints or operational rules. For example, our catchment storages have a limited capacity and once they fill any further inflow is spilt and no longer available. Additionally, a considerable part of the water held in our storages is lost through evaporation and these losses will be amplified with a hotter and drier future climate.

Besides storage capacity limitations and storage evaporation that effect system yield other modelled factors are:

- System demand
- Growth
- Maximum allowable allocation
- Minimum allowable allocation
- Water availability from allocations and inflows (CSIRO projections)
- Variability of inflows and allocations
- Projected drought sequences and severity
- Levels of service
- Carryover provisions that allows unused water to be used in the next year and can provide significant flexibility to manage supply reliability during periods of severe water shortage
- Carryover losses

- Behavioural changes in consumptive use
- Passing flow or regulatory environmental demand
- Minimum storage contents that are kept as reserve to meet restricted supply during periods of water shortage
- Availability of supplementary supplies such as recycled water
- Transfer rules to supply to alternative water supply systems, and
- Water savings due to water restrictions.

The modelling forecasts the sustainable limits of our future water resources and the timing and extent of additional water resources and infrastructure augmentation to ensure our water supply systems remain resilient to the challenges of growth and climate change. Computer modelling enables analysis of the sensitivity of the above factors to determine their relative impact on the supply-demand relationship. Table 25 shows the forecast supply (system yield) for the nine water supply systems for various climate change scenarios.

Table 25: System yields under a range of climate scenarios to 2040 and 2065

System Yield (ML)	Baseline[2]	Post 1997[2]	Medium Climate Change		High Climate Change	
Water Supply System			**2040**	**2065**	**2040**	**2065**
Campaspe	250	230	240	220	240	230
Coliban Northern	15,482	15,542	13,069	7,590	10,085	7,587
Coliban Southern	13,162	8,321	11,673	9,180	9,296	7,014
Elmore[1]	280	280	280	280	280	280
Goulburn	2,420	2,240	2,350	2,320	2,190	2,100
Loddon	580	460	490	490	480	470
Murray	5,580	5,280	5,490	5,200	3,600	3,850[3]
Trentham[1]	160	140	150	150	140	140
Wimmera	180	150	130	100	100	70
Total	**38,094**	**32,643**	**33,872**	**25,530**	**26,411**	**21,741**

Note 1: The yields may vary over time but at a slower rate than surface water, except for Trentham which may be more rapid.
Note 2: Estimated system yield as at 2016.
Note 3: Model derives a higher yield at 2065. This will be examined further in a later revision of the UWS.

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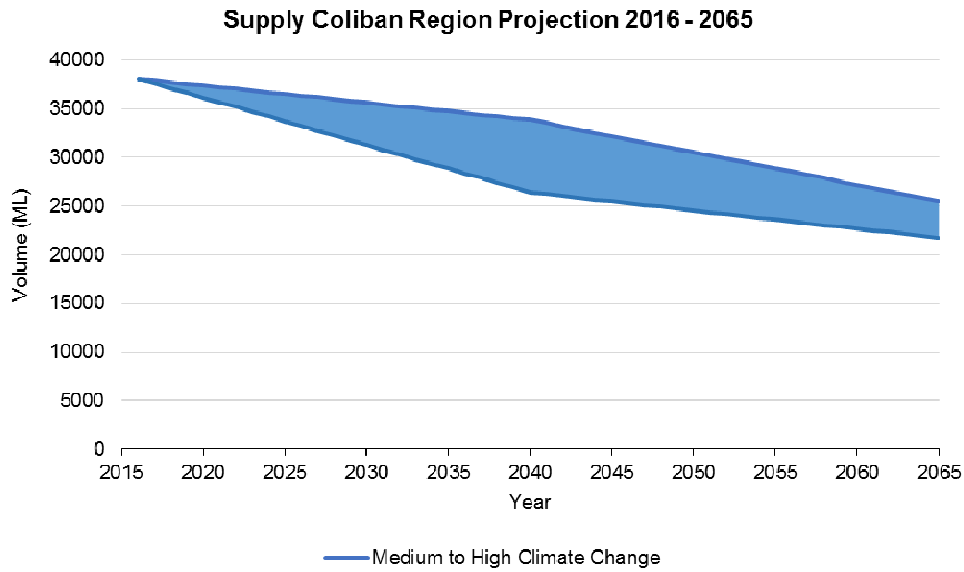

Figure 20: Forecast Regional Supply.

Treatment Plant Infrastructure Requirements

Water Treatment Plants

Coliban Water operates 19 water treatment plants across our nine supply systems. The plants are designed to treat the raw water supplied in that system. The treatment plants also need to supply the demand during extended periods of dry hot weather i.e. average day in the peak month. The latter is the 'nominal capacity' shown in the table below. The other columns are related to potential demands

Table 26: Water treatment plant infrastructure characteristics.

Treatment Plant	Towns Supplied	Nominal Capacity (ML/day)[1]	2016 Demand (ML/day)[2]	2040 HCC Demand (ML/day)[3]	2065 HCC Demand (ML/day)[3]	Estimated Augmentation Year
Campaspe						
Goornong	Goornong	0.43	0.27	0.41	0.58	2044
Coliban Northern						
Bendigo	Bendigo Axedale Huntly Raywood Sebastian	126.0	45.09	75.57	121.07	After 2065
Heathcote	Heathcote Tooborac	2.82	1.56	2.61	4.18	2048
Coliban Southern						

Castlemaine	Castlemaine Elphinstone Taradale Maldon Newstead Harcourt Guildford Fryerstown	18.4	7.98	12.70	16.58	After 2065
Kyneton	Kyneton Malmsbury Tylden	7.0	3.15	5.02	6.55	After 2065
Elmore						
Elmore	Elmore	1.64	0.60	0.83	1.07	After 2065
Goulburn						
Boort	Boort	1.47	0.59	0.75	0.90	After 2065
Lockington	Lockington	0.41	0.41	0.52	0.62	2016
Pyramid Hill	Pyramid Hill	1.32	0.41	0.52	0.62	After 2065
Rochester	Rochester	7.8	4.21	5.35	6.38	After 2065
Serpentine	Serpentine	0.39	0.13	0.16	0.20	After 2065
Loddon						
Bridgewater	Bridgewater Inglewood	2.39	0.97	1.15	1.29	After 2065
Laanecoorie	Laanecoorie Tarnagulla Dunolly Bealiba	2.64	0.56	0.66	0.74	After 2065
Murray						
Gunbower	Gunbower	0.62	0.26	0.43	0.61	After 2065
Cohuna	Cohuna	5.50	2.99	4.95	7.00	2059
Leitchville	Leitchville	1.28	0.78	1.29	1.83	2039
Echuca	Echuca	27.1	13.78	22.78	32.18	2052
Trentham						
Trentham	Trentham	0..85	0.52	0.56	0.78	After 2065
Wimmera						
Korong Vale	Korong Vale Wedderburn	1.36	0.90	1.03	1.37	2064

Note 1: Based on treatment plant operating 16 hours per day.
Note 2: Demand based on peak months of December, January and February.
Note 3: Demand based on peak months of December, January and February under a high climate change scenario (HCC).

Wastewater Treatment Plants

In addition to our water treatment plants, Coliban Water also operates 17 wastewater treatment plants. The only larger communities not served are Goornong and Trentham.

Table 27: Wastewater treatment plant characteristics

Location	Nominal Capacity[1] (ML/day)	Estimated Augmentation Year[2]	Class of Recycled Water[4]	2015-16 Reuse Volume (ML)	2015-16 Discharge to Waterway (ML)
Coliban Northern					
Axedale	0.051	2025	B	15	0
Bendigo	23.1	2029	A, B & C	1,608	3,925

Heathcote	0.425	2026	C	131	0
Castlemaine	4.68	After 2043	C	117	1,019
Coliban Southern					
Kyneton Domestic	2.30	After 2043	B & C	377	258
Kyneton Trade Waste	2.38	After 2043	N/A	N/A	N/A
Elmore					
Elmore	0.212	After 2040	N/A	N/A	N/A
Goulburn					
Boort	0.137	At Capacity	C	20	0
Lockington	0.127	After 2040	C	0	0
Pyramid Hill	0.094	At Capacity	C	0	0
Rochester	N/A[3]	N/A[3]	B	0	0
Loddon					
Bridgewater	0.170	At Capacity	N/A	N/A	N/A
Dunolly	0.117	After 2040	C	0	0
Murray					
Gunbower	0.102	At Capacity	C	0	0
Cohuna	0.425	At Capacity	N/A	N/A	N/A
Echuca	5.09	2027	B	1,148	0
Wimmera					
Wedderburn	0.160	After 2045	C	28	0

Note 1: Relates to Peak Daily Flows, not annual plant capacity.
Note 2: Figures taken from regular internal plant review process.
Note 3: N/A - Not Assessed. Other 'N/A' should be read as 'not applicable'.
Note 4: The class of recycled water relates to the level of treatment and how sterile the water is with Class A having the highest quality. This class of recycled water can be used on crops that will be eaten raw.
Note 5: All values rounded off to the nearest ML, except the 'nominal capacity'.

PART C – MANAGING OUR SERVICE AND SUPPLY

Managing Our Service – Key Strategies

Level of Service / Security

The 'level of service' objective has two components:

- the reliability of supply i.e. how often PWSR demand can be met without restrictions, and
- maximum restriction level i.e. what is the most severe level of restriction that is likely to be imposed.

Coliban Water is committed to providing the systems and infrastructure to support the needs of residential, business and industry customer's throughout our region.

With the major investments made in supply infrastructure in central Victoria through the recent Millennium Drought, significant additional works are not anticipated to be required over the next 5 to 10 years to maintain the Level of Service objective.

However, population and economic growth combined with climate variability and the potential for changes to our future climate may result in water shortages and trigger the need to impose water restrictions. Wherever feasible coliban Water would access the water market to secure additional supply before considering imposing restrictions.

UWS Policy 1 – Level of Service Objective

Urban & Rural - Reliability of Supply
Coliban Water will endeavour to not impose restrictions, on average, more frequently than 5 years out of every 100 years i.e. 1:20 years (a 5% risk). For rural customers this implies 100% allocations in 95 out of 100 years.

Recycled Water - Reliability of Supply
[No policy at present - to be developed at a later date.]

Urban - Restriction Level
Should restrictions be required, then to the extent that it is feasible, the level shall be no more than Stage 1, unless there is a severe shortage then no greater than Stage 3. Coliban Water will seek to avoid imposing Stage 4 restrictions wherever possible.

Rural - Minimum Allocation
Should allocations not reach 100% by 1 March, then to the extent that it is feasible, the allocation shall be no less than 30% of the licence volume unless there is extreme shortage. Coliban Water will seek to avoid imposing 0% allocations whenever possible.

Note: The Statement of Obligations *(SoO) calls for a review of the allocation framework within 12 months if the final rural allocation is less than 50% [SoO, Section 6-5.2(b)].*

Urban - Reliability of Supply
Coliban Water's objective is to provide sufficient water to meet customer demands of PWSR adjusted demand at 95% supply reliability. This means that PWSR would be in place 95 years out of every 100 years and water restrictions should not occur more often than the remaining 5 years.

Urban - Maximum Restriction Level
Coliban Water's objective is that in those years where restrictions are necessary, they be no worse than Stage 1. However in the event of severe or unexpected water shortages, restrictions may need to be more severe, such as Stage 3. Previous feedback from customer surveys indicated while Coliban Water's customers understand water restrictions are necessary, they do not want extreme restrictions imposed.

For urban restrictions the intent is to reduce overall demand by limiting the discretionary use of water.

Under the Victorian Water Industry Association guidelines (VicWater, 2011), Stage 1 restriction is, in the language of the review document, intended to provide an "alert" of an impending possible shortage and Stage 3 restrictions would mean that "just enough" water is provided for use. Stage 3 restrictions includes no watering of lawn areas however garden areas may be watered within restricted hours on alternate days. Full details are available from the www.water.vic.gov.au website.

For the purposes of this analysis and reporting, the additional water needs (or supply shortfall) generally relates to the additional water required to either achieve the target reliability of supply at PWSR and or to enable restriction levels to be no worse than Stage 3. Even then these restrictions levels would only be expected infrequently. Over the long-term the frequency of supply shortages may increase under medium or high climate change.

Under severe or unexpected water shortage conditions, the Drought Preparedness Plans would be triggered which could include emergency water supply measures and harsher restrictions. Occasionally, restrictions may also be required as a short-term management measure to deal with operational constraints.

