Australian Government

Murray–Darling Basin Authority

Murray-Darling Basin Sustainable Yields

River System Modelling Technical Report

February 2026

Published by the Murray–Darling Basin Authority
MDBA publication no: 10/26

ISBN (online): 978-1-923558-34-2

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Cataloguing data
Title: Murray-Darling Basin Sustainable Yields, Murray–Darling Basin Authority Canberra, 2026. CC BY 4.0

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin
We acknowledge the Traditional Owners and Custodians of Country throughout the Murray–Darling Basin and their continuing connection to land, waters and community. We offer our respects to the people, the cultures and the Elders past and present.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

alluvium consulting

This report was developed collaboratively between Alluvium Consulting and the MDBA based on technical assessments undertaken by the MDBA, technical insight from CSIRO and contributions from Basin States.

Foreword

Background to this report

This 2025 Sustainable Yields project (SY) provides a whole of Murray-Darling Basin (MDB) assessment of the challenges that are likely to arise as the climate continues to change. SY is forward looking; and considers a range of plausible scenarios at a 2°C global warming level. SY contributes hydrological and climate science to a wider program of technical assessments that inform the Basin Plan Review.

In line with MDBA's commitment to best available science, the modelling presented here is intended to inform rather than provide definitive answers. River system models offer a transparent, repeatable way to explore system responses under different climate, and management assumptions. However, all models simplify complex Basin processes and carry inherent uncertainties in data, methods and future conditions.

Accordingly, model outputs should be interpreted as one line of evidence within a broader assessment context. They are strengthened when considered alongside observed data, ecological knowledge, operational experience, and expert judgement. Drawing these lines of evidence together provides a more robust understanding of risks, system behaviour and potential outcomes, supporting defensible and well-balanced review process. It also represents the results of river system modelling at a point in time, based on the best information available, but also recognising that the modelling will continue to improve over time as further assessments and advances in science are made.

Summary

This river systems modelling work shows that in the future, climate change impacts on the Basin are likely to result in:

- An overall modest drying trend in the Northern Basin, although with significant variance between the wettest and driest modelled scenarios.
- Stronger and more consistent drying in the Southern Basin catchments
- Existing management arrangements tending to:
    - Protect consumptive use within valleys.
    - Shift impacts to downstream flows.
- Substantial reduction in downstream flows, particularly from the Southern Basin.
- Full implementation of the Basin Plan reducing climate change impacts but not offsetting the climate change signal.

River system modelling uses improved methods

A recent investment to improve river system modelling across the Murray–Darling Basin (MDB), through the Integrated River Modelling Uplift (IRMU) program, has produced the Framework for Integrated River System Modelling (FIRM), This now enables a basin-scale assessment to be completed using contemporary hydrological and water resource modelling based on models shared collaboratively by state jurisdictions within the Basin. The three development scenarios reported on are:

- **Without development (WoD)** – intended to represent the case where there is no water resource development of any kind in the Basin, including no dams, weirs, or extractions.
- **June 2009** – Basin Plan Review reference as at June 2009 intended to represent the development, operation, and water sharing conditions immediately prior to the Basin Plan.
- **Basin Plan fully implemented (BPFI)** – represents a fully implemented Basin Plan and as such relies on assumption of how Basin Plan implementation will be finalised.

Projected changes in inflows across the Basin

Inflow changes largely reflect changes in catchment runoff, and are relatively independent of management or regulation. For downstream rivers, there are some impacts of management on inflows as they receive both local catchment runoff and outflows from upstream valleys.

In the Northern Basin: There are a wide range of plausible inflow changes, with the median scenario showing an overall reduction (~6%), but also expecting that there will be greater variability between wet and dry conditions in the future given the wide range across all scenarios, as highlighted in the SY Hydroclimate projections for the Murray-Darling Basin report.

In the Southern Basin: There is a stronger negative trend for inflows overall when compared to the North, with the median scenario showing larger reductions (~13–14%) than the North, with lower variability between the wet (increase of 5%) and dry (28% reduction) conditions.

