Department of Planning and Environment

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Hydrologic analysis of options for the Lachlan Regional Water Strategy

Regional Water Strategies Program

November 2023

Acknowledging First Nations people

The NSW Government acknowledges First Nations people as the first Australian people and the traditional owners and custodians of the country's lands and water. First Nations people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters.

Today, they practice the oldest living culture on earth.

The NSW Government acknowledges the Nari Nari, Ngiyampaa, Wiradjuri, Barkandji, Maljangapa and Yita Yita people as having an intrinsic connection with the lands and waters of the Lachlan Regional Water Strategy area. The landscape and its waters provide the First Nations people with essential links to their history and help them maintain and practice their traditional culture and lifestyle.

We recognise the Traditional Owners as the first managers of Country. Incorporating their culture and knowledge into management of water in the region is a significant step towards closing the gap.

Under this regional water strategy, we seek to establish meaningful and collaborative relationships with First Nations people. We will seek to shift our focus to a Country-centred approach; respecting, recognising and empowering cultural and traditional Aboriginal knowledge in water management processes at a strategic level.

We show our respect for Elders past and present through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places where First Nations people are included socially, culturally and economically.

As we refine and implement the regional water strategy, we commit to helping support the health and wellbeing of waterways and Country by valuing, respecting and being guided by First Nations people, who know that if we care for Country, it will care for us.

We acknowledge that further work is required under this regional water strategy to inform how we care for Country and ensure First Nations people hold a strong voice in shaping the future for all communities.

Artwork by Nikita Ridgeway.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

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First published: November 2023

Department reference number: PUB23/1000

Cover image: Ballyrogan channel near Lake Brewster. Image courtesy of Amanda Ind

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Executive Summary

The NSW Government is developing 12 regional water strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years. The NSW Government sought feedback from the community on the draft Lachlan Regional Water Strategy, including a long list of proposed options to meet regional water challenges, from 25 September – 13 December 2020[1]

This report provides the outcomes of hydrological assessment that was undertaken to understand the impact of options on existing water supply risks to water users in the catchment, as well as to feed into the economic assessment of options. Assessment of water security and changes in flows regime in the Lachlan valley were undertaken for three climatic regimes:

- instrumental climate – this data includes the period of available instrumental meteorological recordings for the catchment (1889–2020)
- long-term historic climate projections (stochastic data) — these assume that our future climate is similar to what the science is indicating our long-term paleoclimate was like and are based on a 10,000-year dataset
- a dry climate change scenario (NARCliM modelling) — this assumes a dry climate change scenario in the future and is also based on a 10,000-year dataset.

This report summarises the following 5 options:

- Option 25: Lower Lachlan efficiency measures

  Construction of a piped scheme to deliver water more efficiently to landholders (including stock and domestic users) along the Muggabah, Merrimajeel, Merrowie, Booberoi and Willandra Creeks.
- Option 34: Review of water accounting and allocation processes (Lachlan and Belubula regulated systems)

  Increase the take account limit to 1.1 ML/unit share
- Option 35: Investigation of licence conversion (Lachlan and Belubula regulated systems)

  20% conversion of General Security Entitlements to High Security Entitlements (conversion ratio of 4 general security entitlements to one high security entitlement)

[1] The draft Lachlan Regional Water Strategy and long list of options can be viewed at, https://www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/public-exhibition/lachlan-regional-water-strategy

- Option 39: In-stream storage for the Lower Lachlan

  Construction of a new weir between Hillston and Booligal (near Whealbah)

- NEW Option: New weir in the Belubula Regulated River

  Construction of a new re-regulating weir on the Belubula River located near Needles gauging station.

Note that the modelling assessment reported here comprised an initial, high-level assessment with the aim of providing insights into the relative hydrological and water supply benefits and impacts that could be expected for a range of options. This information was then added to the consideration of associated costs (undertaken by DPE Water) to provide comparison across the initial range of options. Put simply, the hydrologic assessment reported here provides one part of the information towards an initial understanding of which options are most likely to provide the best hydrologic outcomes on a subsequently comparative cost basis. This information will inform decision makers as to which options may be most appropriately taken forward towards more detailed, comprehensive assessment and consideration.

Further information about the Lachlan Regional Water Strategy options assessment process, as well as details and conclusions about the options assessed in this report can be found in the draft Lachlan Regional Water Strategy consultation paper (2023).

Introduction

The Lachlan Regional Water Strategy (RWS) is part of a suite of long-term strategies being developed by the NSW Government to maintain the resilience of the state's water services and resources over the coming decades. This suite includes the NSW Water Strategy which is a state-wide, high-level strategy and works in tandem with 12 regional water strategies and two metropolitan water strategies. The suite also includes a state-wide groundwater strategy and an Aboriginal Water Strategy. .

The NSW Water Strategy and the regional and metropolitan water strategies are being developed in parallel. This helps ensure alignment between the overall state-level priorities in the NSW Water Strategy and the place-based solutions being developed for each region. It also allows the NSW Water Strategy to be informed by the evidence and examples that are emerging through work with communities at the regional level.

Each draft regional water strategy is accompanied by a long list of options that could potentially address identified challenges in each region and help to achieve the objectives of the strategy. These options cover a wide range of actions, including investment in infrastructure, adjustments in how we manage surface water and groundwater, initiatives to better use our sources of water through recycling, and further policy changes and reforms.

A risk-based approach to the assessment of hydrologic and economic implications and outcomes for a range of potential water supply/demand options is being applied within the RWS development framework[2]. This approach is aimed at defining risk to the regional and NSW economy from a drought in the Lachlan Valley under current levels of water supply infrastructure, and potential for mitigation of this risk via augmentation of the water supply infrastructure and/or operational changes.

The options assessment process[3] comprised hydrologic, economic and environmental assessment of options that directly impacted supply, demand or allocation of water in the regulated river system.

In the initial stage of assessment the option was incorporated into the Department's Lachlan and Belubula river system models to observe the changes to water extractions and flows when compared to current conditions (Base Case model). An important point to note is that the modelling assumed that the diversion limit set by the Basin Plan is not exceeded. This was done by reducing

[2] https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/development

[3] https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/identifying-and-assessing

the amount of water for lower priority licences if an option resulted in the diversion limits being exceeded.

This report outlines the hydrologic modelling undertaken to understand the water supply risks posed by infrastructure options on water users in the Lachlan and Belubula catchments. Water security modelling for the Lachlan regulated river system was undertaken using the Base Case Lachlan Integrated Quantity and Quality Model (IQQM) and the Base Case Belubula Source Model.

The hydrological modelling has been undertaken in support of the development of the Lachlan RWS and provides quantified insights and understanding of the potential water supply/security benefits associated with options identified through the RWS process.

A range of options (and combinations of options) were modelled to determine how they affect water supply outcomes when compared to the Base Case. This modelling comprised an initial, high-level assessment with the aim to provide insights into the relative hydrological and water supply benefits and impacts that could be expected for each option. This information was then considered alongside associated costs (undertaken by DPE Water) to provide comparison across the options.

Assumptions were made where detailed option design information did not exist (i.e. due to early stage of option conceptualisation) to ensure directly comparable, high-level information regarding potential option benefits and impact. These assumptions are described in the option-specific sections below.

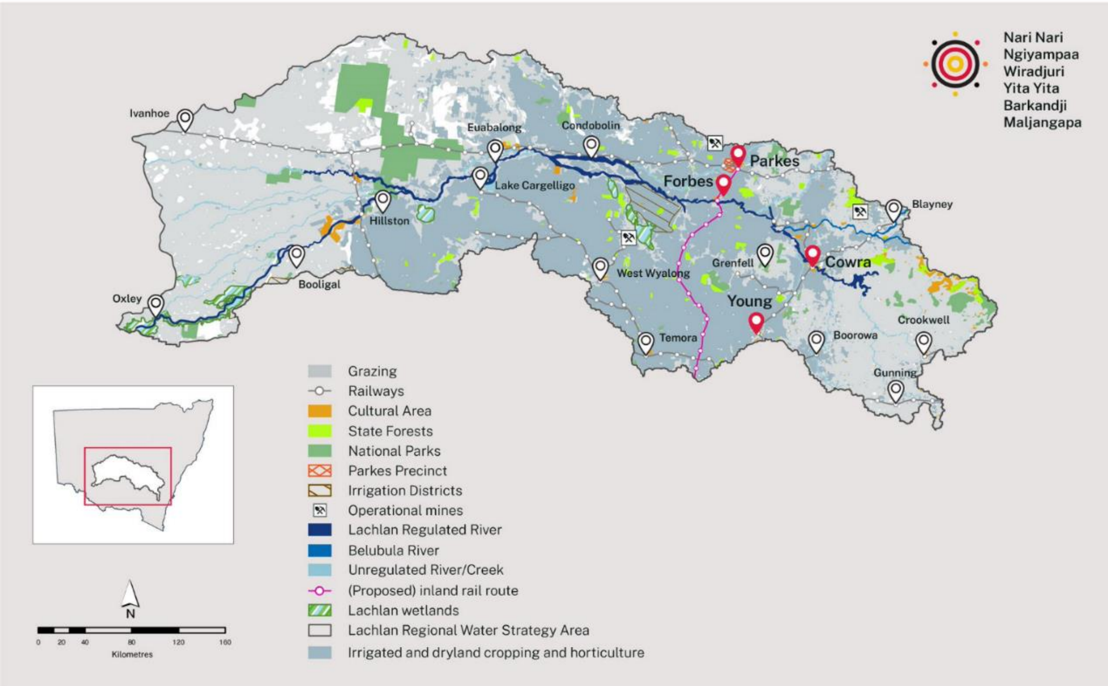
Background

Lachlan Valley catchment

The Lachlan Regional Water Strategy region (Figure 1) lies at the geographic heart of NSW and includes stunning natural landscapes that change from mountainous terrain in the east to flat alluvial plains in the west. The region is home to many vibrant towns and communities, productive agricultural and mining industries, important ecosystems and nationally important and culturally significant wetlands, including the Lake Cowal/Wilbertroy wetlands, Booligal Wetlands and the Great Cumbung Swamp.

The region is located within the traditional lands of the Nari Nari, Ngiyampaa, Wiradjuri, Barkandji, Maljangapa and Yita Yita Nations. These Nations have been caretakers of the Lachlan region for over 60,000 years.

Figure 1: Map of the Lachlan region



Water resource planning and management

The management of water resources within NSW is undertaken via the main planning instrument - *Water Management Act 2000*. The *Water Management Act 2000* is the overarching framework that establishes rules for water sharing amongst the different types of user, including primary industries (e.g. irrigators, mining), tertiary industries (e.g. power generation) and town water supply (i.e. rural and urban). It also sets rules to meet the environmental objective to maintain the sustainability and resilience of the system. The various sources of water resources within the Lachlan Valley are managed under a range of water planning instruments comprising:

- Water Sharing Plan for the Belubula Regulated River Water Source 2012
- Water Sharing Plan for the Lachlan Regulated River Water Source 2016
- Water Sharing Plan for the Lachlan Unregulated Water Sources 2012
- Water Sharing Plan for the Lachlan Alluvial Groundwater Sources Order 2020
- NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2020

Given its location in the Murray Darling Basin, the catchment is also managed under:

- Basin Plan 2012 (along with overarching *Water Act 2007*)

Water supply

Wyangala Dam is the main regulating storage in the Lachlan catchment with a capacity of 1,217,000 megalitres. It provides a regulated water source for irrigators and towns along the Lachlan River. A number of natural lakes have also been modified for use as storages, the largest of these being Lake Cargelligo at 36,000 megalitres, and Lake Brewster at 154,000 megalitres.

Carcoar Dam on the Belubula River has a capacity of 35,800 megalitres and supplies water for irrigation, stock and domestic use within the Belubula valley.

Assessment Framework

Modelled options

Table 1 lists the options and scenarios reported in the draft Lachlan RWS which directly impacted supply, demand or allocation of water in the regulated river system..

Each of the options were modelled using the historical climate datasets. The options that passed the rapid cost-benefit analysis underwent detailed hydrologic assessment using the long-term historical (paleo-stochastic) and dry future NARCliM) datasets[4].

Table 1: Options assessed using hydrologic modelling[5]

Option title	Option description
Option 25: Lower Lachlan efficiency measures	Construction of a piped scheme to deliver water more efficiently to landholders (including stock and domestic users) along the Muggabah, Merrimajeel, Merrowie, Booberoi and Willandra Creeks.
Option 34: Review of water accounting and allocation processes (Lachlan and Belubula regulated systems)	Increase the take account limit to 1.1 ML/unit share
Option 35: Investigation of licence conversion (Lachlan and Belubula regulated systems)	20% conversion of General Security Entitlements to High Security Entitlements (conversion ratio of 4 general security entitlements to one high security entitlement)
Option 39: In-stream storage for the Lower Lachlan	Construction of a new weir between Hillston and Booligal (near Whealbah)
NEW Option: New weir in the Belubula Regulated River	Construction of a new re-regulating weir on the Belubula River located near Needles gauging station

[4] For further details about the climate data and modelling, please refer to www.dpie.nsw.gov.au/water/plans-and-programs/regionalwater-strategies/climate-data-and-modelling

Assessment approach

It is particularly important to note that due to the initial, high-level nature of assessment, no detailed consideration of the potential implications to Planned Environmental Water (PEW) and/or local (or wider) ecological effects was undertaken, nor any assessment of required growth in use mitigation where indicated any benefits associated with the options being assessed therefore representing an 'optimistic' estimate (in that any need for mitigation and/or reduction of impacts would most likely reduce potential benefits below those indicated here). By assessing whether options are indicated to be potentially beneficial and cost effective under optimistic assumptions, those options that still do not show sufficient benefit under these generally optimistic assumptions can be reasonably discounted from further, more detailed assessment.

Put simply, the hydrologic assessment reported here provides one part of the information towards an initial understanding of which options are most likely to provide the best hydrologic outcomes on a subsequently comparative cost basis, with a view to inform decision makers as to those options most appropriately taken forward towards more detailed, comprehensive assessment and consideration.

Climate datasets

Historically based (or 'instrumental') climate

The instrumental climate refers to the period of available instrumental meteorological recordings (1889–2021) that are used as input into the rainfall–runoff models, required to generate runoff for river system models and as direct climate input to river system model simulations. For options assessment, 14 replicates of 40-year periods were sampled from this data to provide a preliminary basis to evaluate options for shortlisting for portfolios.

This climate data is referred to as 'instrumental' throughout this report. It is the building block for incorporating long-term and climate change data. This dataset was used for all of the hydrologic options in this report.

Long-term historic climate projections (paleo-stochastic data)

The long-term historic climate projections refer to the 10,000 years of stochastic-generated climate (developed using paleo climatic information by The University of Adelaide, Australia) that are used to evaluate the final viability of portfolios as well as define the Base Case model. For option assessment, 1,000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of outcomes across many possible climate realisations.

This climate data set is referred to as ‘stochastic’ throughout this report.

Dry future climate scenario (NARCliM modelling)

The ‘dry future climate scenario’ refers to the stochastic climate data generated by multiplying the stochastic time-series of 10,000 years with average monthly scaling factors derived from NSW and Australian Regional Climate Modelling (NARCliM) climate projections for 2060–2079 compared to the baseline period of 1990–2009 for each climate timeseries for every climate station used in the modelling. The average monthly scaling factors represent the mean of three regional climate models of CSIRO-MK3 GCM used in NARCliM 1.0.

This set of stochastic data with climate projections are used in conjunction with the stochastic data to evaluate the final viability of options, as well as to define future base cases. For options assessment, 1,000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of outcomes across many possible climate realisations.

This source of data is referred to as ‘stochastic + NARCliM’ throughout the report.

Outputs for option assessment

A set of metrics were defined to benchmark existing system performance as represented via a Base Case model scenario[6], and provide an understanding of comparative option performance for the range of users, uses, storages and entitlements types within the catchment. The adopted set of performance metrics are summarised in Table 2 to Table 6.

Table 2: Performance metrics (water diversions)

Lachlan regulated system
General Security Entitlement (GSE)
Conveyance (JIL)
High Security Entitlement (HSE)
Town Water Supply (TWS)
Stock and Domestic (S&D)
GSE Environmental/Held Environmental Water (HEW)
HSE Environmental
S&D Environmental
Mean annual total consumptive use
Mean annual total non-consumptive use
Mean annual total accounted use
Belubula regulated system
GSE
HSE
Supplementary
S&D
Mean annual total use
Belubula unregulated system
Central Tablelands Water TWS

[6] Current development, management rules and HEW used for environmental assets and values

Table 3: Performance metrics (allocation reliability)

Effective allocation (Lachlan regulated system)
% of years effective allocation for GSE at 30 June >= 100%
Average effective allocation for GSE at 30 June
% of years HSE allocation 100% at 30 June
Effective allocation (Belubula regulated system)
Total available GSE on 1st July (%) (inc. carry-over)
GSE AWD throughout year (%)
Mean 1st July HSE share per unit (%)
Mean 30th June HSE share per unit (%)

Table 4: Performance metrics (storage behaviour)

Storage
Wyangala (% days active storage falls below at least once)
< 300 GL
< 250 GL
< 210 GL
< 145 GL
< 105 GL
< 90 GL
< 80 GL
< 65 GL
Lake Brewster (% days active storage falls below at least once)
< 75% (109 GL)
< 50% (73 GL)
< 25% (36 GL)

Storage
< 10% (14.5 GL)
< 5% (7.3 GL)
Lake Cargelligo (% days active storage falls below at least once)
< 75%   (32 GL)
< 50%   (21.5 GL)
< 25%   (10.8 GL)
< 10% (4.3 GL)
< 5% (2.2 GL)
Carcoar Dam (% days active storage falls below at least once)
< 75%   (27 GL)
< 50%   (18 GL)
< 25%   (9 GL)
< 10% (3.6 GL)
< 5% (1.8 GL)
Lake Rowlands (% days active storage falls below at least once)
< 75%   (3.4 GL)
< 50%   (2.3 GL)
< 25%   (1.1 GL)
< 10% (0.5 GL)
< 5% (0.2 GL)

Table 5: Performance metrics (town water supply)

Town water supply
% of time full demand not supplied (i.e. some form of restrictions would be in place),
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)
Average water supplied GL/year
Average water supplied as % of full demand

Town water supply metrics were considered for the following towns: Cowra, Forbes, Parkes, Condobolin, Lake Cargelligo, Willandra, Hillston and Booligal

Table 6: Locations and Performance metrics (river flows)

Flows
412033 Belubula River at Helensholme
412027 Lachlan River at Reids Flat
412067 Lachlan River at Wyangala
412002 Lachlan River at Cowra'
412057 Lachlan River at Nanami
412004 Lachlan River at Forbes (Cotton Weir)
412019 Island Creek at Cadow
412023 Island Creek at Fairholme
412017 Bumbuggan Creek at Offtake
412014 Goobang Creek at Condobolin
412016 Wallamundry Creek at Offtake Island Creek
412034 Lachlan River at Condobolin Weir
412021 Lachlan River at Booberoi Weir
412011 Lachlan River at Lake Cargelligo Weir

Flows
412102 Lake Brewster Intake d/s Lake Brewster Weir Regulator + 412048 Lachlan River at Lake Brewster Weir-storage gauge
412038 Lachlan River u/s Willandra Weir
412039 Lachlan River at Hillston Weir
412078 Lachlan River at Whealbah
412087 Merrowie Creek at Merrowie Homestead
Merrowie Creek at modelled end of system (EOS)
412124 Muggabah Creek at Cobb Highway
Muggabah Creek at modelled EOS
412005 Lachlan River at Booligal
412045 Lachlan River at Corrong
412026 Lachlan River at Oxley
412122 Merrimajeel Creek at Cobb Highway

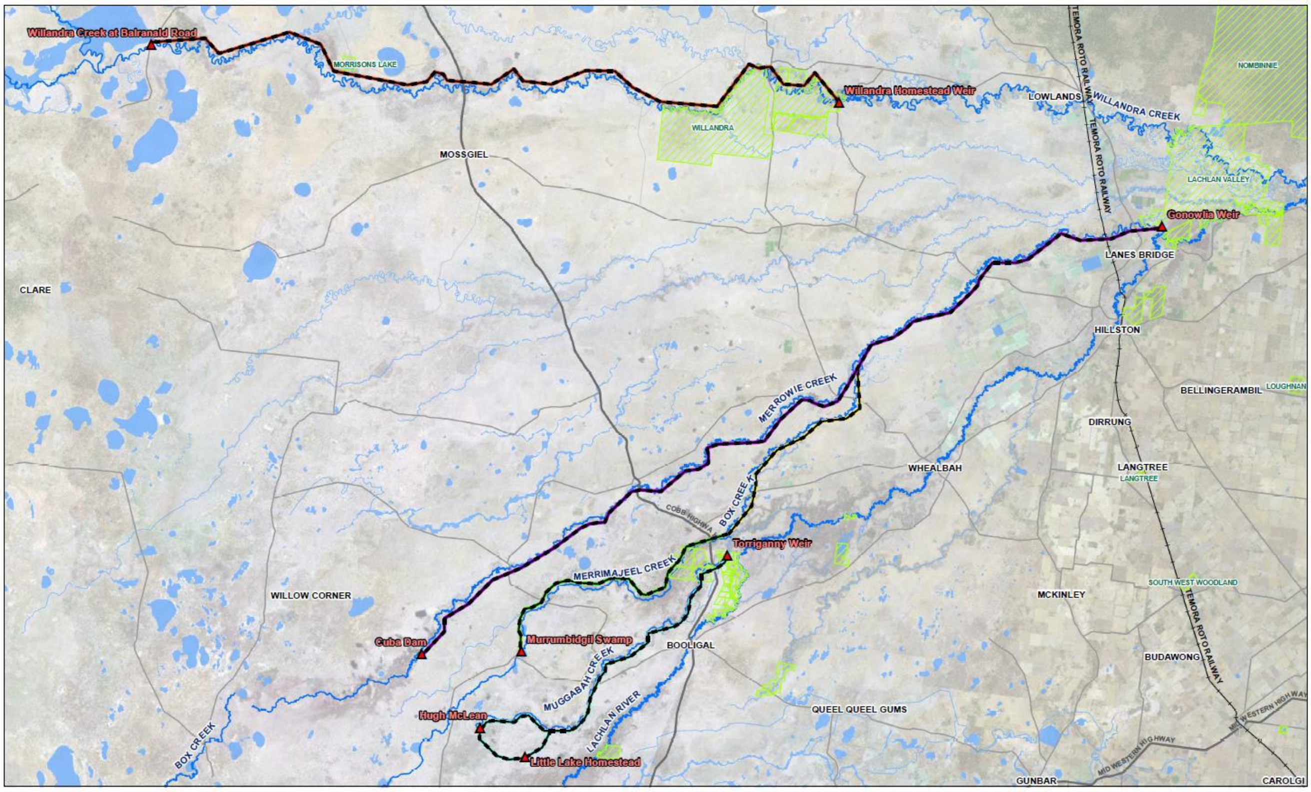
Lower Lachlan efficiency measures

Option description

Option 25 in the Draft Lachlan Regional Water Strategy assessed the construction of a piped scheme to deliver water more efficiently to landholders (including stock and domestic users) along the Muggabah, Merrimajeel, Merrowie, Booberoi and Willandra Creeks.

Each year up to 30,000 megalitres (ML) is set aside in Wyangala Dam to provide replenishment flows for landholders along Willandra, Merrowie, Muggabah and Merrimajeel Creeks (Figure 2).

Figure 2: Lower Lachlan Water Efficiency Options: Creek Locations (source: GHD, 2017)



The proposed measures would provide an alternative water delivery mechanism that includes pipeline supply from the Lachlan River as well as (potentially) alternative 'on-farm' supplies such as groundwater bores and on-farm infrastructure. Improvements on-farm could include efficient pumps, pipes, tanks and troughs – aimed at assisting in the reduction of demand on the Wyangala system and associated transmission losses, replenishment flow requirements and operational surpluses.

A potential means of realising the benefit of improved efficiency/reduced losses was assessed via the creation of 10,000 ML of additional High Security Entitlement (HSE), with an assumed associated offtake at Forbes for supply to Parkes. The volume of HSE created was based on maintaining supply performance for General Security Entitlement (GSE) and other users approximately at Base Case performance levels. Note that further assessment and option refinement would be required for finalisation of potential maximum HSE creation.

Model configuration and assumptions

Key Lower Lachlan efficiency scenario assumptions:

- In the Base Case model, Held Environmental Water (HEW) is used to provide flows to Merrimajeel, Muggabah, Merrowie and Willandra Creeks in addition to those provided by replenishment flows, suggesting that replenishment flows are maintained mostly for stock and domestics (S&D)/basic landholder rights (BLR).
- The IQQM model does not include an explicit simulation of S&D demand from these creeks. Information provided by Stantec GHD Joint Venture (SGJV)[7] suggested that piping the creeks' S&D demand could provide "a water saving of up to 24,000 ML/year" out of a total requirement of 30,000 ML/year, suggesting that the actual S&D requirements of the creeks' are (potentially) 6,000 ML/year. As an initial sensitivity-based assessment of potential benefits, an assumed 50% reduction in replenishment requirements was adopted - effectively assuming that, through the efficiency measures, 6,000 ML S&D demand met by allowance for 15,000 ML of replenishment.

Demands were implemented as per

[7] document 'W0067542W-GEN-REP-008'

- Table 7 below, simulated to be extracted directly from the offtake of each respective creek with demand patterns consistent with other S&D users in the system.
- Additional 10,000 ML HSE created, located at Forbes for supply to Parkes.
- In association with modified replenishment requirements and additional HSE, scheme resource assessment reserves were reduced accordingly (from 120,000 ML to 110,000 ML).

Table 7: Simulated share of assumed replenishment requirements and S&D demand

Creek	Replenishment (ML/year)		Proportion of total (%)	Assumed S&D (ML/year)
	Base Case	**Lower Lachlan efficiency measures**		
Willandra	12,000	6,000	40%	2,400
Merrimajeel	4,500	2,250	15%	900
Muggabah	4,500	2,250	15%	900
Merrowie	9,000	4,500	30%	1,800
Total	*30,000*	*15,000*	*100%*	*6,000*

Note that, as described in Section 3.2, no detailed consideration of the potential implications on Planned Environmental Water (PEW) and/or local (or wider) ecological effects was undertaken and option results should therefore be considered within this context.

Modelling results

Alteration in water diversions

Table 8 summarises average annual water diversions for existing users/uses. Results indicate:

- Small (< 0.5%) decrease in overall GSE diversions (including environmental GSE), indicating need for further refinement of volume of HSE created if option to be developed further.
- Approximately 8 GL/year increase (from 10.8 to 18.6 GL/year) in HSE diversions in association with additional entitlement created under option.

Table 8: Performance metrics (water diversions) (all values in GL/year)

Lachlan regulated system	**Base Case**	**Lower Lachlan efficiency measures**
General Security	154.9	154.5
Conveyance (JIL)	15.4	15.3
High Security	10.8	18.6
Town Water Supply	9.6	9.6
Stock and Domestic	4.2	4.2
GSE Environmental/HEW	50.7	50.5
HSE Environmental	2.3	2.3
Stock and Domestic Environmental	0.1	0.1
Mean annual total consumptive use	195.0	202.1
Mean annual total non-consumptive use	53.2	52.9
Mean annual total accounted use	248.1	255.1
Belubula regulated system		
General Security	1.9	1.9
High Security	1.0	1.0
Supplementary	0.9	0.9
Stock and Domestic	0.2	0.2

Lachlan regulated system	Base Case	Lower Lachlan efficiency measures
Total use	4.0	4.0
Belubula unregulated system		
Town Water Supply (CTW)	1.8	1.8

Figure 3 (below) shows simulated annual diversions/supply under GSE for Base Case and Option scenarios, indicating relatively small changes n GSE supply under the option scenario (0.4 GL/year average reduction from 154.9 GL/year to 154.5 GL/year).

Figure 4 illustrates comparative HSE supply/diversions under the Base Case and Option scenario, with the additional 10,000 ML of HSE assumed in the option scenario representing the difference.

Figure 5 shows annual usage of environmental/non-consumptive entitlements under Base Case and Option scenarios, indicating relatively small changes in supply under the option scenario (0.3 ML/year average reduction from 53.2 GL/year to 52.9 GL/year).

Figure 3: Simulated GSE water diversions

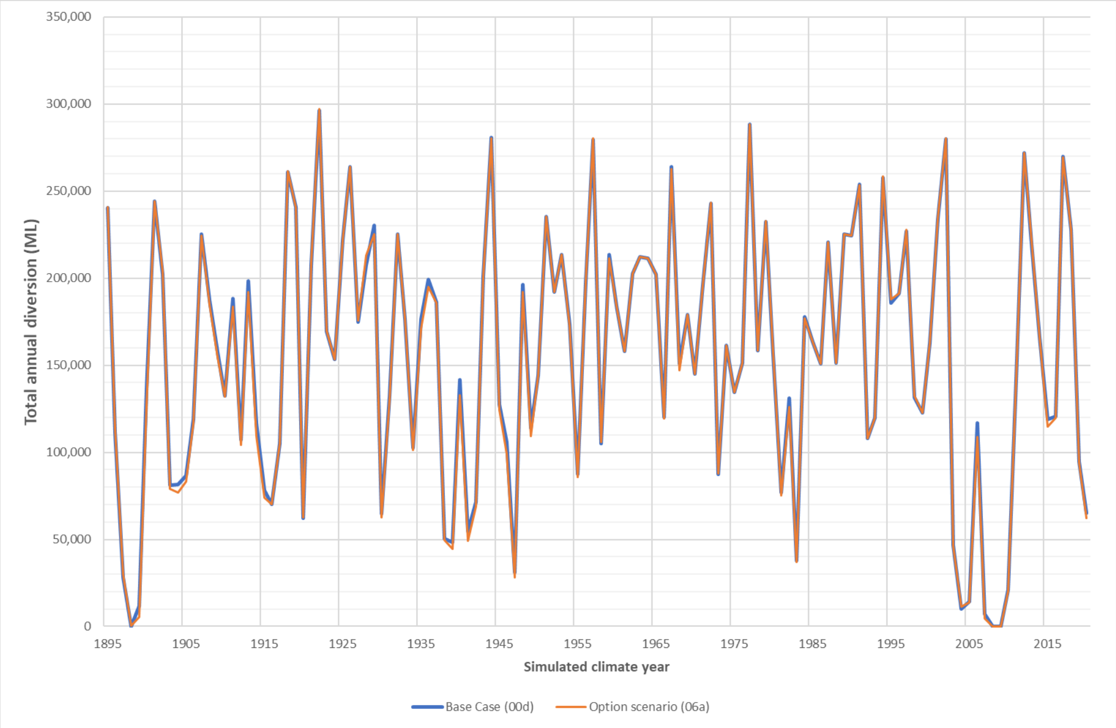
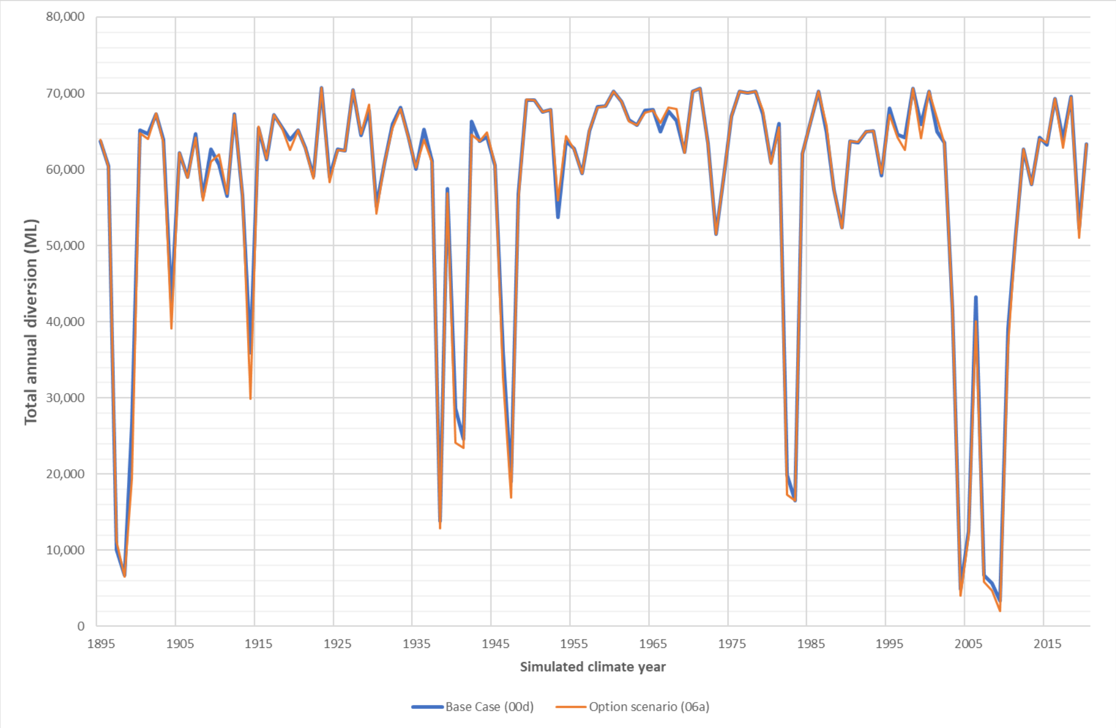


Figure 4: Simulated HSE water diversions (inc. JIL conveyance)

Figure 5: Simulated HEW usage (GSE, HSE & SD)



Alteration in rules based Planned Environmental Water (PEW)

Environmental water rules for the Lachlan River water source are defined within the water sharing plan and comprise:

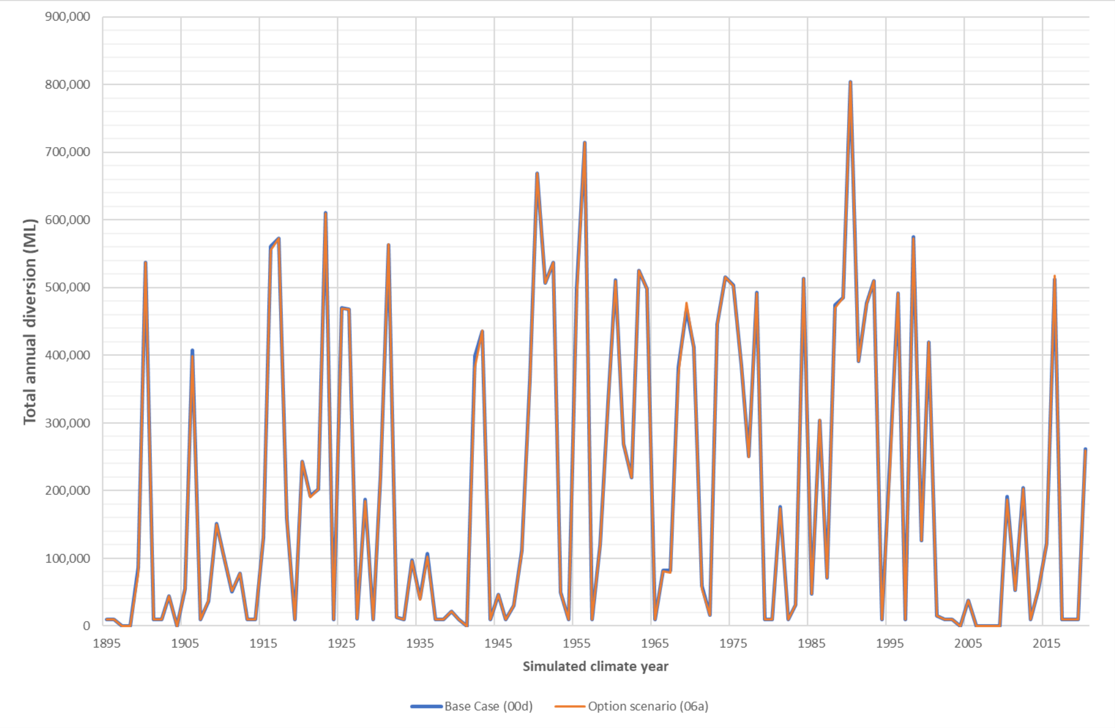
- environmental flow rules for translucency flows (flow dependent)
- environmental water allowances (up to 10,000 ML per year)
- water quality allowance (up to 20,000 ML per year).