Rural - Reliability of Supply
The Level of Service provided to Coliban Water's rural system also has two components.

Coliban Water's objective is to provide sufficient water to meet rural customer demands of 100% of rural allocation at 95% supply reliability. This means that 100% of rural allocation would be in place 95 years out of every 100 years and reduced allocations should not occur more often than the remaining 5 years.

Coliban Water will engage with its rural customers in the near future to gauge their support or otherwise for the proposed rural allocation framework outlined in the UWS.

Rural – Minimum Allocation
Coliban Water's objective is that in those years where restrictions are necessary we would try to maintain allocations to no worse than 70-75% of rural entitlement, however in the event of acute or severe water shortages, lower allocations may be necessary.

For rural allocations the intent is to reduce demand by constraining the volume available to rural customers. The allocation framework does not restriction the use of this rural supply.

Rural allocations are not directly aligned with urban restriction levels. Table 28 shows the indicative relationship between urban restrictions and rural allocations.

Table: 28: Water allocation framework for urban and rural customers.

Restriction Level[1]	Indicative Rural Allocation[3]
Permanent Water Saving Rules (PWSR)	100%
Stage 1 (Alert)	70-99%
Stage 2 (Save)	50-69%
Stage 3 (Just Enough)	30-49%
Stage 4 (Critical)	30%[2]

Note 1: The urban restriction levels are uniform across Victoria (VicWater, 2011).
Note 2: Priority rural customers only.
Note 3: Urban restriction levels and rural allocations are not directly linked (see Rural Policy No. 2 - Supply Parity between Urban and Rural Customers).

Rural - Allocation Framework
When raw water reserves are equal to or exceed 24 months of PWSR demand (aggregated demand) then rural allocations will be 100%. In any water year where there is a risk that the reserve rule (Drought Policy No. 1 – Raw Water Reserves) may be not be maintained over the next 12 months then opening allocations will generally be less than 100% of entitlement.

In applying the 'reserve rule' the assumption is made that there will be 100% uptake of the allocation. This is a deliberately conservative estimate of demand. In an average year with 100%

allocation only 50-55% of the entitlement volume is used. In a dry year this can increase to 70-75%, whereas in a wet year it may be as low as 20-25%.

The main inflow period into our storages is typically July to September when we receive over 60% of our average annual inflow. Hence opening allocations can be increased progressively over time until a final determination is made. Further allocation increases are dependent on additional inflows and reflect the total raw water reserves. Allocations are made in increments of 5%.

Any allocation forecasts will be based on climate outlook, potential for further inflows and anticipated raw water reserves. These are the same criteria as used for the 'volumetric trigger' determinations (see Volumetric Trigger Criteria used for Coliban Headowrks Storages). Where there is a degree of uncertainty the allocation forecast utilises a dry, medium and wet climate outlook.

Rural Policy 1 – Annual Allocation Determinations

Rural allocations shall be based on actual reserves at the time of determination e.g. 1 July and 1 October, and allow for at least 24 months of demand at the determination level.

Allocation determinations will be based on increments of 5% e.g. 45%, 50%, and so on up to 100%.

Generally a final allocation determination will be made by the end of February, however this depends on the pattern of inflows into storage and allocation determinations by GMW (Coliban Northern only).

Note 1: Assume that reserves are not likely to fall below 24 months of reserves during the current water year. If so then the final allocation will be less than 100% and be at a percentage that could be sustained for 24 months without further inflows or allocations from GMW i.e. a conservative allocation.

Note 2: Allocation determinations will assume 100% uptake of the allocation within the water year. It is acknowledged that historically actual demands are less than this and can vary significantly between wet and dry years, and be influenced by the volume of trade within Coliban Channel Zone 4B.

Note 3: Any allocation forecasts will be made on the basis of estimates of likely inflows and final storage volumes, as well as the long-range climate forecast as provided by BoM.

Relationship between Urban Restrictions and Rural Allocations

In general whenever urban customers are unrestricted (i.e. PWSR is in place) then rural customers will have access to 100% of their entitlement volume (see Rural Allocation Framework above). The period for which this determination is made is the 'water year' which is equivalent to the concept of financial year - July to June.

While Coliban Water reserves the right to impose restrictions on urban customers at any time there is a supply shortfall, the same principle does not readily apply to rural customers. Whenever there is less than 24 months of reserves (Drought Policy No. 1 – Raw Water Reserves) allocation determinations are made on the basis of 'available reserves', not potential future reserves.

Rural Policy 2 – Supply Parity between Urban and Rural Customers

Urban Restrictions

Coliban Water will make an annual determination on the possibility of urban restrictions being imposed as part of its Annual Water Outlook and Annual Operating Plan. The level of restriction will be reviewed monthly and be based on the available water reserves, anticipated future allocations from GMW and GWMWater, and long-range climate forecasts.

The determination will take into account the likelihood of raw water reserves falling below the reserve rules - 24 months of supply on-hand for Coliban Systems Northern and Southern, and 12 months for all other systems. In the event that reserves fall below this then consideration will be given to the need or otherwise to impose restrictions (see Level of Service Policy). The net result is that, in any given year, restriction levels will commence as high as practicable and be reduced should the supply position become constrained.

Rural Allocations

As above, annual determinations will be made for rural allocations at the same time as urban restriction levels. In the case of rural allocations, determination will always be made on the basis of the available water on-hand with the objective of not falling below the reserve rules during the course of the year. The rationale is that inflows into our storages and allocations from GMW and GWMWater typically increase as the year progresses allowing further allocations.

Hence when there is a potential supply constraint allocation determinations will be made on the assumption that no further inflow is likely and or allocation increases from an external bulk supplier will not be available.

Once made, an allocation determination may remain fixed, or increase during the course of the year, but not reduce except in extreme circumstances.

Parity

Under a declining resource position where urban restrictions need to be imposed or have been, and rural allocations are less than 100% both customer groups will reach a point of 'parity' where both parties are restricted. At this point a final determination will be made for the year unless the resource position improves. The final determination is proposed to be made no later than 1 March and will also provide an indication of next season's opening rural allocations.

Maintaining Service – Key Strategies

Coliban Water faces a number of challenges over the next 50 years. In particular a sustained growth in demand and a diminishing raw water resource. Household demand into the future is likely to increase with rising temperatures and diminished rainfall. The options under consideration generally fall into one of four broad strategies.

The strategies are intended to utilise our assets as flexibly as possible without disrupting services to our customers; use demand management measures to provide for increased growth in demand; and secure alternative water resources to provide greater resilience to our overall ability to meet service level expectations. The strategies are not presented in any priority order.

- Operational flexibility
- Demand management
- Alternative sources of water
- Supply augmentation

Operational Flexibility

The objective of this strategy is to optimise the use of existing assets (tangible and intangible) to achieve the best water security, social, and economic outcome. The examples below provide an indication of the options that can be considered.

- Coliban Systems Northern and Southern – refine the 'operational modes'. The three operational modes govern the transfer of raw water between our Coliban Headowrks Storages and Bendigo, and are linked to the 'volumetric trigger'.
- Utilise the 'volumetric trigger' to achieve water security and economic efficiency objectives.
- Carryover and Allocation Trade – when conditions permit maximise allocation trade.
- Multiple water sources – Where multiple raw water sources are available utilise them in combination to preserve the highest value resource and minimise losses.
- Use the water market opportunistically to minimise cost of purchases of allocation or entitlements, and optimise allocation sale prices.
- Utilise any 'credit' gained by returning treated wastewater back into a waterway to reduce deductions from our water entitlements.
- Connecting Emu Valley and Spring Gully Channels to the Lake Eppalock pipeline reduces demand on Coliban Southern when the system is no longer supplying Bendigo. This allows greater flexibility in supply as the rural network can be supplied from whichever source has the greatest reserves.

There is some additional operational flexibility available that does not directly address any supply-demand imbalance. These include water trading between our rural customers and improved environmental flows downstream of Malmsbury Reservoir.

Water trade within the Coliban Channel Zone 4B trading zone
Some operational flexibility is available to our rural customers via entitlement and allocation trade within the 'Coliban Channel Zone 4B' trading zone. Over the term of this UWS Coliban Water will investigate options to facilitate increased trade within our two rural networks. This may include the appointment of an independent water broker and or a dedicated trading platform.

Trade can provide an opportunity for rural customers to make up any shortfall when allocations are less than 100%.

Enhanced environmental flows downstream of Malmsbury Reservoir
As 'storage manager' for the Coliban Headworks Storages we have some capacity to control releases from Malmsbury Reservoir into the Coliban River. The majority of the releases however are into the Coliban Main Channel to supply Castlemaine and Harcourt rural customers. Whenever the storages hold reserves above the volumetric trigger water is also released for Bendigo. Any natural soils end up in Lake Eppalock where Coliban Water has an 18% share of any inflow and or volume.

Our Bulk Entitlement makes provision for 'passing flows' downstream of Malmsbury Reservoir. The passing flows are a minimum of 8 ML/day or the natural inflow whichever is the lesser. For much of the year flows can be below 8 ML/day or even zero. During dry periods none of the tributaries flowing into our Coliban Headworks Storages may have any flow for extended periods.

During periods of high flow Malmsbury Reservoir can spill and release substantial volumes downstream. This occurred during 2010-11 and 2016-17. Once the storages are spilling Coliban Water has limited capacity to moderate flows.

To minimise any negative ecological impacts along the Coliban River downstream of Malmsbury Reservoir, Coliban Water has had discussions with the North Central Catchment Management Authority (NCCMA) and the Victorian Environmental Water Holder (VEWH) about an option to improve flows. This has also been discussed with the Dja Dja Wurrung. All parties have agreed to continue discussions on this option.

Put simply the option involves releasing water for Bendigo via the Coliban River and not the Coliban Main Channel. The NCCMA and VEWH would then ‘compensate’ Coliban Water for the 82% of the released volume ‘lost’ and cover the cost of pumping from Lake Eppalock to Bendigo. To fund the cost of pumping the VEWH could sell part of its allocation in any given year. Hence Coliban Water customers are not negatively impacted through additional electricity costs.

The VEWH would need to transfer part of its allocation in Lake Eppalock to Coliban Water to compensate for the water lost in the transfer and the fact that only 18% of the inflow would be available.

This option would not always be available and would need to be managed such that it did not compromise water security for Coliban Southern or Coliban Northern.

Demand Management

PWSR already provides a significant benefit in relation to reducing overall demand, however there has been a trend in recent years towards higher consumption on a per connection basis. Calculations carried out for the UWS have indicated a degree of demand hardening since the preparation of the previous Water Supply-Demand Strategy. The implications of this are that over the long-term there will be less savings achieved from imposing restrictions. Also the community and the Board are not in favour of harsh restrictions where they can be avoided.

Demand management measures are already listed within each system’s drought preparedness plan to address chronic and acute decline in supply.

- Expand the use of pressure zone meters to lower pressure during off-peak periods in order to reduce leaks.
- Develop a more rapid leak detection and repair capability.
- Vary the Coliban Headworks Storages operating levels to minimise evaporative losses.
- Operate the rural channel network in a manner aimed to improve overall system efficiency.
- Continue with community education programs.
- Continue with incentive schemes to improve domestic appliance efficiency, commercial and industrial water use, and capturing rainwater.
- Continue with rural modernisation to improve system efficiency and reduce overall demand.

Alternative Sources of Raw Water

Optimise the use of alternative sources, wherever feasible, in fit-for-purpose applications to minimise diversions from the environment. To a limited extent, this strategy allows for additional growth in demand without increasing our entitlements.

Where rainwater tanks are used they can also have the benefit of reducing peak demand requirements from water treatment plants. Alternative sources such as groundwater can provide a resource that is less affected by short-term climate trends. Potential projects include:

- Treated Bendigo mine water for use in fit-for-purpose applications such as irrigation of public open space.
- Groundwater for Kyneton, Rochester, and the Loddon System as a backup or permanent supply source.

- Access to GMW Goulburn System water for our Wimmera System via the South West Loddon Pipeline project (current under development by GWMWater).
- Greater use of recycled water in fit-for-purpose applications where feasible.

Alternative sources could include consideration of managed aquifer recharge opportunities to 'store' raw water for later use during a dry period.