Changes in water balance responses

Changes in inflows are propagated through river system models under the various management arrangements combined with the historical and future hydroclimates to assess impacts on:

River system process water is a major component of the overall water balance, particularly in the Northern Basin.

Northern Basin water balance

- Large proportion of inflows are lost as river system process water (often ~50% or more).
- Downstream flows more affected than consumptive use.
- Storages are relatively small and provide limited buffering.

Southern Basin water balance

- Much larger contribution to downstream flows than the North.
- Storages are large and become more efficient due to increased headspace, which:
    - Buffers consumptive use within valleys.
    - Further reduces flows passed downstream.

Across the river systems in the Basin, we have used specific river valleys to illustrate the impacts on the water balances for different systems.

Flows at the end-of-system

The river system modelling shows the largest impacts occur in the Southern Basin, especially flows reaching South Australia.

Under the median hydroclimate scenario (warmer/hotter and drier):

- The Northern Basin shows an ~8–9% reduction in flows at the end of the system.
- The Southern Basin is projected to have a ~22–24% reduction at the end of the system.

For the much drier climate scenario, these changes could be up to a ~30% reduction in the Northern Basin and up to ~49% reduction in the Southern Basin.

Low-flow conditions

- The changes in average inflows across the hydroclimate scenarios translate to changes in low flows. There will be longer low-flow spells, especially in the Southern Basin.
- Low-flow impacts are more severe in the Southern Basin catchments than those in the Northern Basin.
- With changes in low flows, especially in the drier hydroclimate scenarios, the time spent in drought conditions will increase, which is consistent with other lines of evidence around drought in the Basin.

This report

This report documents river system modelling to inform understanding of climate change impacts on the water resources of the Murray Darling Basin (MDB). To do that, it documents the model development process, results of that modelling and detailed analysis of combinations of model scenarios that consider historical and plausible future climate conditions. Through the hydroclimate scenarios, model parameters, and the different planning contexts of WoD, June 2009 and BPFI, the model results are presented to help understand the resultant impacts from tributary rivers to downstream systems.

This report characterises climate impacts on:

- Inflows across the Basin,
- Water balances within illustrative river valleys in the Northern and Southern Basin to show impacts on different water resource flow components,
- Flows through the MDB in both northern and southern Basins,
- End of system flows,
- Availability of water for different uses,
- Storage behaviours under future climates; and
- Changes in low flow periods.

This report is therefore the culmination of a body of modelling work to provide a whole of Basin insights around the possible impacts of future hydroclimates on river system outcomes for the MDB.

Contents

Introduction

Overview of the Sustainable Yields Project

The Sustainable Yields (SY) project provides fundamental information about climate change impact in the Basin, which is crucial to ensure water management strategies are robust and adaptive.

In 2009, the then Murray Darling Basin Commission (MDBC) in conjunction with the CSIRO and state jurisdictions developed the first SY Assessment. At the time, this was the most comprehensive and complex whole-of-basin assessment conducted for the Murray-Darling Basin (MDB). The outcomes of this assessment were critical in informing the 2012 Basin Plan.

In 2022, the Australian Government recognised the need to update understanding of Basin water resources in the face of climate change. The 2025 SY assessment seeks to provide a whole of Basin assessment of the challenges that are likely to arise under future water resources management conditions. SY is forward looking; and considers several Basin Plan development conditions under a range of plausible climate future scenarios out to 2050. SY falls under a wider program of technical assessment that will contribute to the Basin Plan Review and ensure the 2026 Basin Plan is informed by the latest hydrological and climate science. It provides foresight into the possible state of water resources within the Basin and helps the understanding of the scale of possible impacts of climate change on the management of river systems in the Basin.

Figure 1: Timeline of Sustainable Yields and the Basin Plan Review (SY Summary Report

The SY project covers various technical modules that provide the detailed information, grounded in scientific research and modelling.

SY 2025 has 5 modules, designed to provide a comprehensive picture of climate change and its possible effects on the Basin. The modules are delivering:

- Basin-wide hydroclimate projections that describe what can be expected from the changing climate;
- updated river system modelling that incorporates future hydroclimate projections;
- improved understanding of groundwater recharge and surface water interception by farm dams;
- improved understanding of ecological thresholds of change across the Basin; and
- collaboration with First Nations peoples, to increase knowledge sharing and First Nations involvement in water management.