Table 9 summarises average annual simulated usage for rules-based PEW under the Base Case and Option scenarios, while Figure 6 illustrates simulated annual supply to rules-based PEW. Results show a small (< 0.5%) decrease in total rules-based PEW, indicating the need for further refinement of option detail regarding translucency and potentially other scheme operational rules if the option is to be developed further.

Table 9: Performance metrics (rules-based PEW) (all values in GL/year)

Lachlan regulated system	Base Case	Lower Lachlan efficiency measures
Wyangala Translucency	184.6	183.6
Wyangala Environmental Water Allowance	4.6	4.6
Brewster Environmental Water Allowance	4.6	4.6
Water Quality Allowance	6.8	6.8
Total rules-based PEW	**200.5**	**199.5**

Figure 6: Simulated rules-based PEW (GSE, HSE & SD)



Alteration in allocation reliability

Changes in end of year allocation outcomes for GSE and HSE are shown in Table 10 for the Base Case and Option scenario. Results indicate:

- No material change in GSE allocation outcomes.
- Small (approximately1.5%) reduction in the number of years in which HSE allocation reached 100% by 30 June.

The results also indicate no change in Belubula regulated system outcomes. Difference in annual GSE available water determination outcomes under Base Case and Option scenarios are illustrated in Figure 7 (Lachlan scheme) and Figure 8 (Belubula scheme)

Table 10: Performance metrics (allocation reliability)

Allocation outcomes	Base Case	Lower Lachlan efficiency measures
Lachlan regulated system		
% of years effective allocation for GS at 30 June >= 100%	64.3%	64.3%
Average effective allocation for GS at 30 June	113%	113%

Allocation outcomes	Base Case	Lower Lachlan efficiency measures
% of years HS allocation 100% at 30 June	97.6%	96.0%
Belubula regulated system		
Total available GSE on 1st July (%) (inc. carry-over)	50.2%	50.2%
GSE added throughout year (%)	16.6%	16.6%
Mean 1st July HSE share per unit (%)	84.1%	84.1%
Mean 30th June HSE share per unit (%)	96.0%	96.0%

Figure 7: End of water year Lachlan GSE effective allocation

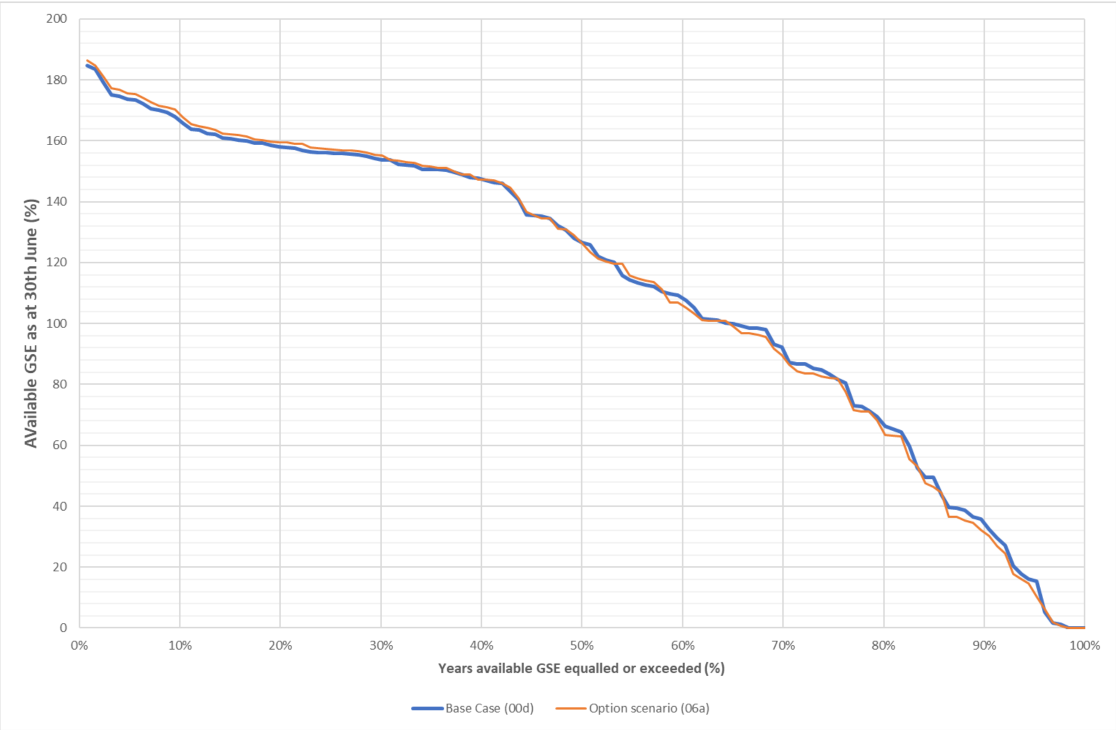
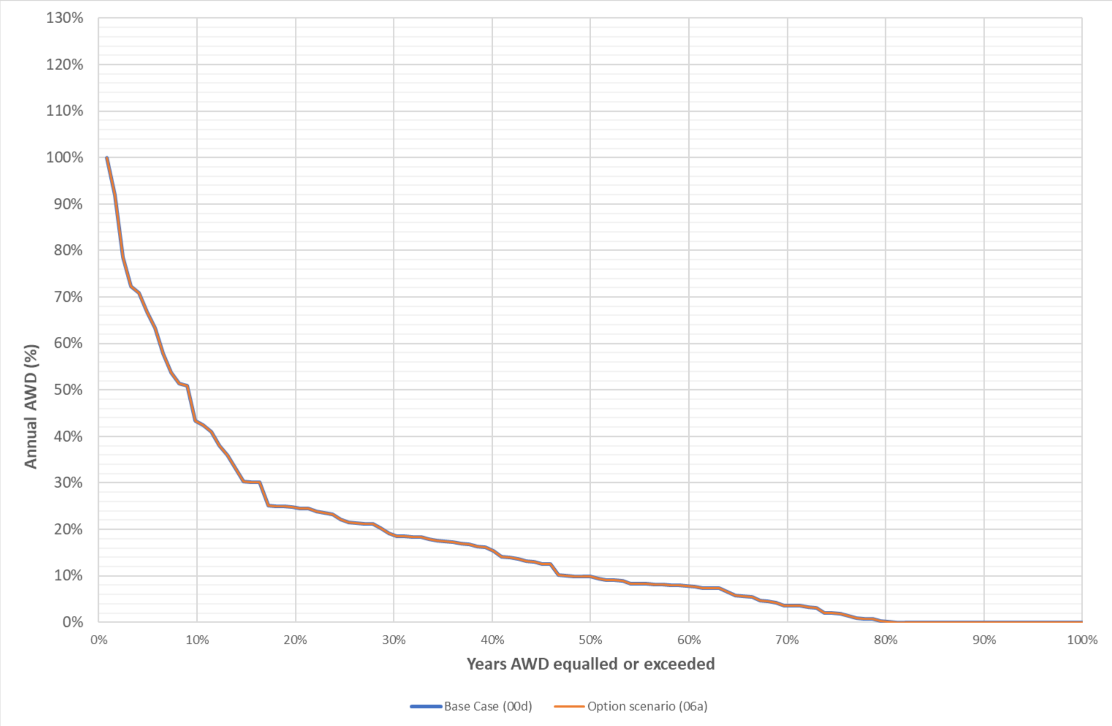


Figure 8: Ranked full year Belubula GSE available water determinations



Alteration in storage behaviour

Storage behaviour outcomes for Wyangala Dam, Lake Brewster and Lake Cargelligo in the Lachlan, as well as Carcoar Dam and Lake Rowland in the Belubula catchment, are summarised in Table 11. Simulated storage behaviour is shown in Figure 9 to Figure 13. Results indicate relatively minor change in overall storage behaviour between Base Case and Option scenarios, except for indications of increased drawdown of Wyangala Dam at low storage volumes, due to the influence of increased HSE and associated ongoing supply under depleted storage conditions. Modelling shows that the option results in Wyangala Dam drawing down more frequently than in the Base Case, indicating that the total savings in efficiency under option assumptions are less than additional usage under created HSE. This again illustrates the need for further option assessment and refinement should the option be developed further, while Lake Brewster and Lake Cargelligo show small (<0.5%) increases in drawdown frequency).

Table 11: Performance metrics (storage behaviour)

Storage	Base Case	Lower Lachlan efficiency measures
Wyangala (% days active storage falls below at least once)		
< 300 GL	9.8%	11.2%

Storage	Base Case	Lower Lachlan efficiency measures
< 250 GL	6.6%	8.5%
< 210 GL	4.3%	5.9%
< 145 GL	1.8%	2.9%
< 105 GL	0.3%	1.5%
< 90 GL	0.1%	1.1%
< 80 GL	0.0%	0.7%
< 65 GL	0.0%	0.2%
Lake Brewster (% days active storage falls below at least once)		
< 75% (109 GL)	76.1%	76.6%
< 50% (73 GL)	67.0%	67.2%
< 25% (36 GL)	55.6%	55.9%
< 10% (14.5 GL)	43.3%	43.6%
< 5% (7.3 GL)	31.4%	32.2%
Lake Cargelligo (% days active storage falls below at least once)		
< 75% (32 GL)	32.1%	32.5%
< 50% (21.5 GL)	2.7%	2.9%
< 25% (10.8 GL)	0.0%	0.0%
< 10% (4.3 GL)	0.0%	0.0%
< 5% (2.2 GL)	0.0%	0.0%
Carcoar Dam (% days active storage falls below at least once)		
< 75% (27 GL)	74.2%	74.2%
< 50% (18 GL)	50.8%	50.8%
< 25% (9 GL)	29.7%	29.7%
< 10% (3.6 GL)	18.4%	18.4%
< 5% (1.8 GL)	12.8%	12.8%
Lake Rowlands (% days active storage falls below at least once)		

Storage	Base Case	Lower Lachlan efficiency measures
< 75% (3.4 GL)	33.0%	33.0%
< 50% (2.3 GL)	8.0%	8.0%
< 25% (1.1 GL)	0.8%	0.8%
< 10% (0.5 GL)	0.0%	0.0%
< 5% (0.2 GL)	0.0%	0.0%

Figure 9: Wyangala Dam storage behaviour

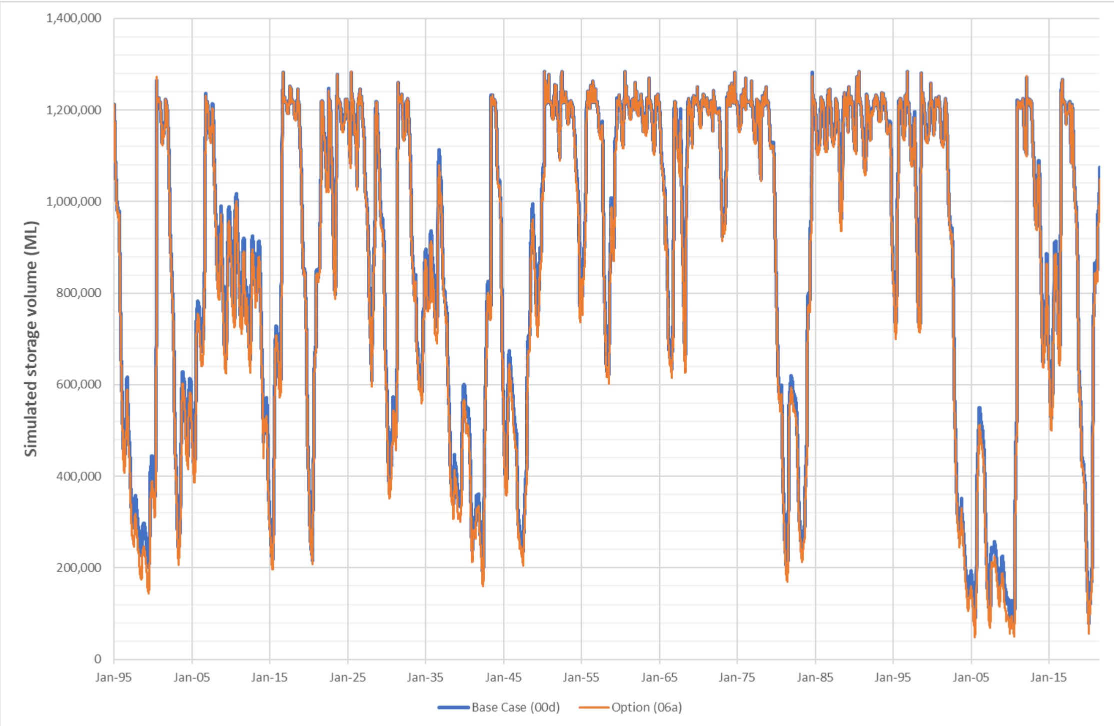


Figure 10: Lake Brewster storage behaviour

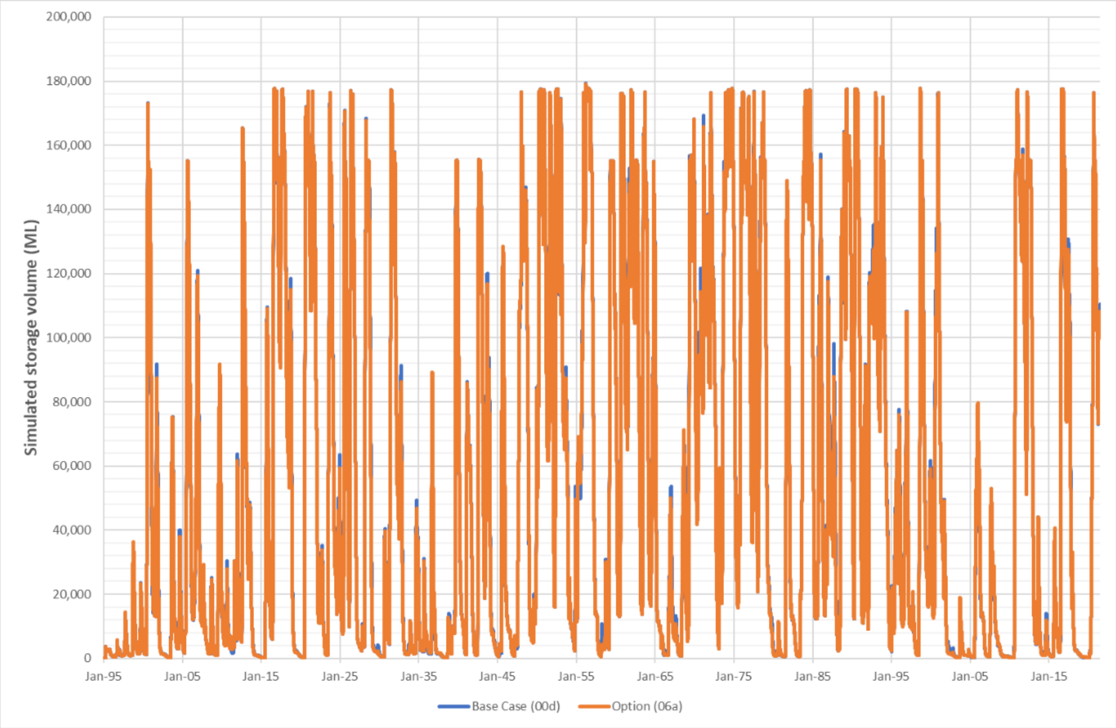


Figure 11: Lake Cargelligo storage behaviour

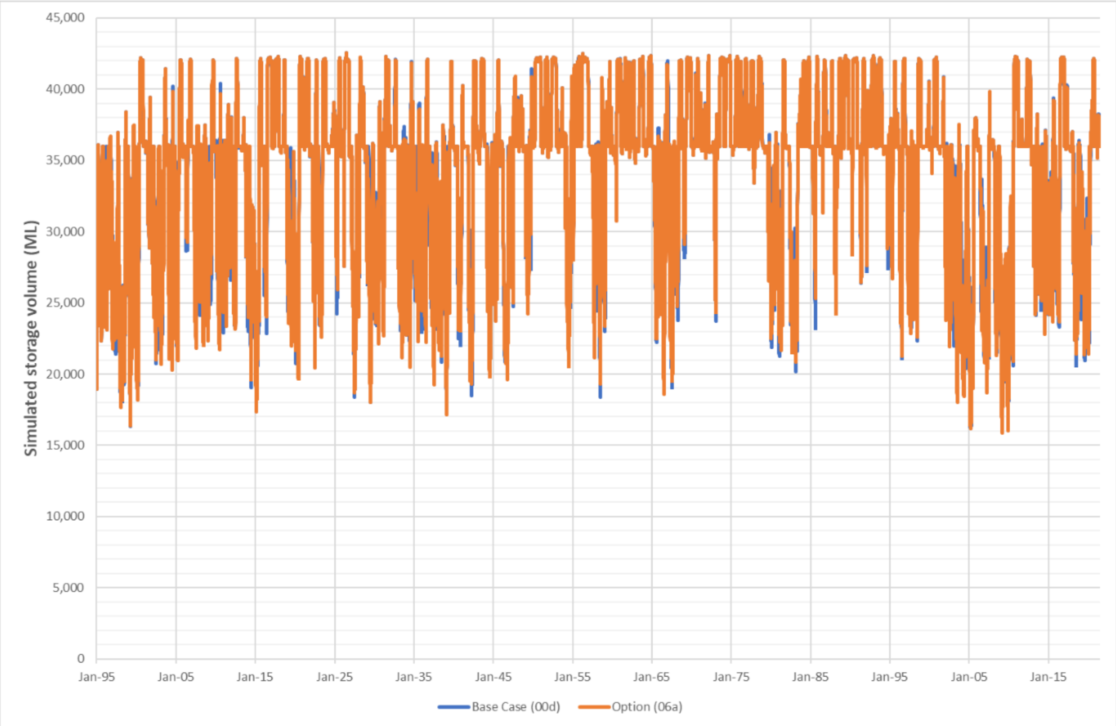


Figure 12: Carcoar Dam storage behaviour

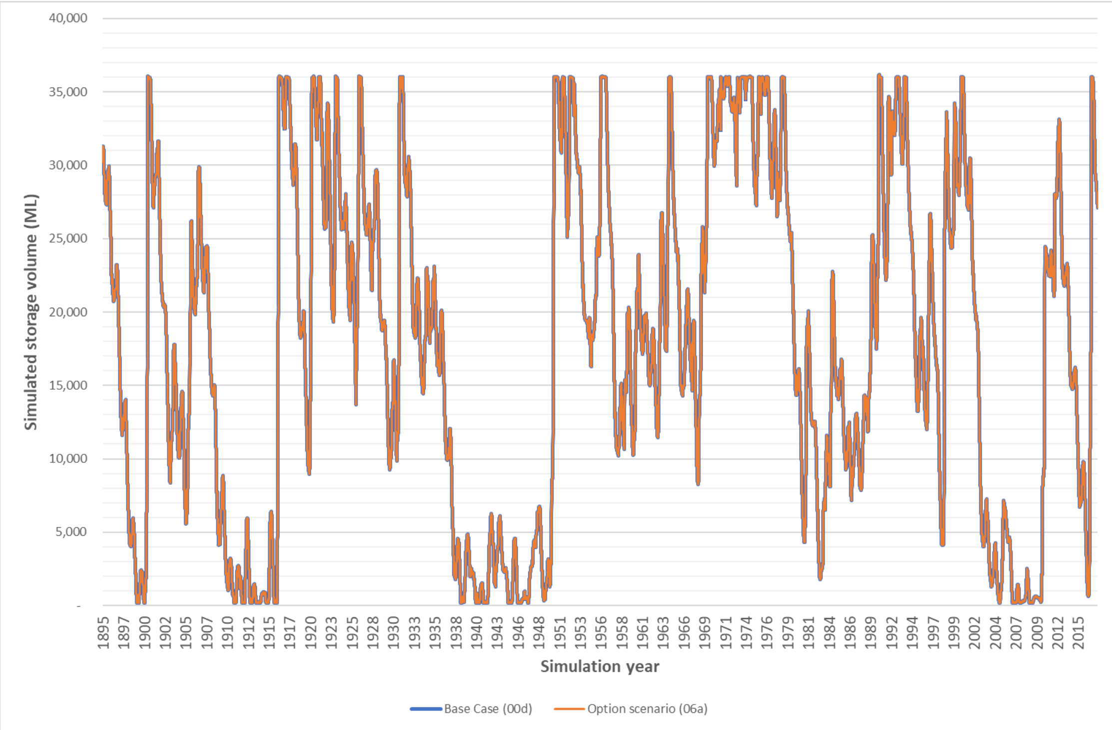
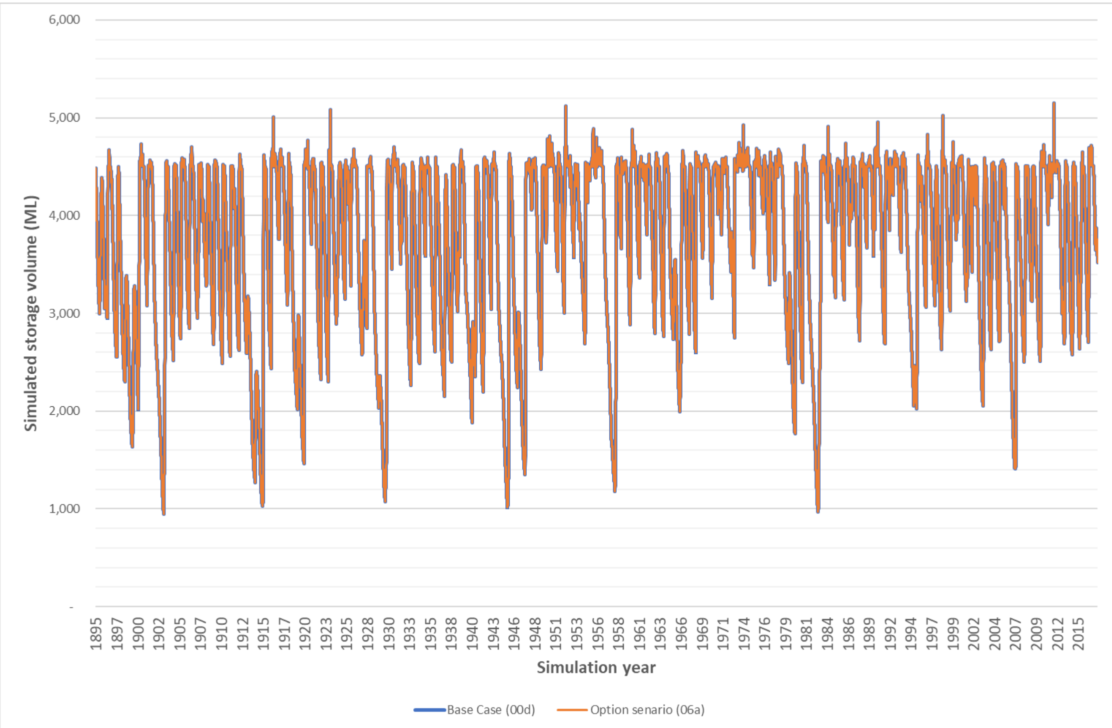


Figure 13: Lake Rowland storage behaviour



Town water supply

Table 12 summarises the modelled town water supply outcomes. Results show a decrease in Local Water Utility (LWU) entitlement performance for most town water supply schemes, indicating that total savings in efficiency under option assumptions are less than additional usage under created HSE and the need for further assessment and option refinement should the option be developed further.

Table 12: Town water supply performance

Town water supply	Base Case	Lower Lachlan efficiency measures
Cowra		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%
Average water supplied GL/year	2.84	2.83
Average water supplied as % of full demand	99.3%	98.7%
Forbes		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%
Average water supplied GL/year	2.20	2.18
Average water supplied as % of full demand	99.3%	98.7%
Parkes		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	31.2%	31.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%

Town water supply	Base Case	Lower Lachlan efficiency measures
Average water supplied GL/year	4.16	4.16
Average water supplied as % of full demand	99.4%	99.4%
Condobolin		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%
Average water supplied GL/year	0.95	0.95
Average water supplied as % of full demand	99.3%	98.8%
Lake Cargelligo		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%
Average water supplied GL/year	0.40	0.40
Average water supplied as % of full demand	99.1%	98.6%
Willandra		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%
Average water supplied GL/year	0.11	0.11
Average water supplied as % of full demand	99.1%	98.6%
Hillston		
% of time full demand not supplied (i.e. some form of restrictions would be in place),	3.3%	4.6%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.1%

Town water supply	Base Case	Lower Lachlan efficiency measures
Average water supplied GL/year	0.27	0.27
Average water supplied as % of full demand	99.1%	98.6%

Alteration in river flows

Changes in the flow regime resulting from the proposed stormwater harvesting are shown for selected locations in Table 13, with annual flow exceedance curves for selected gauging stations in below in Figure 14 to Figure 16.

Option results show a relatively minor change in the distribution of flows throughout the upper and lower valley, with slightly increased (< 0.1%) long-term average flows in the upper reaches upstream of Forbes and slightly reduced (< 0.1%) flows at downstream locations (due to the location of the additional 10,000 ML of HSE at Forbes), with the generally minor nature of flow regime change illustrated in Figure 14 to Figure 16.

Table 13: Performance metrics (river flows)

Mean annual flow (GL/year)	Base Case	Lower Lachlan efficiency measures
412033 - Belubula River at Helensholme	139.7	139.7
412027 - Lachlan River at Reids Flat	358.4	358.4
412067 - Lachlan River at Wyangala	678.2	678.8
412002 - Lachlan River at Cowra'	832.2	832.6
412057 - Lachlan River at Nanami	1039.0	1039.7
412004 - Lachlan River at Forbes	1015.5	1007.7
412019 - Island Ck at Cadow	400.0	396.9
412023 – Island Ck at Fairholme	399.4	396.3
412017 – Bumbuggan Creek at offtake	149.2	148.3
412014 – Goobang Creek at Condobolin	202.3	201.5
412016 - Wallamundry Creek at Offtake Island Creek	81.1	80.5

Mean annual flow (GL/year)	Base Case	Lower Lachlan efficiency measures
412034 - Lachlan River at Condobolin Weir	744.4	739.3
412021 - Lachlan River at Booberoi Weir	731.1	726.0
412011 - Lachlan River at Lake Cargelligo Weir	561.0	557.8
Combined flow at 412102 - Lake Brewster Intake D/S Lake B. Weir Pool Regulator And 412048 - Lachlan River at Lake Brewster Weir-Storage Gauge	700.1	695.3
412038 - Lachlan River U/S Willandra Weir	584.0	579.9
412039 - Lachlan River at Hillston Weir	382.0	379.3
412078 - Lachlan River at Whealbah	354.9	352.4
412087 - Merrowie Ck at Merrowie Homestead	69.7	69.1
Merrowie Creek modelled EOS	3.4	3.4
412124 - Muggabah Ck at Cobb Hwy	5.3	5.3
Muggabah Creek modelled EOS	5.0	5.0
412005 – Lachlan River at Booligal	205.2	203.7
412045 – Lachlan River at Corrong	139.7	138.7
412026 – Lachlan River at Oxley	115.5	114.5
412122 - Merrimajeel Ck at Cobb Hwy	5.8	5.8
Total model EOS flow	183.9	182.4

Figure 14: Annual flow exceedance – Lachlan River at Forbes (412004)

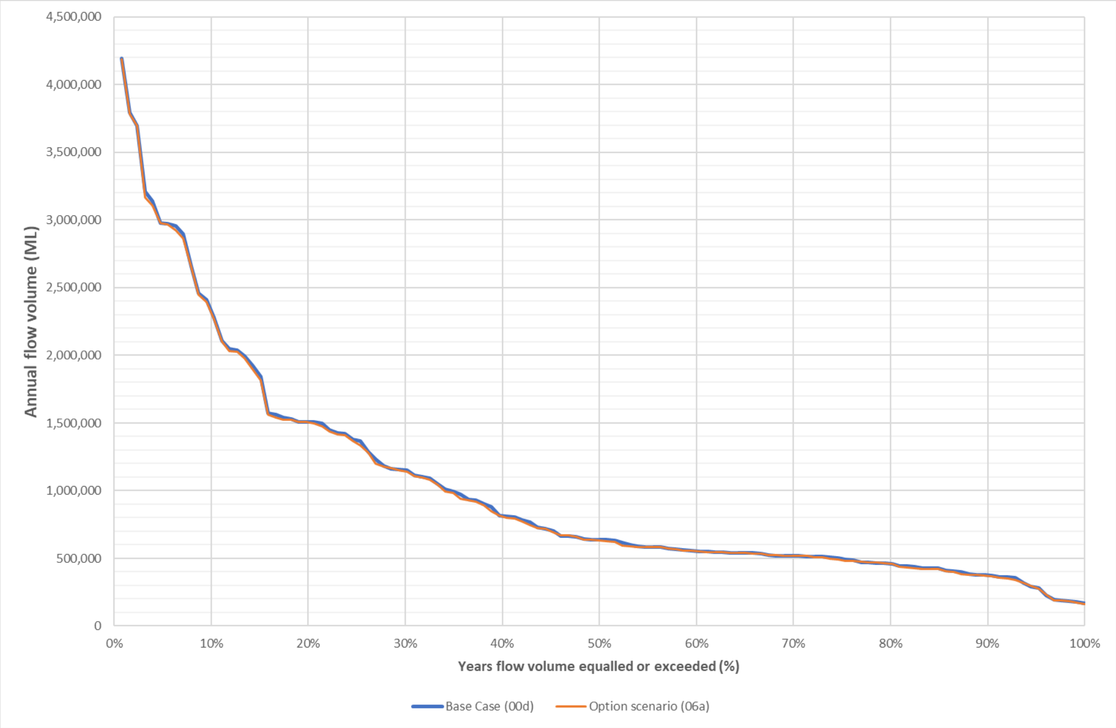


Figure 15: Annual flow exceedance – Lachlan River at Booligal (412005)

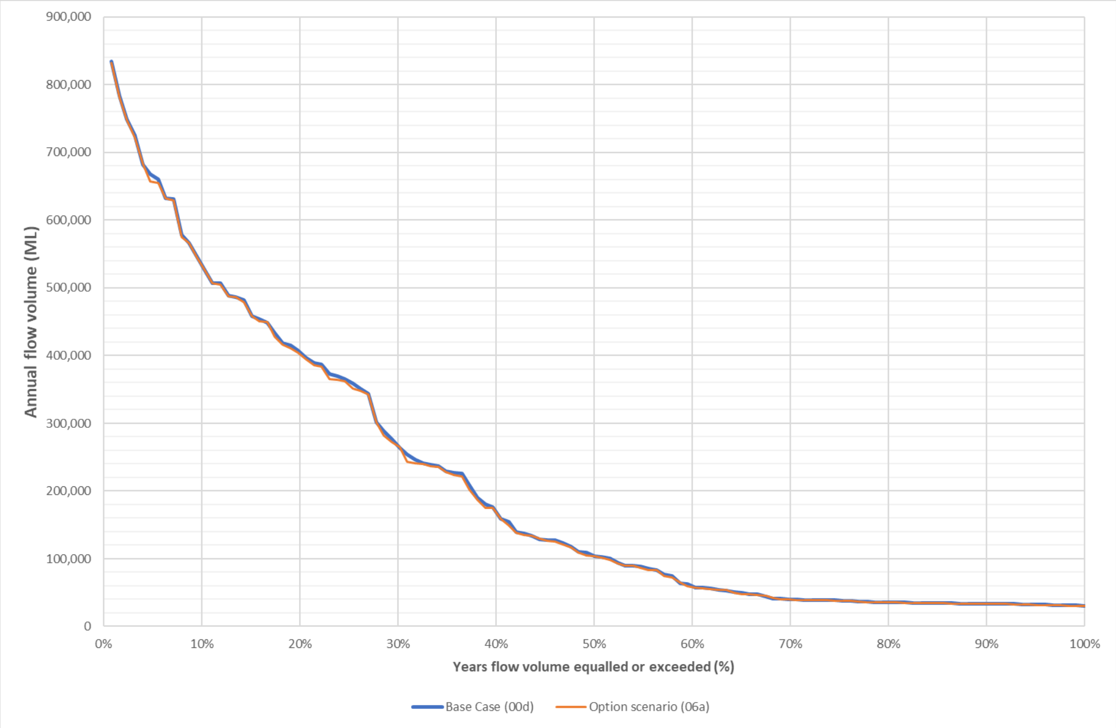
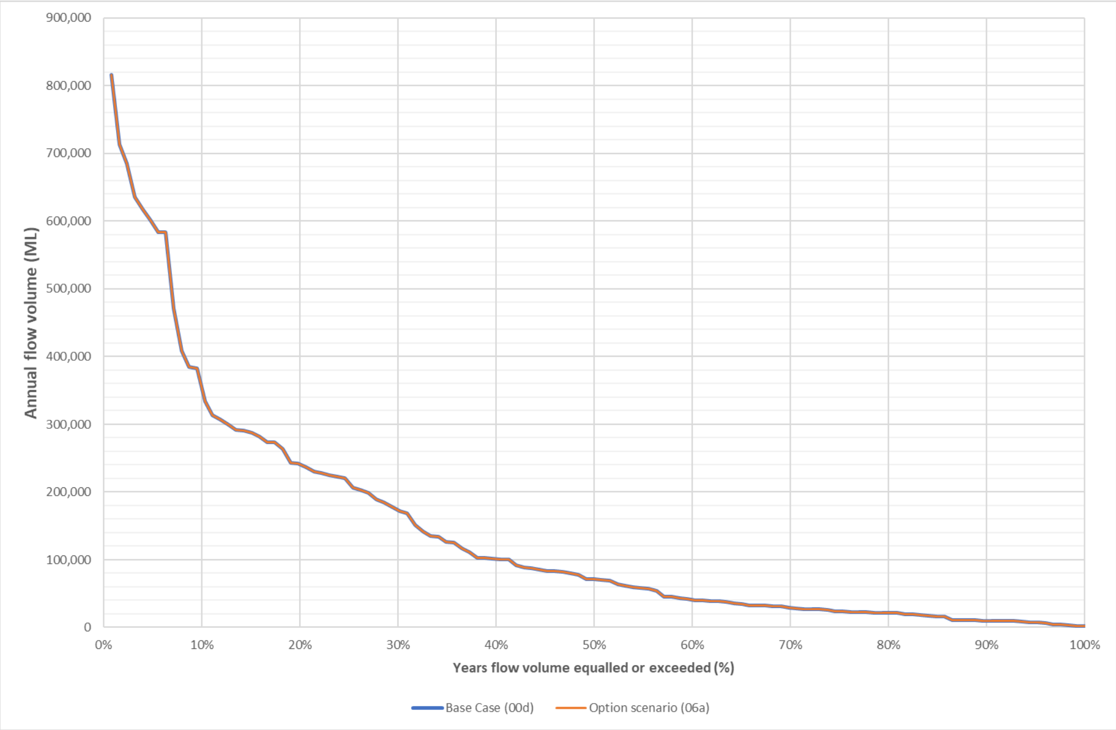


Figure 16: Annual flow exceedance – Belubula River at Helensholme (412033)



Review of water accounting and allocation processes

Option description

Option 34 investigated whether increasing the take account limit (i.e. maximum volume allowed to be accessed in any single water year) could enable some 'highly geared' users to access more water in some years - i.e. those with existing infrastructure able to support an increase in water use during high water availability years.

Model configuration and assumptions

Model configuration for Option 34 comprised increase of annual take limit from 1 ML/day to 1.1 ML/share for all GSE users. No other changes to model configuration where made.

Modelling results

Alteration in water diversions

Table 14 summarises average annual water diversions for existing users/uses. Results show a relatively small (< 0.5%) increase in GSE diversions and no other material change in usage, with illustration of this minor change in usage under GSE, HSE and HEW shown in Figure 17, Figure 18 and Figure 19, respectively.