UWS Policy 4 – Diversification of Supply Sources
Wherever feasible and cost effective, Coliban Water will seek to develop the capacity to access multiple sources of raw water in order to meet its Level of Service Obligation. For example the Coliban System Northern is able to access three sources of raw water as well as enter the water market to purchase additional allocation. Systems supplied by GMW can usually trade water within the southern interconnected Murray Darling Basin (links to UWS Policy 3 – Use of the Water Market).

Supply Augmentation

Supply augmentation relates to provision of additional supply. This can be achieved by acquiring additional entitlements and or allocation from the water market. The strategy also includes connecting an existing system to another supply source e.g. connecting Loddon System towns to Bendigo.

The more common use of the water market over the medium term would be to make up any shortfall supply during a period of drought.

UWS Policy 3 – Use of the Water Market	
Coliban Water may enter the water market to acquire additional allocation and or entitlements to maintain raw water reserves at levels sufficient to meet demand at Stage 1 or higher restriction levels.	
Note 1:	*The policy only applies to Coliban Water systems that are part of the southern connected Murray Darling Basin. The Coliban Water systems affected are Campaspe, Coliban Northern, Goulburn, Loddon, and Murray.*
Note 2:	*It is not envisaged that this policy would apply to the Elmore System for groundwater trading.*
Note 3:	*Purchase of additional allocation would only be considered for vulnerable systems during a prolonged acute drought or in the event of a severe shortage. The purchase of allocation would be considered in preference to entitlement (i.e. water shares).*
Note 4:	*Allocation trade can include transfers from other Coliban Water allocation accounts.*

Liveability

As part of our estimates of future demand, as outlined in Part B – Supply and Demand Projections, we have considered the potential to exclude the irrigation of public open space from restrictions (see UWS Policy 2 below). The intent is to retain the amenity value that such spaces provide during periods of water shortages.

Coliban Water will engage with local government and community interest groups to identify priority areas for exemption. The engagement may involve direct discussions and or an Expression of Interest process to select the priority sites. The proposed Integrated Water Management Forums present an additional opportunity to identify priority sites.

These community amenity sites could also be considered suitable for use of fit-for-purpose water supplies that are less subject to climate impacts.

UWS Policy 2 – Alternative Water Product(s)
Public Amenity and Liveability During periods of water shortages, when restrictions are imposed, a priority supply will be provided to designated public facilities. The designated facilities will be exempt from restrictions in all but the most severe shortages. The water supply could include potable, recycled or raw water, or any combination of these where the infrastructure was capable of delivering a mixed supply and / or the risks to public health were minimal.

Chronic Trend in Supply-Demand Balance

Characteristics of Long-Term Change

Long-term (15 - 50 years) climate change and increased demand, have the potential to increase the risk of an imbalance between demand and supply. Actions are needed to maintain the water security objective of 95% reliability. As the section title suggests the change is chronic in nature and can be quite minor on a year-to-year basis.

A changing climate may result in lower volumes of inflows into storages over time, or more erratic rainfall and inflows. Drier conditions coupled with warmer weather would exacerbate any demand supply imbalance. The scenarios lead to greater uncertainty in relation to estimating supply volumes. A changing climate may also result in lower allocations of water provided by GMW and GWM Water.

Several factors can impact on increased demand.

- Population growth and other demographic factors are likely to increase demand for water over time. The current estimate residential population of 156,256 is forecast to grow at a rate of approximately 1.6% per annum. The residential population at year 2040 is estimated to reach 229,923 and by 2065 it is estimated to more than double to 338,911.
- Economic growth will also increase demand due to the additional water needed to provide for industrial and commercial activity.

Population growth estimates have been based on reference to growth in connection numbers, the *Victoria in Future* (2016), census data and Local Government sources.

Strategies to Manage Chronic Changes

Given the nature of long-term chronic change in terms of increased demand, coupled with lower average inflows and allocations, any strategy needs to be capable of implementation over the long-term. Given that supply augmentation is likely to become increasing costly a prudent strategy would be to minimise demand.

Operational Strategies

- Increased internal monitoring and review of water resources and demand, both urban and rural.

Examples of Demand Management Strategies

- Minimise operational losses through leak detection and repair.
- Community awareness and education campaigns.
- Rural modernisation including rationalisation, and improving channel efficiency.

- Self-reliant households and communities.
- Implement evaporation reduction measures on storages including minor service basins.

Examples of Supply Management Strategies

- Vary the volumetric trigger for the Coliban Headworks Storages to reduce the 'spills' from storage and secure water for the Coliban System Southern.
- Transfer allocation between systems that are connected to the Victorian water market.
- Enter the water market to purchase additional allocation.
- Integrated Water Cycle Management Strategies that utilise alternative supplies in fit-for-purpose applications and the increased uptake of recycled water.
- Diversify sources of supply wherever feasible. Preferably including less rainfall dependent raw water sources such as groundwater.

Action Plan for Long-Term Change

The demand management strategies individually will only deliver an incremental benefit over time and hence their adoption needs to be widespread and sustained. Some, such as behavioural change, have a long-lead time and their implementation will be on-going.

Strategies that are capital intensive will form part of the 'business as usual' process for inclusion in the five year planning framework of the pricing submission and the 50 year planning in the Urban Water Strategy.

While these chronic changes occur slowly and are incremental on a year to year basis, they have the potential to result in an imbalance of water supply and demand over the long term if ignored. To adequately manage chronic change the overall strategy needs to include some or all of the following elements.

- Cope with variability of climate (rainfall and runoff) and supply (runoff and allocations).
- Increase access to fit-for-purpose supplies to off-set potable water which includes diversification of sources and volume.
- Provide standpipes for rural customers with sufficient capacity to meet domestic (when household rainwater tanks are empty), and livestock needs (intensive animal industries).
- Avoid short-term responses to long-term trends i.e. climate change and population growth and supply reduction caused by drought.
- Self-reliant households across region with priority given to remote and small communities, or those with no access to alternative supplies.
- Increase the rate of leak detection and rectification.
- Scale up rural channel modernisation and rationalisation including closing the least efficient channels.

Coliban Water will continue to refine the potential options over the next few years on a system by system basis. The intent is to prioritise the suite of options and document key project stages, preliminary costs and prepare concept designs.

Option Identification and Evaluation

Water security and other water services are critical to our economy, jobs and livability. It is Coliban Water's legal and moral responsibility that we ensure the short and long term water security of our region through forward planning and timely investments. Community and other stakeholder engagement will be a major part of the planning process particularly when major investment decisions are made.

> *Water is fundamental to our communities. We will manage water to support a healthy environment, a prosperous economy and thriving communities, now and into the future.*
> *Water For Victoria (2016)*

It is crucial that the most appropriate and cost effective investments are made at the right time. When proposing initiatives the following are considered:

- The analysis and initiatives are system based but consider 'whole of business' implications
- Use the multi-criteria analysis outcome to rank (and priorities) the possible options
- The proposed initiative(s) should at least satisfy any short term demand shortfall
- High cost investments should satisfy long term shortfalls
- The proposed initiative should be value for money and at the lowest possible unit cost per ML of water gained, and
- Commence the investment process at the appropriate time so that the benefits are realised at the right time when the short fall is experienced.

Water businesses are faced with major challenges in the form of climate change and population growth, to maintain water security and the level of service that is acceptable to the community. The Urban Water Strategy presents a suite of options to manage the challenges and address water shortages both chronic and acute. The options fall under the four key strategies:

- **Operational Flexibility**: to maintain adequate year-on-year raw water reserves, use external sources of water where ever possible and explore operational efficiencies such as re-use of backwash water
- **Demand Management**: continue with customer education, continue to improve system efficiencies, reduce evaporation from storages and service basins, expand the use of fit-for-purpose supplies, and impose restrictions, and
- **Alternative Water Sources**: optimise the use of alternative raw water sources in fit-for-purpose applications, and
- **Supply Augmentation**: Increase system capacity through upgrades, pipeline interconnections and use of the water market.

The investment sequence has four broad categories and will be investigated further over the coming years:

- **On-Going**: Options that are on-going in nature. Typically these require only limited capital investment and can include operational options.
- **Initial (Years 1 – 3)**: Low cost ('no regrets') options are implemented. Options that require investigations are initiated e.g. business case development for new pipelines.

- **Consolidation (Years 4 – 10)**: Implementation of capital cost options which will include 'no regrets' options and options listed in the next Pricing Submission.
- **Extreme Events**: These options are implemented on a case by case basis as the supply situation deteriorates.

The process of evaluating and shortlisting of options is shown in this flow chart:

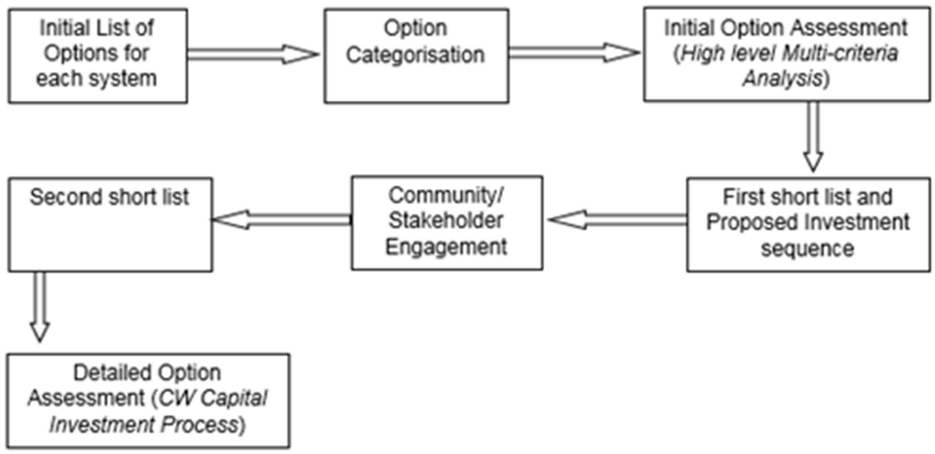

Figure 21: Flow chart for evaluating and shortlisting options

Criteria for Option Selection and Evaluation

The initial list of options were assessed against the following four main criteria and the relevant sub criteria using Coliban Water's Multi-Criteria Analysis (MCA) tool.

Table 29: Criteria used in the multi-criteria analysis.

Criteria Sub-Criteria	**Comments**
Economic	
Unit Cost ($/ML)	The capital cost for each ML of water gained or saved.
Capital Cost	The estimated cost of construction.
Operational Cost	Annual operating cost over the project's life.
Flexibility of Expenditure	How easily the costs be spread out over a number of years.
Environmental	
Heritage Impact	Includes Aboriginal and European.
Flora and Fauna	The impacts to flora and fauna under Victorian and Commonwealth legislation.
Greenhouse Gas Emissions	Extent to which greenhouse gases will increase, remain neutral or decrease.
Impact on Water Quality	Includes source and receiving water(s).
Construction Footprint	Area impacted during construction and post completion.
Waste	Quantity generated during construction and or implementation.
Social	
Water Security	Potential reduction of restriction frequency; reliability of supply; benefits to system security; Ability to cover supply shortfalls during drought.
Customer Impact	Acceptance by customers; direct cost to customer; any land acquisition required; level of engagement needed; number of customers impacted.
Reputational Risk	Potential negative community perceptions.

Community Amenity	Impact on liveability and economic prosperity; ability for the population to continue to grow; level of economic activity; any health & safety impacts from implementation.
Technical	
Benefit	Volume of water saved or gained; avoided waste; potential improvements in water quality.
Constructability	Expected asset life; reliability of technology; time required to implement; experience of the construction techniques; approvals required.
Operability	Level of experience with the technology.
Secondary Benefits	Other potential benefits and/or dis-benefits; Enhanced opportunities to trade water.

The initial assessment provides a high level indication how the options stack against each other and be able to priorities the options based on the MCA outcome. The choice of options however, will also depend on a qualitative (common sense) assessment that the preferred option will address the need (ex: water shortfall, water quality) at the point in time with minimum cost.

The shortlisted options will be subjected to community and stakeholder consultation and feedback process. For details about the community and stakeholder engagement, refer to Engagement Plan (Appendix E).

Options

A range of potential options are proposed to be actioned either as 'Capital Projects' or 'Business as Usual', for each system. A description of system specific initiatives can be found in Appendix C under each individual system.

Table 30: Capital projects.