Each module has developed methodology to meet the aims of SY 2025, including developing detailed computer models through iterative modelling and evaluation, desktop research, expert elicitation, pilot testing, and analysis of quantitative and qualitative data. The hydroclimate projections module feeds into the other modules to support the development of a comprehensive picture of the future of Basin water resources.

All of the modules and how they conceptually fit together are shown in Figure 2 below.

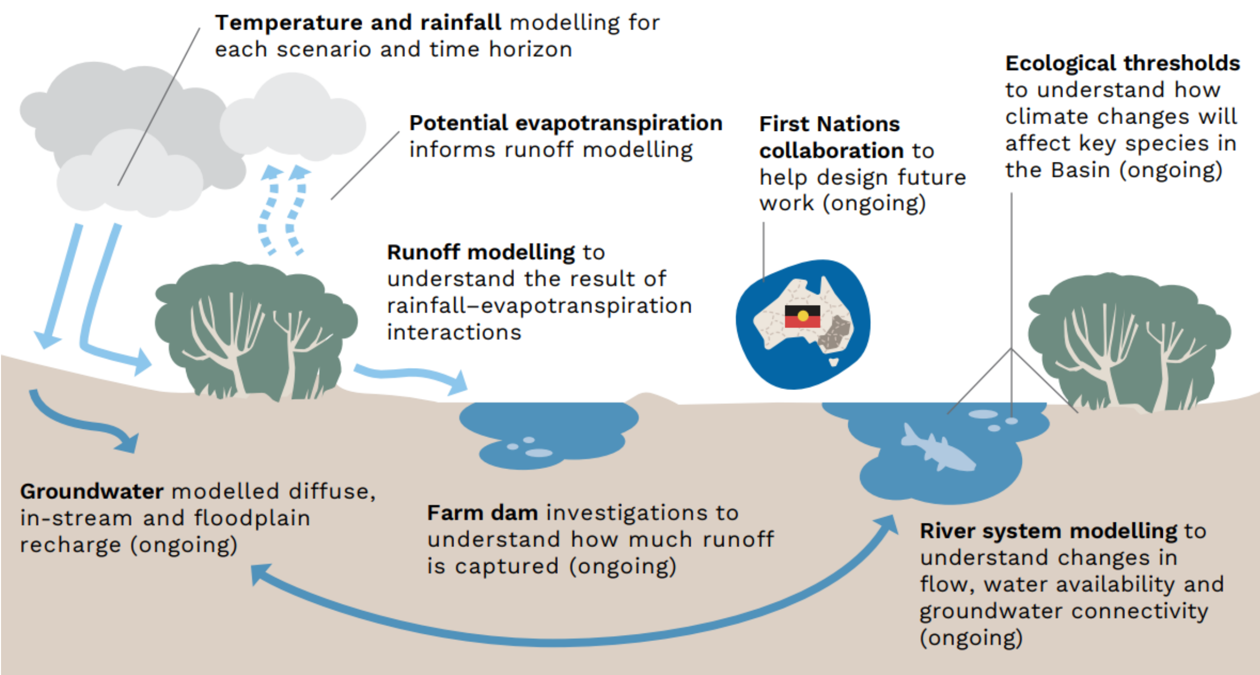

Figure 2: The Sustainable Yields Modules

General approach to river systems modelling in the Murray-Darling Basin

River system modelling in the MDB is built on the established river system models that exist for respective valleys within each of the Basin states. MDB accredited river system models within the Basin have been established under the Water Resource Plan Accreditation process[1], whereby existing river system models have been updated to incorporate water management arrangements, such as agreed rules and Sustainable Diversion Limits (SDLs) that are established through Basin State Water Resource Plans. As part of this process, models have been updated to incorporate consistent Basin Plan development scenarios and be compatible with the MDB approach to hydroclimate scenario modelling. For this modelling, the majority of models used were accredited.