Table 14: Performance metrics (water diversions) (all values in GL/year)

Lachlan regulated system	**Base Case**	**Increased annual take limit**
General Security	154.9	155.4
Conveyance (JIL)	15.4	15.4
High Security	10.8	10.8
Town Water Supply	9.6	9.6
Stock and Domestic	4.2	4.2

Lachlan regulated system	**Base Case**	**Increased annual take limit**
GSE Environmental/HWE	50.7	50.7
HSE Environmental	2.3	2.3
Stock and Domestic Environmental	0.1	0.1
Total consumptive use	195.0	195.5
Total non-consumptive use	53.2	53.1
Total accounted use	**248.1**	**248.6**
Belubula regulated system		
General Security	1.9	1.9
High Security	1.0	1.0
Supplementary	0.9	0.9
Stock and Domestic	0.2	0.2
Total use	4.0	4.0
Belubula unregulated system		
Town Water Supply (CTW)	1.8	1.8

Figure 17: Simulated GSE water diversions

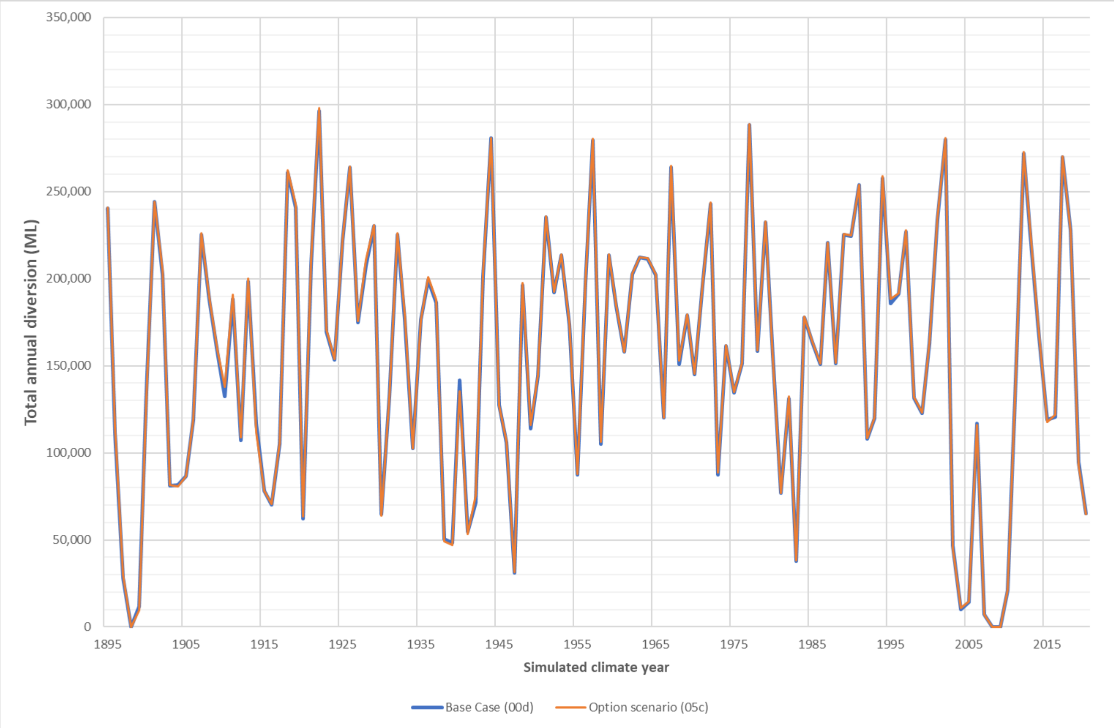


Figure 18: Simulated HSE water diversions (inc. JIL conveyance)

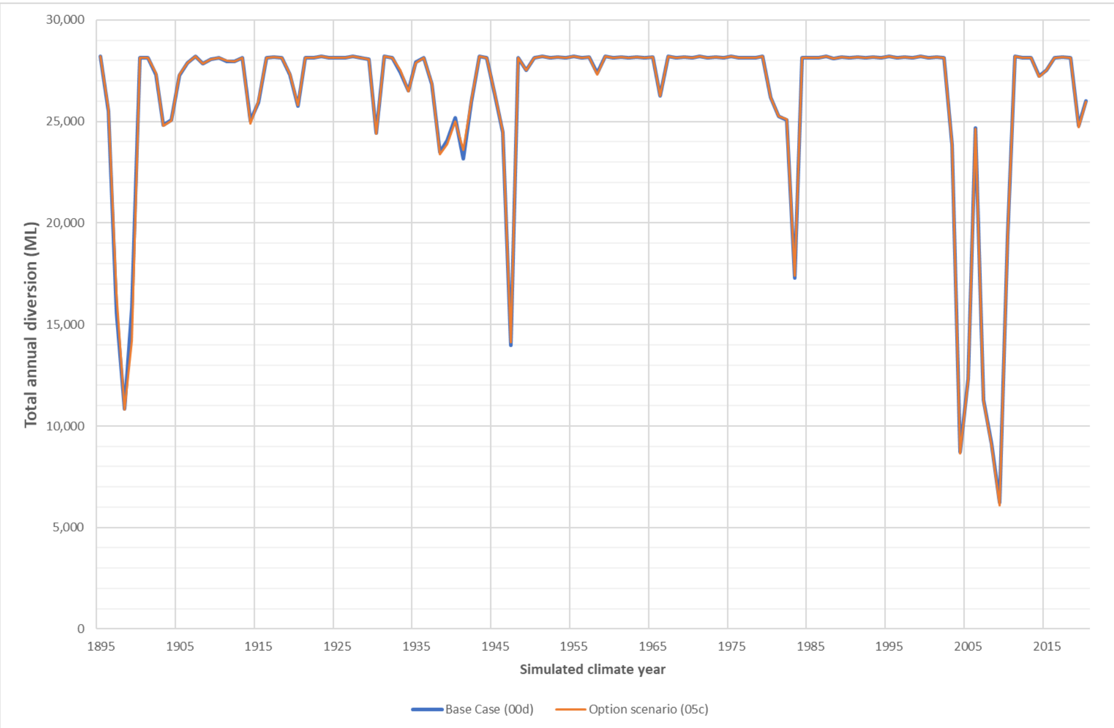
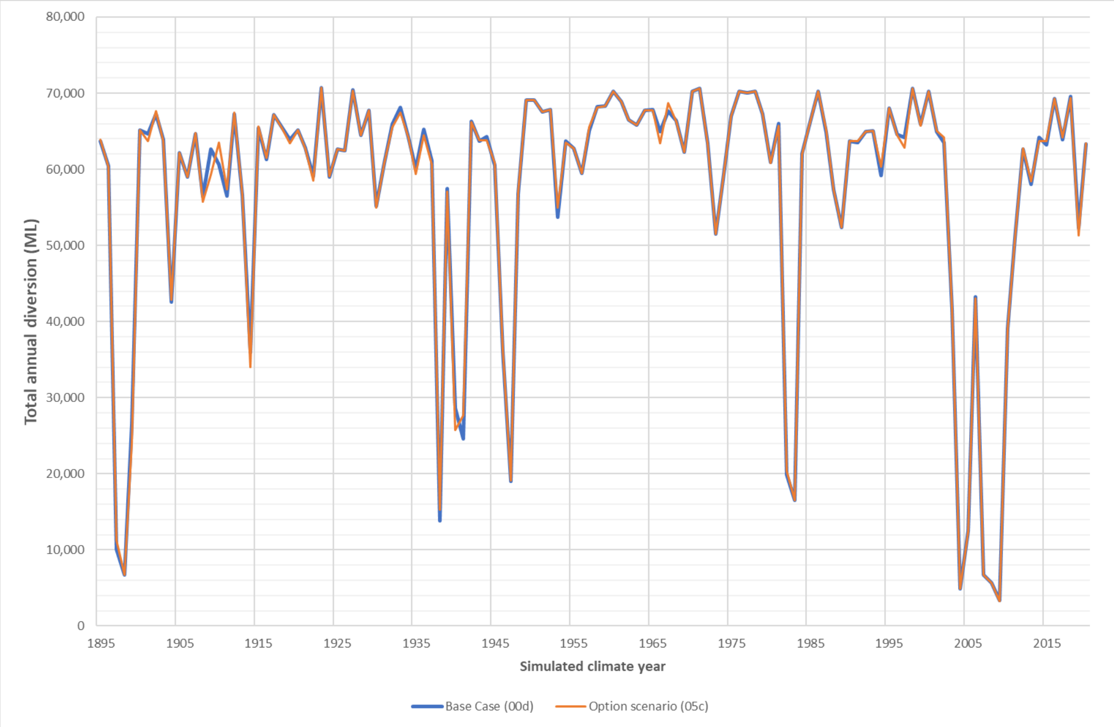


Figure 19: Simulated HEW usage (GSE, HSE & SD)



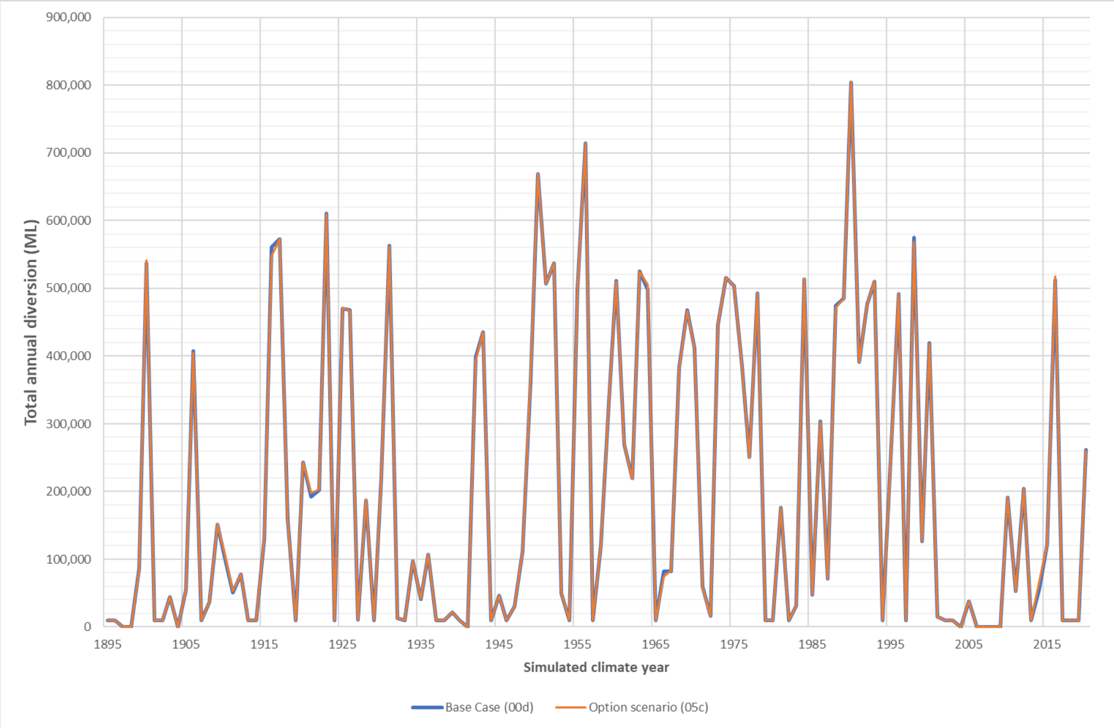
Alteration in rules based PEW

Table 15 summarises average annual simulated usage for rules-based PEW. Results show a very small change (< 0.1%) in translucency flows, with comparative annual volumes shown in Figure 20., Whilst this is a very small change, it indicates a net adverse impact under the adopted option assumptions and the need for further assessment and option refinement should the option be developed further.

Table 15: Performance metrics (rules-based PEW) (all values in GL/year)

Lachlan regulated system	Base Case	Increased annual take limit
Wyangala Translucency	184.6	184.5
Wyangala Environmental Water Allowance	4.6	4.6
Brewster Environmental Water Allowance	4.6	4.6
Water Quality Allowance	6.8	6.8
Total rules-based PEW	**200.5**	**200.4**

Figure 20: Simulated rules-based PEW (GSE, HSE & SD)



Alteration in allocation reliability

Changes in end of year allocation outcomes are shown in Table 16 for the Base Case and Option scenarios. Results show slight increase (about 1%) in average end of water year effective Lachlan regulated system GSE allocation (shown also in Figure 21) and no change on HSE allocation outcomes.

Table 16: Performance metrics (allocation reliability)

Allocation outcomes	Base Case	Increased annual take limit
Lachlan regulated system		
% of years effective allocation for GS at 30 June >= 100%	64.3%	65.9%
Average effective allocation for GS at 30 June	113%	114%
% of years HS allocation 100%	97.6%	97.6%
Belubula regulated system		
Total available GSE on 1st July (%) (inc. carry-over)	50.2%	50.2%
GSE added throughout year (%)	16.6%	16.6%

Mean 1st July HSE share per unit (%)	84.1%	84.1%
Mean 30th June HSE share per unit (%)	96.0%	96.0%

Figure 21: End of water year Lachlan GSE effective allocation

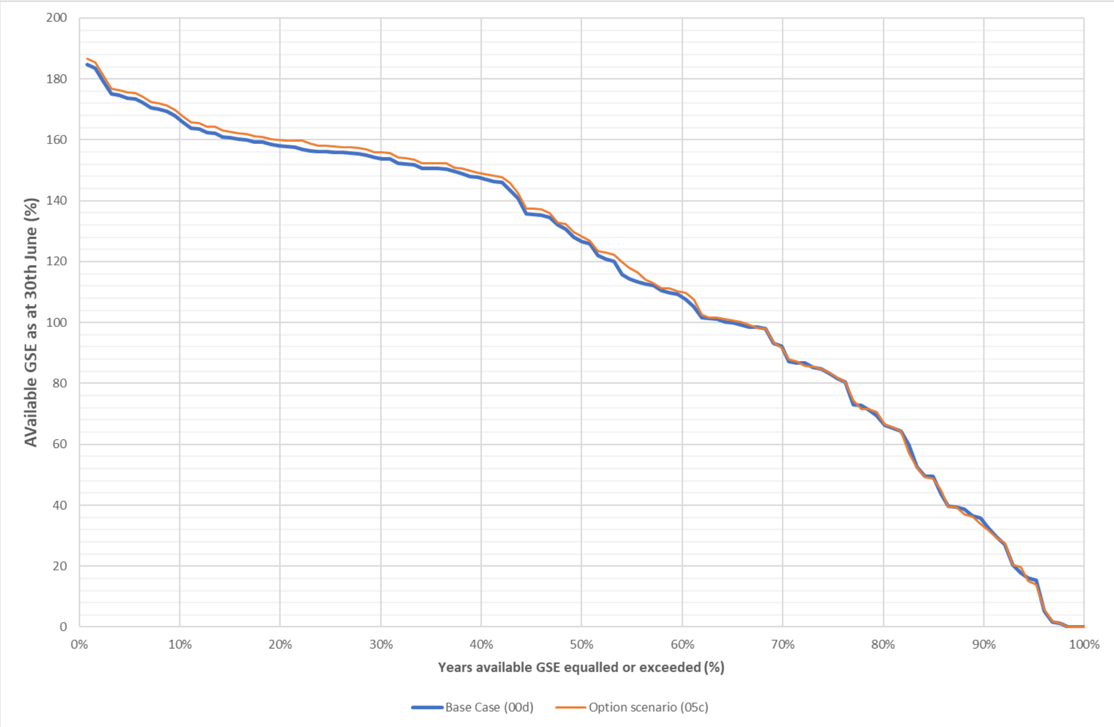
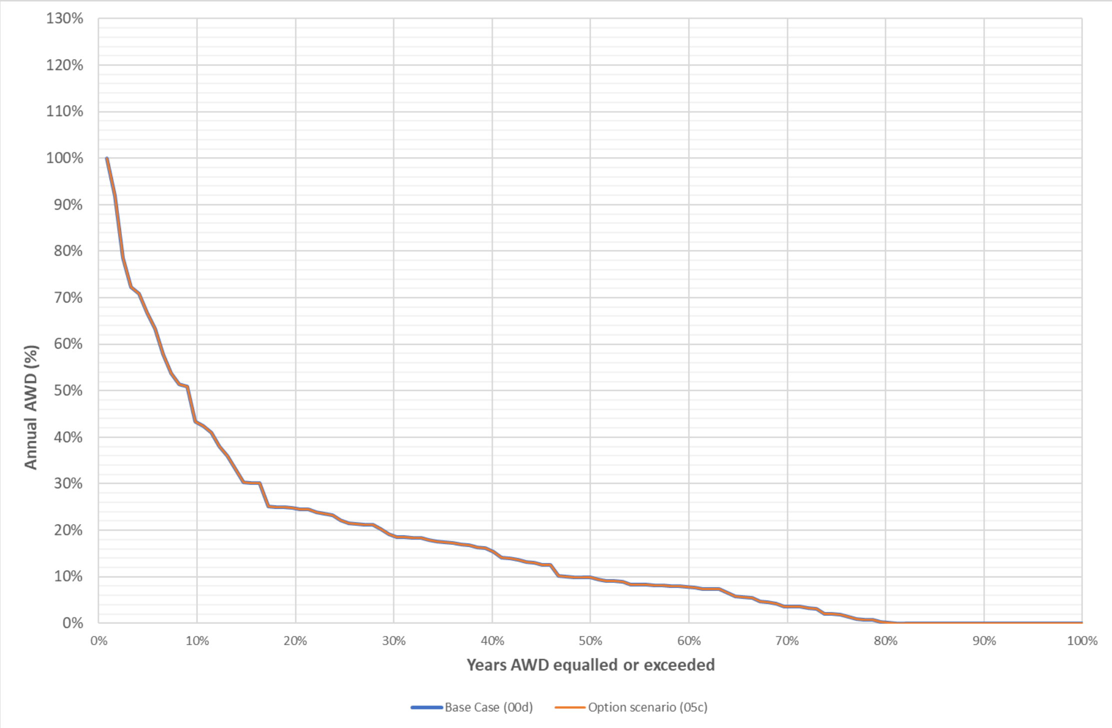


Figure 22: Ranked full year Belubula GSE available water determinations



Alteration in storage behaviour

Storage behaviour outcomes for Wyangala Dam, Lake Brewster and Lake Cargelligo in the Lachlan, as well as Carcoar Dam and Lake Rowland in the Belubula catchment, are summarised in Table 17 with simulated behaviour illustrated in the figures below.

Results indicate that under this option, Wyangala Dam draws down a little more frequently (< 0.5%) than under Base Case conditions, with no material effect on other storage behaviours.

Table 17: Performance metrics (storage behaviour)

Storage	Base Case	Increased annual take limit
Wyangala (% days active storage falls below at least once)		
< 300 GL	9.8%	10.0%
< 250 GL	6.6%	6.7%
< 210 GL	4.3%	4.3%
< 145 GL	1.8%	1.9%
< 105 GL	0.3%	0.5%
< 90 GL	0.1%	0.1%
< 80 GL	0.0%	0.0%

Storage	Base Case	Increased annual take limit
< 65 GL	0.0%	0.0%
Lake Brewster (% days active storage falls below at least once)		
< 75% (109 GL)	76.1%	76.1%
< 50% (73 GL)	67.0%	67.0%
< 25% (36 GL)	55.6%	55.6%
< 10% (14.5 GL)	43.3%	43.3%
< 5% (7.3 GL)	31.4%	31.6%
Lake Cargelligo (% days active storage falls below at least once)		
< 75% (32 GL)	32.1%	32.0%
< 50% (21.5 GL)	2.7%	2.9%
< 25% (10.8 GL)	0.0%	0.0%
< 10% (4.3 GL)	0.0%	0.0%
< 5% (2.2 GL)	0.0%	0.0%
Carcoar Dam (% days active storage falls below at least once)		
< 75% (27 GL)	74.2%	74.2%
< 50% (18 GL)	50.8%	50.8%
< 25% (9 GL)	29.7%	29.7%
< 10% (3.6 GL)	18.4%	18.4%
< 5% (1.8 GL)	12.8%	12.8%
Lake Rowlands (% days active storage falls below at least once)		
< 75% (3.4 GL)	33.0%	33.0%
< 50% (2.3 GL)	8.0%	8.0%
< 25% (1.1 GL)	0.8%	0.8%
< 10% (0.5 GL)	0.0%	0.0%
< 5% (0.2 GL)	0.0%	0.0%

Figure 23: Wyangala Dam storage behaviour

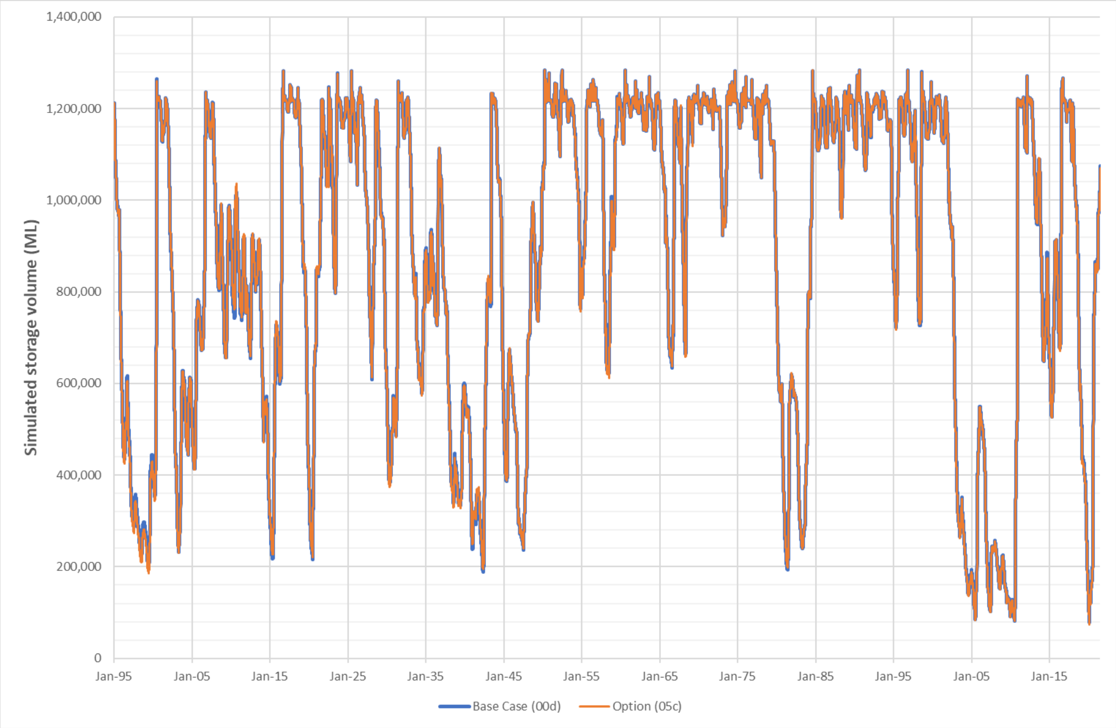


Figure 24: Lake Brewster storage behaviour

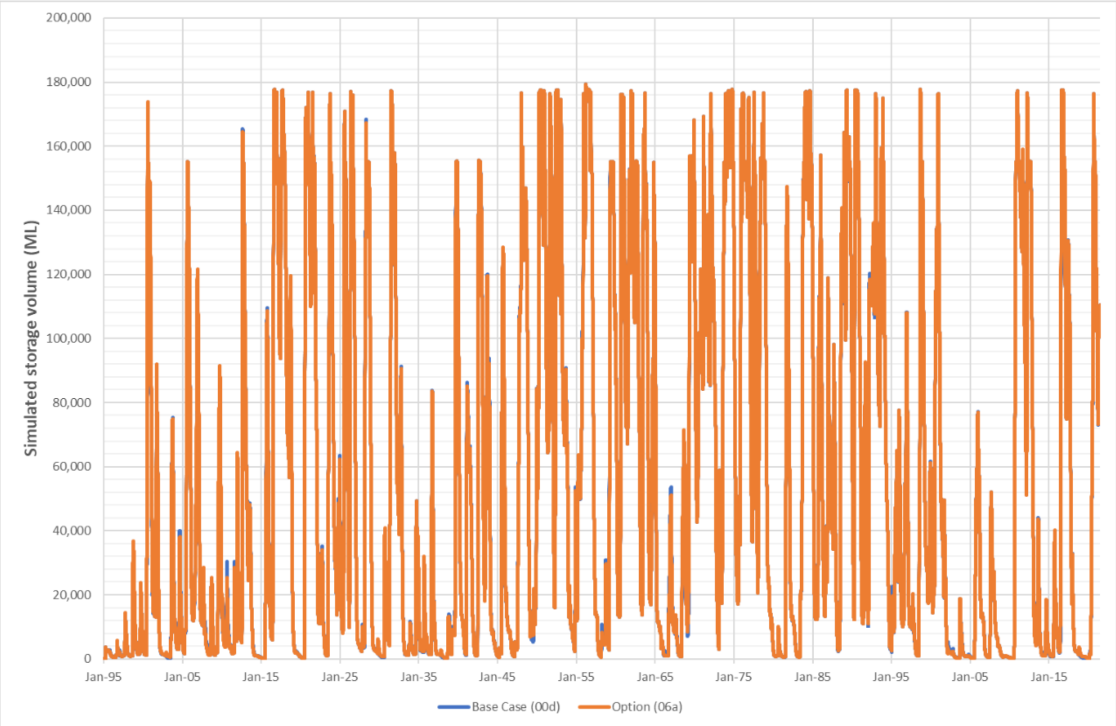


Figure 25: Lake Cargelligo storage behaviour

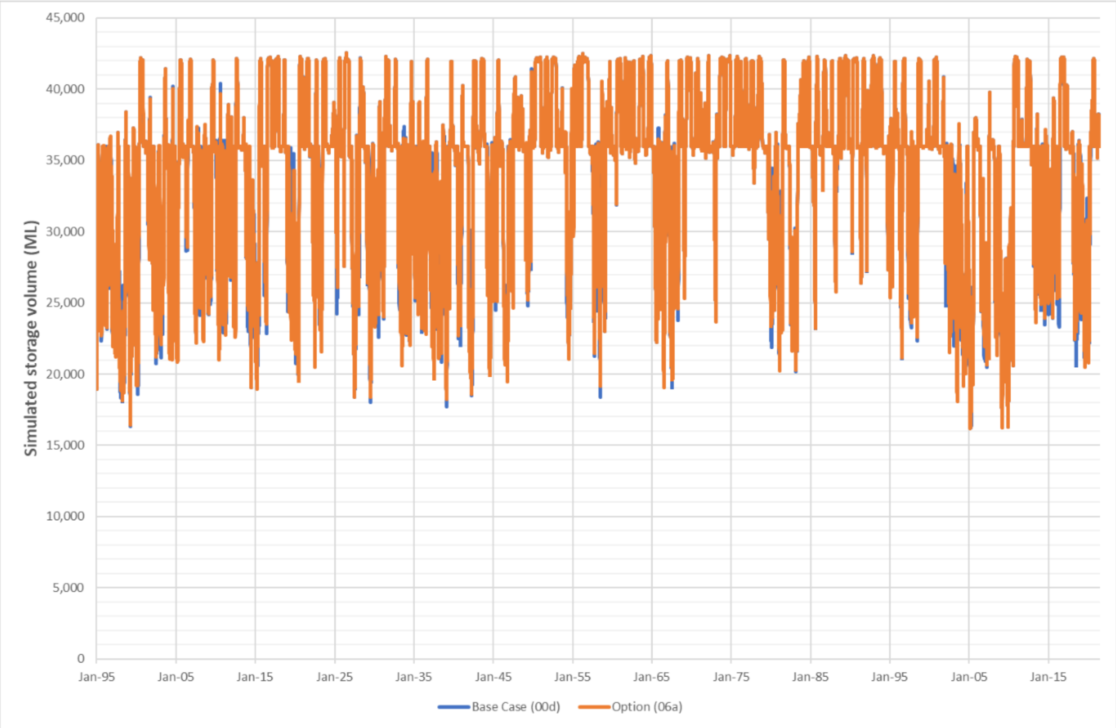


Figure 26: Carcoar Dam storage behaviour

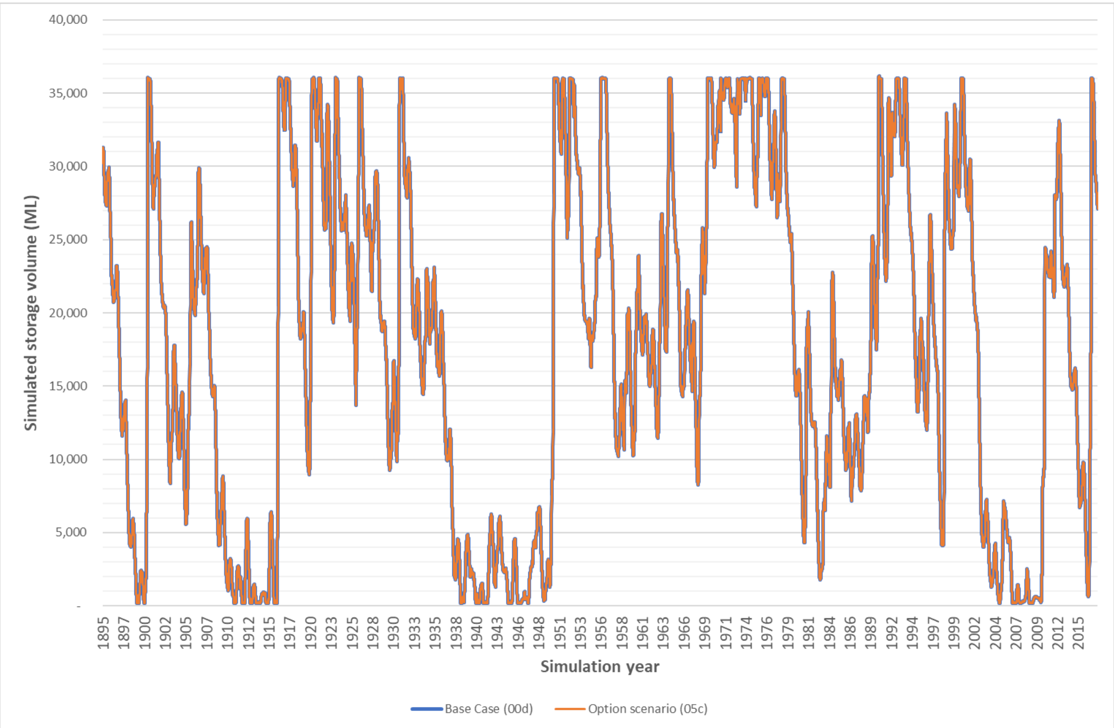
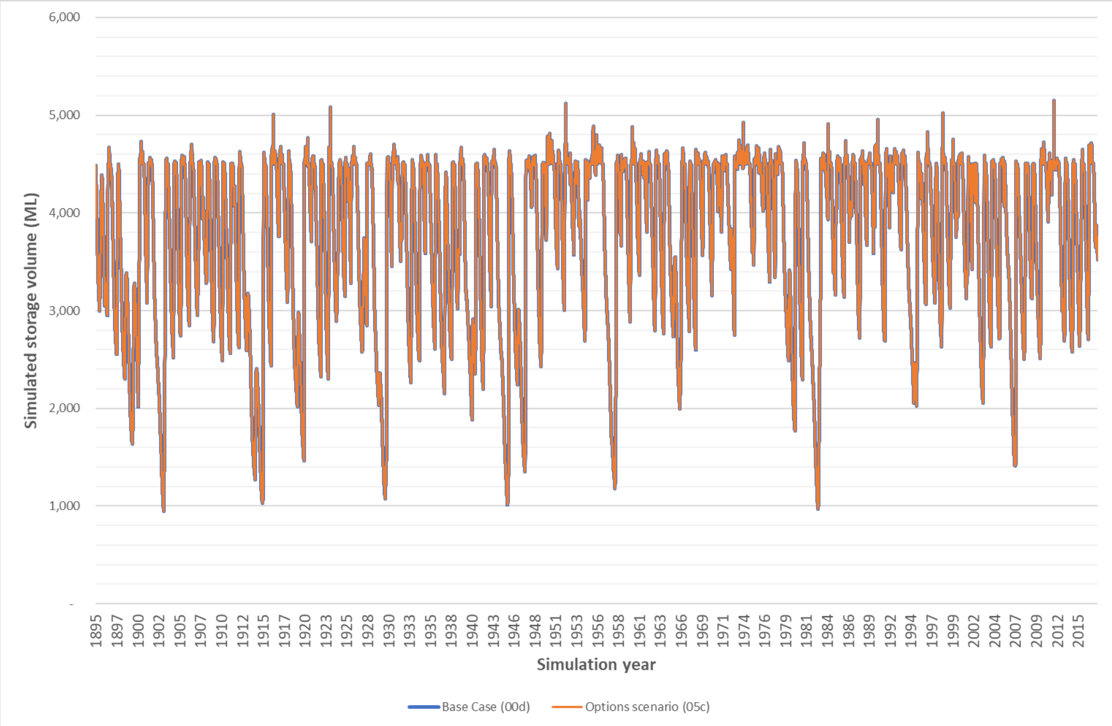


Figure 27: Lake Rowland storage behaviour



Town water supply

Table 18 summarises the modelled town water supply results for the Base Case and Option scenarios. Results show no material effect on local water utility supply performance under the option scenario.

Table 18: Town water supply performance

Town water supply	Base Case	Increased annual take limit
Cowra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	2.84	2.84

Town water supply	Base Case	Increased annual take limit
Average water supplied as % of full demand	99.3%	99.3%
Forbes		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	2.20	2.20
Average water supplied as % of full demand	99.3%	99.3%
Parkes		
% of time full demand not supplied (ie some form of restrictions would be in place),	31.2%	31.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	4.16	4.16
Average water supplied as % of full demand	99.4%	99.4%
Condobolin		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.95	0.95
Average water supplied as % of full demand	99.3%	99.3%
Lake Cargelligo		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.40	0.40

Town water supply	Base Case	Increased annual take limit
Average water supplied as % of full demand	99.1%	99.1%
Willandra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.11	0.11
Average water supplied as % of full demand	99.1%	99.1%
Hillston		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.27	0.27
Average water supplied as % of full demand	99.1%	99.1%

Alteration in river flows

Changes in the flow regime resulting from the proposed stormwater harvesting are shown for selected locations in

Table 19, with annual flow exceedance curves for selected gauging stations in figures below. Results indicate no material change in flow characteristics at the locations listed.