Initiative	Volume Gained per Year	Est. Capital Cost
Campaspe System		
Raw water supply system - reduce evaporation	3 ML	$100,000
Additional storage capacity	0 ML	$750,000
Groundwater	70 ML	$1 m
Pipeline connection to Bendigo	70 ML	$4.8 m
Coliban Northern		
Upgrading Superpipe	29.2 GL	$100 m
Coliban Southern		
Additional storage capacity - Increase storage capacity	30 - 40 GL	$20 m
Selected rural channels connected to external supply via pipeline	1 GL	$3 m
Raw water supply system – reduce evaporation from storages (Investigation)	-	$1 m
Pipeline connection between Lauriston Reservoir and Coliban Main Channel	500 ML	$4.3 m
Groundwater (for Kyneton) (Investigate and Implement)	1 GL	$4 m
Pipeline from Lauriston Reservoir to Kyneton Treatment Plant	1 GL	$2.2 m
Connect Castlemaine to Bendigo	10 GL	$27 m
Elmore System		
Additional storage capacity	-	$750,000
Goulburn System		
Backwash water internal reuse	200 ML	$1.1 m
Erosion control measures on the Lockington basin	-	$130,000
Make Campaspe raw water infrastructure operational	134 ML	$200,000
Erosion control measures on the Pyramid Hill raw water channel	-	$200,000
Raw water supply system – reduce evaporation from storage basins	94 ML	$1.6 m
Groundwater – deep lead	500 ML	$1.1 m
Emergency raw water basin for Rochester	-	$1.3 m
Desalination for Boort	85 ML	$3.2 m
Murray River connection to Rochester and Lockington	336 ML	$18.5 m
Loddon System		
Raw water supply system - Reduce evaporation	18 ML	$315,000
Groundwater - deep lead (including desalination plant)	400 ML	$7 m
New raw water storage - Laanecoorie	-	$1.1 m
Pipeline from Maldon to Laanecoorie	170 ML	$7.5 m
Treated water pipeline from Bendigo to Laanecoorie and Bridgewater	400 ML	$30 m
Local sewer mining	270 ML	$4 m

Extend East Loddon pipeline to Bridgewater	190 ML	$8.4 m
Murray System		
Groundwater (Echuca & Cohuna)	1.25 GL	$2 m
Trentham System		
Groundwater: operation of the second bore	200 ML	$1 m
Capping of springs (Investigation)	unknown	$100,000
Connect to Tylden	60 ML	$4.8 m
Wimmera System		
Connect Korong Vale to Waranga Western Channel (under construction by GWM Water)	-	unknown

'Business as Usual' (Generic Initiatives)

These initiatives, are as the title suggests, part of the routine operations of Coliban Water. However the interactions with other discretionary options means there could be scope for further synergies and or refinement about how they are implemented on a year-by-basis. The latter will be part of further investigations over the next five years.

Operational Flexibility (On-Going Initiative)

- Reserve Rules: The current minimum reserve rule for Coliban Systems supplied from external sources is to maintain 12 months of supply at Permanent Water Saving Rules (PWSR) adjusted demand.
- Conservative Demand Forecasts: Conservative estimates of demand (i.e. high) that include an allowance for increased demand during dry weather - PWSR adjusted demand plus 20% increase for urban demand and 50% for rural demand.
- Conservative Supply Forecasts: Conservative estimates of supply (i.e. low) such that there is a high likelihood of a surplus at 30 June.
- Restricted Demand Forecasts: Ongoing reassessment of expected water usage during periods of restriction to allow for accurate demand during periods of high stress.

Demand Management (On-Going Initiative)

- Customer Behaviour Change: Ongoing communication with the public about the need to conserve water as well as where the water is coming from for each system and the constraints involved. Campaign to be ramped up during times of drought which may include public seminars or media releases during times of low supply to ensure that all customers are aware of the situation and what customers can do to help ease demand. Implementation is on-going. The option is appropriate for chronic water shortage or reduction in per capita demand.
- "*Target*" Water Saving Campaign: Initiate a campaign, challenging customers to reduce daily, per capita consumption below a set target volume. This is similar to the Victorian Government's 'Target 155' initiate for Melbourne. The target volume could be different to each system or zone. Such a program could at least prompt customers to monitor their daily consumption.
- Water Treatment Plant Efficiency Study: Undertake a systematic review of water treatment plant efficiencies and identify priorities for water use efficiency improvements. Prioritise plants for upgrades as required.
- Reticulation Network Pressure Management: Avoiding high pressure zones assists in directly reducing leakage and indirectly by lowering demand for discretionary demand. It also has the capacity to reduce repair costs and extend the life of the pipeline assets.

Pressure management would be linked to leak detection and repair as part of an overall efficiency improvement program.

- Reticulation Network (minimise operational losses through leak detection & repair): Expand an ongoing proactive leak detection / monitoring program which constantly monitors the system's performance and condition of pipes to predict which pipes are leaking or may leak shortly. Pipes that are found to be leaking or close to breaking point can be repaired and/or replaced before large water losses occur. Coliban Water is currently investigating multiple methods for leak detection and will implement a leak detection program. Also included in this option could be the quickening of response times once a leak is reported. Rate of implementation could be accelerated as any water shortage worsens. Implementation is on-going as part of routine operations and maintenance. The option would benefit from a system wide monitoring program that incorporates a capacity to identify the locality of the leak.

- Water Savings Incentives and Community Education: A number of water saving incentives and education programs are in place to achieve permanent behavioural change in community water consumption. Incentives and schemes have included the fitting of efficient water fixtures such as low-flow shower roses and taps in new dwellings and the 'water-efficiency' labelling of water using appliances such as washing machines. Other schemes have provided rebates for households and organisations involved in 'water smart' programs such as the retro fitting of existing dwellings and the maintenance of efficient garden irrigation systems. These programs and other options such as grey-water re-use, installation of rain water tanks, continued improvement in the efficiency of appliances and fixtures are expected to continue to change the behaviour and volumes of community water consumption. The option could be managed as an on-going 'business as usual' program, or a discrete capital/operational project. Evaluation would require monitoring the decline in water use per customer connection. Implementation requires the determination of the 'value' of the water savings.

- Pricing Incentives: Increases in the customer's water charges can have an influence on reducing consumption. Pricing increases could be linked to scarcity or time of use. The potential benefit is deferral of major capital upgrades to water treatment plants to meet peak demand. The option could be managed as an on-going 'business as usual' program. Any such scheme would require ESC approval and a 'safety net' measure to protect vulnerable customers. Our customer base would need to be supportive which may require a long-lead time.

- Efficiency Improvement of Usage on Public Spaces: Review the water usage on public spaces to identify possible water savings through efficiency improvement programs such as sprinklers and timers.

- Efficiency Improvement on Industrial Usage: Initiate communication with industries to explore possible site specific water saving measures and potential use of alternative sources such as rain/stormwater. Coliban Water has been engaged in such communication with a number of major customers. It may be appropriate to extend such engagement to other medium sized customers.

- Water Efficiency Measures for New Developments: In collaboration with the Loddon Shire Council, implement water saving measures such as community stormwater collection for new developments. This may be implemented through the planning approval process.

- Water Treatment Plant Capacity (Investigation): Water treatment plants are able to meet required customer water quality standards, even when the source water is of poorer quality than normal e.g. the Millennium Drought when levels in storage were low. The February 2016 revision of the Australian Drinking Water Guidelines 2011 has set more stringent health based target for urban water supply. Some WTPs may require upgrades to achieve the required water quality standards set out by the guidelines.

- Alternative and Fit-for-Purpose Supplies: Implement generic options (e.g. rain water tank, grey water systems) to overcome chronic reduction in supply and increased demand from population growth. These could include expansion of recycled water schemes where this option reduces demand for potable or raw water. Alternative fit-for-purpose water supplies can be either viewed as a demand or supply management measure. In this context the assumption here is that if the alternative supply can substitute for existing potable water demand or satisfy 'unmet' demand then the option is viewed as a supply management measure. The indicative options address the chronic water shortage and enhance the capacity of system to cope with acute shortages.
- Impose Restrictions: Imposing restrictions can reduce demand and alert customers to current water supply levels. Four stages of restrictions are available with each restriction level applying harsher conditions to allowable water usage.
- Qualification of Rights: Apply to the Minister for Water for a change in entitlement and/or allocation rules to secure access to additional water resources. A lead time of at least 12 months is required. This option requires a risk assessment, analysis of impacts and consultation with affected stakeholders before it can be considered by the Minister. This is an option of last resort and should not be relied on to secure supply.

Alternative Water Sources (On-Going Initiative)

- Currently only selected rural channels (raw and recycled water) and residential dwellings (recycled water) have access to alternative water supplies. Part of future investigations will look into opportunities for expansion.

Supply Augmentation (On-Going Initiative)

- Supply via Road or Rail Tanker: Some of the small towns can be serviced by road and/or rail tankers.
- Water Market: Purchase entitlement and or allocation from the market.

All 'business as usual' initiatives will continue to be reviewed and refined. The scale at which they are implemented in any given system is yet to be investigated (see 'Proposed Next Steps').

Proposed 'Next Steps'

The current Urban Water Strategy 2017 will be further refined over the next five years. Some additional work will be required earlier as part of the pricing submission to the Essential Services Commission which is due later in 2017. The proposed next steps fall into several broad categories.

Investment Sequence

The 'business as usual' and capital options listed earlier are indicative of the options mix that can secure all or a large part of any supply shortfall. However the next step in UWS is to analyse the interactions between the options and their timing i.e. the investment sequence.

The analysis may also identify additional options or strategies that may complement the current suite of options. The analysis will include drought scenarios and the challenges of longer droughts, different growth projections, and the impact of high demand during periods of dry hot weather.

Research and Investigations

The investigations relate to additional studies and or analysis of more complex or high cost capital options that may be required in the short to medium term e.g. the next 5 – 10 years. These investigations are part of the typically process of proving up an option and preparing a business case for future investment.

The other main area for investigation is groundwater. Groundwater can serve as an alternative source of water to communities with constrained supplies, or as a 'back up' supply during water shortages. There may also be scope to develop managed aquifer recharge schemes for selected communities. However these possibilities cannot be progressed without the evidence that field investigations can generate.

The research relates to the need to minimise evaporative losses which are currently the equivalent to about 70% of Bendigo's annual urban demand. This is a significant volume to lose each year in light of the drier future that climate change will bring.

Engagement

Coliban Water has developed an Engagement Plan (Appendix E) that will progressively be rolled out over the five year life of the UWS. The four main aspects of the engagement relate to the following.

- Customer engagement including rural customers to discuss topics such as level of service, use of fit-for-purpose water, and the policies outlined in the UWS.
- Discussions with Local Government Authorities over the amenity value of public open space and the priorities each community may have to maintain these spaces during acute or severe water shortages. The discussions will also include local and regional economic growth plans.
- Local aboriginal organisations to provide a forum for dialogue over the indigenous cultural value of water. This will require on-going dialogue with the Dja Dja Wurrung, and initiating dialogue with the Yorta Yorta and Taungurong.
- Regional integrated water forums that will bring together multiple agencies to discuss aspects of common interest and opportunity in relation to water management.

Coliban Water is committed to an on-going process of review of our Urban Water Strategy 2017 and creating a 'living' document that is revised on an on-going basis.

PART D - DROUGHT

Drought Preparedness Strategy

Context For Drought Preparedness Planning

The Bureau of Meteorology (BoM, 2013) defines drought as a "prolonged absence or marked deficiency of precipitation (rain)". In practice the planning for 'drought' needs to take place on a continuous basis given the often long lead times associated with implementation of options to ensure continuity of supply. The actual decisions and actions taken, at any point in time, should reflect the extent or potential extent of the shortfall between the available supply and forecast demand.

Therefore the objective of the planning is to minimise or eliminate the risk of a water shortage in preference to managing a shortage after it occurs, i.e. a proactive approach versus a reactive approach. To better reflect this objective the concept of 'drought risk management' is preferred to 'drought response'. The DELWP 'drought preparedness' embodies the drought risk approach.

Coliban Water also has a requirement under Section 6-4 of its *Statement of Obligations* (Minister for Water, 2015) to: *"… develop a Drought Response Plan that governs the management of the supply of water by the Corporation in any period of drought or when the supply of water is limited."*

Locally, in the context of drought planning, a "limited" water supply could be any volume that is unlikely to provide sufficient water to meet Coliban Water's unrestricted demand forecast over at least the next 12-24 months. For planning purposes the unrestricted demand is that volume of raw water needed to satisfy consumptive demand and operational losses under Permanent Water Saving Rules adjusted demand (PWSR adjusted demand).