River system models have been developed in a number of different software packages, such as eWater Source, REALM, IQQM, and MSM-BigMod over many years. For this assessment, current models have been uplifted to the Framework for Integrated River Modelling (FIRM), which pieces the various models together into an integrated platform. Further details on how FIRM has been

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[1] Murray–Darling Basin Authority, *Developing water resource plans*, https://www.mdba.gov.au/water-management/Basin-plan/water-resource-plans/developing-water-resource-plans

developed and connects the various river systems models are outlined in the **Basin Plan Review reference scenarios** section of this report.

Across the Basin states, there are differences in policy, legislation and regulation, and challenges arise in drawing insights consistently across the Basin, due to the way water resource management metrics have been defined. Water diversions are represented within the models according to the specific water products that exist within each member Basin state, for example, the High Reliability entitlements in Victoria are not exactly equivalent to the High Security Water Shares that exist in NSW. These have been established through the development and accreditation of state Water Resource Plans, and model results and interpretations are dependent on the way in which the various water uses have been represented. In drawing trends and insights from the regional scale, these differences have been considered and described where appropriate, however there are some limitations to the interpretation that is able to be drawn from the different indicators or model outputs.

Due to the differences across the Basin states in modelling methodology, the river system conceptualisation, parameterisation of water balance and calibration methodology pose a challenge for comparison. Each jurisdiction within the Basin has developed models with varying approaches to how the river system is conceptualised. The Basin models vary in spatial detail and temporal resolution (i.e. daily or monthly) and model program logic. Differences lie in the representation of inflows, diversions, evaporation, floodplain and groundwater interactions, data quality and calibration approaches. These factors affect the veracity of aggregated outputs, where scaling or grouping output parameters can mask or distort the detail. For example, due to the differences in timesteps (daily vs monthly), modelled variables must report on a monthly scale, otherwise monthly data must be disaggregated using an assumed pattern to report on a daily timescale.

The journey from SY 2009 to SY 2025

SY 2025 river system modelling as reported here, builds on the processes and lessons learned from SY 2009 and other initiatives.

Following the delivery of the 2009 project, CSIRO identified that key uncertainties remained in modelling of climate, catchment water yields and groundwater. SY 2025, including the river system modelling documented here, has benefited from the significant advancements that have been made in climate science and modelling capabilities since then and has delivered results based on robust, up-to-date science and methodology.

Key changes and improvements that are relevant to the work reported in this document include:

- additional data – the 17 years of new data between SY 2009 and SY 2025 include the breaking of the Millennium drought, several flood years and the short but severe Tinderbox drought, providing a better characterisation of the historical baseline hydroclimate which now covers the period of 1895-2024.
- improved hydrological impact modelling – SY 2025 uses a more consistent modelling approach across the entire Basin and uses a more detailed approach to representation of future climate to place climate variability and climate change into historical context.
- improved river system modelling – water use and attenuation through the Basin is more accurately captured in SY 2025 with the addition of flood plain harvesting, land use and crop

retention to the models, as well as improvements to the distribution of environmental watering sites and water recovery estimates.

- broader considerations – SY 2025 considers rainfall, in-stream and overbank groundwater recharge, whereas SY 2009 only looked at rainfall recharge.

This report

This report describes the results of the river system modelling that forms Module 2 of the SY 2025 package. This is a technical report that covers the methodology, model performance, results and interpretation of the Basin Plan Review reference scenarios that have been modelled to form this assessment. The discussion in this report is linked with the work that is being undertaken in adjacent studies and is herein limited to the analysis of hydroclimatic and river system water availability to deliver water allocations to consumptive entitlements, environmental water entitlements and non-entitlement water users, under three Basin Plan Review reference scenarios.

The information contained in this report therefore forms a line of evidence that can be used for subsequent studies associated with the Basin Plan Review, including assessment of Sustainable Diversion Limits for surface water resources across the Basin. It also represents the results of river system modelling at a point in time, based on the best available information, but also recognising that the modelling will continue to improve over time as further assessments are undertaken.