Table 19: Performance metrics (river flows)

Mean annual flow (GL/year)	Base Case	Increased annual take limit
412033 - Belubula River at Helensholme	139.7	139.7
412027 - Lachlan River at Reids Flat	358.4	358.4
412067 - Lachlan River at Wyangala	678.2	678.2

Mean annual flow (GL/year)	Base Case	Increased annual take limit
412002 - Lachlan River at Cowra'	832.2	832.2
412057 - Lachlan River at Nanami	1039.0	1039.0
412004 - Lachlan River at Forbes	1015.5	1015.1
412019 - Island Ck at Cadow	400.0	399.8
412023 – Island Ck at Fairholme	399.4	399.2
412017 – Bumbuggan Creek at offtake	149.2	149.2
412014 – Goobang Creek at Condobolin	202.3	202.3
412016 - Wallamundry Creek at Offtake Island Creek	81.1	81.0
412034 - Lachlan River at Condobolin Weir	744.4	744.1
412021 - Lachlan River at Booberoi Weir	731.1	730.7
412011 - Lachlan River at Lake Cargelligo Weir	561.0	560.9
Combined flow at 412102 - Lake Brewster Intake D/S Lake B. Weir Pool Regulator And 412048 - Lachlan River at Lake Brewster Weir-Storage Gauge	700.1	699.8
412038 - Lachlan River U/S Willandra Weir	584.0	583.7
412039 - Lachlan River at Hillston Weir	382.0	381.7
412078 - Lachlan River at Whealbah	354.9	354.6
412087 - Merrowie Ck at Merrowie Homestead	69.7	69.7
Merrowie Creek modelled EOS	3.4	3.4
412124 - Muggabah Ck at Cobb Hwy	5.3	5.3
Muggabah Creek modelled EOS	5.0	5.0
412005 – Lachlan River at Booligal	205.2	205.0
412045 – Lachlan River at Corrong	139.7	139.6

Mean annual flow (GL/year)	Base Case	Increased annual take limit
412026 – Lachlan River at Oxley	115.5	115.4
412122 - Merrimajeel Ck at Cobb Hwy	5.8	5.8
Total model EOS flow	183.9	183.7

Figure 28: Annual flow exceedance – Lachlan River at Forbes (412004)

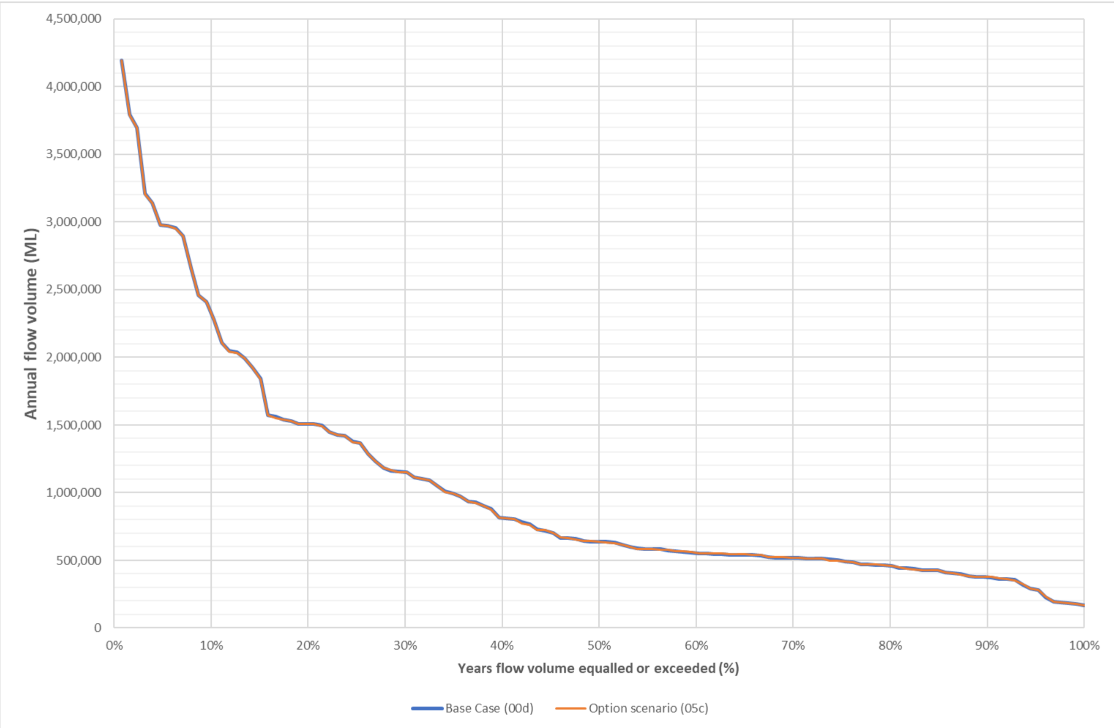


Figure 29: Annual flow exceedance – Lachlan River at Booligal (412005)

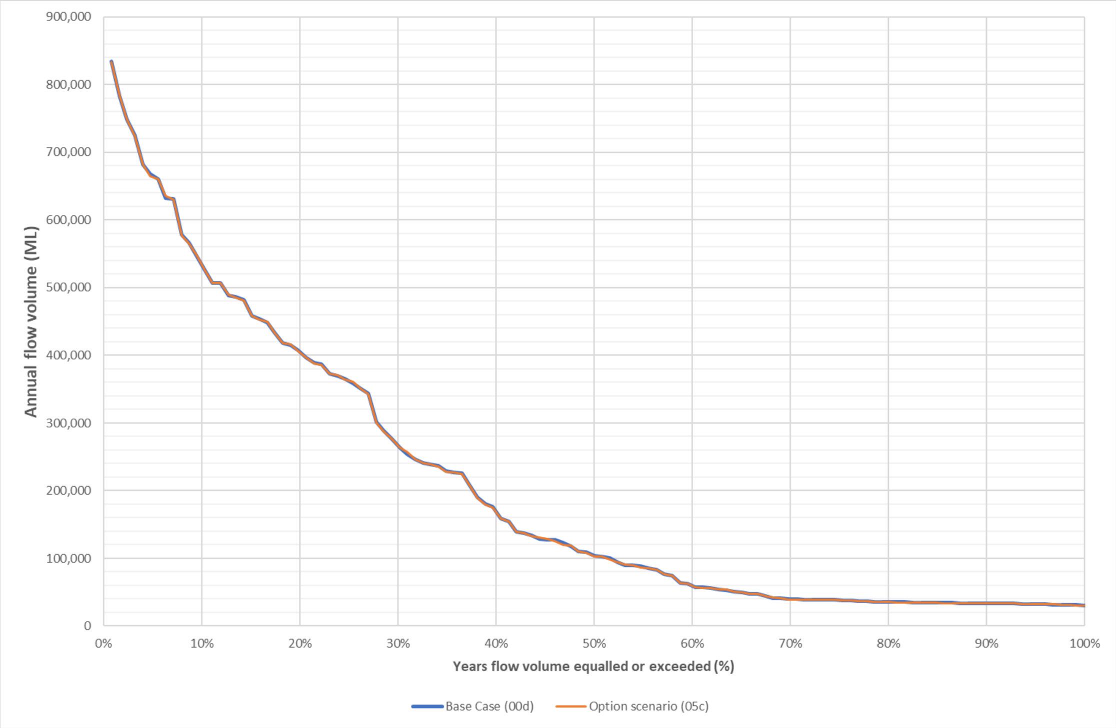
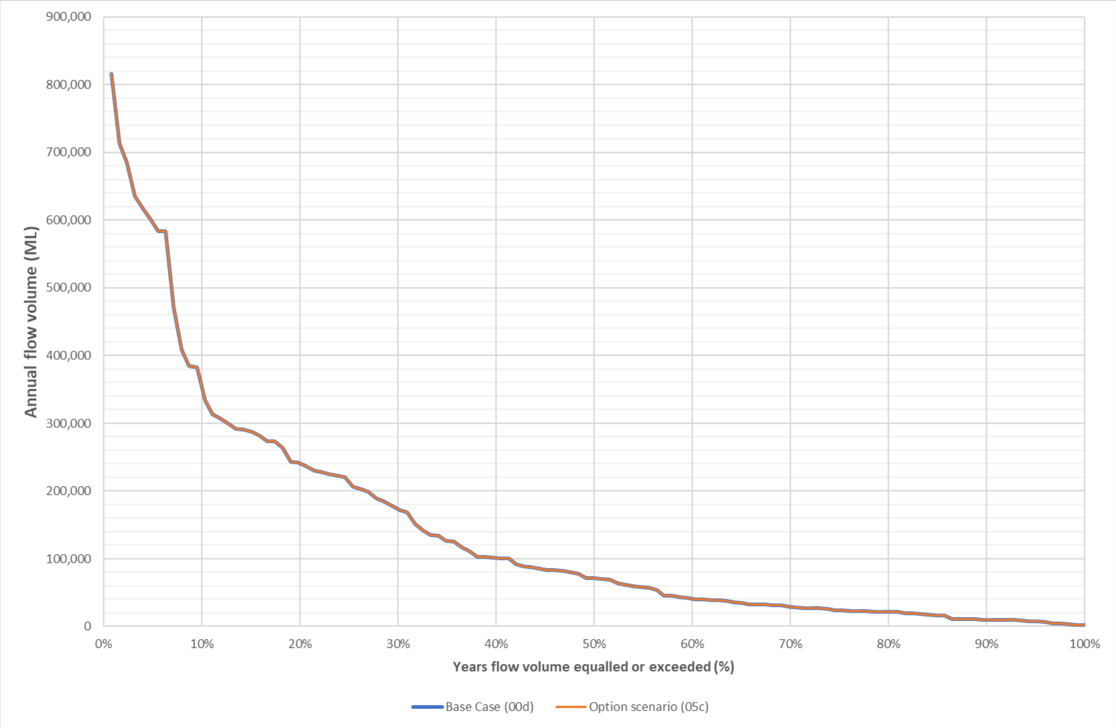


Figure 30: Annual flow exceedance – Belubula River at Helensholme (412033)



Investigation of licence conversion

Option description

Option 35 assessed the potential to make more high security water entitlements available to give water users more flexibility in production, including long-term transition to higher value enterprises that require high security water. A small amount of consumptive general security entitlement is converted to assess the benefit and impact on reliability of the remaining water access licence holders.

The objective of the analysis is to identify the level of 'discount' to be applied to convert a general security entitlement to a high security product such that third party impacts to users who are not party to the conversion are avoided. This facility would enable individual water users to target improved reliability as a trade-off for reduced entitlement volume.

Model configuration and assumptions

Model configuration comprised:

- Conversion of 20%[8] of Lachlan GSE to HSE, as per Table 20.
- Conversion ratio of 4:1 (GSE:HSE) was adopted[9].
- Increase in resource assessment reserve to account for supply of additional HSE with 30% delivery loss.
- All converted HSE (23,400 ML) assumed to be fully utilised.

Table 20: Adopted GSE to HSE conversion locations/volumes

	Base Case	Licence conversion option
General Security Entitlements (units)		
Between Nanami and Forbes	38,634	19,317
Between Forbes and Jemalong	16,970	8,485

8 As defined by RWS personnel as representative of a reasonable/realistic proportion of potential allowed conversion

9 Based on outcomes of sensitivity assessment of range of conversion factors for range of conversion volumes.

	Base Case	Licence conversion option
Between Jemalong and Island Creek	10,046	5,023
JWP	62,393	48,390
Bumbuggan Creek	24,719	12,360
Between Condobolin and Booberoi Creek	69,540	35,071
All other	245,981	245,981
TOTAL	**468,283**	**374,627**
High Security Entitlements (HSE) (units)		
New HSE for Parkes area	-	23,400
Resource assessment		
Reserve	120,000	150,000

Modelling results

Alteration in water diversions

Table 21 summarises average annual water diversions for existing users/uses, with illustration of comparative simulated annual usage volumes shown in Figure 31 (GSE), Figure 32 (HSE) and Figure 33 (HEW).

Results show a decrease in GSE diversions of 31 GL/year (~20%) associated with the reduction in total entitlements and an increase in HSE diversions of 23.3 GL/year (~200%), with an overall decrease in total system diversions of 8.4 GL/year.

Table 21: Performance metrics (water diversions)

Lachlan regulated system	Base Case	Licence conversion option
General Security	154.9	123.9
Conveyance (JIL)	15.4	15.2
High Security	10.8	34.1
Town Water Supply	9.6	9.7

Lachlan regulated system	Base Case	Licence conversion option
Stock and Domestic	4.2	4.2
GSE Environmental/HWE	50.7	50.2
HSE Environmental	2.3	2.3
Stock and Domestic Environmental	0.1	0.1
Total consumptive use	195.0	187.0
Total non-consumptive use	53.2	52.7
Total accounted use	**248.1**	**239.7**
Belubula regulated system		
General Security	1.9	1.9
High Security	1.0	1.0
Supplementary	0.9	0.9
Stock and Domestic	0.2	0.2
Total use	4.0	4.0
Belubula unregulated system		
Town Water Supply (CTW)	1.8	1.8

Figure 31: Simulated GSE water diversions

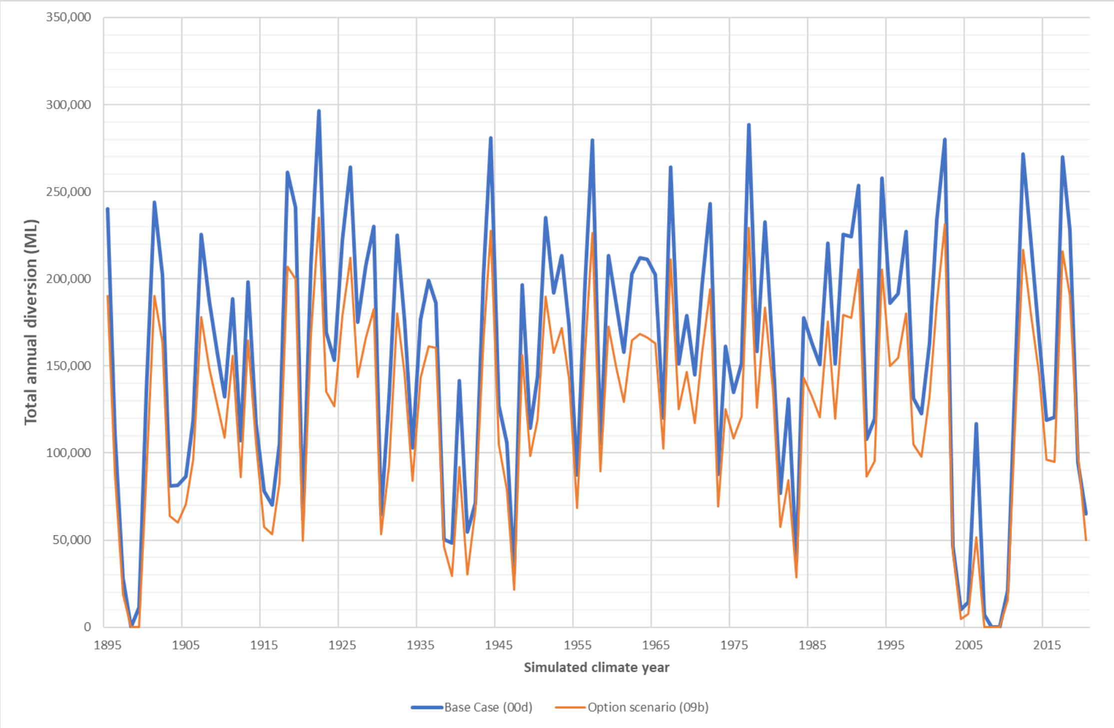
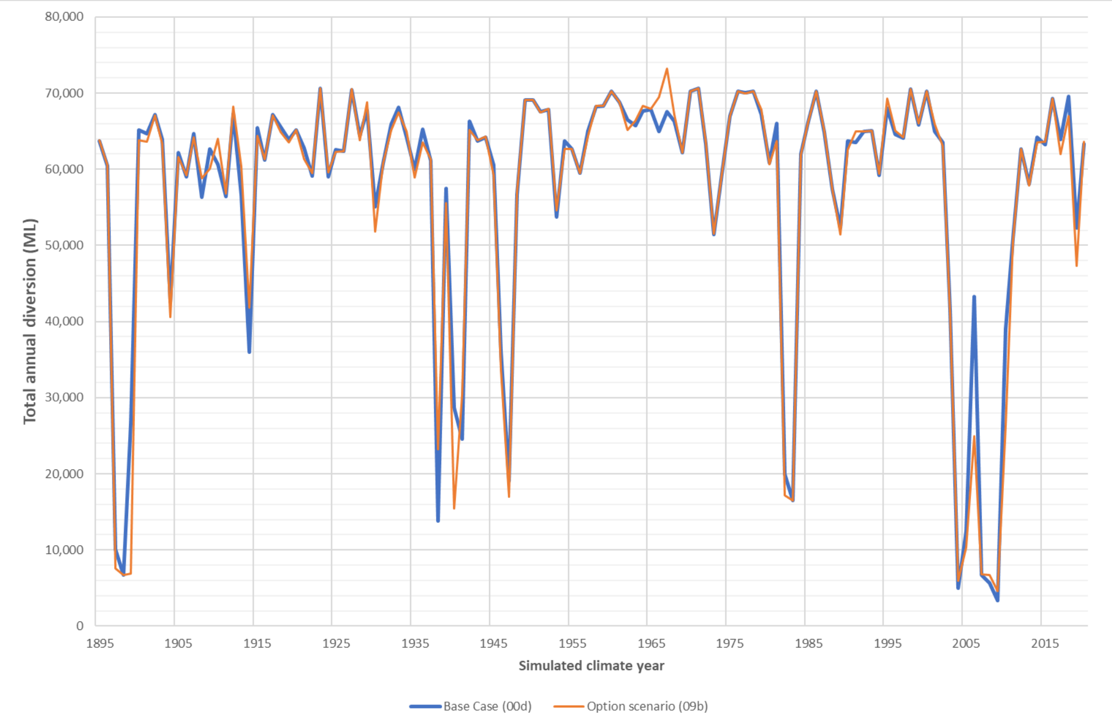


Figure 32: Simulated HSE water diversions (inc. JIL conveyance)

Figure 33: Simulated HEW usage (GSE, HSE & SD)



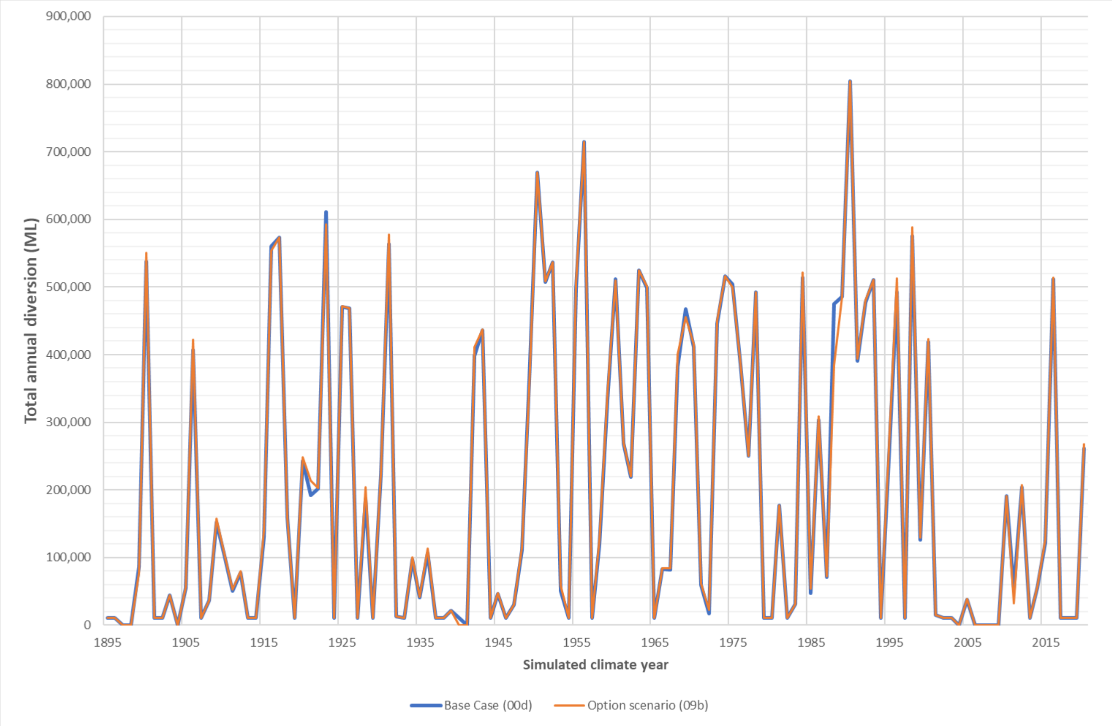
Alteration in rules based PEW

Table 22 summarises average annual simulated usage for rules-based PEW. Results show an increase in long-term average translucency flows of approximately 1 GL/year (about 0.5%).

Table 22: Performance metrics (rules-based PEW)

Lachlan regulated system	Base Case	Licence conversion option
Wyangala Translucency	184.6	185.7
Wyangala Environmental Water Allowance	4.6	4.5
Brewster Environmental Water Allowance	4.6	4.5
Water Quality Allowance	6.8	6.8
Total rules-based PEW	**200.5**	**201.5**

Figure 34: Simulated rules-based PEW (GSE, HSE & SD)



Alteration in allocation reliability

Changes in end of year allocation outcomes are shown in Table 23. Overall model results show a small (about 1%) increase in GSE allocation results as well as a small increase in HSE allocation results.

Table 23: Performance metrics (allocation reliability)

Allocation outcomes	Base Case	Licence conversion option
Lachlan regulated system		
% of years effective allocation for GS at 30 June >= 100%	64.3%	65.1%
Average effective allocation for GS at 30 June	113%	114%
% of years HS allocation 100%	97.6%	98.4%
Belubula regulated system		
Total available GSE on 1st July (%) (inc. carry-over)	50.2%	50.2%
GSE added throughout year (%)	16.6%	16.6%

Mean 1st July HSE share per unit (%)	84.1%	84.1%
Mean 30th June HSE share per unit (%)	96.0%	96.0%

Figure 35: End of water year Lachlan GSE effective allocation

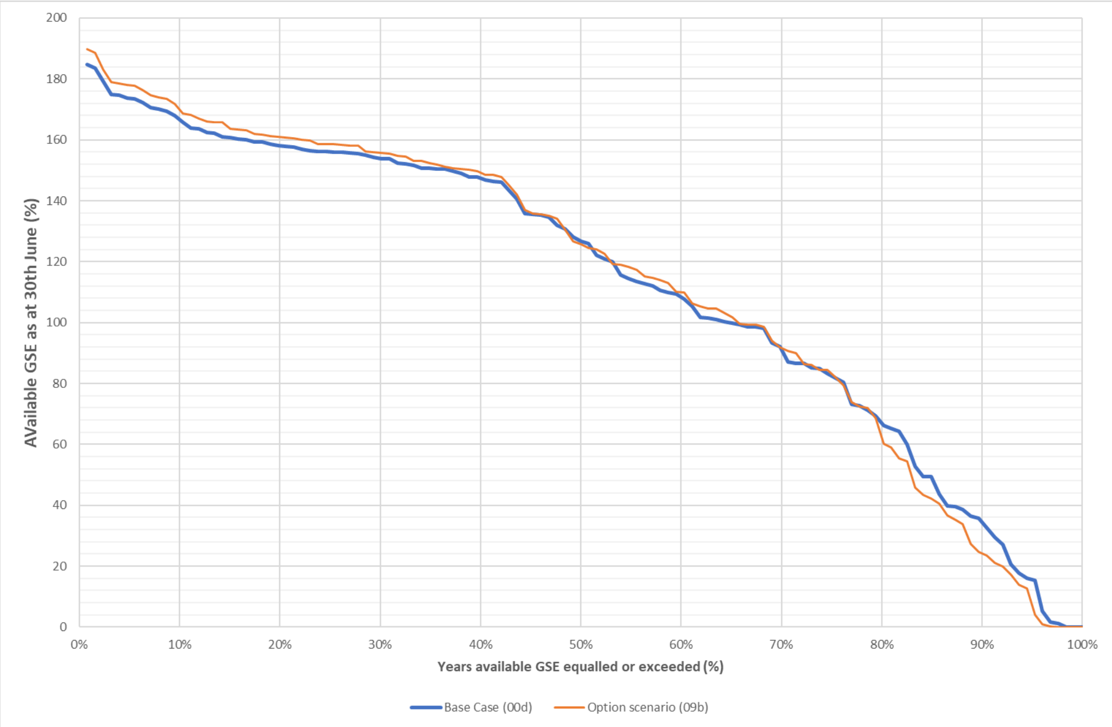
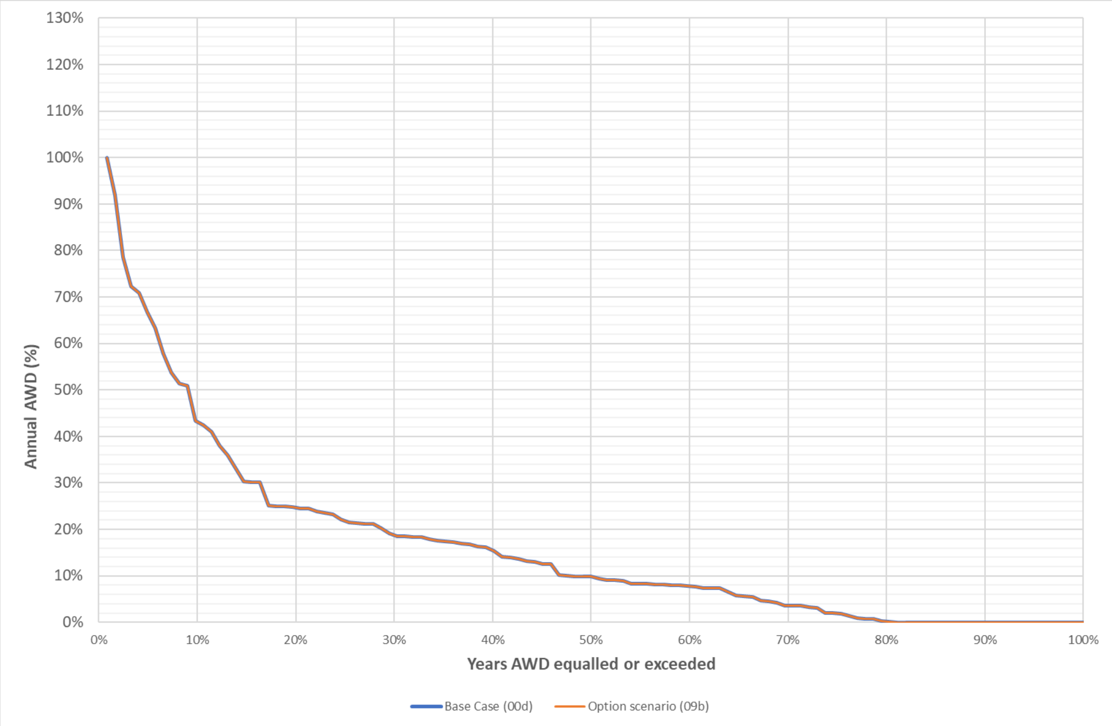


Figure 36: Ranked full year Belubula GSE available water determinations



Alteration in storage behaviour

Storage behaviour outcomes for Wyangala Dam, Lake Brewster and Lake Cargelligo in the Lachlan, as well as Carcoar Dam and Lake Rowland in the Belubula catchment, are summarised in Table 24 with simulated behaviour illustrated in the figures below.

Results show a decrease in Wyangala Dam drawdown frequencies, with little to no effect shown in results for other storages.

Table 24: Performance metrics (storage behaviour)

Storage	Base Case	Licence conversion option
Wyangala (% days active storage falls below at least once)		
< 300 GL	9.8%	5.5%
< 250 GL	6.6%	3.7%
< 210 GL	4.3%	2.4%
< 145 GL	1.8%	0.7%
< 105 GL	0.3%	0.0%

Storage	Base Case	Licence conversion option
< 90 GL	0.1%	0.0%
< 80 GL	0.0%	0.0%
< 65 GL	0.0%	0.0%
Lake Brewster (% days active storage falls below at least once)		
< 75% (109 GL)	76.1%	76.2%
< 50% (73 GL)	67.0%	67.3%
< 25% (36 GL)	55.6%	56.2%
< 10% (14.5 GL)	43.3%	44.0%
< 5% (7.3 GL)	31.4%	32.4%
Lake Cargelligo (% days active storage falls below at least once)		
< 75% (32 GL)	32.1%	34.1%
< 50% (21.5 GL)	2.7%	3.2%
< 25% (10.8 GL)	0.0%	0.0%
< 10% (4.3 GL)	0.0%	0.0%
< 5% (2.2 GL)	0.0%	0.0%
Carcoar Dam (% days active storage falls below at least once)		
< 75% (27 GL)	74.2%	74.2%
< 50% (18 GL)	50.8%	50.8%
< 25% (9 GL)	29.7%	29.7%
< 10% (3.6 GL)	18.4%	18.4%
< 5% (1.8 GL)	12.8%	12.8%
Lake Rowlands (% days active storage falls below at least once)		
< 75% (3.4 GL)	33.0%	33.0%
< 50% (2.3 GL)	8.0%	8.0%
< 25% (1.1 GL)	0.8%	0.8%
< 10% (0.5 GL)	0.0%	0.0%

Storage	Base Case	Licence conversion option
< 5% (0.2 GL)	0.0%	0.0%

Figure 37: Wyangala Dam storage behaviour

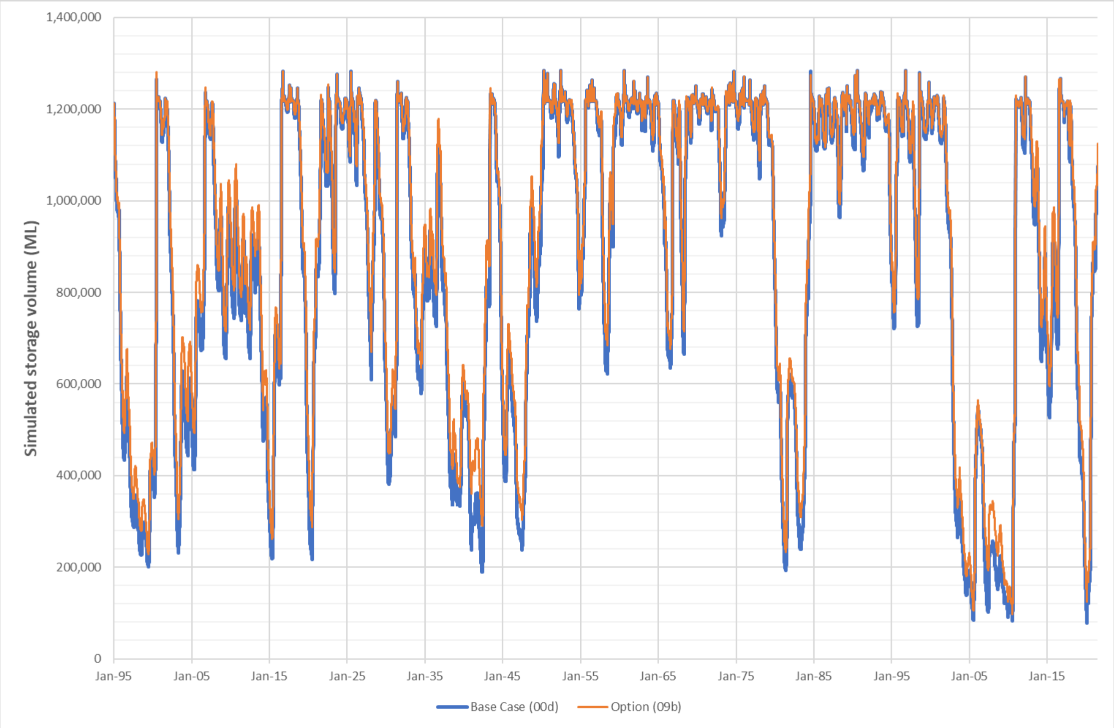


Figure 38: Lake Brewster storage behaviour

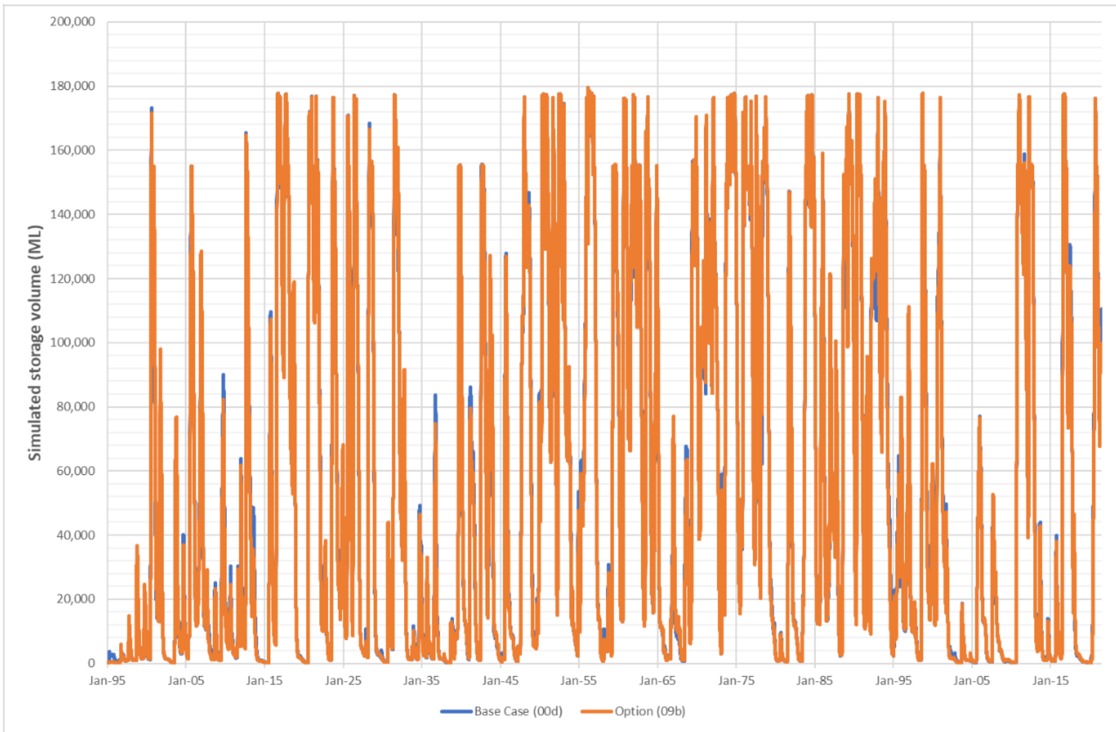


Figure 39: Lake Cargelligo storage behaviour

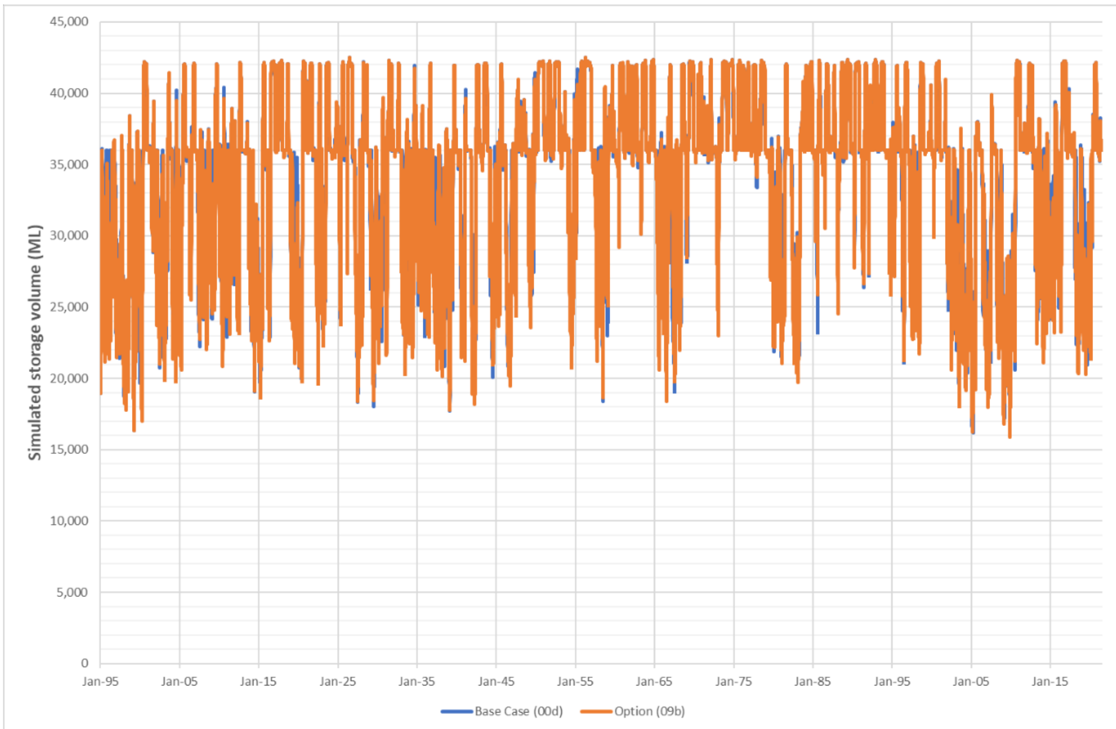


Figure 40: Carcoar Dam storage behaviour

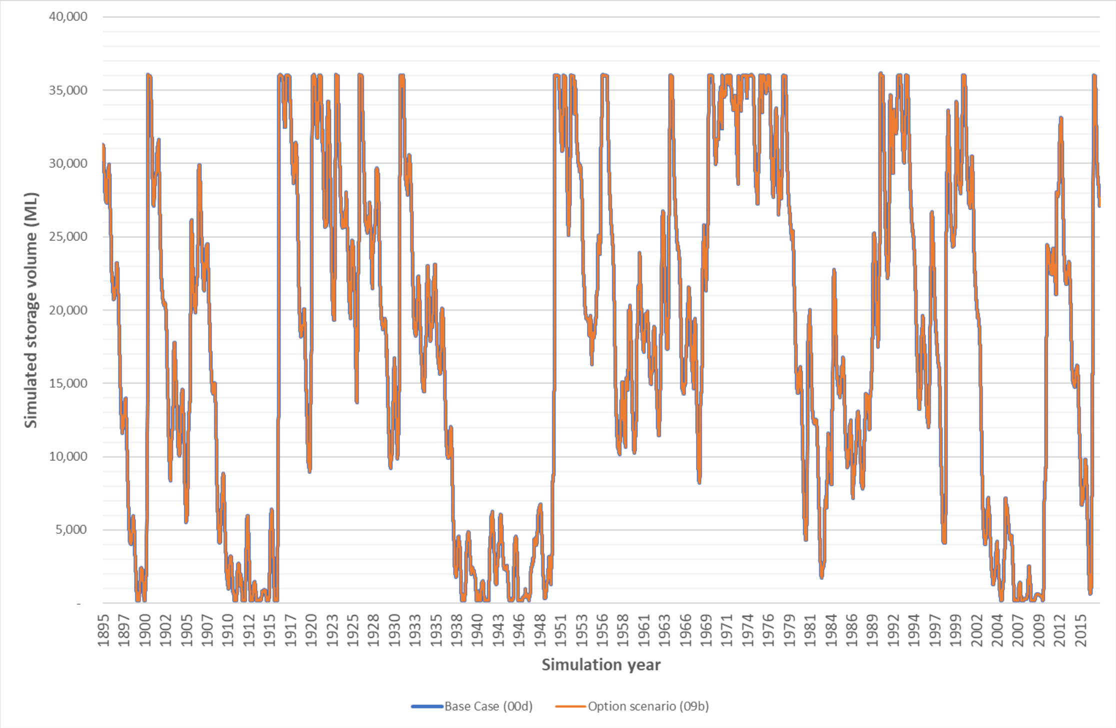
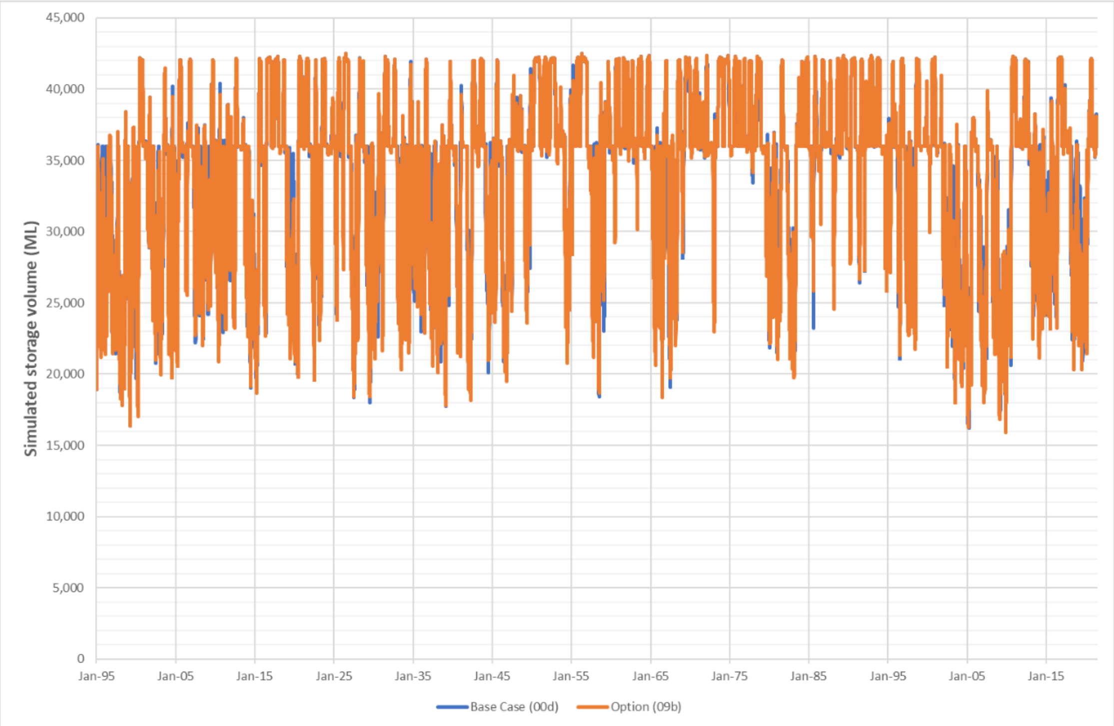


Figure 41: Lake Rowland storage behaviour



Town water supply

Table 25 summarises the modelled town water supply results. The results indicate some improvement in local water utility performance, with reductions in frequency of restrictions and/or shortfall across many town water supply schemes.