In meeting customer service obligations, water corporations **must not** rely on the qualification of rights by the Minister under Section 33AAA of the *Water Act 1989* in order to maintain supplies. This option is still available however, but only as a measure of last resort.

Direction is provided in Section 11 of the *Guidelines for the Development of Urban Water Strategies and the Melbourne Water System Strategy* (DELWP, 2016a). Coliban Water's *Drought Preparedness Plans* are intended to be a dynamic documents and reviewed at least every 5 years, or within 12 months of the lifting of restrictions.

Coliban Water also has in place a *Water Restriction By-law 12* (Minister for Water, 29 March 2012) which is publicly available on its website.

At a regional level, the *Loddon Mallee Region Integrated Regional Vulnerability Assessment and Climate Adaption Plan* (AECOM, 2014) highlights that:

- Future rainfall and runoff is likely to be lower in the future
- Water resources, water infrastructure and rural activities are at major risk due to climate change
- Identification of [mitigation] options needs to be undertaken, and
- Ranks water resources as a high risk for the City of Greater Bendigo.

Coliban Water will work towards minimising that risk to water security through this Urban Water Strategy, drought planning, and its internal planning and review processes.

Potential System Vulnerabilities

The reliability of supply varies in accordance with the primary source of supply. The strategies and options identified later in this Plan and in Appendix C, primarily target these vulnerabilities. It should be noted that Table 31 mainly focusses on supply risks and quality. Coliban Water's internal risk management framework also deals with these risks. The capability of each water treatment plant is also designed to manage water quality risks.

Table 31: Potential system vulnerabilities during severe events.

System	Vulnerability
Campaspe	Poor water quality, low flow, and low allocations for HRWS. Bulk Entitlement has 50% minimum allocation.
Coliban Northern	Poor water quality, high cost of pumping from Lake Eppalock or Waranga Western Channel, seasonal shutdown of channel, high demand within the system during hot dry weather.
Coliban Southern	Only a single source of supply with a large urban and rural demand. Demand too large to cart in water via road or rail.
Elmore	Always a risk of restrictions, but very reliable groundwater supply.
Goulburn	Potential low allocations but Bulk Entitlement provides 99% reliability, reduced operation of Waranga Western Channel during drought, only periodic flows to top up storages during winter (non-irrigation season), deterioration of water quality held in service basins.
Loddon	Poor water quality, low allocation but Bulk Entitlement has 50% as a minimum, high salinity when flows are low.
Murray	Low allocations, Bulk Entitlement has same reliability as HRWS.
Trentham	Low yield from springs or groundwater, but overall a very reliable system.
Wimmera	Low allocations, unpredictable inflows into Grampians Wimmera Mallee Water storages.

Coliban Headworks Storages – Evaporation Losses

The major headworks storages incur significant losses through evaporation. These losses are taken into account in the determination of the available supply to Coliban Northern and Coliban Southern. Evaporation is most severe in the warmer months and varies significantly depending on the storage level and resultant surface area. Annual evaporation loss ranges from an estimated:

- Maximum of 13,170 ML during 2010-11, when the storages were full, to a
- Minimum of 2,100 ML in 2006-07, when the storages were near empty.

Coliban Water proposed to further investigate opportunities to minimise losses. Given that many water corporations also experience significant losses this could potential be the subject of a State-wide project.

Objective of the Drought Preparedness Plans (DPP)

The objective of the DPPs is to set out the framework for responding to a supply-demand imbalance that may be:

- **Chronic:** Long-term climate change or the increasing demand from population growth and economic activity
- **Acute:** When inflows into storages are below median, e.g. the year to year variation in inflows or the multi-year reductions that occur during 'El Nino' events, or
- **Severe:** Similar to water shortages that occurred during the driest years of the Millennium Drought, or that can be exacerbated by infrastructure and water quality constraints.

The latter would generally trigger extraordinary measures to keep supply in balance with demand. Later sections of the Plan outline the approach to manage each acute and severe shortages. The potential for chronic shortages is dealt with in Part C.

The intended outcome of the framework is to ensure that Coliban Water customers, wherever possible, do not experience water restrictions higher than Stage 3, other than during severe shortages.

Integration of Drought Planning within Coliban Water

Coliban Water recognises the three phases of declining water resources - chronic, acute and severe. Each phase warrants a specific form of response that may be operational in nature or require capital expenditure. A further refinement makes the distinction between externally driven climate and weather related shortfalls that do not result in customer restrictions ('meteorological drought') and shortfalls whereby Coliban Water seeks to reduce demand ('operational drought').

Meteorological and Operational Drought

Meteorological Drought
A climatic drought reflects an external restriction on raw water supply beyond Coliban Water's control i.e. a climatic reduction in supply. However a decline in raw water availability does not automatically require the imposition of restrictions. A number of mechanisms allow for 'smoothing out' the year to year variations in supply.

These include capture of inflows into headworks and other balancing storages, the use of carryover of seasonal allocation and the water market to purchase allocation. Any year-to-year variations or shortfalls are dealt with through 'business as usual' operations i.e. there is no operational drought.

Operational Drought
In an operational drought, Coliban Water makes a deliberate decision to restrict the demand on its supply systems i.e. a man-made reduction in supply. These decisions are within the control of Coliban Water but are imposed only when necessary to ensure continuity of supply.

Typically such restrictions would only occur when other operational decisions are unlikely to maintain supply at PWSR adjusted demand, or where exceptional water quality or infrastructure constraints arise.

Operational responses are dealt with in the 'business as usual' annual planning cycle through the *Annual Water Outlook* and *Annual Operating Plan*. Coliban Water also has an internal Water Resources Committee (WRC) that meets on a monthly basis, or more frequently when necessary, to provide an oversight of supply and demand. The WRC may make recommendations on restriction levels, the volumetric trigger or any other matter in connection with supply and demand.

Any proposed capital expenditure would need to form part of a future 'Pricing Submission' (previously 'Water Plan'). Capital works that are already included in *Water Plan 3* still undergo review through an internal committee before proceeding to implementation.

Under a scenario of declining water availability (volume in storage and seasonal allocations) the normal operational water resource plans apply. However under acute or severe water shortages, then actions identified within the DPP would be triggered, including emergency water supply measures and harsher restrictions. On occasion, harsh restrictions may also be required as a short-term measure to deal with operational constraints.

The key supply level, for the Coliban Water Systems, is at least enough water to meet critical human needs (i.e. Stage 4 Restriction) for 2 years. However to meet the Level of Service obligation of no more than Stage 1 Coliban Water will enter the water market to secure additional entitlement whenever necessary.

For systems supplied by external Resource Managers (GMW and GWMWater) the critical time period is 12 months.

Drought Policy 1 – Raw Water Reserves

Coliban Southern
Under a 'dry' or 'neutral' climate scenario Coliban Water will reserve 3 years of raw water supply in the Coliban Headworks Storages (Upper Coliban, Lauriston and Malmsbury Reservoirs). Demand includes; urban and rural customers, operational losses and evaporation. Only when there is insufficient volume to meet a minimum of 24 months of PWSR adjusted demand will the next level of restriction be considered i.e. Stage 1.

The intent is to always maintain a minimum of 24 months of reserve at the estimated demand based on the next highest restriction level. The reserve for the Coliban Headworks Storages is linked to the volumetric trigger.

Note 1: The 3 years of supply provides additional lead time to finalise the design of the proposed southern interconnector that would link Castlemaine and Harcourt to Coliban Northern (Bendigo), obtain the necessary approvals, construct and commission the connection should it be deemed necessary.

Coliban Northern
Under a 'dry' climate scenario Coliban Water will endeavour to maintain a combined volume sufficient to meet a minimum of 24 months of raw water demand. Supply includes; the volume held in the Coliban Headworks Storages that is allocated to Coliban Northern, Sandhurst Reservoir and Lake Eppalock. In addition there are seasonal allocations held against water shares in the GMW Goulburn System and GMW Campaspe System.

Demand includes urban and rural customers, operational losses and evaporation. When there is insufficient volume to meet a minimum of 24 months at PWSR adjusted demand levels then the next level of restriction will be considered i.e. Stage 1.

The intent is to always maintain a minimum of 24 months of reserve at the estimated demand based on the next highest restriction level. The reserve for the Coliban Headworks Storages is linked to the volumetric trigger.

In order of preference, raw water will be drawn from Coliban Headworks Storages (Coliban River), Lake Eppalock (GMW Campaspe System), and Waranga Western Channel (GMW Goulburn System). Water quality or operational constraints may require a variation in the order of preference from time to time e.g. Waranga Western Channel is operational only during the irrigation season that runs from mid-August to mid-May.

Coliban Systems Supplied from External Sources
Maintain a minimum of 12 months at PWSR adjusted demand. If raw water supply for an individual system falls below this volume then the next stage of restrictions is imposed **if** continuing dry conditions are likely to persist.

This policy applies to all GMW or GWM Water supplied systems, except for Coliban Northern.

Drought Policy 2 – Operational Readiness for 'Drought'

Planned Development and Infrastructure Requirements
Any [critical] infrastructure requirements deemed necessary to secure supplies during acute or severe raw water shortages shall be capable of being in place prior to such conditions being experienced. The objective is to minimise the lead time needed for full implementation. The infrastructure requirements can include design work (from concept to functional and detailed design), planning and/or works approvals, and land acquisition or creation of easements.

Any such infrastructure shall be included as 'business as usual' capital expenditure and form part of the investment planning process.

Operational readiness for 'drought' can include customer and stakeholder engagement. Coliban Water is currently developing an engagement strategy for a suite of extreme events.

The Lessons Learnt from Drought

The review of the impact of the Millennium Drought on Coliban Water, drought in general, and restrictions has included:

- One-on-one interviews with Coliban Water staff who worked for the business during that period
- Customer surveys undertaken on behalf of Coliban Water by external parties for the preparation of the Water Supply-Demand Strategy (Coliban Water, 2012b), and
- State-wide consultation by a VicWater working group in relation to uniform drought restrictions (VicWater, 2011).

Internal Engagement with Coliban Water Staff
Common themes emerged from the feedback provided by staff.

- Droughts are expensive in terms of capital and operational expenditure, and lost revenue to the business.
- Diversification of water sources was important from a system resilience perspective.
- There was a need for better engagement with the community over the status of water supplies and the actions Coliban Water was taking to maintain supply.
- Coliban Water must be better prepared for [the next] drought.
- Appropriate policy settings are necessary.
- Raw water quality can deteriorate significantly during drought, hence water treatment plants should be upgraded where necessary, to cope with the expected variation in quality.
- Water related data requirements increase during water shortages, especially for information related to the status of water resources and inflows.

Internal engagement will continue as the system specific plans are developed over the next two years.

Customer Surveys and Enquiries, and Offences
Surveys were conducted during 2011, a couple of years after the Millennium Drought had ended. The results provide an insight into customer attitudes and preferences.

- Stage 1 restriction level is preferred over Stage 2 or higher.
- The community is prepared to accept restrictions up to Stage 3 if they are necessary, but Stage 4 was considered onerous.
- Approximately one third of those surveyed did not support supply augmentation, while two thirds preferred demand management.
- Many people chose to conserve water during the drought because it was the ‘right thing to do’ rather than responding to restrictions.
- A majority of customers had used greywater during the drought and one fifth had a rainwater tank plumbed to for allow internal use.

Data obtained from our Contact Centre indicates that the three most common themes were customer enquiries on the water restriction by-laws, water quality and an increase in the number of breaches of the water restrictions.

In relation to the water restriction by-law there were nearly 10,000 enquiries registered over a four year period between 2006 and 2009. At the peak of the drought in 2007, nearly 3,000 enquiries were received. By comparison, in 2013 less than 200 enquiries were recorded. The imposition restrictions had generated considerable community interest.

Water quality can alter during extended periods of water shortages and the Millennium Drought was no exception with colour, taste and odour dominating (in order from highest to lowest). Colour however had approximately four times the number of enquires than taste. Managing water quality will continue to be an issue in future droughts with Coliban Water already having undertaken an upgrade at its Sandhurst Water Treatment Plant.

There were three years (2004, 2006 and 2007) where the number of water restriction offences peaked at over 350 per annum. This was at a time when Stage 3 and Stage 4 restrictions were in place. By comparison in 2013 only five offences were recorded. The DPP identifies actions to reduce the frequency, severity and duration of future restrictions which complement the works undertaken during the drought.

State-wide Consultation of Uniform Drought Restrictions
The Victorian Water Association coordinated a State-wide consultation program to review the drought restriction levels. The working group held community forums, engaging directly with water businesses, industry groups and local government authorities.