Included in this report are Sections detailing:

Modelling methodology	A high-level description of the FIRM and adoption of state-based valley river system models that have been uplifted to form the basis of the Basin wide river system modelling platform. This section discusses the Basin reference scenarios used to frame the assessment, and describes on a high level the hydroclimate modelling methodology to form the 6 hydroclimate scenarios (along with the historic scenario) in this assessment.
Basin Plan Review reference scenarios	A description of the modelling scenarios and representation of system delivery rules, demands, environmental water and recovery assumptions in the river system models used to generate information presented in this report.
Hydroclimate scenarios	A description of the hydroclimate scenarios used in this assessment, including how they were developed and a description of the logic distinguishing each scenario.
Model veracity	A discussion of the model quality assurance and veracity. This section details the review and engagement process that was undertaken to uplift the models to MDB accreditation and how the model veracity was maintained from accreditation through to use in this assessment.
Results	A summary of model results for model outputs, including Northern and Southern and all Basin totals, plus illustrative results for particular river systems across the Basin to describe the outputs and trends that are evidenced through the modelling.

Interpretation and discussion	This section describes the significance of the results in interpreting how well the Basin Plan is working under a set of climate scenarios, representing a set of plausible climate conditions under which to compare future Basin Plan implementation options.
Conclusions and considerations for future modelling	From the previous sections, this section summarises what the results show and what this means for the future of the Basin, the future state of modelling and research within the Basin, and where further efforts to explore the future trends are required.

Modelling methodology

Modelling framework

The FIRM tool was developed under the IRMU project to provide an efficient and transparent way to undertake collaborative modelling projects across the Basin. FIRM is the successor to the previous Integrated River System Modelling Framework (IRSMF) tool that was used previously to produce whole-of-Basin modelling outputs. The IRSMF was developed to support the initial development of the Basin Plan, and it does not support models built with later versions of Source, IQQM, REALM and other bespoke hydrological modelling software.

FIRM has been developed to allow hydrological modelers across the Basin to efficiently incorporate ongoing model developments and improvements to produce model outcomes at the whole of Basin scale.

The FIRM tool consists of three primary components.

1. Model Git Repositories are the primary location from which FIRM ingests models, these repositories provide provenance for the models input into FIRM and includes the capability to trace changes to models, control access and to add additional model versions or scenarios.
2. The Firm Onboarding Manager (FOM) supports onboarding new models into FIRM, it helps to ensure consistency and reliability for all models that are being onboarded. The FOM ensures that the right folders, files and information are present before a model is ingested into the FIRM.
3. The Delft-Fews Platform (FIRM Interface) is the primary way in which a user interacts with the FIRM tool. It is the core component of FIRM and enables users to run model scenarios, view model outputs, calculate statistics and export results.

A conceptual diagram of the FIRM is shown in Figure 3 below outlining how the process of moving from state jurisdiction modelling to the final model repositories. The FIRM provides some key benefits for whole of MDB modelling as listed below:

- **Consistency** – The FIRM development has involved developing a number of additional components that are beneficial on their own merit, this includes the metadata framework for FIRM, the Basin wide registry of model output measurands and locations.
- **Increased Transparency** – The FIRM Tool allows users to directly see how models, data and information are being utilised to develop whole of Basin outcomes. It provides insight into the linkages that have been developed between hydrological models, the transformations and outputs produced by the MDBA and its partners.
- **Reliability** – The FIRM allows modelers to complete complex runs in a repeatable manner with provenance systems, dynamic scalability and ability to recall data produced from previous model runs.
- **Adaptability** – It is able to accept a variety of models with the capability to 'plug and play' models that have been prepared for FIRM. This means that once a model has been appropriately prepared for FIRM it can incorporated into the tool in a straightforward way. Note, that more bespoke and unique models may require additional development to incorporate.

- **Single Whole-Of-Basin View** – The FIRM has capability to provide a holistic snapshot of the entire MDB is significant and coupled with the capability to rapidly model and export this information it will significantly improve the ability of MDBA and jurisdictions to assess the broader impacts of changes within the Basin.