Table 25: Town water supply performance

Town water supply	Base Case	Licence conversion option
Cowra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	2.84	2.85
Average water supplied as % of full demand	99.3%	99.6%
Forbes		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	2.20	2.20
Average water supplied as % of full demand	99.3%	99.6%
Parkes		
% of time full demand not supplied (ie some form of restrictions would be in place),	31.2%	31.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	4.16	4.16
Average water supplied as % of full demand	99.4%	99.4%

Town water supply	Base Case	Licence conversion option
Condobolin		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.95	0.95
Average water supplied as % of full demand	99.3%	99.6%
Lake Cargelligo		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.40	0.40
Average water supplied as % of full demand	99.1%	99.3%
Willandra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.11	0.11
Average water supplied as % of full demand	99.1%	99.3%
Hillston		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.2%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.27	0.27
Average water supplied as % of full demand	99.1%	99.3%

Alteration in river flows

Changes in the flow regime resulting from the proposed stormwater harvesting are shown for selected locations in Table 26, with annual flow exceedance curves for selected gauging stations in figures below. Results indicate no material change in flow characteristics at the locations listed.

Table 26: Performance metrics (river flows)

Mean annual flow (GL/year)	Base Case	Licence conversion option
412033 - Belubula River at Helensholme	139.7	139.7
412027 - Lachlan River at Reids Flat	358.4	358.4
412067 - Lachlan River at Wyangala	678.2	677.1
412002 - Lachlan River at Cowra'	832.2	831.5
412057 - Lachlan River at Nanami	1039.0	1038.1
412004 - Lachlan River at Forbes	1015.5	996.3
412019 - Island Ck at Cadow	400.0	397.4
412023 – Island Ck at Fairholme	399.4	396.8
412017 – Bumbuggan Creek at offtake	149.2	142.6
412014 – Goobang Creek at Condobolin	202.3	196.1
412016 - Wallamundry Creek at Offtake Island Creek	81.1	78.9
412034 - Lachlan River at Condobolin Weir	744.4	740.9
412021 - Lachlan River at Booberoi Weir	731.1	734.9
412011 - Lachlan River at Lake Cargelligo Weir	561.0	569.3
Combined flow at 412102 - Lake Brewster Intake D/S Lake B. Weir Pool Regulator And 412048 - Lachlan River at Lake Brewster Weir-Storage Gauge	700.1	704.1
412038 - Lachlan River U/S Willandra Weir	584.0	587.4
412039 - Lachlan River at Hillston Weir	382.0	383.8
412078 - Lachlan River at Whealbah	354.9	357.0
412087 - Merrowie Ck at Merrowie Homestead	69.7	70.6
Merrowie Creek modelled EOS	3.4	3.5

Mean annual flow (GL/year)	Base Case	Licence conversion option
412124 - Muggabah Ck at Cobb Hwy	5.3	5.3
Muggabah Creek modelled EOS	5.0	5.0
412005 – Lachlan River at Booligal	205.2	207.2
412045 – Lachlan River at Corrong	139.7	141.1
412026 – Lachlan River at Oxley	115.5	116.7
412122 - Merrimajeel Ck at Cobb Hwy	5.8	5.8
Total model EOS flow	183.9	185.8

Figure 42: Annual flow exceedance – Lachlan River at Forbes (412004)

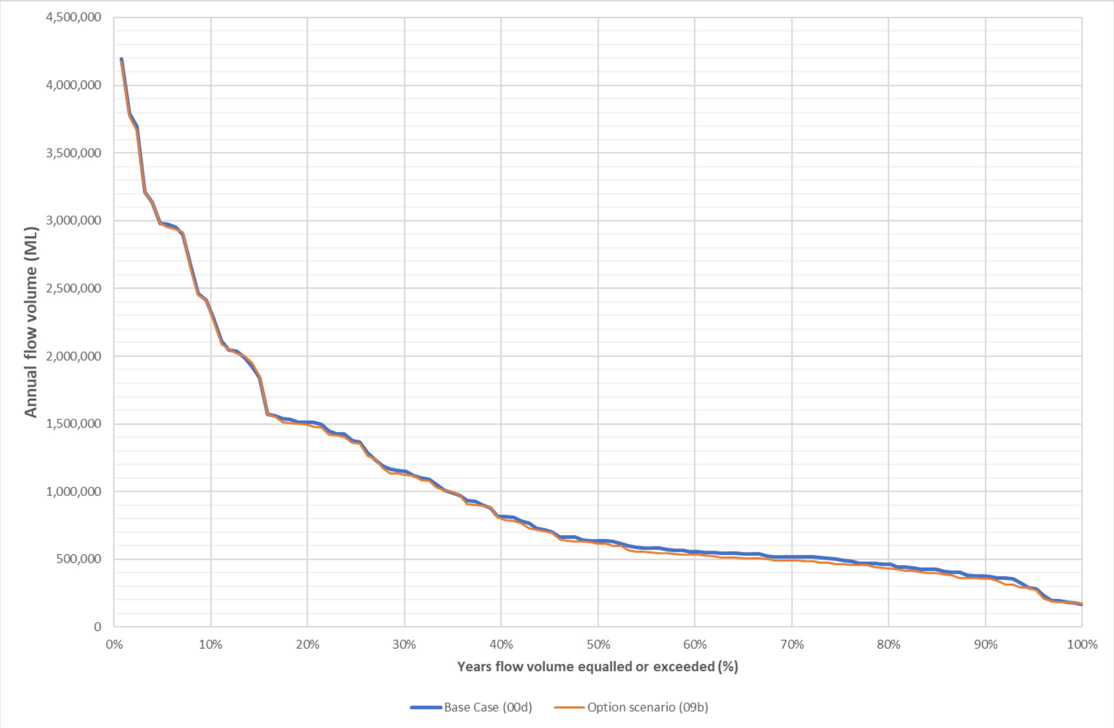


Figure 43: Annual flow exceedance – Lachlan River at Booligal (412005)

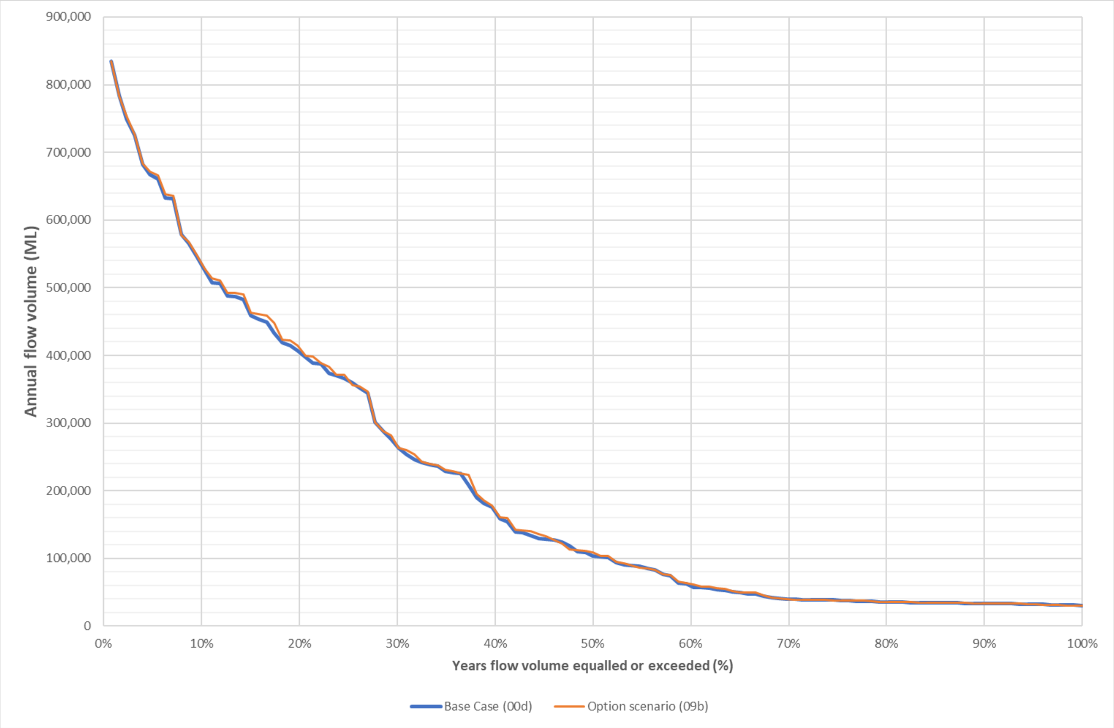
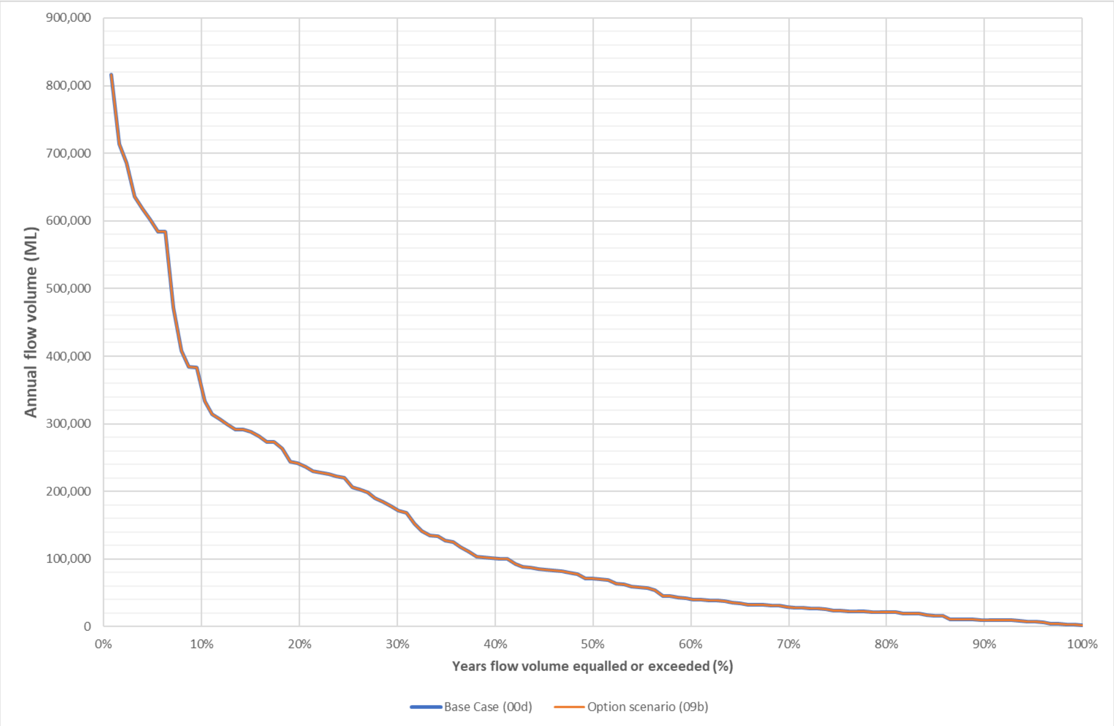


Figure 44: Annual flow exceedance – Belubula River at Helensholme (412033)



In-stream storage for the lower Lachlan

Option description

Option 39 assessed the potential for greater operational flexibility for WaterNSW and to provide a tool to capture/manage surplus flows in the lower Lachlan via the upgrading of 2 existing weirs and the installation of a new weir to allow for the re-regulation of water released from Wyangala Dam.

Model configuration and assumptions

Model configuration comprised:

- New weir providing an additional 3,000 ML of in-stream storage in the lower Lachlan near Whealbah. Orders are placed to upstream storages (Lake Brewster, etc) to maintain approximately 1,000 ML of storage within the weir to ensure continuity of supply to downstream users, with 2,000 ML of freeboard for capture and re-regulation of rainfall rejection events and other natural inflows.
- Addition of 6,500 ML high security entitlement (with demand assumed as full utilisation) near Forbes/Parkes, based on maintaining GSE at approximately Base Case levels of mean annual diversion and performance.
- Adjustment of resource assessment reserve to provide approximately 1 year supply of additional HSE inclusive of 30% delivery loss.

No other model configuration changes were made.

Modelling results

Alteration in water diversions

Table 27 summarises average annual water diversions for existing users/uses. Results show a 6.5 GL/year increase in HSE diversions associated with the additional HSE created, and no material effect on other users. Overall growth in use under the adopted option assumptions indicates the need for further assessment and refinement should the option be developed further.

Comparative simulated annual usage results are shown in Figure 45 (GSE), Figure 46 (HSE) and Figure 47 (HEW).

Table 27: Performance metrics (water diversions)

Lachlan regulated system	Base Case	Lachlan in-stream storage
General Security	154.9	154.9
Conveyance (JIL)	15.4	15.4
High Security	10.8	17.3
Town Water Supply	9.6	9.7
Stock and Domestic	4.2	4.2
GSE Environmental/HWE	50.7	50.7
HSE Environmental	2.3	2.3
Stock and Domestic Environmental	0.1	0.1
Total consumptive use	195.0	201.5
Total non-consumptive use	53.2	53.1
Total accounted use	**248.1**	**254.7**
Belubula regulated system		
General Security	1.9	1.9
High Security	1.0	1.0
Supplementary	0.9	0.9
Stock and Domestic	0.2	0.2
Total use	4.0	4.0
Belubula unregulated system		
Town Water Supply (CTW)	1.8	1.8

Figure 45: Simulated GSE water diversions

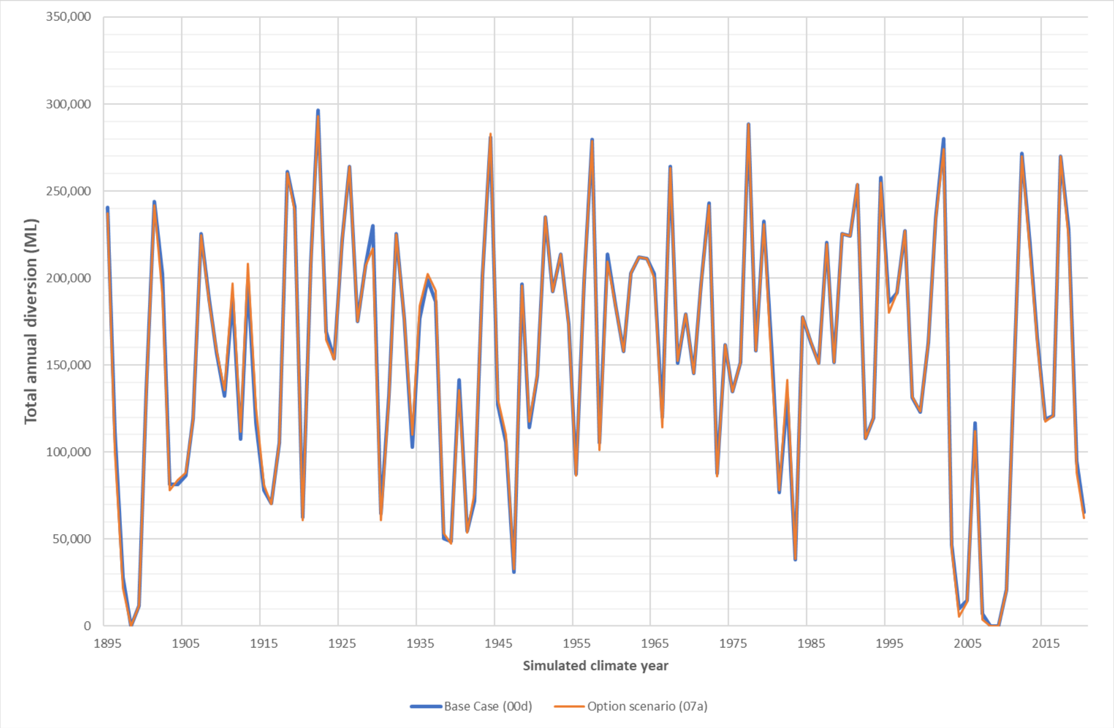


Figure 46: Simulated HSE water diversions (inc. JIL conveyance)

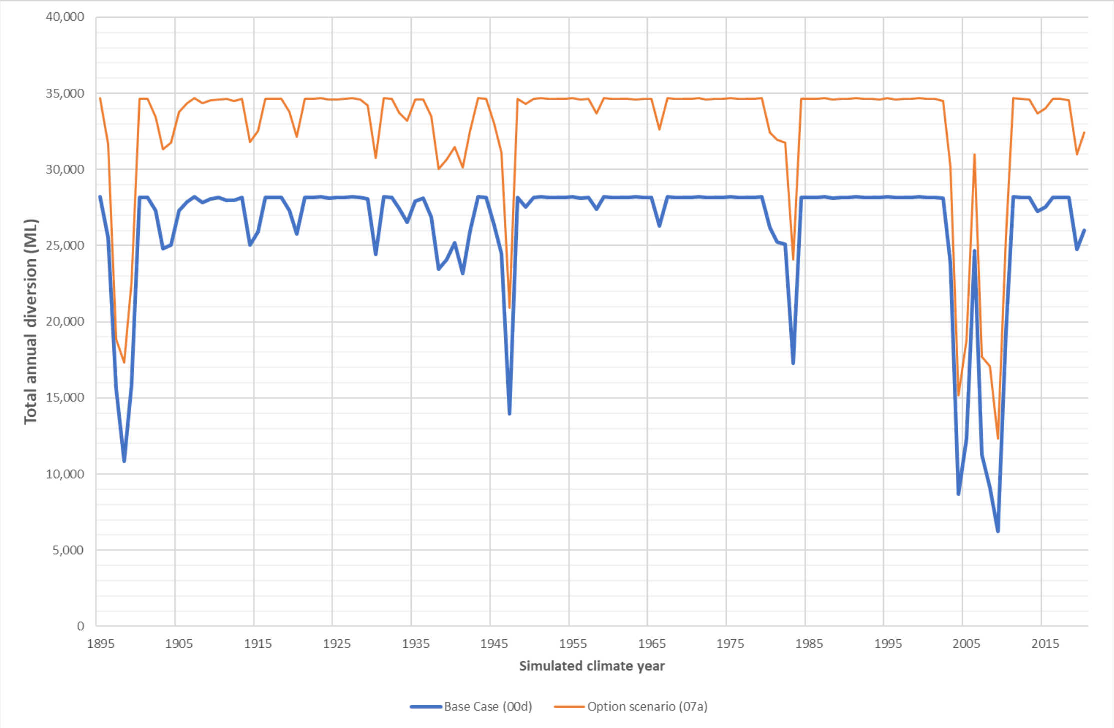
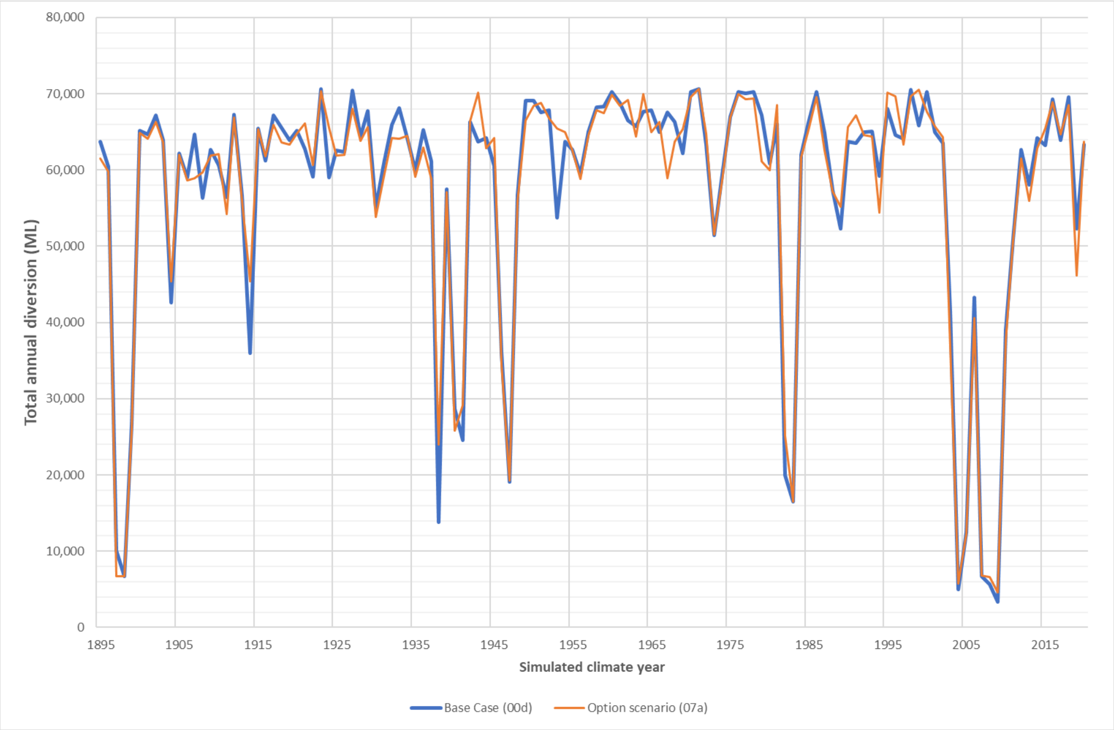


Figure 47: Simulated HEW usage (GSE, HSE & SD)



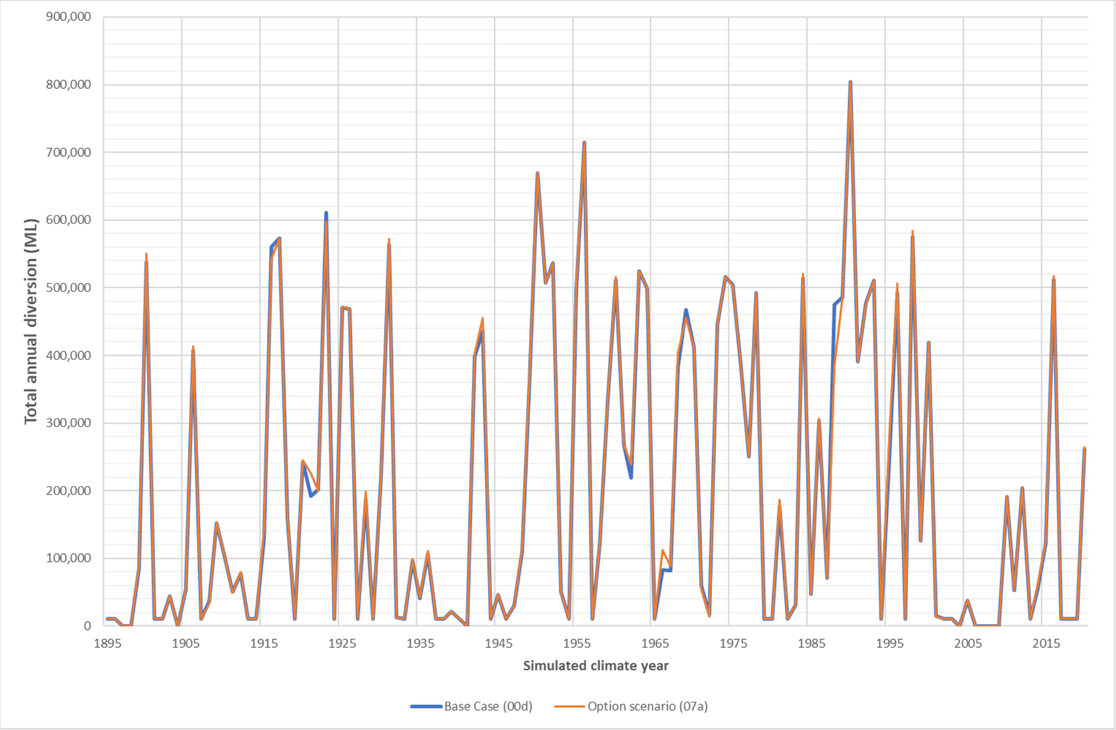
Alteration in rules based PEW

Table 28 summarises average annual simulated usage for rules-based PEW. Results show no material effect on rules-based PEW outcomes, noting however that regardless of materiality, the simulated 0.2 GL/year reduction indicates a net adverse impact under the adopted option assumptions and the need for further assessment and refinement should the option be developed further.

Table 28: Performance metrics (rules-based PEW)

Lachlan regulated system	Base Case	Lachlan in-stream storage
Wyangala Translucency	184.6	183.4
Wyangala Environmental Water Allowance	4.6	4.5
Brewster Environmental Water Allowance	4.6	4.5
Water Quality Allowance	6.8	7.9
Total rules-based PEW	**200.5**	**200.3**

Figure 48: Simulated rules-based PEW (GSE, HSE & SD)



Alteration in allocation reliability

Changes in end of year allocation outcomes are shown in Table 29. Results show a slight (0.3%) increase in years with greater than 100% GSE effective allocation, with a slight decrease (2%) in average end of year effective allocation and a small (about1%) increase in years where HSE end of water year allocation is 100%.

Table 29: Performance metrics (allocation reliability)

Allocation outcomes	Base Case	Lachlan in-stream storage
Lachlan regulated system		
% of years effective allocation for GS at 30 June >= 100%	64.3%	64.6%
Average effective allocation for GS at 30 June	113%	111%
% of years HS allocation 100%	97.6%	98.4%
Belubula regulated system		
Total available GSE on 1st July (%) (inc. carry-over)	50.2%	50.2%
GSE added throughout year (%)	16.6%	16.6%
Mean 1st July HSE share per unit (%)	84.1%	84.1%
Mean 30th June HSE share per unit (%)	96.0%	96.0%

Figure 49: End of water year Lachlan GSE effective allocation

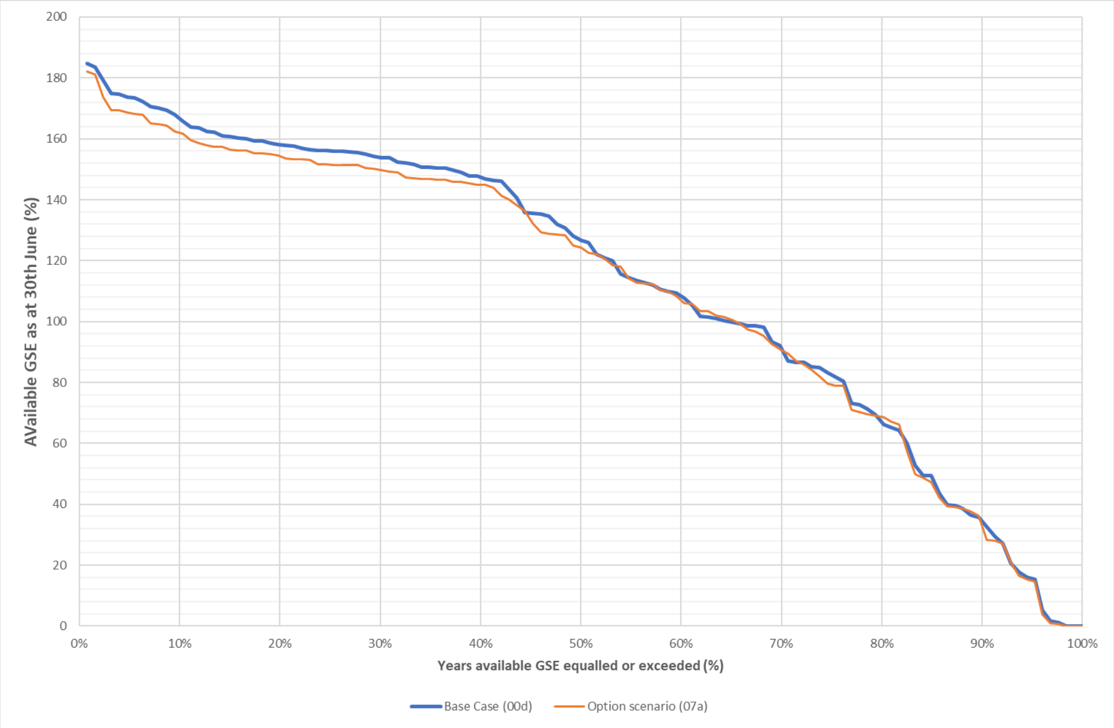
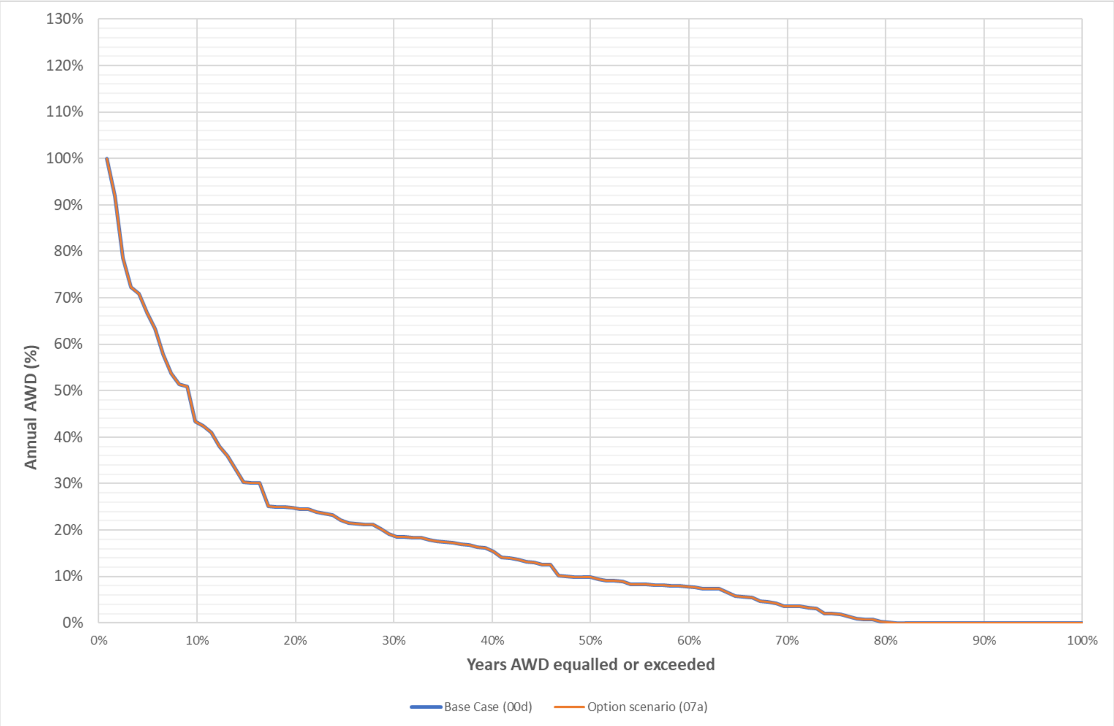


Figure 50: Ranked full year Belubula GSE available water determinations



Alteration in storage behaviour

Storage behaviour outcomes for Wyangala Dam, Lake Brewster and Lake Cargelligo in the Lachlan, as well as Carcoar Dam and Lake Rowland in the Belubula catchment, are summarised in Table 30 with simulated behaviour illustrated in the figures below.