- While there was general acceptance of the need to constrain demand during times when there were supply limitations, each interest group highlighted the potential impact on their respective stakeholders.
- Stage 4 restrictions were regarded as a measure of last resort.
- Water Use Plans were seen as a useful mechanism to provide flexibility for high water use businesses.
- Support for an 'allocation' to local government during drought. The local Council could then determine where best to apply this water.
- Strong support to maintain high value recreational assets and public amenities.

While there was an acknowledgement that restrictions were necessary, the survey found that public awareness and voluntary measures were also an important demand management measure. Some of the feedback has been applied to policy statements throughout the Urban Water Strategy.

Allocations Against High Reliability Water Shares (HRWS)

Seven of Coliban Water's nine supply systems are supplied from external sources i.e. Goulburn-Murray Water (GMW) or Grampians Wimmera Mallee Water (GWMWater). Only Coliban Southern is solely dependent on the headwork storages of Upper Coliban, Lauriston and Malmsbury reservoirs. Coliban Northern obtains the majority of supply from the headworks but can also be supplied from Lake Eppalock and the Waranga Western Channel.

Raw water allocations from external sources are allocated against Bulk Entitlements (BE) and water shares (High Reliability Water Shares – HRWS, and Low Reliability Water Shares - LRWS). The allocations against each form of entitlement can vary between supply systems.

Bulk Entitlements are legislative instruments which provide a right to take and use water. They are granted under the *Water Act 1989* to water corporations, the Victorian Environmental Water Holder and other specified bodies.

A water share is a continuous entitlement to a share of the water available in a water system. It gives the owner a right to a share of the water held in storage reservoirs. Water shares can be acquired or sold on the water market on an 'as required' basis.

Bulk Entitlements and water shares both carry a volume of water and specify the conditions to receiving that water. Water shares can provide different forms of reliability. As the name implies, high reliability water shares have a higher priority of receiving water than low reliability water shares, however Bulk Entitlements typically have a higher priority than both.

Table 32: Comparison of allocations against HRWS[1] during the Millennium Drought.

GMW System	10 years[4]	5 years[4]	3 years[4]	BE Comments[1]
Campaspe	50%	10%	0%	minimum 50%
Goulburn	75%	50%	40%	99% reliability
Loddon[2]	60%	15%	0%	minimum 50%
Murray	85%	75%	60%	equivalent to HRWS
Wimmera[3]	90%	80%	75%	100% allocation when inflow reaches 50% of median
Wimmera[5]	76%	69%	48%	post drought allocations

Note 1: Bulk Entitlements (BE) held on these systems typically have more secure allocation compared to High Reliability Water Shares (HRWS).

Note 2: While the minimum allocation is 50% of the volume, the water quality is very poor for this system when flows are low.

Note 3: GWMWater: Allocations for Bulk Entitlement – Coliban Water does not hold water shares on the Wimmera Mallee Pipeline product.

Note 4: The percentage allocations are the average of the lowest allocations for the time period specified. They do not necessarily indicate the lowest allocation (except for 0%).

Note 5: Actual average allocations over the last 10 years.

Effectiveness of Drought Response Measures

The measures implemented by Coliban Water during the Millennium Drought kept communities supplied with water but at a cost in terms of increased borrowing. The behavioural legacy is a lower consumptive demand under PWSR adjusted demand than earlier predicted in the 'WSDS 2060' allowing greater flexibility in managing raw water resources. Coliban Water now has over five years of data where no restrictions have been in place except the Permanent Water Saving Rules (PWSR). From this data, a decision was made internally to revise demand forecasts on an annual basis using a three year rolling average - the 'PWSR adjusted demand'.

Operationally the legacy from the drought has been to increase the resilience of Coliban Northern that supplies Bendigo and connected communities. This has a secondary benefit of allowing more resources to be held in the Coliban Headworks Storages during dry periods for the benefit of Castlemaine and Kyneton and their connected communities. This has led to a review of the volumetric trigger for the storages to provide greater flexibility for bulk transfers between the Coliban Systems Southern and Northern.

The final major long-term benefit is the capacity to engage in the water market and trade allocation (purchase and sale). This provides access to a greater volume of resource and the infrastructure needed to physically move this resource to Bendigo and Ballarat when needed via the Colbinabbin Pump Station and Goldfields Superpipe. In vulnerable systems the capacity to engage in the water market is one of the key mechanisms to minimise the risk of initiating an operational drought.

Overview of Drought Preparedness Strategy

Anticipating the Inevitable

The strategy recognises 'drought' as a deficiency of rainfall compared to the long-term average. A rainfall deficiency, over time has the potential to reduce the overall raw water supply through reduced inflows into Coliban Water owned storages, and reduced seasonal allocations by GMW and GWM Water.

Coliban Water within its *Drought Risk Management Plan 2014* (DRMP, 2014) recognises that a potential deficiency can manifest itself in one of three ways and the proposed actions reflect this. Potential deficiencies can be:

- **Chronic** - Occurring over long time scales (>50 years) as a result of climate change and or demand growth,

- **Acute** - Over shorter time scales (1-15 years) e.g. the annual wet and dry cycle of our Mediterranean climate or a prolonged water shortage like the Millennium Drought (1997 - 2009), or
- **Severe** - Short-term but high impact deficiency that threatens supply i.e. a severe shortage warrants or triggers a response to Stage 4 restrictions, or potentially beyond.

The three aspects of 'drought' addressed in the drought strategy suggest discrete approaches but these need not be mutually exclusive. The key strategy is to deal with the intra and inter-year variability of supply (inflows into storage and seasonal allocations).

Over a long temporal scale, climate and land use changes are likely to have an impact on both rainfall and runoff. On shorter temporal scales major climatic drivers such El Nino events are likely to dominate.

Operational Response to a Supply Constraint

Coliban Water's main response to meteorological drought will be to make up the supply shortfall wherever feasible. Therefore the overall strategy is to avoid imposing an 'operational drought' through restrictions. Various supply management and demand management options are available and these are detailed elsewhere in the UWS but include some or all of the following.

- Vary the volume of water carried over between years to provide a higher level of reserve at the start of the season.
- Develop an allocation trade strategy that provides the flexibility to sell surplus reserves during average to wet years, and buy allocation as needed to make up any shortfall in vulnerable systems in dry years. Trade can include transfers from other Coliban Water allocation accounts.
- Develop a strategy and or policy on the appropriate ratio of water entitlements to demand based on an agreed allocation scenario (includes purchase of allocation and or entitlements).
- Implement a volumetric trigger than has a suite of levels, for the Coliban Headworks Storages, which reflect the long-range climate outlook.
- Implement supply augmentation options to maintain supply; including purchase of seasonal allocation and capital intensive options (when warranted).
- For Coliban Northern, pump water from either Lake Eppalock or the Waranga Western Channel.

Increased Level of Review and Monitoring

Coliban Water, through the Water Resources Committee, will increase its level of oversight of the water security outlook during periods of potential shortfall. This includes some or all of the following factors.

- Current Supply Level and Allocation Volumes: Analyse volume of water that is currently available in storages and or what volume of water has been allocated to Coliban Water via external parties.
- Climatic Outlook: Using Bureau of Meteorology data to determine if the short-term and or long-term forecast is for dry, neutral or wet conditions.
- Inflows and Allocations: Analyse the current and expected inflows into storages for the year and deviations from the historical record. Determine what the current allocations and expected allocations granted to Coliban Water via external parties are.
- Demand Forecast: Analyse the expected demand based on a three year rolling average of the previous annual demands (i.e. PWSR adjusted demand). Decide whether these demands will increase with drier and or warmer weather.

At the beginning of each financial year an Annual Water Outlook (AWO) and Annual Operating Plan (AOP) is prepared by Coliban Water. It is within the AWO where the above factors are considered and are used in order to determine the baseline for any operational trigger points for that year.

Within the AWO, if the water supply outlook is lower than needed, then this can act as a trigger point to outline operational actions needed to balance the demand and supply. These operational actions are then outlined in the AOP for that water year.

All feasible actions for each system (both operational and capital), their trigger points and lead times will be outlined in later versions of drought preparedness plans. Only the operational actions that are going to be undertaken in the upcoming year are to be included in the AOP.

Impact of Restrictions on Urban and Rural Demand

The Millennium Drought has shown that demand can still vary widely during the course of a year when restrictions are imposed. Therefore demand reductions are estimates only, and of themselves cannot be used to accurately predict future raw water requirements. Table 33 provides an estimate of reductions in urban demand once restrictions are imposed.

Currently rural demand is approxiamately half of the licensed volume. Rural customers are a mix of commercial horticultural enterprises, sporting organisations, intensive animal industries and other minor users. Operational losses are high within the rural network and these losses would be expected to remain in proportion as conditions become drier. Once Stage 1 restrictions are imposed rural demand however may increase slightly as conditions become drier. At Stage 1 urban restrictions the rural customers receive less than their licensed volume but may use more than is actually recorded under PWSR adjusted demand.

Table 33: Estimated urban reduction in raw water demand by system and restriction level.

System	Baseline[1] PWSR[2]	Demand Reduction[1] Stage 1	Stage 2	Stage 3	Stage 4
Campaspe	59 ML	1 ML (1%)	12 ML (21%)	16 ML (28%)	19 ML (32%)
Coliban Northern	11,173 ML	215 ML (2%)	961 ML (9%)	1,304 ML (12%)	1,651 ML (15%)
Coliban Southern	2,855 ML	76 ML (3%)	343 ML (12%)	405 ML (14%)	578 ML (20%)
Elmore	125 ML	3 ML (3%)	38 ML (30%)	50 ML (40%)	58 ML (46%)
Goulburn	1,656 ML	25 ML (1%)	269 ML (16%)	354 ML (21%)	414 ML (25%)
Loddon	375 ML	8 ML (2%)	83 ML (22%)	110 ML (29%)	128 ML (34%)
Murray	4,263 ML	91 ML (2%)	989 ML (23%)	1,301 ML (31%)	1,520 ML (36%)
Trentham	157 ML	4 ML (3%)	45 ML (29%)	59 ML (38%)	69 ML (44%)
Wimmera	172 ML	3 ML (2%)	36 ML (21%)	47 ML (27%)	55 ML (32%)
Total	**20,834 ML**	**514 ML (2%)**	**2,968 ML (14%)**	**4,022 ML (19%)**	**4,941 ML (24%)**

Note 1: Excludes rural demand.

Note 2: Demand estimates are based on the 2016 baseline demands used in the development of the UWS.

Water Restriction Triggers

In determining whether to impose Stage Restrictions, Coliban Water will take into consideration the future status of raw water reserves in line with *Drought Policy 1 – Raw Water Reserves*. In assessing the risk, the factors to take into consideration are similar to those referred to in the 'Volumetric Trigger for Coliban Headworks Storages' (see next section) plus forecasts of allocation from external bulk water providers and capacity to carryover unused allocation between years.

For Coliban Northern and Coliban Southern, the restriction levels are set at a minimum of two years of the next Stage's water demand for that system based on PWSR adjusted demand. Only following the construction of the Goldfields Superpipe connecting Coliban Water to the GMW Goulburn System and the purchase of sufficient water shares, is it possible to maintain 24 months of raw water supply for Coliban Northern and Coliban Southern.

For example, Stage 1 restrictions are imposed once there is only two years supply of water at PWSR adjusted demand, Stage 2 set at two years supply of Stage 1 demands and so on for Stages 3 and 4. These triggers are designed to be review points and to be flexible, allowing restrictions to be enforced at an earlier or later time depending on the water security outlook. The exit triggers for each stage of restriction work in the opposite direction. If conditions change, the trigger points can be reviewed and altered.

For all other systems the forecast period is 12 months. The rationale is set out below:

- Groundwater resources for Elmore and Trentham are not as volatile as surface water systems and traditionally these have been very reliable.
- For externally supplied systems only 100% of entitlement can be carried over from year to year, the exception is Loddon which has a limit of 50%. From an operational perspective only 12 month's supply can be provided without the risk of 'spill' and hence not available for consumptive use in all but dry years when allocations are low.
- Most externally supplied systems have access to an active water market which allows Coliban Water to access additional allocation when needed to make up any supply shortfall.

A good example of the latter case is Echuca, where the consequence of a supply shortfall is greater because of its size and which hosts regionally significant high water use industries that are economically dependent on a reliable supply. Communities such as this may also be less resilient to any impacts on health and wellbeing resulting from water shortages.