Table 30: Performance metrics (storage behaviour)

Storage	Base Case	Lachlan in-stream storage
Wyangala (% days active storage falls below at least once)		
< 300 GL	9.8%	7.1%
< 250 GL	6.6%	4.1%
< 210 GL	4.3%	2.9%
< 145 GL	1.8%	0.7%
< 105 GL	0.3%	0.0%
< 90 GL	0.1%	0.0%
< 80 GL	0.0%	0.0%
< 65 GL	0.0%	0.0%
Lake Brewster (% days active storage falls below at least once)		
< 75% (109 GL)	76.1%	72.9%
< 50% (73 GL)	67.0%	63.3%
< 25% (36 GL)	55.6%	51.8%
< 10% (14.5 GL)	43.3%	39.6%
< 5% (7.3 GL)	31.4%	28.4%
Lake Cargelligo (% days active storage falls below at least once)		
< 75% (32 GL)	32.1%	27.8%
< 50% (21.5 GL)	2.7%	1.7%
< 25% (10.8 GL)	0.0%	0.0%
< 10% (4.3 GL)	0.0%	0.0%

Storage	Base Case	Lachlan in-stream storage
< 5% (2.2 GL)	0.0%	0.0%
Carcoar Dam (% days active storage falls below at least once)		
< 75% (27 GL)	74.2%	74.1%
< 50% (18 GL)	50.8%	50.4%
< 25% (9 GL)	29.7%	29.4%
< 10% (3.6 GL)	18.4%	18.2%
< 5% (1.8 GL)	12.8%	12.7%
Lake Rowlands (% days active storage falls below at least once)		
< 75% (3.4 GL)	33.0%	33.0%
< 50% (2.3 GL)	8.0%	8.0%
< 25% (1.1 GL)	0.8%	0.8%
< 10% (0.5 GL)	0.0%	0.0%
< 5% (0.2 GL)	0.0%	0.0%

Figure 51: Wyangala Dam storage behaviour

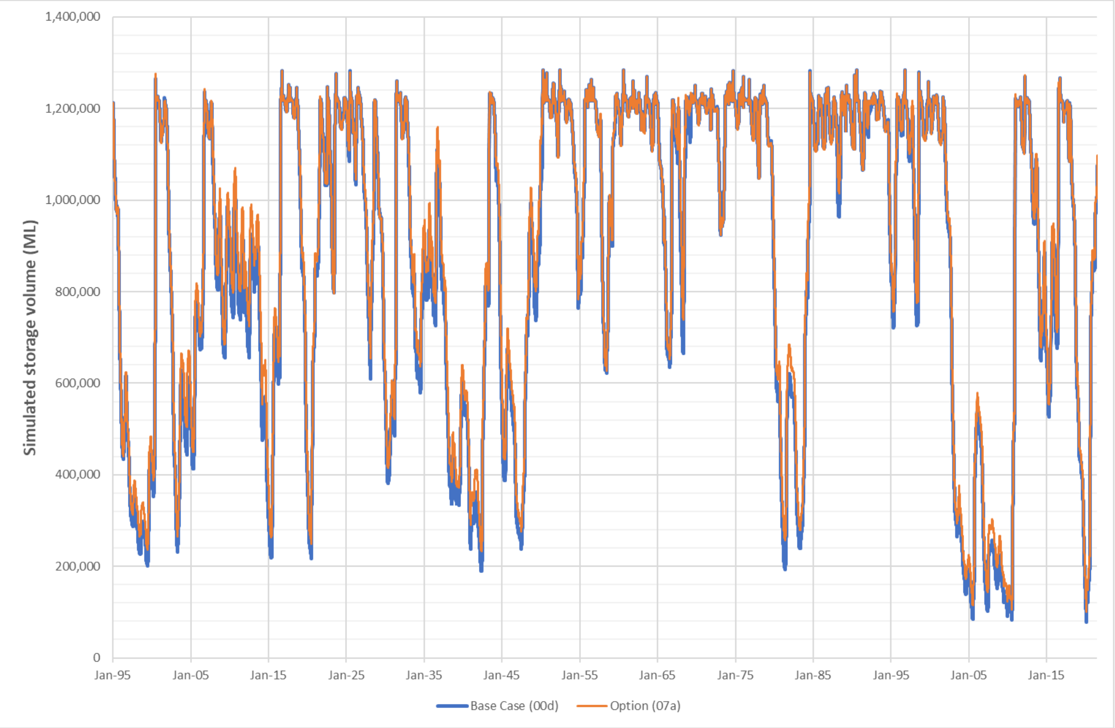


Figure 52: Lake Brewster storage behaviour

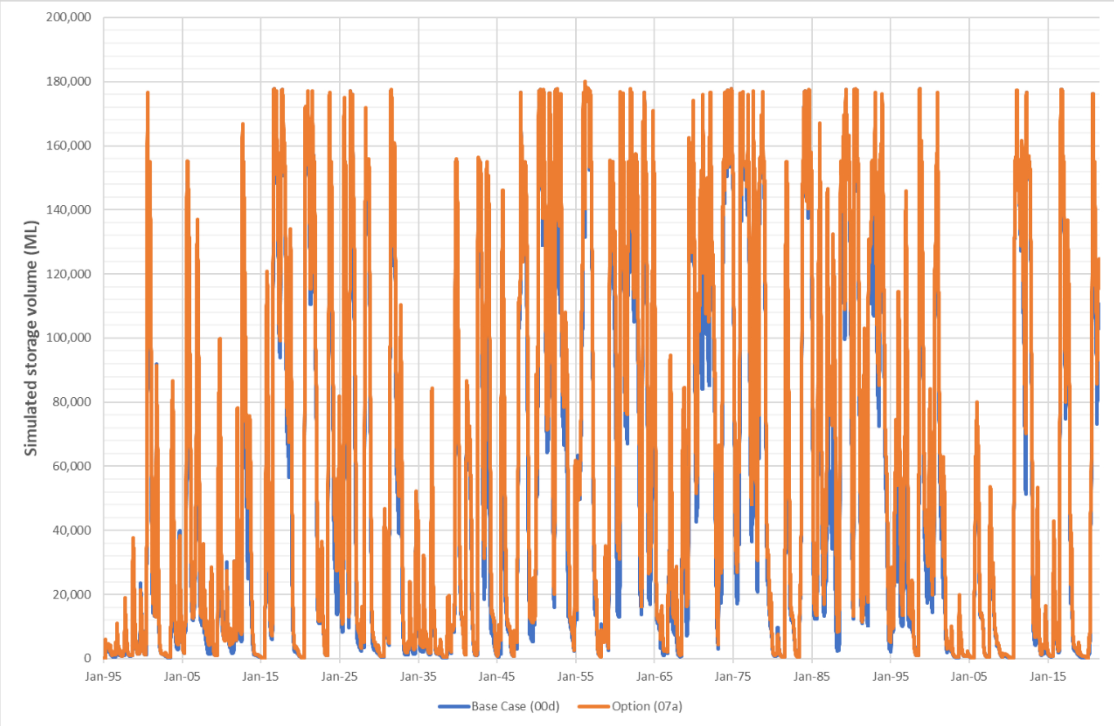


Figure 53: Lake Cargelligo storage behaviour

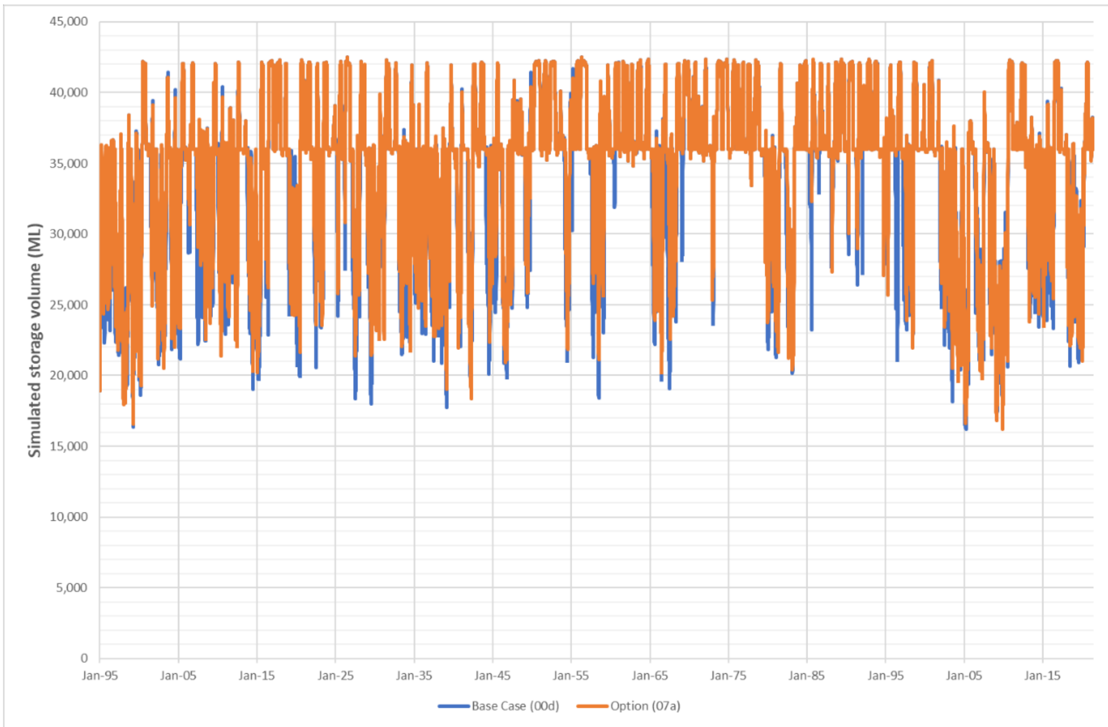


Figure 54: Carcoar Dam storage behaviour

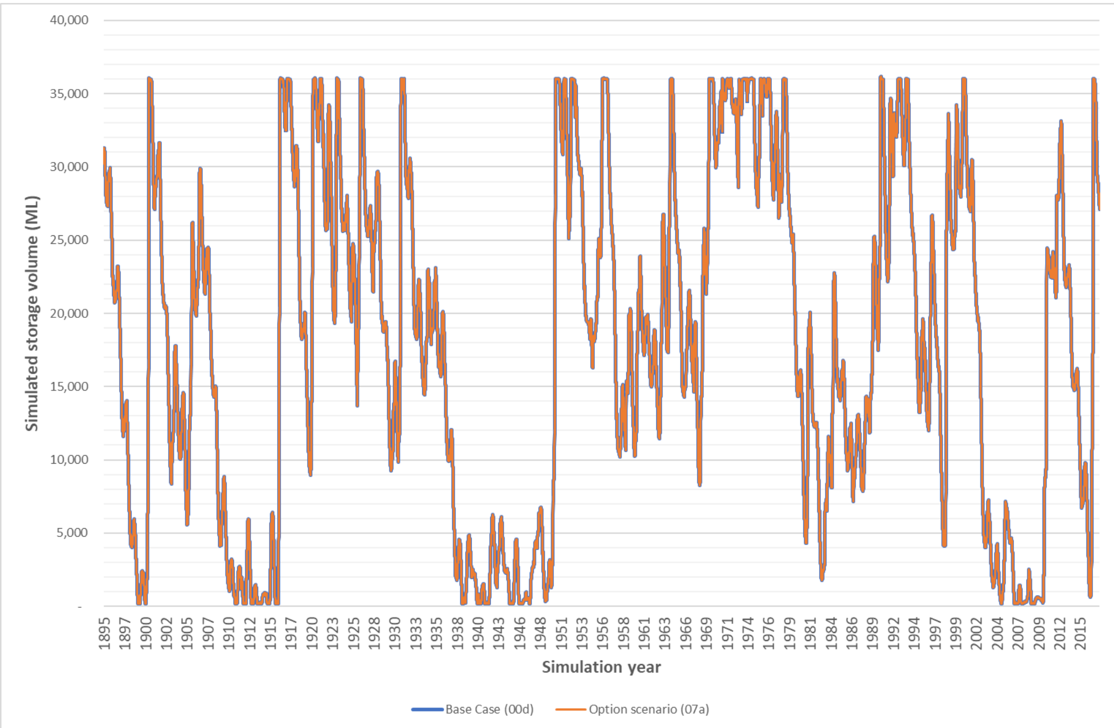
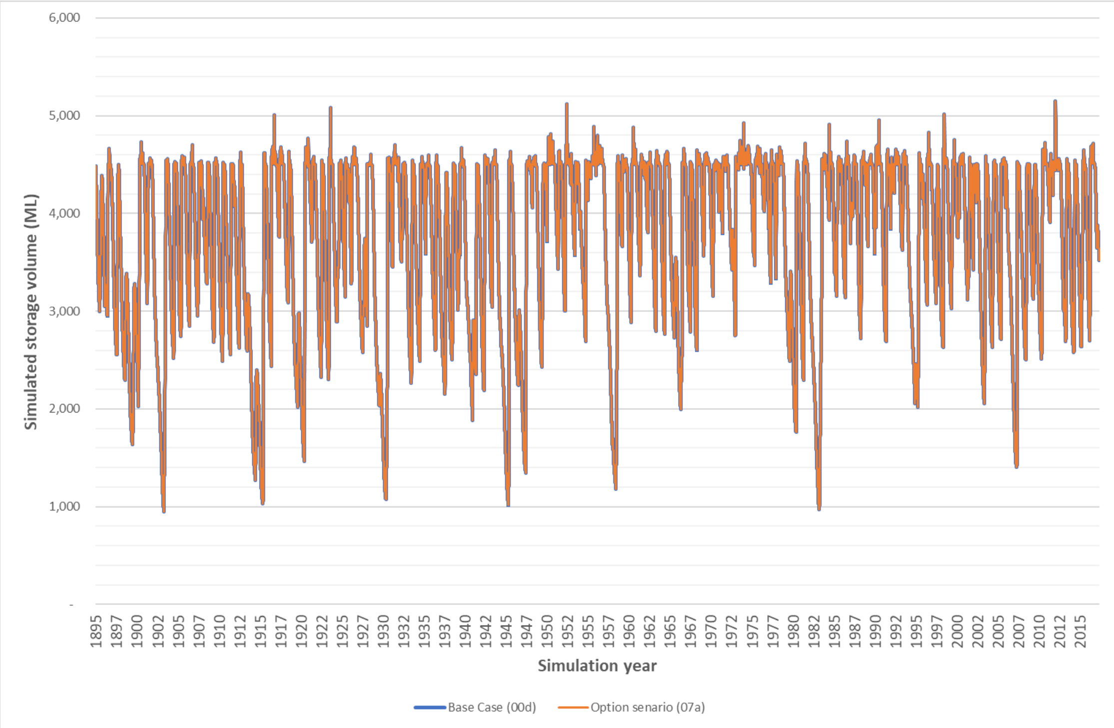


Figure 55: Lake Rowland storage behaviour



Town water supply

Table 31 summarises the modelled town water supply results. Results indicate relatively material improvement in LWU water performance, with reductions in frequency of restrictions and/or shortfall across the majority of town water supply schemes.

Table 31: Town water supply performance

Town water supply	Base Case	Lachlan in-stream storage
Cowra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%

Town water supply	Base Case	Lachlan in-stream storage
Average water supplied GL/yr	2.84	2.85
Average water supplied as % of full demand	99.3%	99.6%
Forbes		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	2.20	2.20
Average water supplied as % of full demand	99.3%	99.6%
Parkes		
% of time full demand not supplied (ie some form of restrictions would be in place),	31.2%	0.0%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	4.16	4.16
Average water supplied as % of full demand	99.4%	100.0%
Condobolin		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.95	0.95
Average water supplied as % of full demand	99.3%	99.6%
Lake Cargelligo		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%

Town water supply	Base Case	Lachlan in-stream storage
Average water supplied GL/yr	0.40	0.40
Average water supplied as % of full demand	99.1%	99.3%
Willandra		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.11	0.11
Average water supplied as % of full demand	99.1%	99.3%
Hillston		
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	2.3%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%
Average water supplied GL/yr	0.27	0.27
Average water supplied as % of full demand	99.1%	99.2%

Alteration in river flows

Changes in the flow regime resulting from the proposed stormwater harvesting are shown for selected locations in

Table 32, with annual flow exceedance curves for selected gauging stations in figures below. Results indicate no material change in flow characteristics at the locations listed.

Table 32: Performance metrics (river flows)

Mean annual flow (GL/year)	Base Case	Lachlan in-stream storage
412033 - Belubula River at Helensholme	139.7	138.8

Mean annual flow (GL/year)	Base Case	Lachlan in-stream storage
412027 - Lachlan River at Reids Flat	358.4	356.2
412067 - Lachlan River at Wyangala	678.2	676.8
412002 - Lachlan River at Cowra'	832.2	829.8
412057 - Lachlan River at Nanami	1039.0	1034.8
412004 - Lachlan River at Forbes	1015.5	1004.7
412019 - Island Ck at Cadow	400.0	395.8
412023 – Island Ck at Fairholme	399.4	395.2
412017 – Bumbuggan Creek at offtake	149.2	145.4
412014 – Goobang Creek at Condobolin	202.3	198.2
412016 - Wallamundry Creek at Offtake Island Creek	81.1	79.8
412034 - Lachlan River at Condobolin Weir	744.4	735.1
412021 - Lachlan River at Booberoi Weir	731.1	720.8
412011 - Lachlan River at Lake Cargelligo Weir	561.0	550.8
Combined flow at 412102 - Lake Brewster Intake D/S Lake B. Weir Pool Regulator And 412048 - Lachlan River at Lake Brewster Weir-Storage Gauge	700.1	690.2
412038 - Lachlan River U/S Willandra Weir	584.0	571.8
412039 - Lachlan River at Hillston Weir	382.0	371.3
412078 - Lachlan River at Whealbah	354.9	344.2
412087 - Merrowie Ck at Merrowie Homestead	69.7	69.8
Merrowie Creek modelled EOS	3.4	3.5
412124 - Muggabah Ck at Cobb Hwy	5.3	5.3
Muggabah Creek modelled EOS	5.0	5.0

Mean annual flow (GL/year)	Base Case	Lachlan in-stream storage
412005 – Lachlan River at Booligal	205.2	196.3
412045 – Lachlan River at Corrong	139.7	132.4
412026 – Lachlan River at Oxley	115.5	108.7
412122 - Merrimajeel Ck at Cobb Hwy	5.8	5.8
Total model EOS flow	183.9	177.3

Figure 56: Annual flow exceedance – Lachlan River at Forbes (412004)

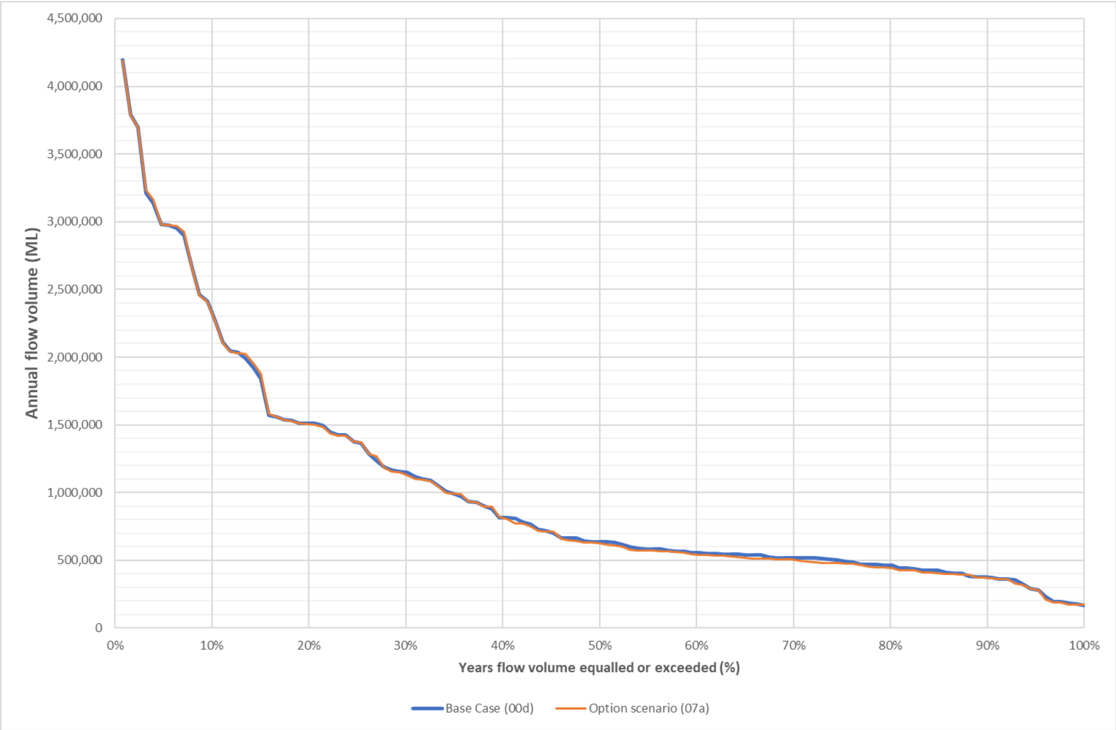


Figure 57: Annual flow exceedance – Lachlan River at Booligal (412005)

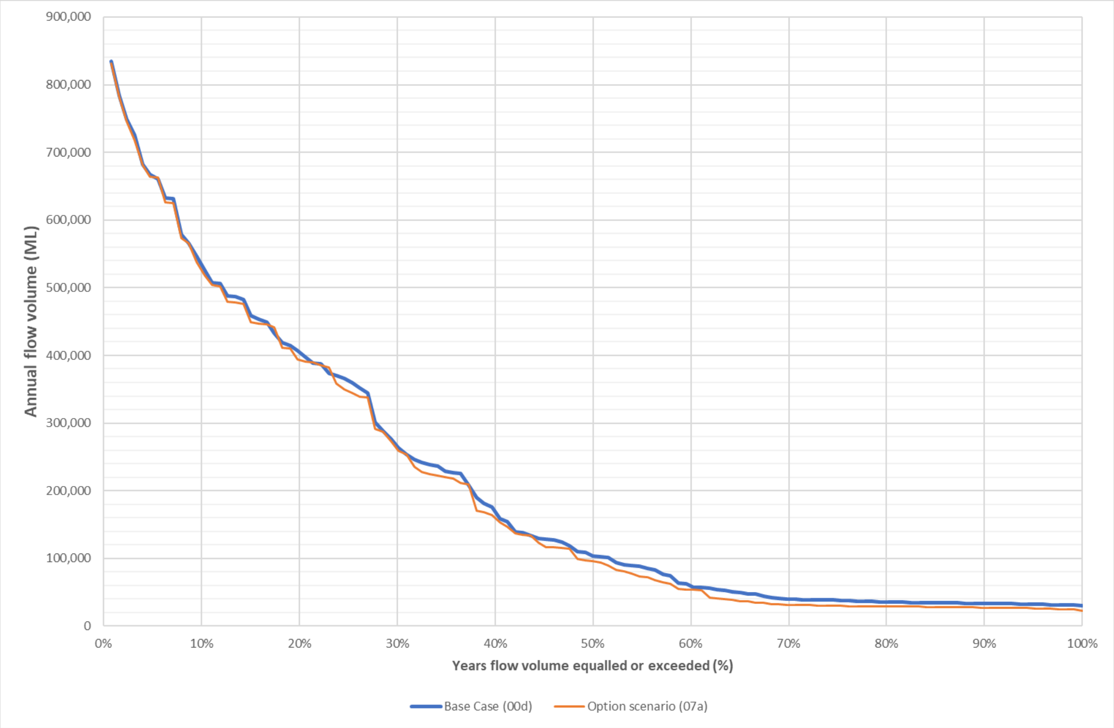
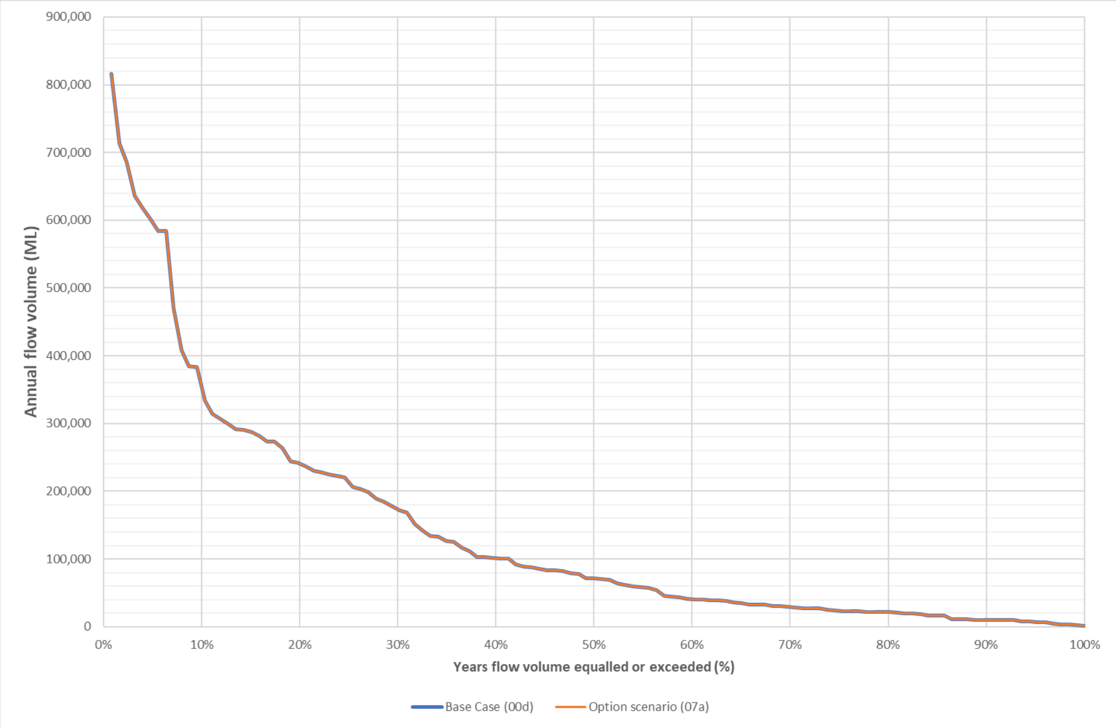


Figure 58: Annual flow exceedance – Belubula River at Helensholme (412033)



New weir in the Belubula regulated river

Option description

Developed as a new option following stakeholder feedback to the initial draft RWS, this option investigates the potential for a new weir on the Belubula River to improve system operations and reliability for Belubula River system water licence holders (scenario 08a).

Model configuration and assumptions

Model configuration comprised:

- New weir providing an additional 3,000 ML of in-stream storage on the Belubula River at the Needles. Orders are placed to Carcoar Dam to maintain approximately 500 ML of storage within the weir to ensure continuity of supply to downstream users, with 2,500 ML of freeboard for capture and re-regulation of natural tributary inflows and rainfall rejection events.
- Two sub-option scenarios were developed comprising:
    1. Addition of 1,000 ML new HSE taken directly from the new weir and simulated as full utilisation (Scenario 08a(i)).
    2. Addition of 10,000 ML new HSE taken directly from the new weir and simulated as full utilisation (Scenario 08a(ii)).

No other modifications to model configuration were made.

Modelling results

Alteration in water diversions

Table 33 summarises average annual water diversions for existing users/uses. Results show:

- For sub-option 1 (1,000 ML additional Belubula HSE): increase in long-term average GSE extractions (from 1.9 GL/year to 3 GL/year) as well as an approximately 100% increase in HSE extractions (from 1.0 GL/year to 2.1 GL/year.
- For sub-option 2 (10,000 ML additional Belubula HSE): No change in long-term average GSE extractions from Base Case results, and an increase in HSE extractions from 1.0 GL/year to 10.6 GL/year.
- Reduction in Lachlan Valley GSE long-term average diversions, indicating potential adverse impacts due to reduced Belubula River end of system flows associated with assessed option.

The adverse impact on the Lachlan regulated system under the adopted option assumptions indicates the need for further assessment and refinement should the option be developed further.

Table 33: Performance metrics (water diversions)

Lachlan regulated system	**Base Case**	**Belubula re-regulating weir (1,000 ML HSE)**	**Belubula re-regulating weir (10,000 ML HSE)**
General Security	154.9	153.9	152.8
Conveyance (JIL)	15.4	15.4	15.4
High Security	10.8	10.8	10.8
Town Water Supply	9.6	9.6	9.6
Stock and Domestic	4.2	4.2	4.2
GSE Environmental/HWE	50.7	50.6	50.3
HSE Environmental	2.3	2.3	2.3
Stock and Domestic Environmental	0.1	0.1	0.1
Total consumptive use	195.0	193.9	192.7
Total non-consumptive use	53.2	53.0	52.7
Total accounted use	**248.1**	**246.9**	**245.5**
Belubula regulated system			
General Security	1.9	3.0	1.9
High Security	1.0	2.1	10.6

Lachlan regulated system	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Supplementary	0.9	0.2	0.6
Stock and Domestic	0.2	0.2	0.2
Total use	4.0	5.5	13.3
Belubula unregulated system			
Town Water Supply (CTW)	1.8	1.8	1.8

Figure 59: Simulated GSE water diversions (sub-option 1)

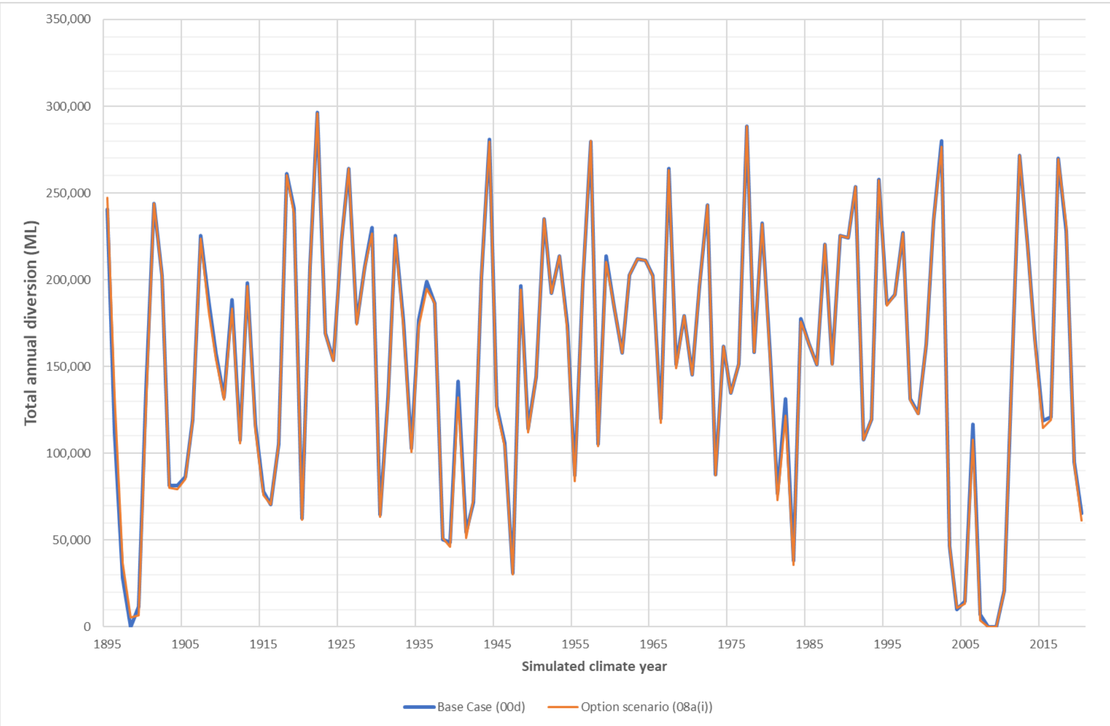


Figure 60: Simulated GSE water diversions (sub-option 2)

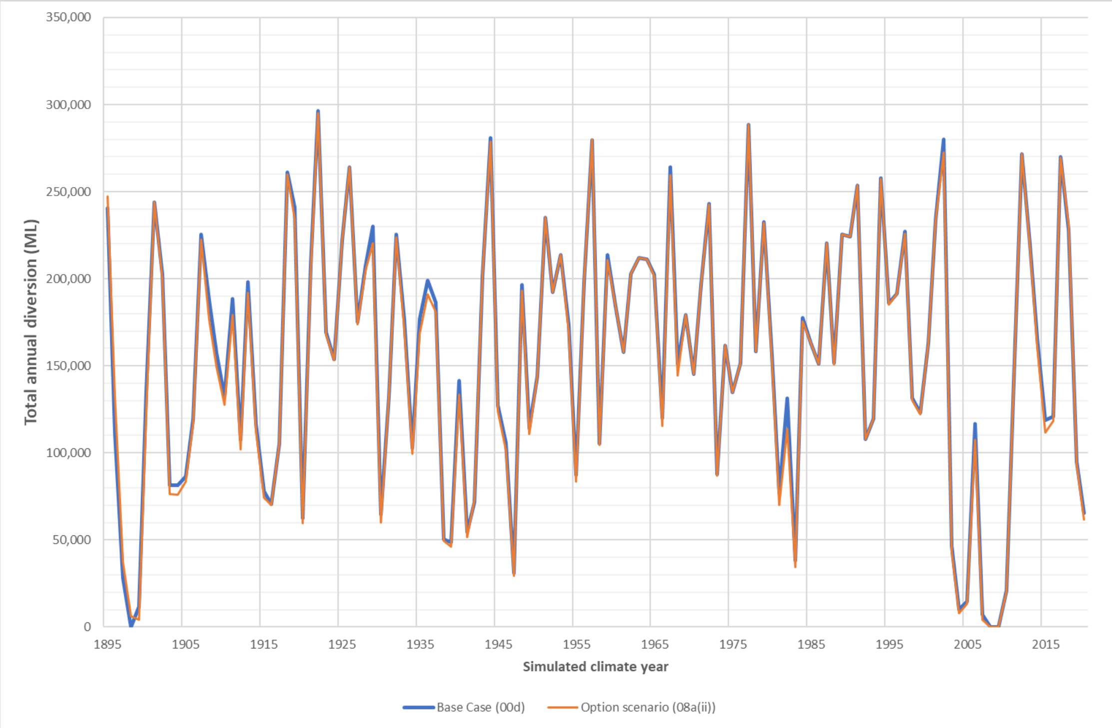


Figure 61: Simulated HSE water diversions (inc. JIL conveyance) (sub-option 1)

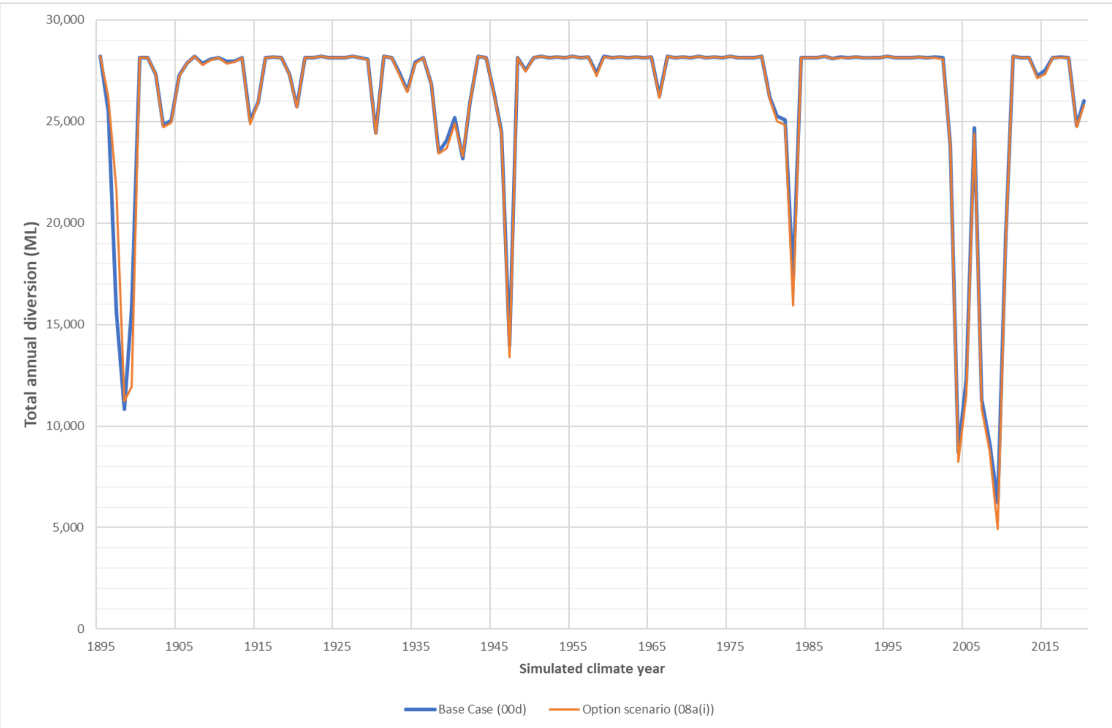


Figure 62: Simulated HSE water diversions (inc. JIL conveyance) (sub-option 2)

Figure 63: Simulated HEW usage (GSE, HSE & SD) (sub-option 1)

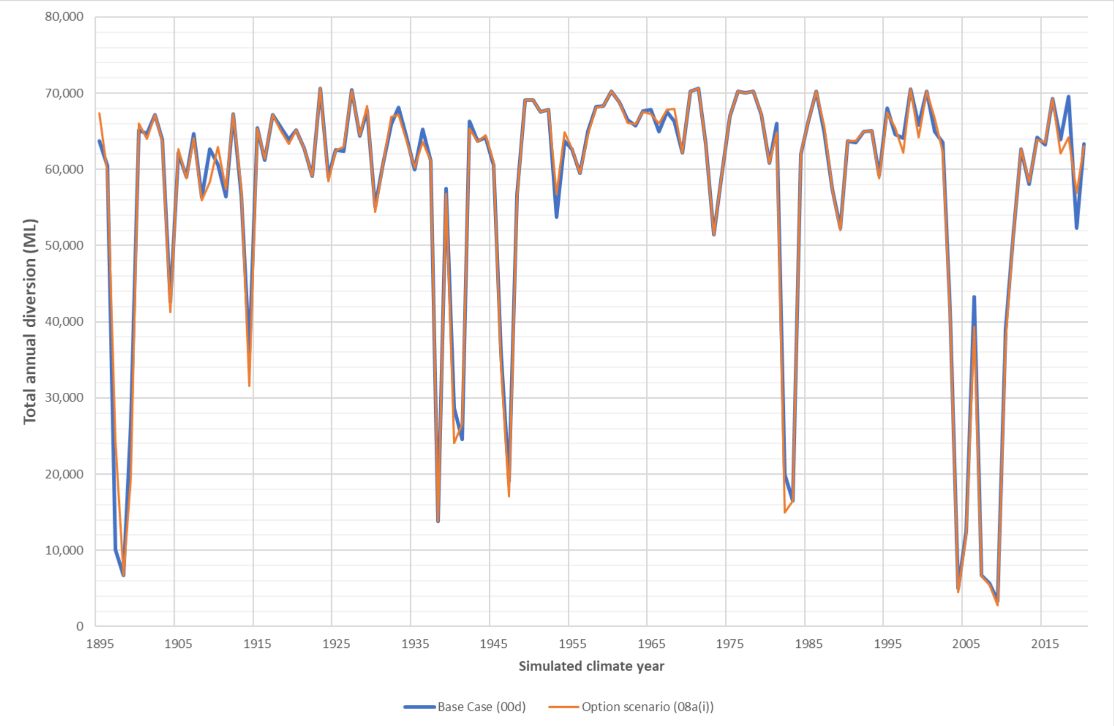
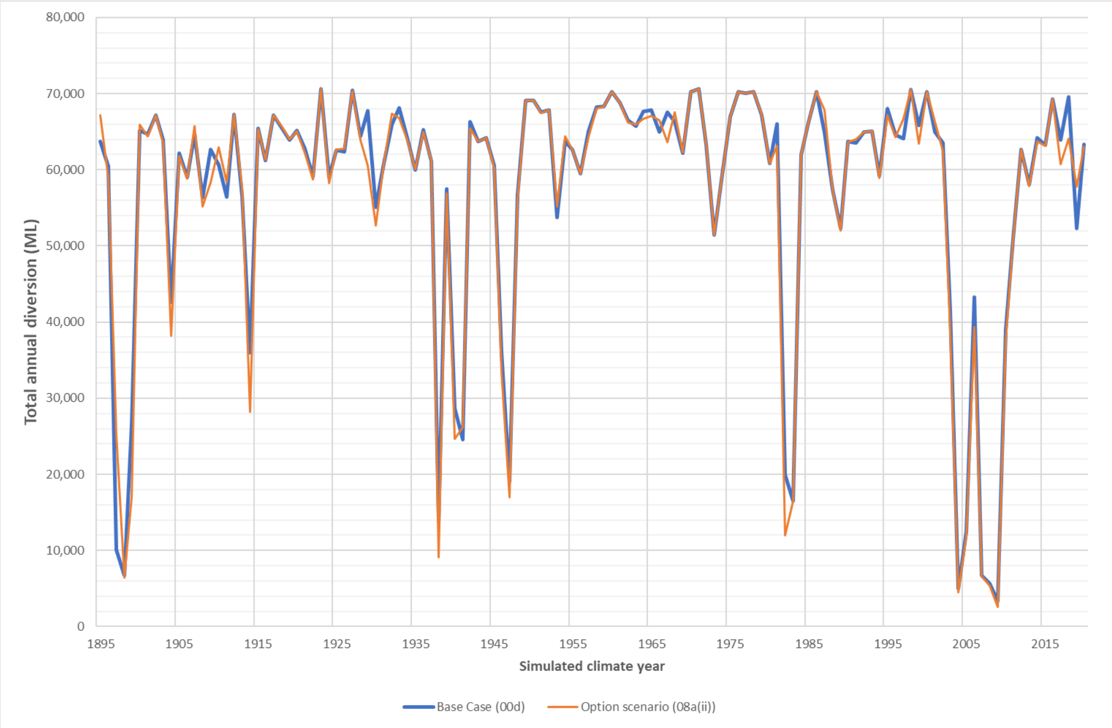


Figure 64: Simulated HEW usage (GSE, HSE & SD) (sub-option 2)



Alteration in rules based PEW

Table 34 summarises average annual simulated usage for rules-based PEW. Results show:

- Reduction in long-term average translucency flows indicating potential adverse impacts due to reduced Belubula River end of system flows. This would need further assessment and refinement should the option be developed.