In Echuca the policy of holding 12 months' supply is workable, given that it draws its supply from the reliable GMW Murray System. The Murray System still achieved an average allocation of 60% during the worst three years of the Millennium Drought. The system has an active water market that would allow for the purchase of additional allocation when there is a potential shortfall. There would be limited economic benefit to increase water holdings in the [Coliban Water] Murray System to always hold sufficient raw water to meet 24 months demand when any supply shortfall can be met through other means for the few years in every 100 years that it would be required.

For externally supplied systems additional entitlement would need to be purchased such that the total entitlement volume would allow for the equivalent of 12 months of raw water demand even at the end of a water year i.e. at 30 June, before further allocations are made in the next year. However this would be expensive and incur storage charges and other fees. Operationally and within limits, surplus allocation can be transferred between systems to maintain 12 months of supply.

Drought Policy 3 – Restriction Triggers

Coliban Northern and Coliban Southern
Coliban Water will consider imposing the next stage of restriction once there is a high probability that raw water reserves will fall below the volume required to meet a minimum of 24 months of demand at the current stage's requirements. That is, there will always be at least two years of supply.

Coliban Systems that are only supplied from external sources
Coliban Water will consider imposing the next stage of restriction once there is a high probability that raw water reserves will fall below the volume required to meet a minimum of 12 months of demand at the current stage's requirements. That is, there will always be at least 12 months of supply.

All Systems - Severe and Unforeseen Inability to Supply Events
Coliban Water will consider imposing restrictions where an unexpected event results in an inability to supply services. Such events may include, but are not limited to; infrastructure failure, power

outage, and poor water quality that exceeds the capacity of the relevant water treatment plant. Any such restrictions are likely to be of short duration and independent of the volume of raw water reserves on-hand.

It is not intended that stage restrictions will be implemented automatically but rather based on the likelihood that the raw water supply over the short-term will decline below the volume needed for the current stage and remain below that level. The Water Resources Committee will oversee the water resource position on a monthly basis.

The exit trigger, when restrictions are eased, will be when there is a high probability that raw water reserves can be sustained above 24 months of demand for Coliban Northern and Coliban Southern, or 12 months for all other systems.

Risk Profile

The restriction triggers are targeted at lowering one of Coliban Water's key risks – the inability to supply services. Water shortages brought about by drought are inevitable. '*Drought Policy 3 – Restriction Triggers*', in combination with the volumetric trigger (see next section) will lower the residual risk by adjusting the supply-demand balance well ahead of a critical shortage making the risk more manageable.

Volumetric Trigger for Coliban Headworks Storages

The volumetric trigger applies to the combined storage volume of the Coliban Headworks Storages (CHS). The storages are Upper Coliban, Lauriston and Malmsbury. The storages provide for all of the demands for Coliban Southern and any volume above this requirement is allocated to Coliban Northern (Bendigo and connected communities). The northern system is able to draw on additional external sources of supply hence there is some flexibility to provide for Bendigo while securing water for Castlemaine and Kyneton.

Coliban Water has introduced four trigger levels. The criteria for setting the levels allows for improved harvesting of inflow and minimisation of pumping from Lake Eppalock and the Waranga Western Channel. The trigger takes into account the climate outlook, inflows into storage during winter and spring, and final combined storage volume at 30 September. Figure 22 flowcharts the decision making process.

Annual Water Outlook and Annual Operating Plan

The Water Resources Committee will make a recommendation on the volumetric trigger to the Coliban Water Board each year as part of the *Annual Water Outlook* and *Annual Operating Plan* process. The recommendation will nominate the initial trigger level to the Board in August with a final recommendation in November each year.

The Water Resources Committee will monitor the status of raw water resources on a regular basis (typically monthly) and in the event that the resource position changes and the volumetric trigger needs to be revised to a higher or lower level, the approval of the Board will be sought.

Note 1: The only 'drought' related trigger is 55 GL.

The main rationale for the trigger levels is to secure the maximum supply of raw water for Coliban Southern while minimising any negative impacts on Coliban Northern. In practice, the less favourable the supply outlook, the higher the trigger level. Multiple trigger levels also allow greater operational flexibility in average and wet years.

Table 34: [Volumetric] Trigger levels for the Coliban Headworks Storages

Trigger Level	Comments
55 GL	Applied when the climate forecast is for dry conditions, inflows are below median and storages fail to fill after winter and spring. Assuming no further inflows, it provides well over 3 years of supply of PWSR adjusted demand for rural and urban customers for Coliban Southern. No further inflow is an extreme case and not even experienced during the Millennium Drought. The demand makes an allowance for evaporative losses (6 to 9 GL per year depending on storage levels) and operational losses for the rural system. **Advantages:** Secures a supply for Coliban Southern early in the year as there is no alternative supply available. Provides for additional lead time to initiate preconstruction activities for the 'southern interconnector' pipeline should this connection be required. The use of higher triggers may allow the indefinite postponement of construction of the southern interconnector thus reducing capital expenditure by an estimated $20-30 million. **Disadvantages:** If applied too frequently, or when the risks to Coliban Southern supply are not as great as anticipated, then additional pumping costs are incurred for Coliban Northern. If the shortfall in supply to Coliban Northern needs to be met from water share allocations then the allocations cannot be traded on the water market and a revenue opportunity is lost. The storages may spill more frequently should a subsequent year be more favourable and reserves at the start of the year remain high.
50 GL	As above, but one or more criteria may suggest caution e.g. inflows below median or storages fail to fill. **Advantages:** Provides additional supply for Coliban Northern but still retains just over 3 years of supply for Coliban Southern without further inflow. As indicated in the comments for the 55 GL trigger level, no further inflow would be an unprecedented event. **Disadvantages:** Increases the risk of incurring pumping costs from external sources for Coliban Northern. If the shortfall in supply to Coliban Northern needs to be met from water share allocations then the allocations cannot be traded on the water market and a revenue opportunity is lost. The storages may spill more frequently should a subsequent year be more favourable and reserves at the start of the year remain high.
45 GL	The default trigger level that is applied when climate forecast is neutral, median inflow is received and the storages fill at the end of winter and spring. Provides for around 3 years of supply for Coliban Southern. **Advantages:** Provides for approximately 1.5 years of PWSR adjusted demand for Coliban Northern while retaining approximately 3 years supply for Coliban Southern. Avoids incurring pumping costs for Coliban Northern and allows flexibility to trade allocation on the water market. Allows for more efficient capture of inflow into the storages by creating additional space ahead of the inflow season, and minimises spills from Malmsbury Reservoir. **Disadvantages:** In a run of favourable seasons (i.e. average years) the storages may still spill large volumes.
40 GL	Only applied under a wet climate forecast with above median inflow, and storages spilling for an extended period at the end of winter and spring. **Advantages:** Increases the flexibility to supply Coliban Northern exclusively from the storages during wet periods. Lowers the volume of spill from the storages by creating additional space. **Disadvantages:** It may compromise supply if subsequent years are dry and the end of season volume is low leading into winter.

Volumetric Trigger Criteria

The volumetric trigger uses three criteria to determine the level. Each criteria has three states.

Climate Forecast
Climate forecast is classified into three categories of dry, neutral and wet.
Dry: There is a greater than a 50% chance of below average rainfall. Dry conditions are also often accompanied by warmer weather. Influences are dominated by El Nino events in the Pacific Ocean, but include influence from a positive Indian Ocean Dipole (IOD).
Neutral: Approximately 50% change of average rainfall and temperature over the forecast period.
Wet: There is a greater than 50% chance of above average rainfall. Wet conditions can be dominated by events in the Pacific Ocean (La Nina event) or the Indian Ocean (negative IOD).

The climate forecast is based on two main sources of information along with Coliban Water's own rainfall and evaporation data monitoring site located at Malmsbury Reservoir. While the forecast is taken into account, it is the current condition as of 30 September that will be used to set the final trigger for the year.

- Bureau of Meteorology (BoM) for the seasonal forecast (3 month outlook), and the long-range forecast 'Predictive Ocean Atmosphere Model for Australia' (POAMA) which provides a nine month outlook.
- 'Australian Water Availability Project' (AWAP) which is a consortium of BoM, the 'South East Australia Climate Initiative' and CSIRO. The AWAP provides weekly and monthly information on soil moisture levels across Australia for the upper (0-20 cm) and lower (20-150 cm) soil profiles.

In broad terms, approximately three years out of every ten years are likely to be dry on average. From information derived from Coliban Water records, the dry periods appear to be generally equally divided into dry and very dry periods. However this may be an artefact of the limited historical record and has not been validated statistically.

Average or wet years are likely to be experienced approximately seven out of every ten years, with an average of one of those years being very wet (i.e. a flood year or one with well above average rainfall).

Inflow into Coliban Headworks Storages	
The 'inflow' is a measure of deviation from the expected volume (the median) recorded between 1 July and 30 September each year. The median inflow calculation has used data from July 1975 to June 2016 - the 'current climate' baseline.	
Dry:	Less than 7.6 GL represents a trend below the 10^{th} percentile of inflow.
Median:	34.1 GL represents the 50^{th} percentile i.e. 50% of all inflows are higher or lower than the median.
Wet:	More than 60.7 GL represents a trend above the 90^{th} percentile of inflows.

On average about 71% of inflow into our Coliban Headworks Storages occurs between July and September.

Coliban Headworks Storages Volume

The Coliban Headworks Storages volume is the final combined volume of Upper Coliban, Lauriston and Malmsbury Reservoirs as at 30 September of any given year. The three levels reflect the ideal condition of 80-100% full, or the deviation from this.

Dry: Less than 80% indicates that 55 GL has not been reached by 30 September indicating dry conditions with a low probability of further inflows.

Full: 80-100%[1] is defined as the volume that would be above the highest trigger level up to '100% full'.

Wet: Greater than 100%[2] would indicate spilling, or close to spilling indicating wet conditions.

Note 1: 80-100% full is any volume from 55 GL to the 'maximum operating level' of 68.8 GL. The full supply level is 69.6 GL but Lauriston Reservoir is operated at 95% of capacity. The 55 GL is a net figure after allowing for the filling of McCay, Barkers Creek, and Sandhurst Reservoirs.

Note 2: The Coliban Headworks Storages rarely fill after 30 September if not already full or close to full.

The combined storage volume is estimated daily from reservoir elevation readings while the volume calculations are derived from 'rating tables' developed by external specialists.

Capital Infrastructure Triggers

Any proposed capital expenditure needs to be assessed at an earlier date and included in the Capital Works Program for the year, or as part of the five year pricing submission process. The usual assessment period for capital works in the next financial year occurs well before July and any prospective works will need to be flagged in a timely manner.

Infrastructure deemed critical during an acute or severe shortage will, to the extent possible, already be scoped out with preliminary costing. The implementation lead time will be established such that should the infrastructure be needed, then the 'trigger' for the functional and detailed design and planning approvals can commence in sufficient time to allow the delivery of the project.

If the drought is severe or acute, then some options may need to be 'fast-tracked'. As some options need several years lead time and have large planning requirements, there may be separate triggers for the planning and delivery stages of those options. This may result in the planning phase going ahead and being completed but the delivery phase not proceeding until necessary. This would mean that the lead time will be shortened significantly if the 'delivery trigger is hit at a future date.

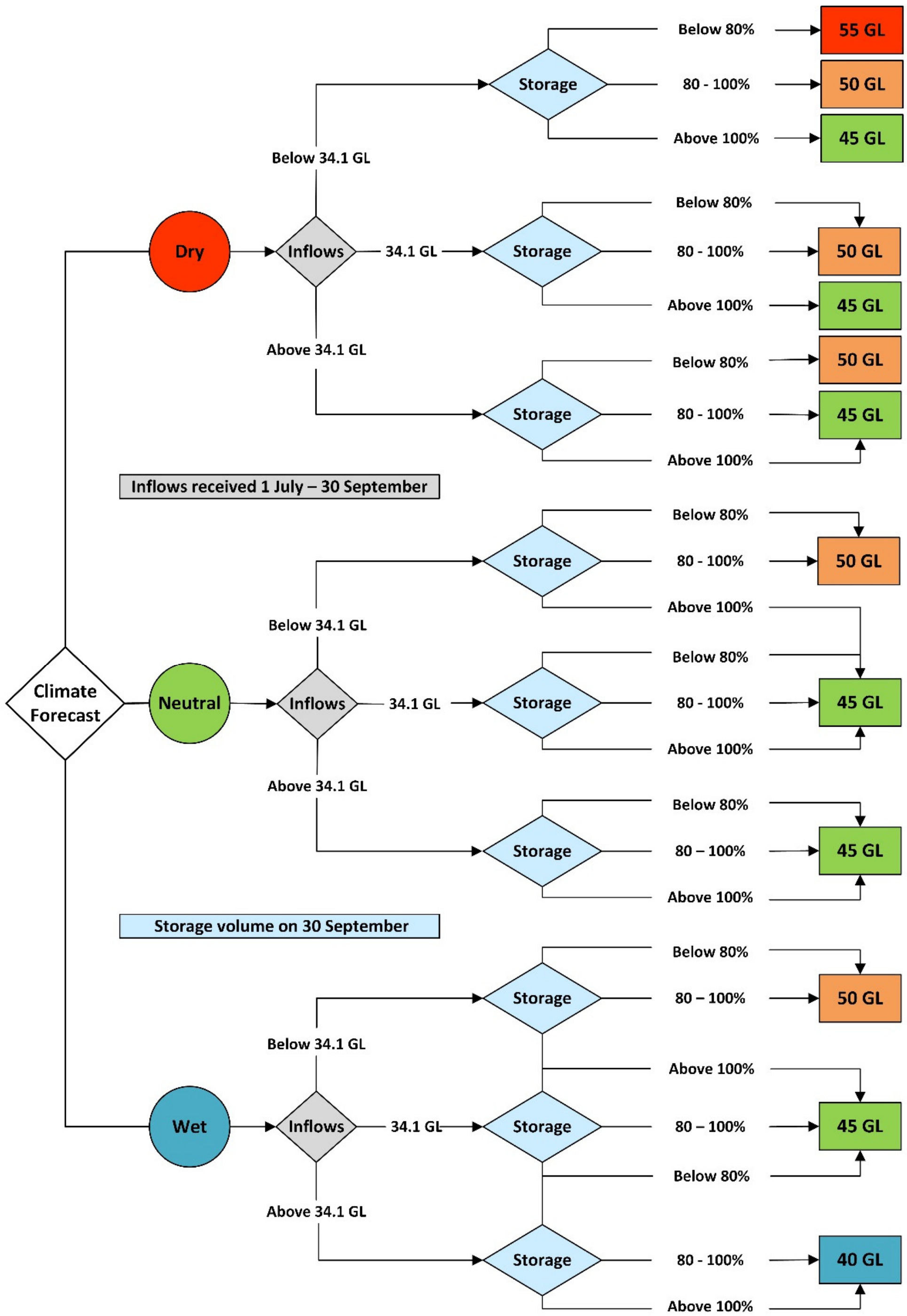

Figure 22: Decision making flowchart for the volumetric trigger.

Acute Shortage of Supply

Characteristics

In broad terms an acute shortage reflects what is commonly recognised as a drought. But droughts vary considerably in severity and duration. The most severe shortages are dealt with separately in the next section. A ‘typical’ El Nino driven shortage usually only lasts 1-3 years, however the Millennium Drought persisted for 12 years. Even during the Millennium Drought there was a wide variation to the extent that a short duration ‘severe’ shortage was recognised during 2007.

A meteorologically driven water shortages are often accompanied by warmer weather which exacerbates the shortage and any water restrictions that may be imposed. However a meteorological shortage does not necessarily result in an operational shortage whereby restrictions would be imposed.

Two components of an acute shortage are recognised:

- Meteorological drought whereby the shortage is externally driven and beyond Coliban Water’s control, and
- An operational drought whereby the corporation imposes an artificial constraint on demand by imposing restrictions.

In meteorological drought, a lack of rainfall is often accompanied by increased temperatures and higher evapotranspiration rates. This is the familiar vision that we all have of Australia’s frequent droughts. An operational drought reflects the actions a water business takes to balance its available supply to meet forecast demand.

Strategies to Manage Acute Shortages

The proposed management strategies reflect the wide variation of responses needed to cope with large annual changes in supply.

Examples of Demand Management Strategies

- Increase the investment rate in strategies identified previously.
- Impose restrictions to reduce demand on the supply system. This could include Stage 1 to Stage 3 restriction levels.
- Adopt a higher volumetric trigger for the Coliban Headworks Storages e.g. 55 GL or 50 GL depending on the water supply outlook. The outlook is based on climate forecast, inflows into storages and storage volumes.
- Advertising campaign to increase community awareness in order to avoid imposing restrictions. The campaign could use multiple forms of media so that consumers are fully aware of the details of the drought and any restrictions.

Examples of Supply Management Strategies

- Increase the investment rate in strategies identified previously.
- Bring forward capital works scheduled for future pricing submissions or those listed in the DPP.
- Diversification of supply sources e.g. interconnections such as the southern interconnector to Castlemaine.
- Desalination of saline surface or groundwater e.g. Loddon System.
- Access groundwater through new or re-developed bores.
- Increase the uptake of recycled water.

- Implement options selected from the individual system's drought preparedness plans under the chronic and acute sections, including those that may have been planned for in other response steps.
- Cart water to small communities using tankers.

Action Plan to Manage Acute Shortages

The primary action is to intensify internal monitoring and planning such that the resource position is evaluated monthly but with a 12 – 24 month outlook. The Water Resources Committee will review the need to augment supplies, implement restrictions or initiate capital works to respond to a potential demand-supply imbalance.

When prudent to do so, additional information via media, would be released to the community to inform them of any potential shortfall.

Severe Shortage of Supply

Characteristics

Severe shortages are usually short duration, but potentially high impact events and can include some or all of the following.

- Meteorologically driven shortages whereby inflows or allocations are among the lowest on record, in general events that would occur less than 10% of the time. Duration could be from several months to a few years.
- Infrastructure failure that includes major pipe bursts or power blackouts. Duration would usually be measured in hours or days at the most. These events are dealt with under Coliban Water's Emergency Management System and as such are not considered further in the drought preparedness plans.
- Major tunnel collapse on Coliban Main Channel immediately downstream of Malmsbury Reservoir. Reinstatement could take up to 12-18 months, however restrictions would need to be imposed on some rural customers if any failure were to occur during the irrigation season.
- Poor raw water quality that is beyond the capacity of a water treatment plant to manage. Short duration events (hours or days) would be dealt with under Coliban Water's Emergency Management System and as such are not considered further in the drought preparedness plans. However poor water quality can occur over extended periods and be more chronic than acute. For example the increased salinity of surface water in Loddon System as the Millennium Drought progressed.

Severe shortages may arise with little forewarning and hence any strategies to deal with these events must be operationally ready to be implemented. (See Drought Policy 2 – Operational Readiness for Drought.)

Strategies to Manage Severe Shortages

The key strategy to manage these events is to ensure that Coliban Water can rapidly implement its 'Plan B' to ensure continuity of supply; the options that have previously been identified and that are operationally ready to proceed to full implementation.

A good example of operational readiness is the Harcourt Rural Modernisation Project whereby the trunk main has been upsized to provide additional capacity to meet urban demand for Castlemaine, and potentially Kyneton, should the southern interconnector pipeline ever be constructed to connect with it.

The investment in upsizing the main has been made in advance of a specific requirement and hence it provides a strategic asset that may, or may not ever be needed. Having to establish a dedicated alignment for an additional main at a later date would have a long-lead time and would be contrary to the objective of providing an alternative source of water at short notice.

Examples of Demand Management Strategies

- Impose Stage 4 restrictions.
- Ration water supply to industry and commercial customers.
- Initiate evaporation reduction measures across major and or minor storages.

A failure of the Coliban Main Channel may trigger immediate restrictions for urban and or rural customers. The extent and severity of the impact is dependent on the season and location the failure occurs. For example if McCay Reservoir was low then restrictions may need to be applied on short notice for the Castlemaine urban supply.

Examples of Supply Management Strategies

- Seek a temporary qualification of rights from the Minster for Water. See Text Box – 'Temporary Qualification of Rights' for detail.
- Cart water via tanker where feasible.
- Access the 'dead' storage through pumping. Dead storage is the water that is below an outlet valve on a reservoir.
- In the event of a tunnel collapse then by-pass arrangements could be initiated around the collapse, or alternative supplies provided where feasible.

Temporary Qualification of Rights

Rights to water are clearly specified in bulk entitlements, environmental entitlements, water shares and groundwater licences. Water corporations and individuals are obliged to plan their water use within the entitlement provisions.

The Minister for Water (the 'Minister') has emergency powers under section 33AAA of the Water Act 1989 (the 'Act') to declare that a water shortage exists and qualify rights to water. The Act sets out the notification procedures applying to qualifications, as well as the conditions that may be imposed on the holder of an entitlement that is qualified.

A qualification of rights is considered to be an emergency measure to avoid unacceptable water shortages for entitlement holders. It is a measure of last resort and therefore beyond the reasonable scope of a water corporation's water resource and contingency planning activities undertaken as part of conducting its business.

DEPI have expectations of entitlement holders requesting a qualification of rights to water under Section 33AAA of the Act and several items should be noted. The key points to note are, that for any request for a qualification of rights:

- The proponent (e.g. Coliban Water) needs to take all reasonable steps to prevent a shortage of supply, **before** making a request to the Minister via DELWP. These steps include entering the water market to secure allocation;
- As part of the work of providing the justification for a qualification the proponent **must** undertake a risk assessment. The assessment **must** be conducted by an external independent expert at the proponents own cost, and include consultation with affected stakeholders; and
- Any given qualification does not come into effect until all affected parties have been notified e.g. Catchment Management Authorities and rural landholders for stock and domestic supplies.

The risk assessment component may have an extended lead time and if Coliban Water were likely to have insufficient supply to meet Stage 4 requirements, then such an assessment would need to be commissioned earlier in the drought response phase as identified in the action plan. The assessment would be conducted so that it is available long before the time it is actually needed.

Action Plan to Manage Severe Shortages

Actions by Coliban Water under a severe shortage outlook would be similar to those of an acute shortage. The crucial difference will be the increased risk that supply will be less than needed to meet critical human needs. Hence planning for the implementation of previously identified projects will commence. The action plan and project planning would include some or all of the following:

- Constant and regular monitoring
- Commissioning cost-benefit analysis and concept designs before the option is needed
- Allocate the necessary budget and resources to undertake the pre-construction activities, and
- Identify critical elements and those with the longest lead times and implement these ahead of severe shortage.

Over the next few years Coliban Water will work to scope out options capable of managing a severe shortfall in supply.

Drought Preparedness Plan Review

It is a requirement to review a drought preparedness plan on a regular basis to ensure that the information contained within the document is both appropriate and up to date. Coliban Water will review its drought planning either after restrictions are lifted, when the next drought has broken or at a minimum of every five years i.e. before 2022.

Post Drought Evaluation and Revision of Plan

In the event of Coliban Water experiencing another drought, once the drought has broken and all systems have been on PWSR for at least one month, Coliban Water will move into the post-drought phase and a review of the drought preparedness plans effectiveness will be undertaken. This review will be in the form of a short report to be presented to the Water Resources Committee and later for noting by the Board of Coliban Water. The items to be included in this report can include, but are not limited to:

- A summary of the nature of the drought encountered including the length and harshness of any restrictions imposed for each system
- The impact of any restrictions
- A summary of the options undertaken as part of the drought response
- The cost of the drought, including the cost to implement any options and strategies, and projects as well as the reduced revenue resulting from lower demands
- An estimation of the volume of water saved through the options implemented
- The effectiveness of any triggers or timing of project and option implementation including the time allowed to implement the options
- Any refinements or variables that need to be added to triggers
- Any impediments to implementing the drought response
- Any post drought impacts on the systems
- The impact the drought had on customers, including any attitude changes, and
- The impact the drought had on Coliban Water staff.

From this report and the considerations above, any anticipated changes to the drought preparedness plans are to be outlined and recommended to the WRC. If the committee agrees to these changes, the plans are to be updated to reflect these variations after any required public consultation is undertaken. Proposed variations are then to be sent to the Minister as required after final approval from the Board of Coliban Water. The revised plan will be sent to the Minister within one year of the systems moving back into PWSR.

Periodic Review and Revision of Drought Preparedness Plan

In cases where there has been no drought response undertaken, a review of the plan is to be undertaken at least every five years. In this review the appropriateness of the plan is to be assessed and any updates or variations required are to be undertaken. If variations are needed, the required Ministerial approval process must be undertaken.