Table 34: Performance metrics (rules-based PEW)

Lachlan regulated system	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Wyangala Translucency	184.6	184.4	183.3
Wyangala Environmental Water Allowance	4.6	4.6	4.6
Brewster Environmental Water Allowance	4.6	4.6	4.6

Water Quality Allowance	6.8	6.8	6.7
Total rules-based PEW	**200.5**	**200.4**	**199.2**

Figure 65: Simulated rules-based PEW (GSE, HSE & SD) (sub-option 1)

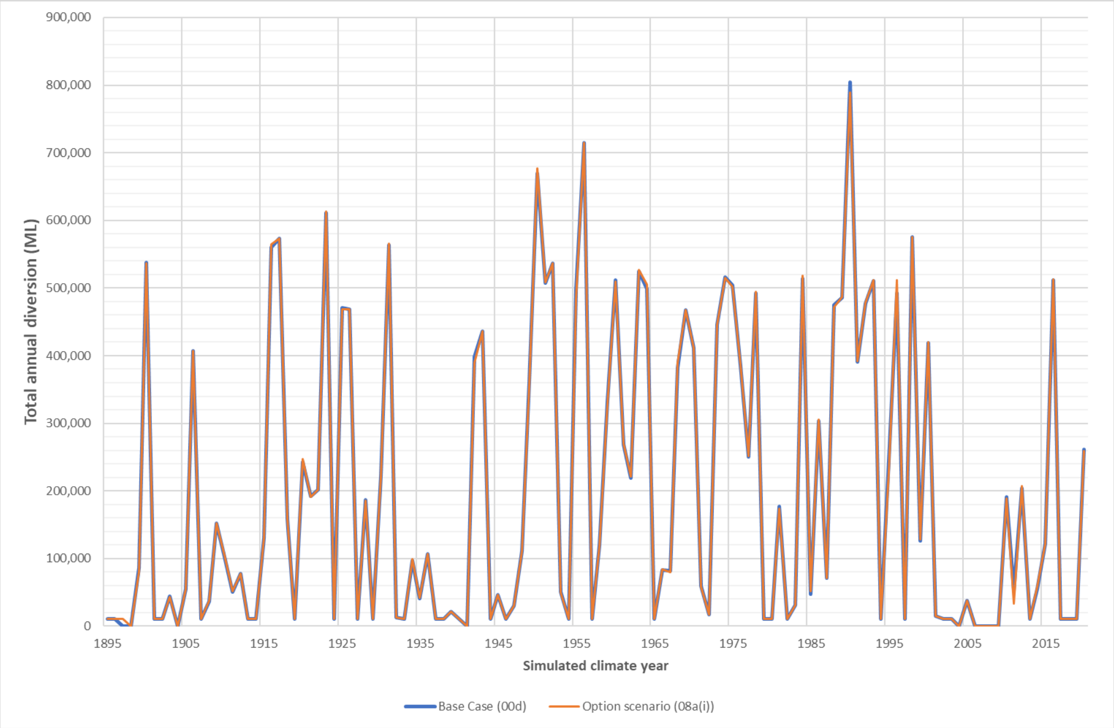
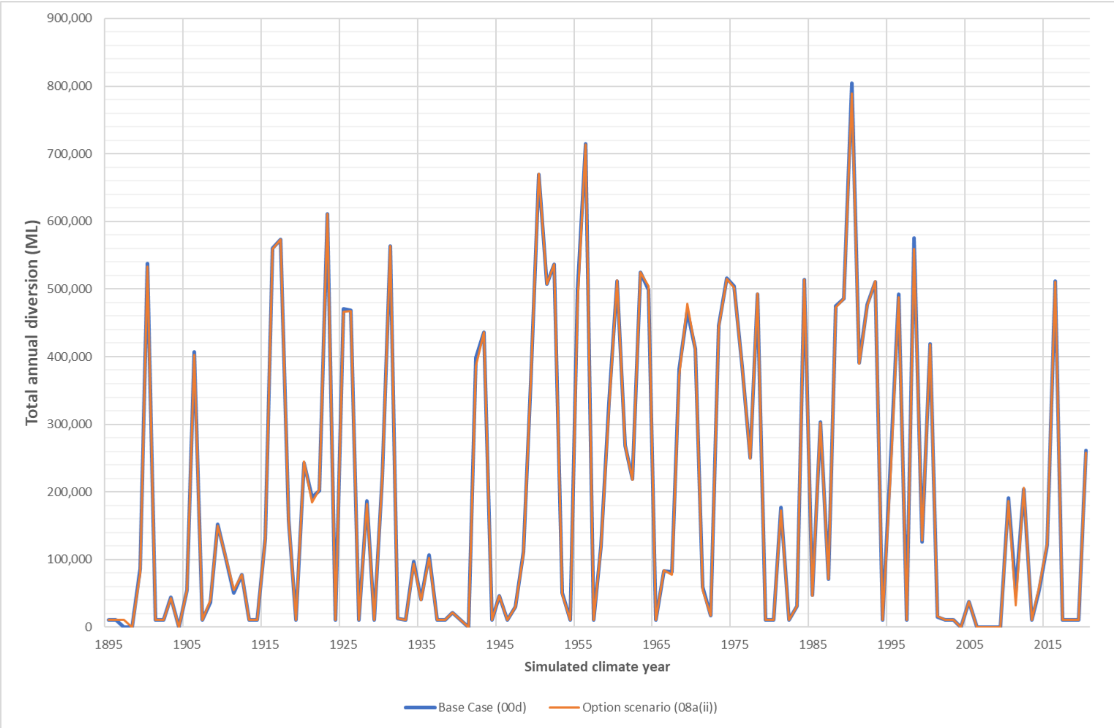


Figure 66: Simulated rules-based PEW (GSE, HSE & SD) (sub-option 2)



900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Total annual diversion (ML)
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
Simulated climate year
Base Case (00d)
Option scenario (08a(ii))

Alteration in allocation reliability

Changes in end of year allocation outcomes are shown in Table 35. Results for the Lachlan Valley WSS show a decrease in years with greater than 100% GSE effective allocation, with a slight decrease (1%) in average end of year effective allocation and a small (about 1%) decrease in years in which HSE end of water year allocation is 100%.

Results for the Belubula regulated system show significant improvements in HSE results under sub-option 1 and HSE results under sub-option 2 relatively consistent with the Base Case model. GSE results show significant (and different) change in both sub-option 1 and sub-option 2 with results indicating significant change in reported performance indicators. It is likely that model assumed demand represents a material factor in long-term supply performance indicators and further assessment of GSE behaviours and potential changes in that behaviour under modified system conditions would be required if option is to be progress or considered further.

Table 35: Performance metrics (allocation reliability)

Allocation outcomes	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Lachlan regulated system			
% of years effective allocation for GS at 30 June >= 100%	64.3%	62.7%	61.9%
Average effective allocation for GS at 30 June	113%	112%	112%
% of years HS allocation 100%	97.6%	96.8%	96.8%
Belubula regulated system			
Total available GSE on 1st July (%) (inc. carry-over)	50.2%	86.9%	47.9%
GSE added throughout year (%)	16.6%	14.2%	23.8%
Mean 1st July HSE share per unit (%)	84.1%	100.0%	83.2%
Mean 30th June HSE share per unit (%)	96.0%	100.0%	96.3%

Figure 67: End of water year Lachlan GSE effective allocation (sub-option 1)

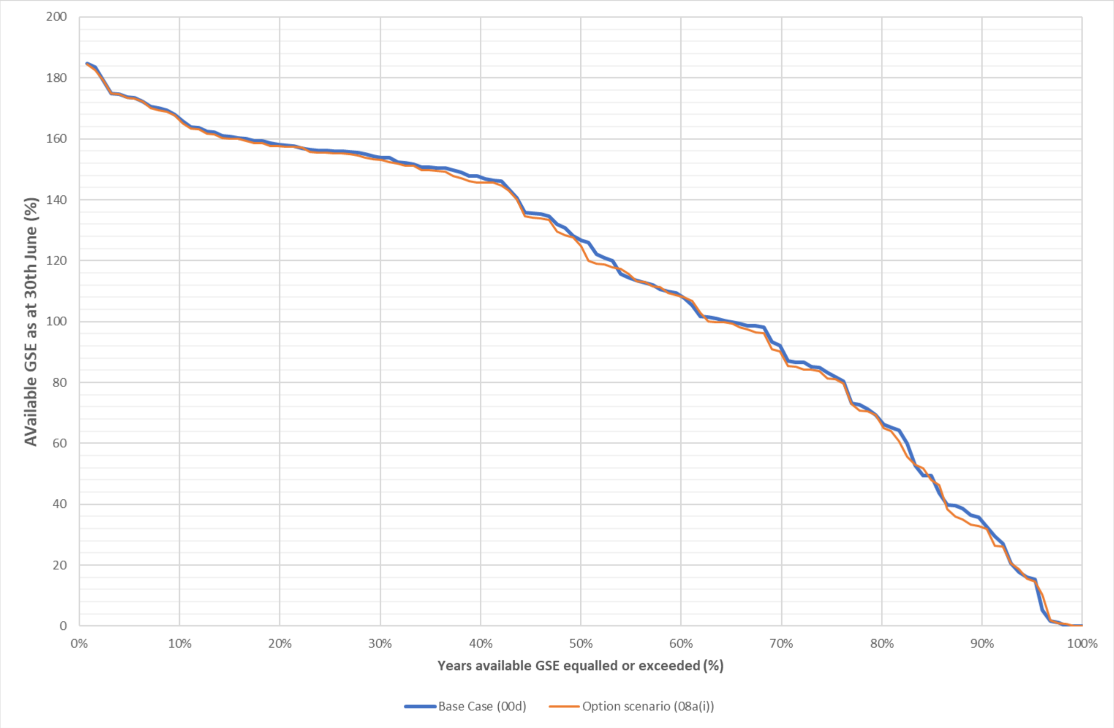


Figure 68: End of water year Lachlan GSE effective allocation (sub-option 2)

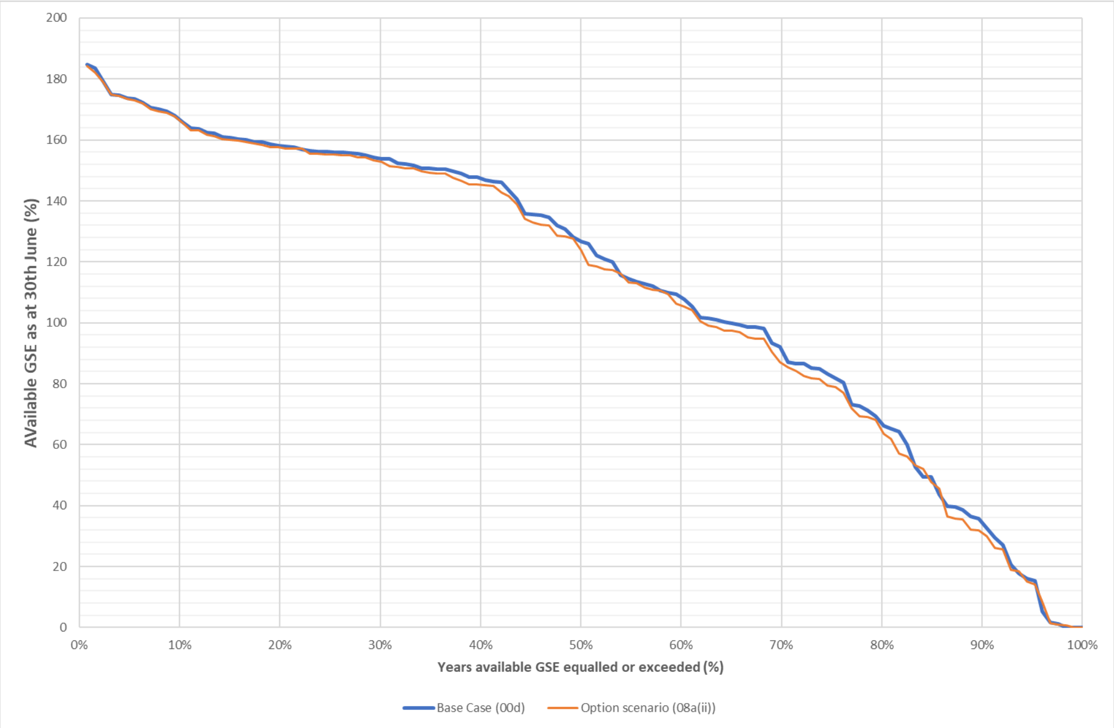


Figure 69: Ranked full year Belubula GSE available water determinations (sub-option 1)

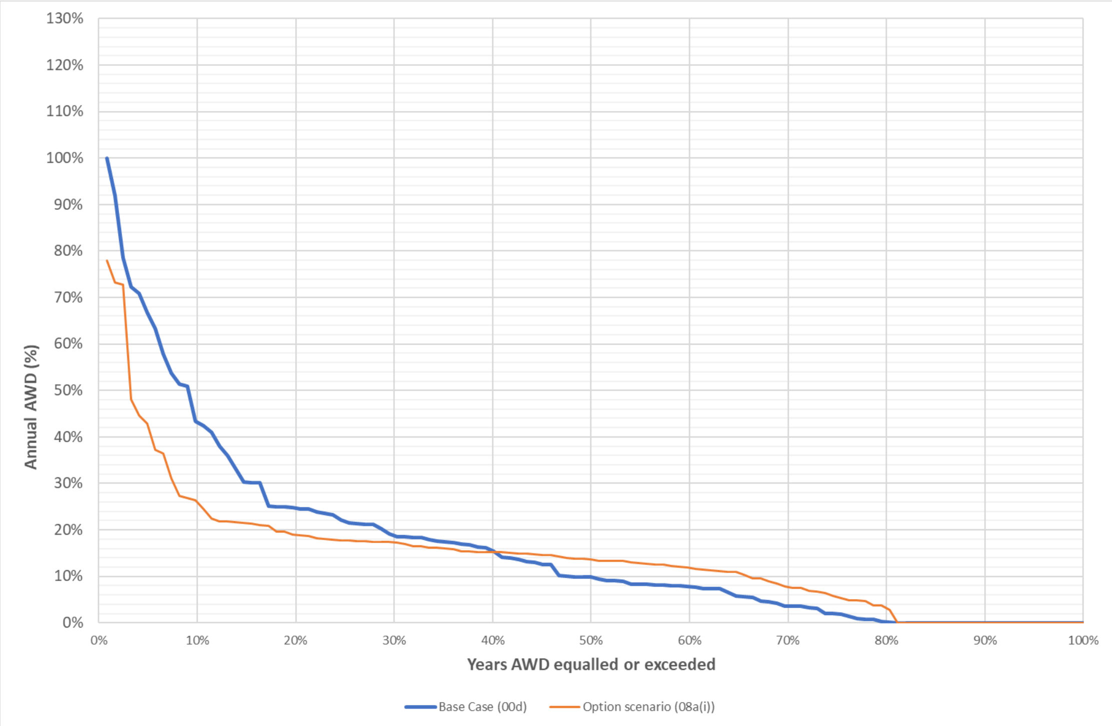
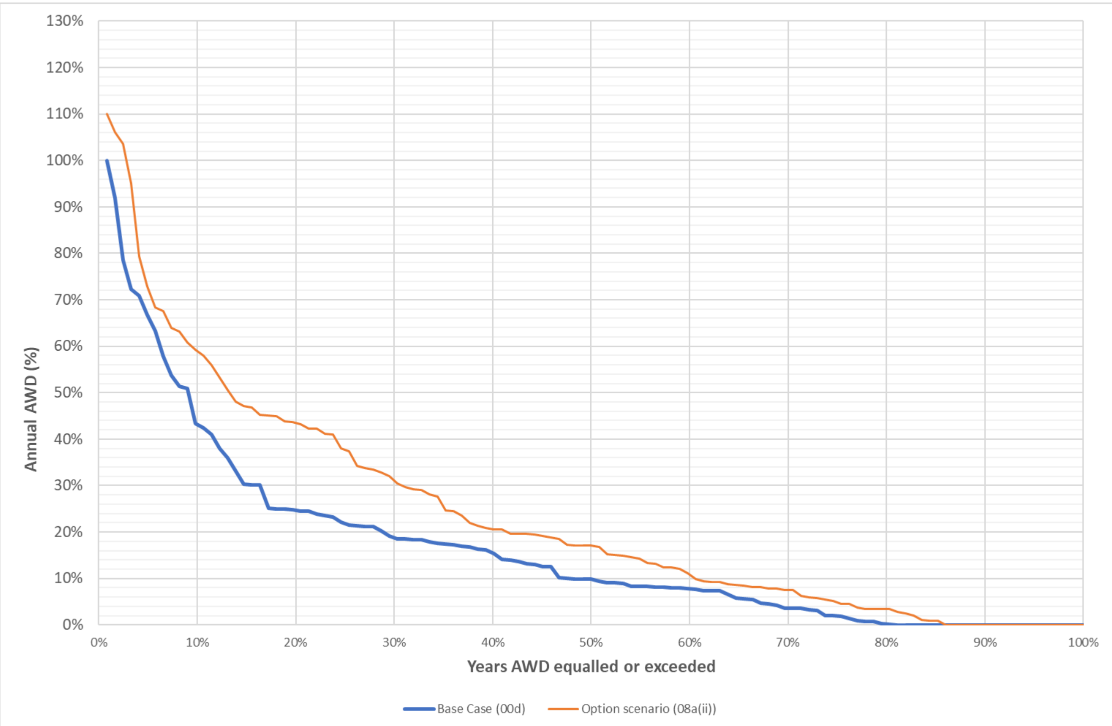


Figure 70: Ranked full year Belubula GSE available water determinations (sub-option 2)



Alteration in storage behaviour

Storage behaviour outcomes for Wyangala Dam, Lake Brewster and Lake Cargelligo in the Lachlan, as well as Carcoar Dam and Lake Rowland in the Belubula catchment, are summarised in Table 36 with simulated behaviour illustrated in the figures below.

Results show some small (< 0.5) increase in Wyangala Dam drawdown outcomes, likely associated with decreased Belubula River end-of-system flows.

Carcoar Dam behaviours are significantly improved, with reduced numbers of days below each reported storage level indicating the increased regulation of tributary flows and reduced reliance on dam releases to meet regulated demands with the Belubula scheme.

Table 36: Performance metrics (storage behaviour)

Storage	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Wyangala (% days active storage falls below at least once)			
< 300 GL	9.8%	10.1%	10.3%
< 250 GL	6.6%	7.5%	7.9%
< 210 GL	4.3%	5.0%	5.2%
< 145 GL	1.8%	2.3%	2.3%
< 105 GL	0.3%	0.9%	0.9%
< 90 GL	0.1%	0.3%	0.2%
< 80 GL	0.0%	0.1%	0.1%
< 65 GL	0.0%	0.0%	0.0%
Lake Brewster (% days active storage falls below at least once)			
< 75% (109 GL)	76.1%	76.6%	77.1%
< 50% (73 GL)	67.0%	67.3%	67.7%
< 25% (36 GL)	55.6%	56.1%	56.6%
< 10% (14.5 GL)	43.3%	43.7%	44.3%

Storage	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
< 5% (7.3 GL)	31.4%	32.2%	32.8%
Lake Cargelligo (% days active storage falls below at least once)			
< 75% (32 GL)	32.1%	33.0%	33.1%
< 50% (21.5 GL)	2.7%	2.8%	2.8%
< 25% (10.8 GL)	0.0%	0.0%	0.0%
< 10% (4.3 GL)	0.0%	0.0%	0.0%
< 5% (2.2 GL)	0.0%	0.0%	0.0%
Carcoar Dam (% days active storage falls below at least once)			
< 75% (27 GL)	74.2%	24.7%	52.5%
< 50% (18 GL)	50.8%	4.8%	34.4%
< 25% (9 GL)	29.7%	0.5%	18.4%
< 10% (3.6 GL)	18.4%	0.0%	8.1%
< 5% (1.8 GL)	12.8%	0.0%	6.0%
Lake Rowlands (% days active storage falls below at least once)			
< 75% (3.4 GL)	33.0%	33.0%	33.0%
< 50% (2.3 GL)	8.0%	8.0%	8.0%
< 25% (1.1 GL)	0.8%	0.8%	0.8%
< 10% (0.5 GL)	0.0%	0.0%	0.0%
< 5% (0.2 GL)	0.0%	0.0%	0.0%

Figure 71: Wyangala Dam storage behaviour (sub-option 1)

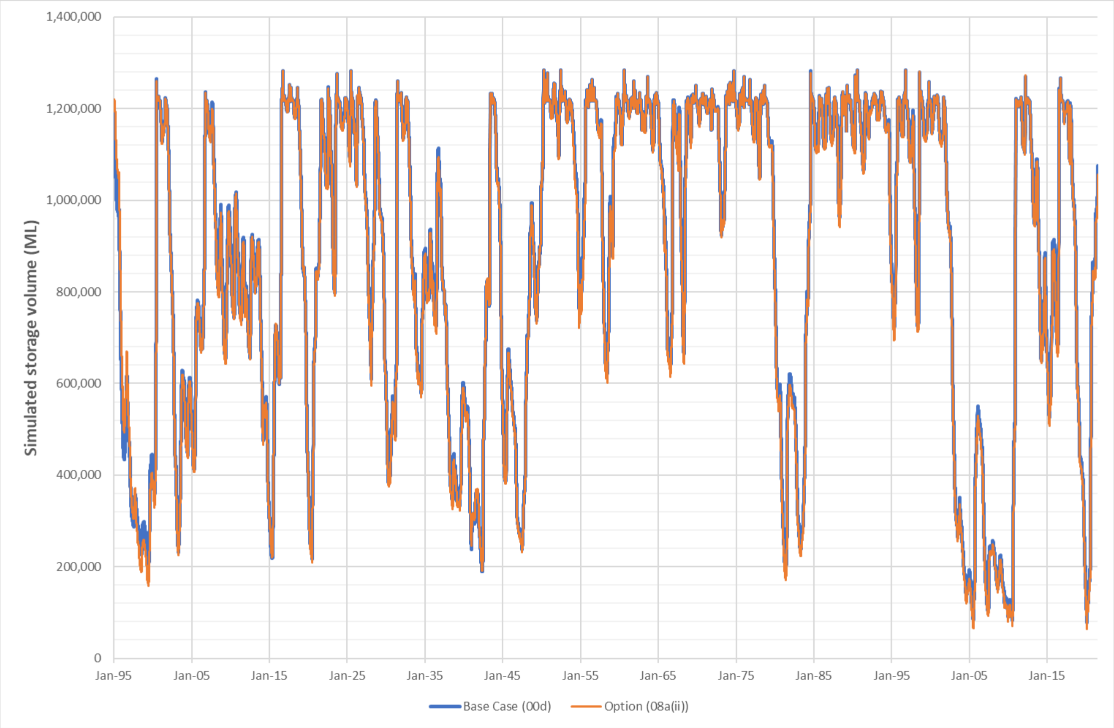


Figure 72: Wyangala Dam storage behaviour (sub-option 2)

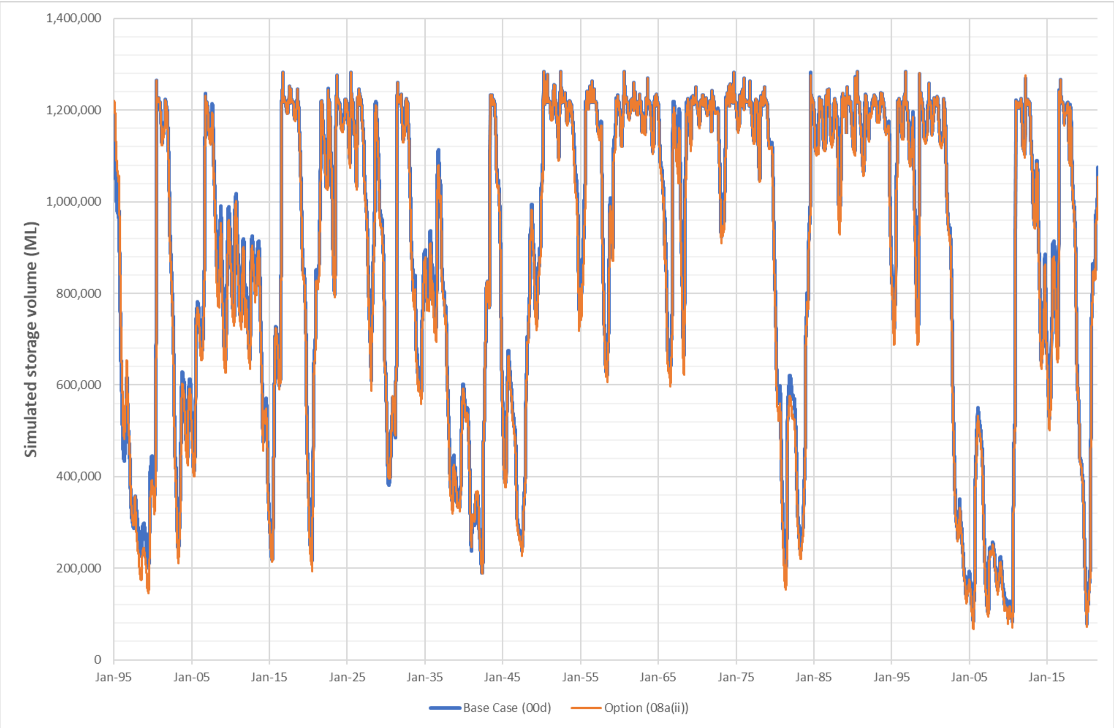


Figure 73: Lake Brewster storage behaviour (sub-option 1)

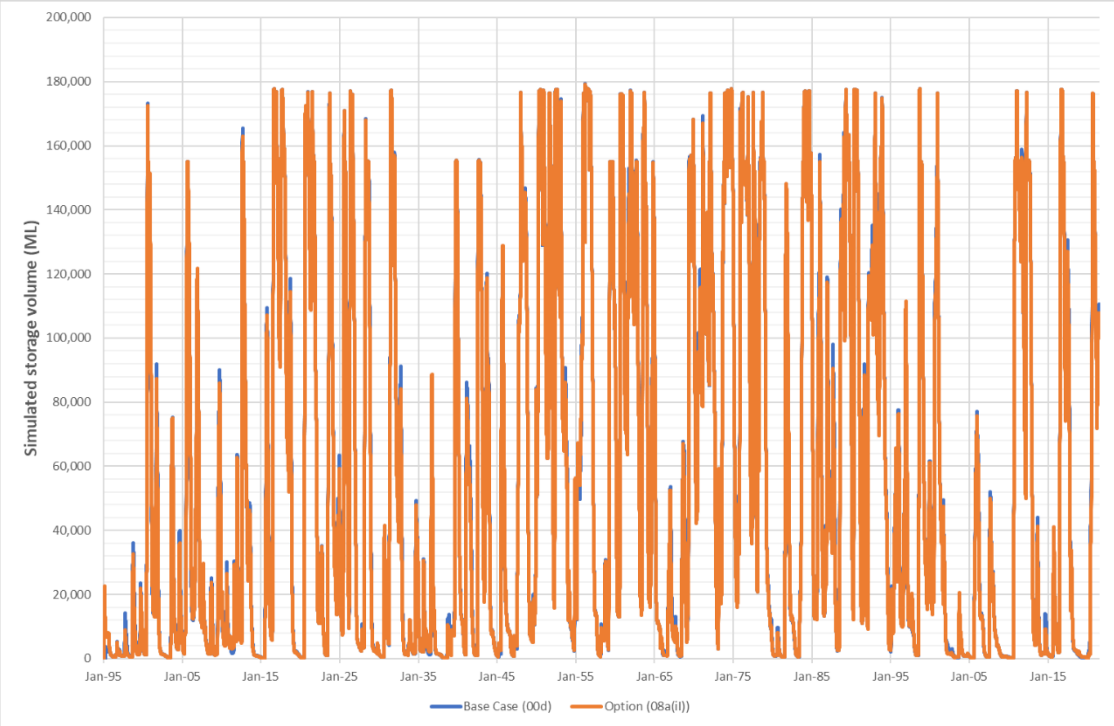


Figure 74: Lake Brewster storage behaviour (sub-option 2)

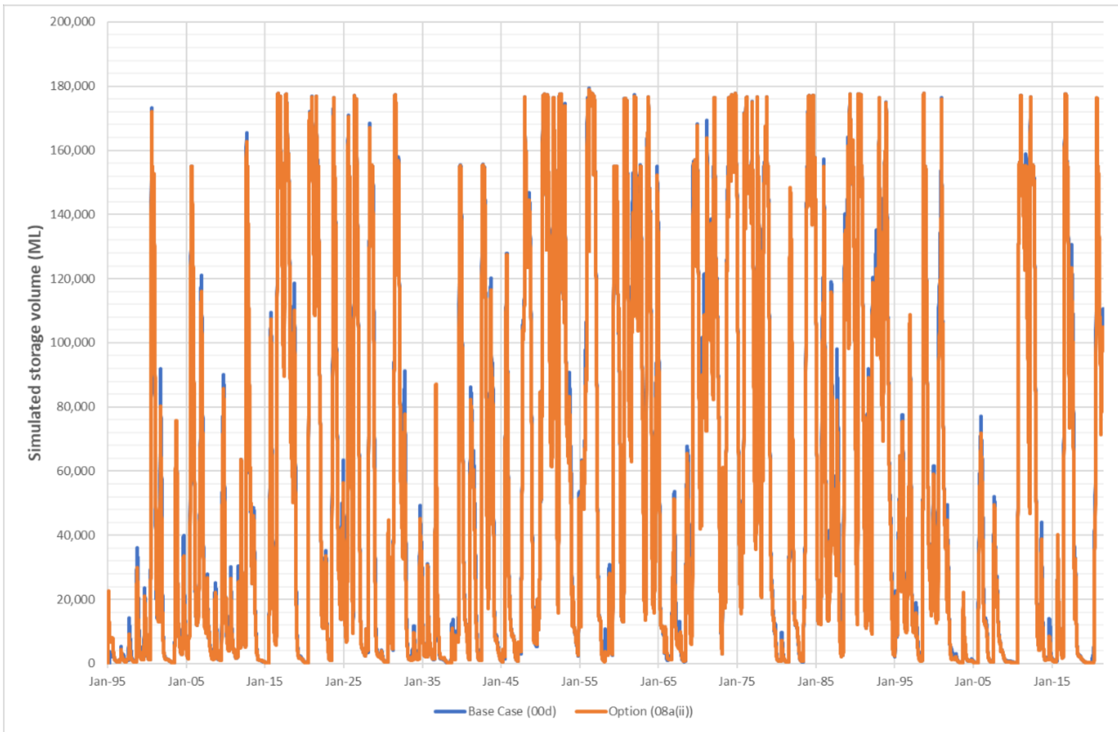


Figure 75: Lake Cargelligo storage behaviour (sub-option 1)

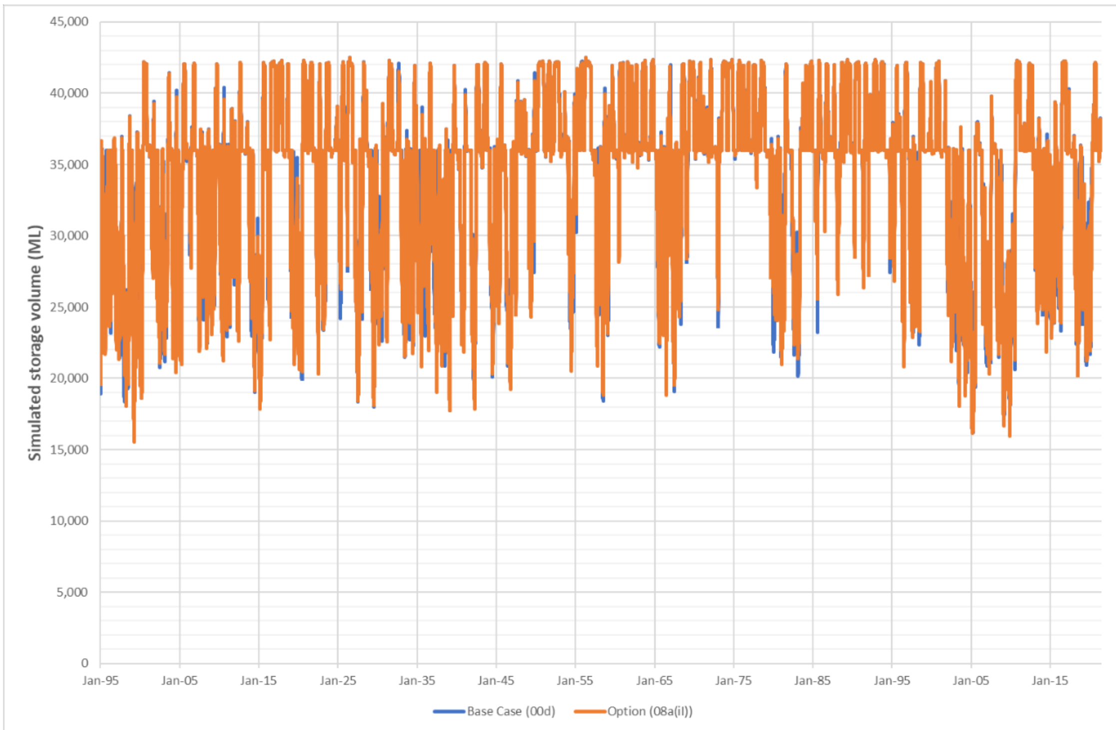


Figure 76: Lake Cargelligo storage behaviour (sub-option 2)

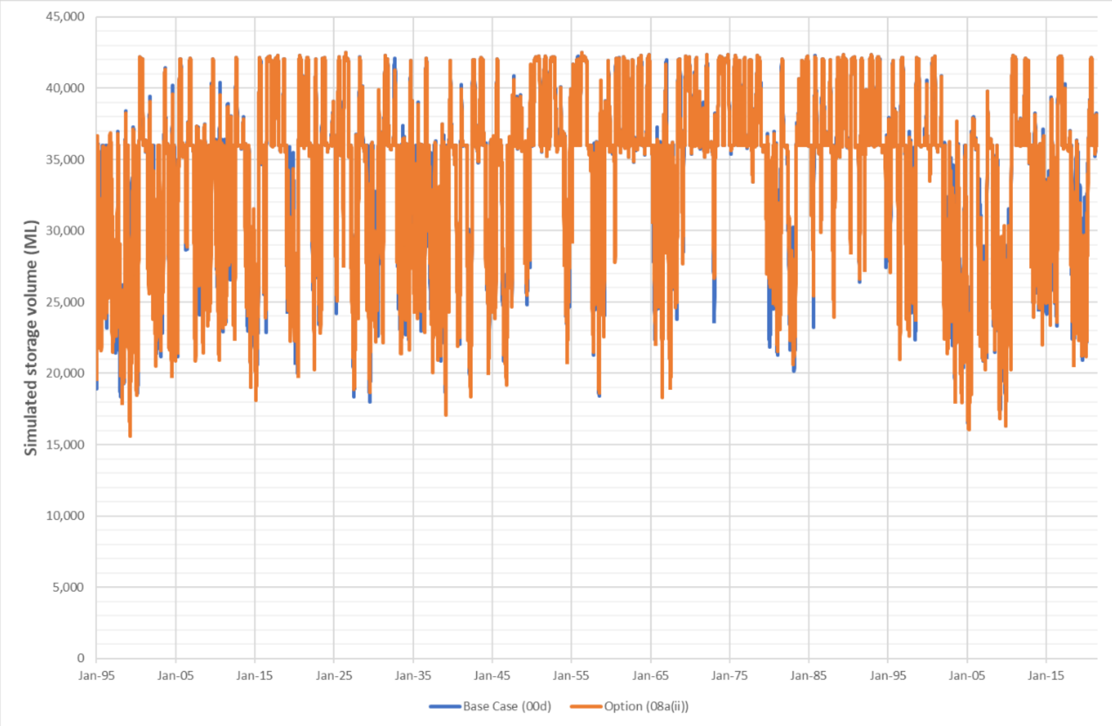


Figure 77: Carcoar Dam storage behaviour (sub-option 1)

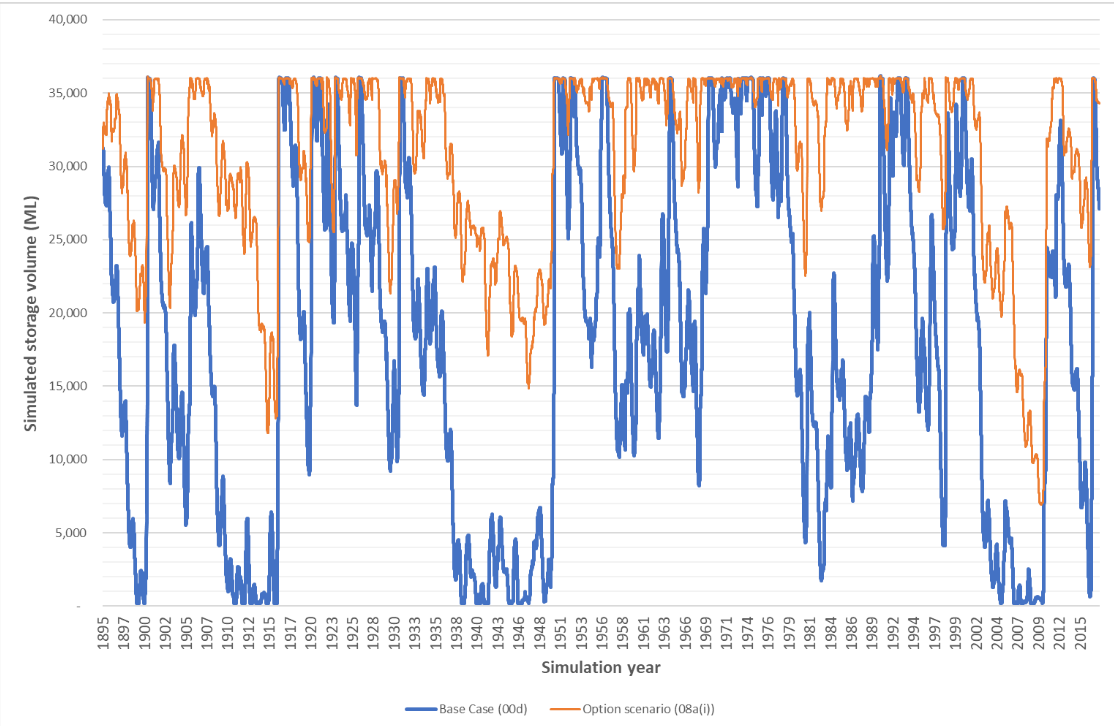


Figure 78: Carcoar Dam storage behaviour (sub-option 2)

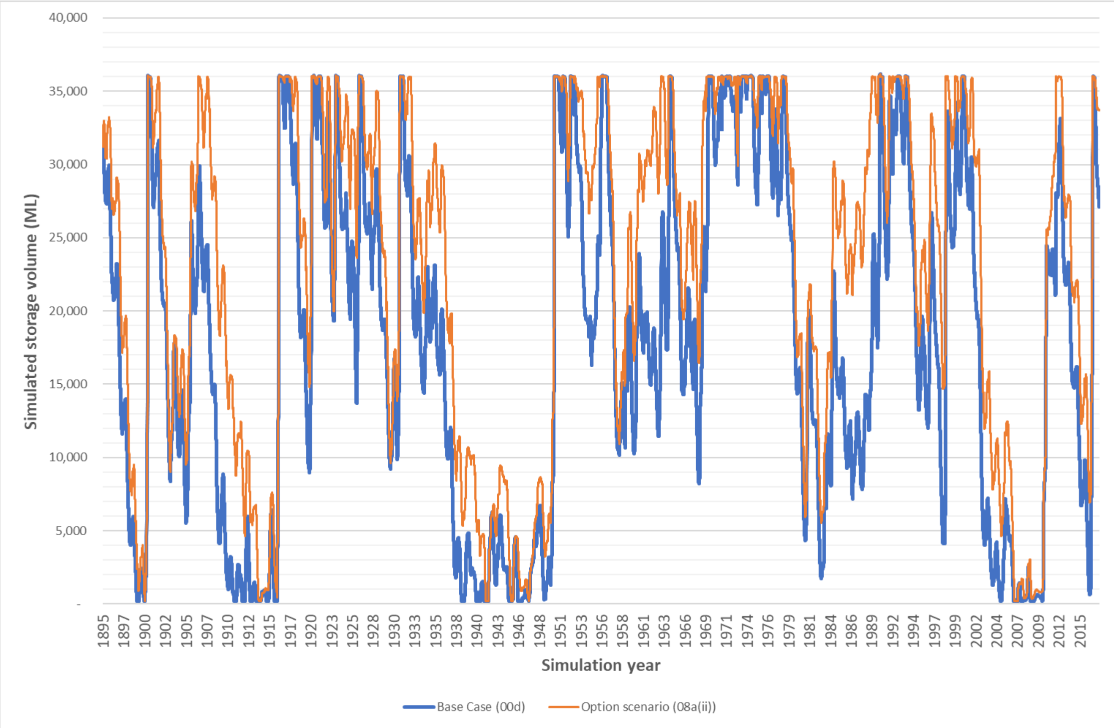


Figure 79: Lake Rowland storage behaviour (sub-option 1)

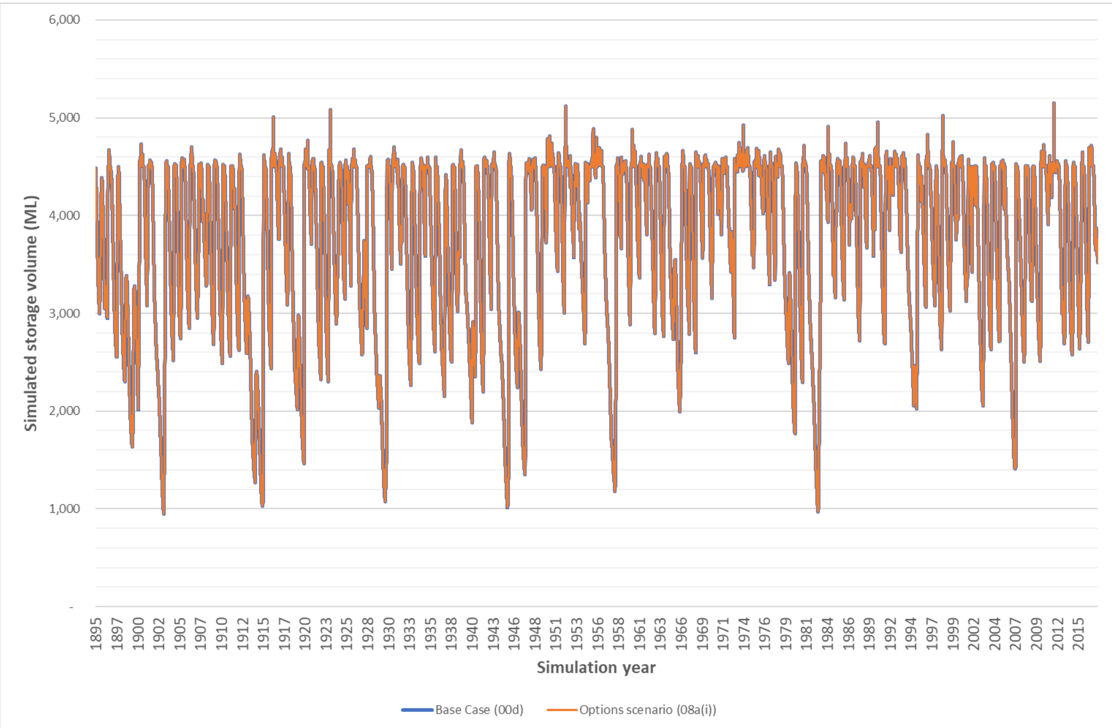
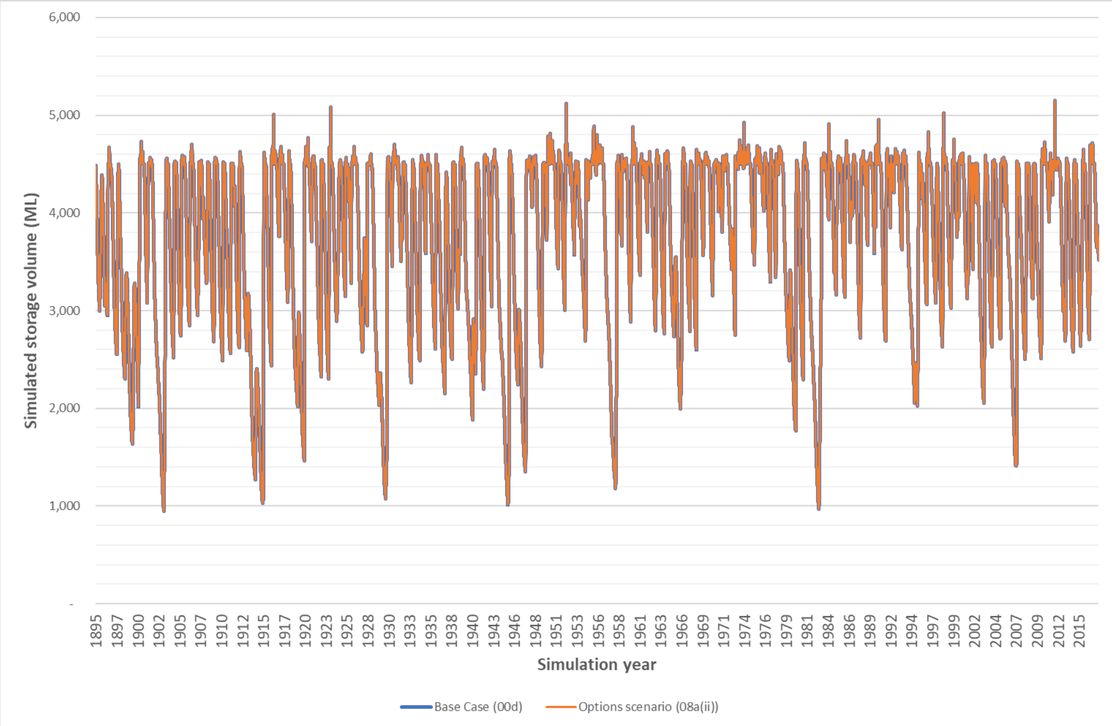


Figure 80: Lake Rowland storage behaviour (sub-option 2)



Town water supply

Table 37 summarises the modelled town water supply results. Scenario results show some adverse impact on town water supply local water utility performance results, with an increase in the amount of time spent with restricted supply and reduction in overall long-term supply, with consequent need for option refinement should option be developed further.

Table 37: Town water supply performance

Town water supply	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Cowra			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or	0.0%	0.0%	0.0%

Town water supply	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Cowra			
an assumed equivalent of 65% of full demand)			
Average water supplied GL/yr	2.84	2.84	2.83
Average water supplied as % of full demand	99.3%	99.1%	98.9%
Forbes			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%	0.0%
Average water supplied GL/yr	2.20	2.19	2.19
Average water supplied as % of full demand	99.3%	99.1%	98.9%
Parkes			
% of time full demand not supplied (ie some form of restrictions would be in place),	31.2%	0.0%	0.0%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%	0.0%
Average water supplied GL/yr	4.16	4.16	4.16
Average water supplied as % of full demand	99.4%	100.0%	100.0%
Condobolin			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or	0.0%	0.0%	0.0%

Town water supply	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Cowra			
an assumed equivalent of 65% of full demand)			
Average water supplied GL/yr	0.95	0.95	0.95
Average water supplied as % of full demand	99.3%	99.1%	98.9%
Lake Cargelligo			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%	0.0%
Average water supplied GL/yr	0.40	0.40	0.40
Average water supplied as % of full demand	99.1%	98.9%	98.7%
Willandra			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or an assumed equivalent of 65% of full demand)	0.0%	0.0%	0.0%
Average water supplied GL/yr	0.11	0.11	0.11
Average water supplied as % of full demand	99.1%	98.9%	98.7%
Hillston			
% of time full demand not supplied (ie some form of restrictions would be in place),	3.3%	3.9%	4.1%
% of time failure (when supply not enough to meet demand at level 5 restrictions or	0.0%	0.0%	0.0%

Town water supply	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
Cowra			
an assumed equivalent of 65% of full demand)			
Average water supplied GL/yr	0.27	0.27	0.27
Average water supplied as % of full demand	99.1%	98.9%	98.7%

Alteration in river flows

Changes in the flow regime resulting from the proposed stormwater harvesting are shown for selected locations in Table 38, with annual flow exceedance curves for selected gauging stations in figures below. Results indicate no material change in flow characteristics at the locations listed.

Table 38: Performance metrics (river flows)

Mean annual flow (GL/year)	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
412033 - Belubula River at Helensholme	139.7	138.4	131.7
412027 - Lachlan River at Reids Flat	358.4	358.4	358.4
412067 - Lachlan River at Wyangala	678.2	679.2	679.3
412002 - Lachlan River at Cowra'	832.2	833.0	833.1
412057 - Lachlan River at Nanami	1039.0	1038.6	1032.3
412004 - Lachlan River at Forbes	1015.5	1012.6	1005.2
412019 - Island Ck at Cadow	400.0	399.0	396.0
412023 – Island Ck at Fairholme	399.4	398.4	395.4
412017 – Bumbuggan Creek at offtake	149.2	149.7	149.1
412014 – Goobang Creek at Condobolin	202.3	202.8	202.3
412016 - Wallamundry Creek at Offtake Island Creek	81.1	80.6	80.1
412034 - Lachlan River at Condobolin Weir	744.4	742.3	737.4
412021 - Lachlan River at Booberoi Weir	731.1	728.7	723.8
412011 - Lachlan River at Lake Cargelligo Weir	561.0	560.6	557.2
Combined flow at 412102 - Lake Brewster Intake D/S Lake B. Weir Pool Regulator	700.1	698.1	693.1

Mean annual flow (GL/year)	Base Case	Belubula re-regulating weir (1,000 ML HSE)	Belubula re-regulating weir (10,000 ML HSE)
And 412048 - Lachlan River at Lake Brewster Weir-Storage Gauge			
412038 - Lachlan River U/S Willandra Weir	584.0	582.4	578.4
412039 - Lachlan River at Hillston Weir	382.0	380.7	378.1
412078 - Lachlan River at Whealbah	354.9	353.8	351.4
412087 - Merrowie Ck at Merrowie Homestead	69.7	69.6	69.0
Merrowie Creek modelled EOS	3.4	3.4	3.4
412124 - Muggabah Ck at Cobb Hwy	5.3	5.3	5.3
Muggabah Creek modelled EOS	5.0	5.0	5.0
412005 – Lachlan River at Booligal	205.2	204.5	202.8
412045 – Lachlan River at Corrong	139.7	139.2	138.1
412026 – Lachlan River at Oxley	115.5	115.0	114.0
412122 - Merrimajeel Ck at Cobb Hwy	5.8	5.8	5.7
Total model EOS flow	183.9	183.2	181.6

Figure 81: Annual flow exceedance – Lachlan River at Forbes (412004) (sub-option1)

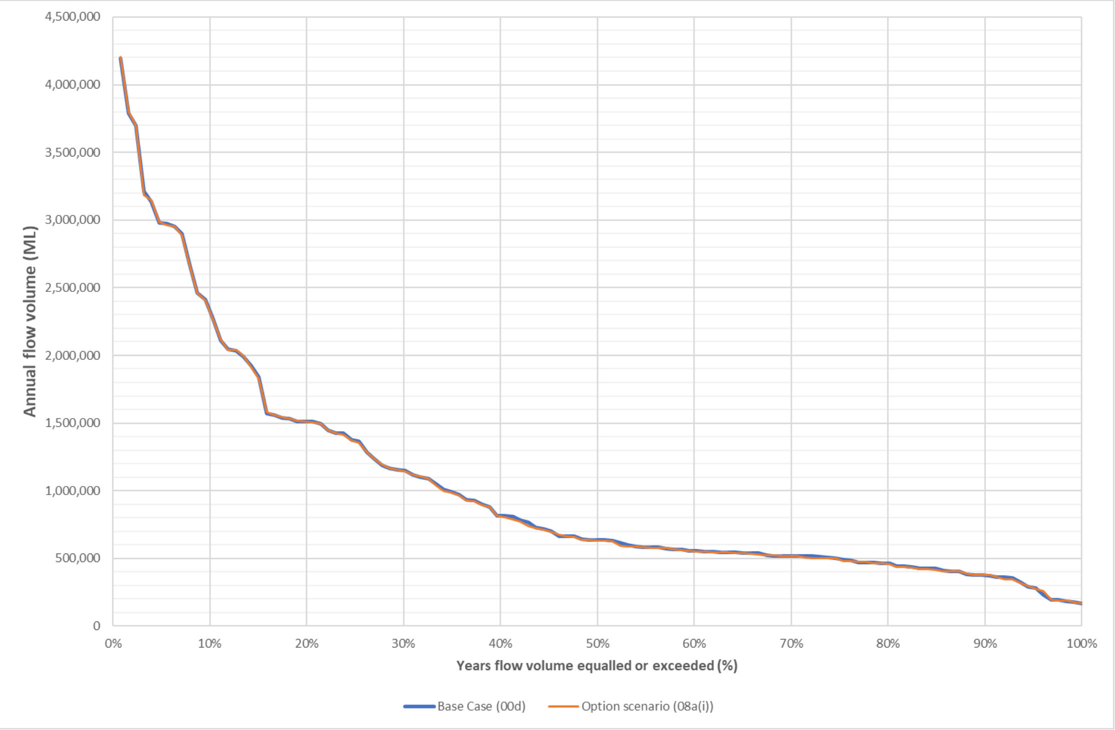


Figure 82: Annual flow exceedance – Lachlan River at Forbes (412004) (sub-option 2)

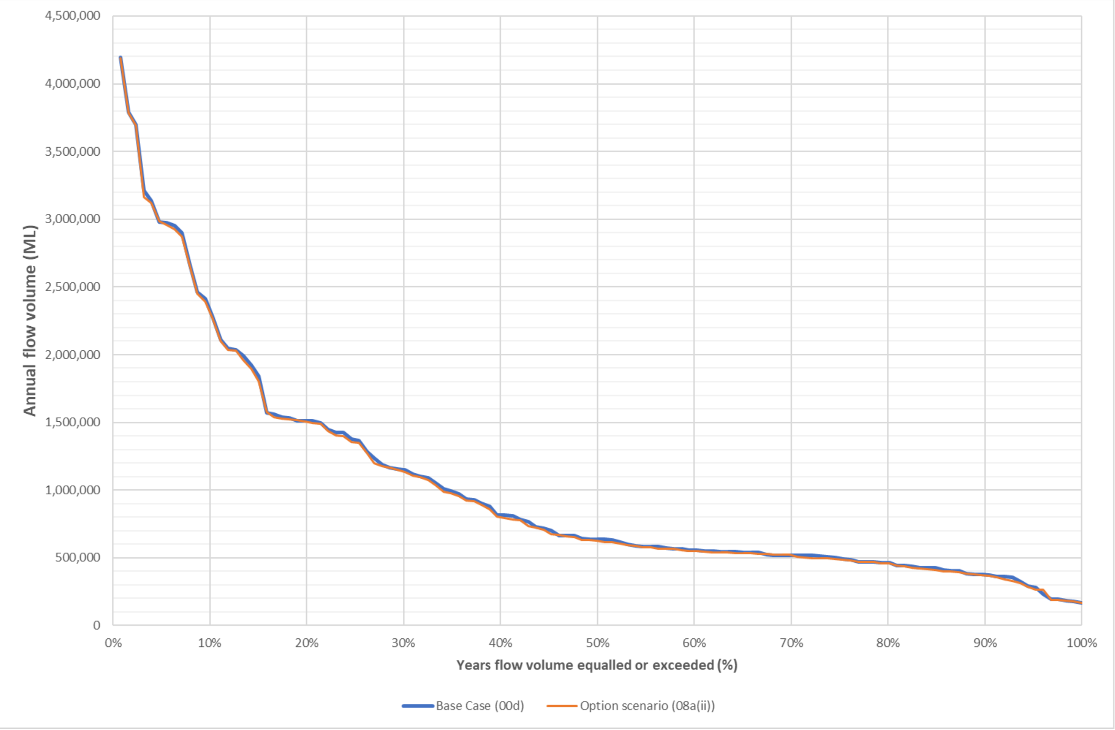


Figure 83: Annual flow exceedance – Lachlan River at Booligal (412005) (sub-option 1)

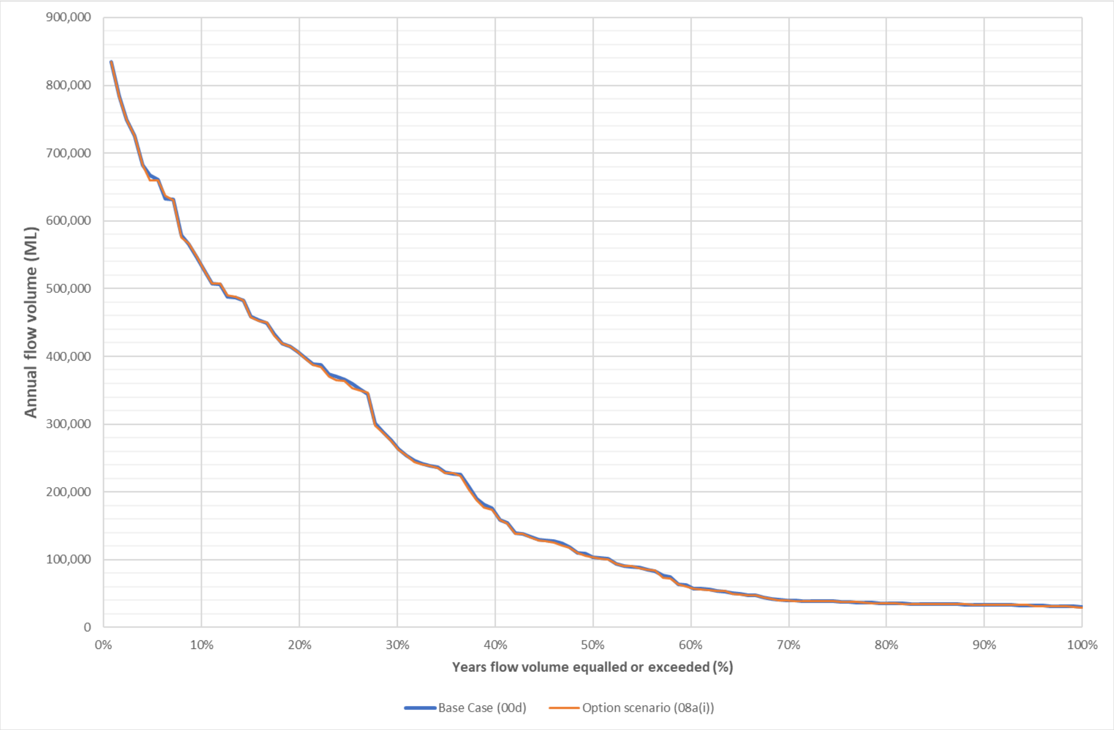


Figure 84: Annual flow exceedance – Lachlan River at Booligal (412005) (sub-option 2)

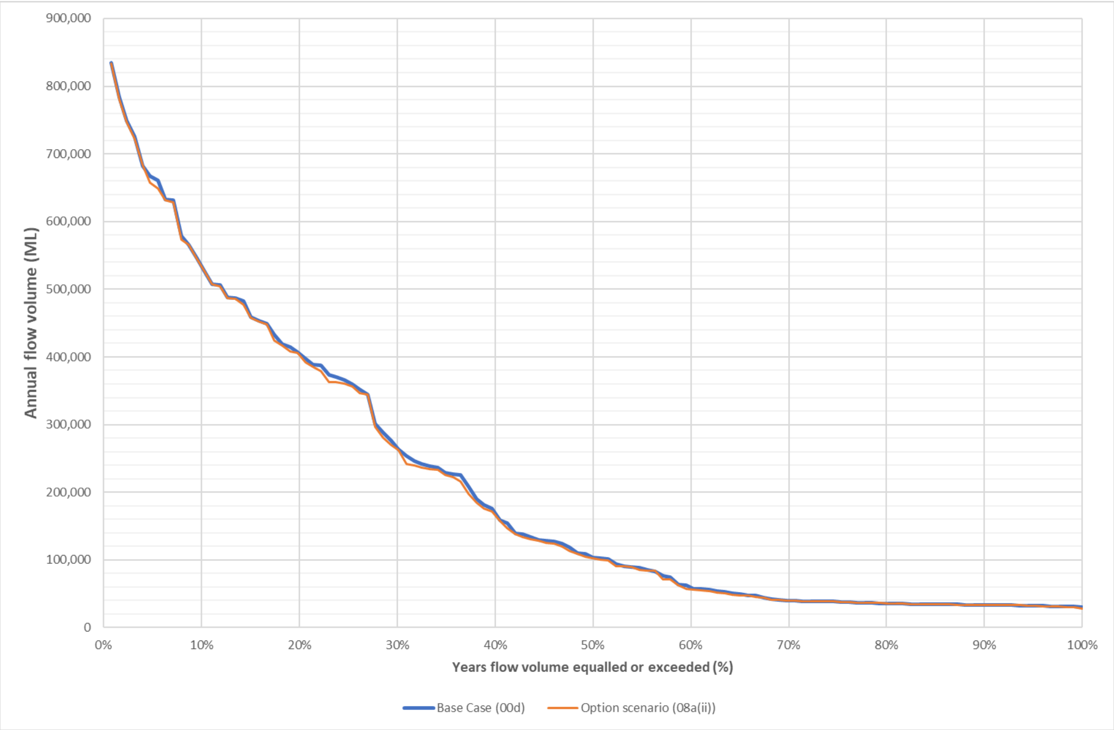


Figure 85: Annual flow exceedance – Belubula River at Helensholme (412033) (sub-option 1)

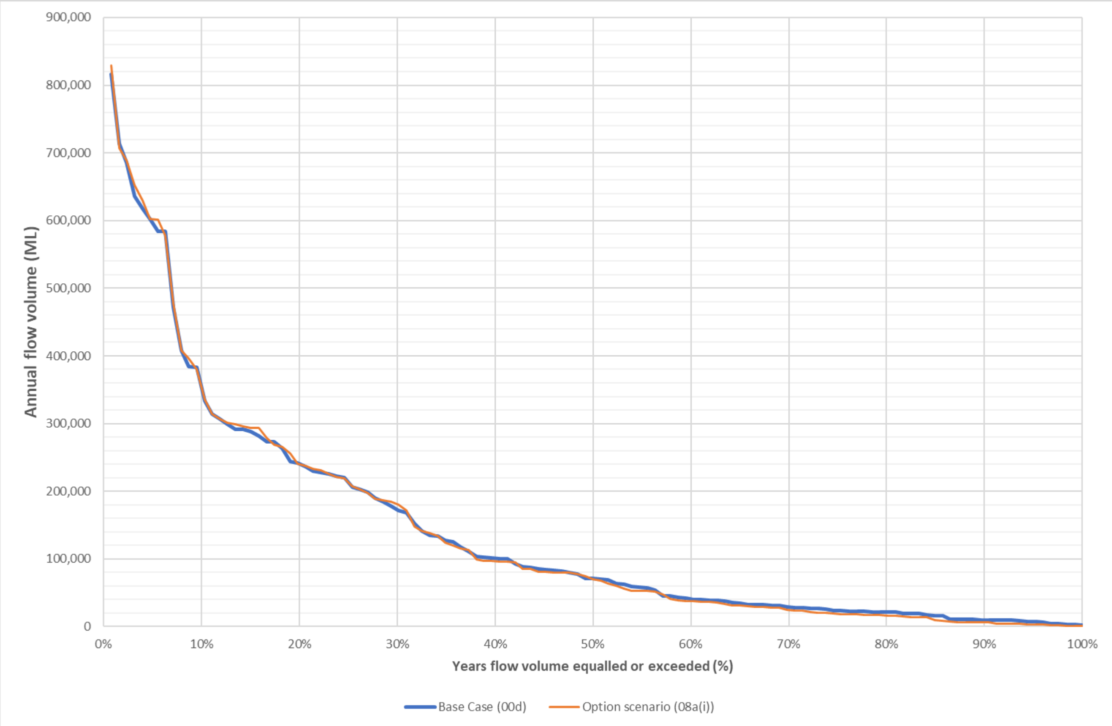
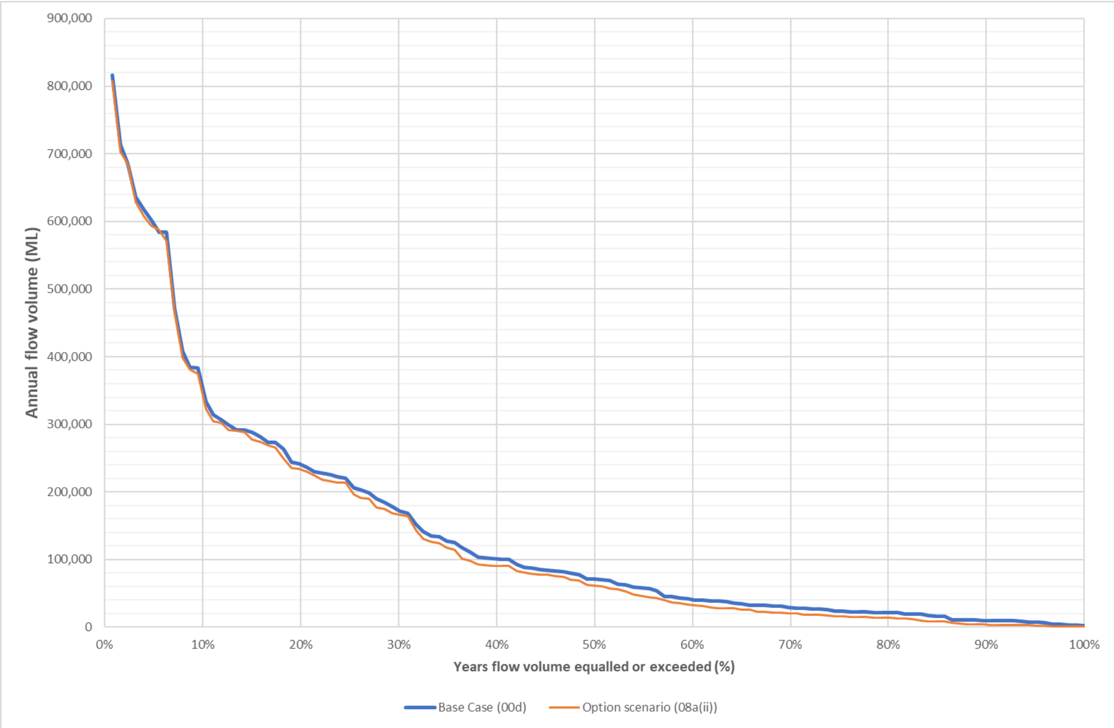


Figure 86: Annual flow exceedance – Belubula River at Helensholme (412033) (sub-option 2)


900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual flow volume (ML)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Years flow volume equalled or exceeded (%)
Base Case (00d)
Option scenario (08a(ii))

Limitations

The model set-up, assumptions and reconfiguration for each option as described in this report are considered appropriate for the current assessment. However confirmation and update/improvement (if required) is recommended if subsequent, detailed studies into specific, short-listed options are to be undertaken.

All assessment undertaken as reported herein is intended for comparative analysis between options, and to provide high-level understanding of the magnitudes and variability of the various demand types and sources of supply. It is not intended or appropriate for detailed operational applications or demand/supply assessment for specific projects or individual water users.

References

Carr, R, Podger, G. (2012). eWater Source — Australia's Next Generation IWRM Mo Platform. 34th Hydrology and Water Resources Symposium (December 2012), ISBI 922107-62-6.

Welsh WD, Vaze J, Dutta D, Rassam D, Rahman JM, Jolly ID, Wallbrink P, Podger GM Hardy M, Teng J, Lerat J. (2012). An integrated modelling framework for regulated Environmental Modelling and Software, DOI 10.1016/j.envsoft.2012.02.022.