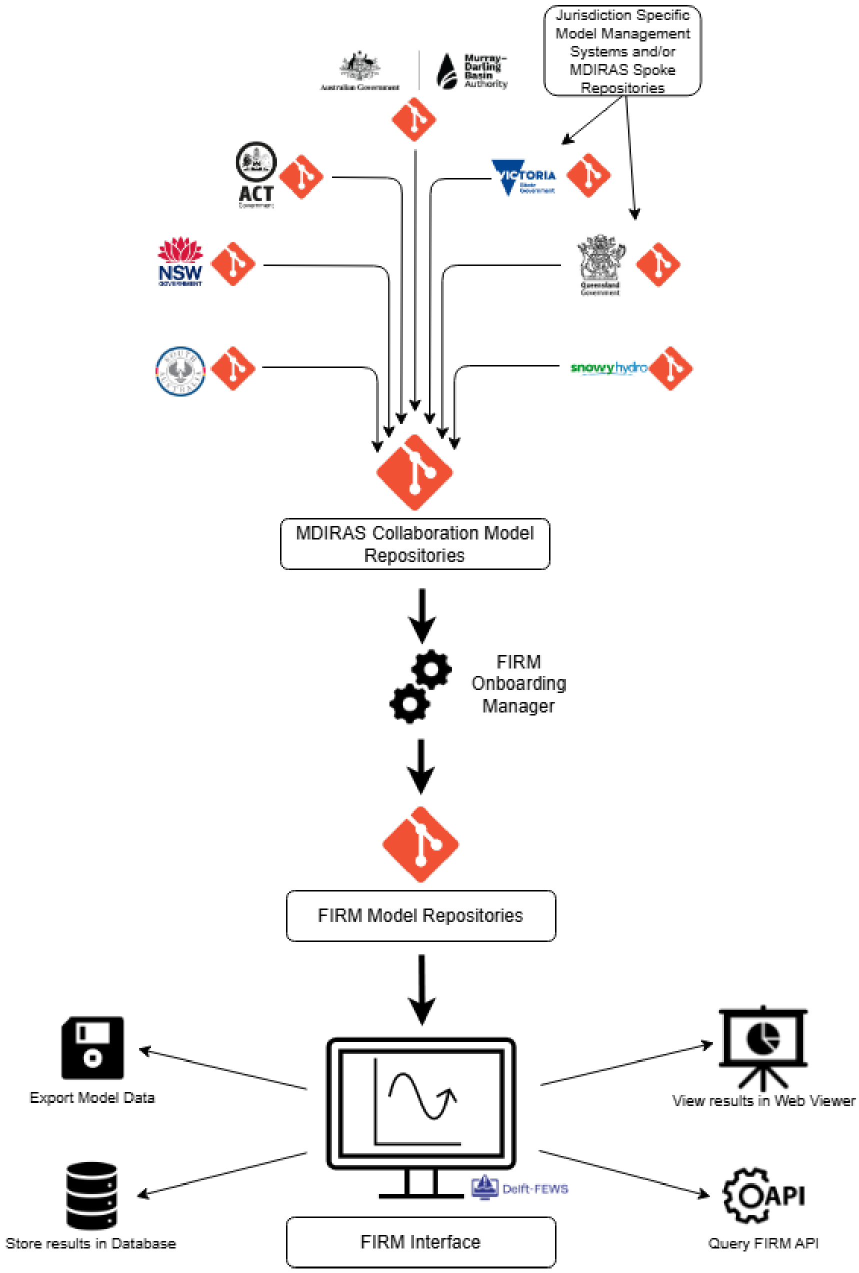


Figure 3: FIRM Modelling Process Flow

River System Model Software

River system modelling in Australia has been steadily evolving both nationally and within each state jurisdiction. This means that there are a number of modelling packages that may be used with accredited models, though there is an overarching intention that all models will eventually be brought under the National Hydrologic Modelling Platform of eWater Source. The hydrological modelling software packages used for this study are briefly described below.

eWater Source

eWater Source™ is developed and maintained by eWater Pty Ltd. It was jointly developed by all Basin jurisdictions and other partners under the eWater Cooperative Research Centre (2005-2012), before the establishment of eWater Pty Ltd in 2012.

eWater Source™, an integrated water resource management modelling tool, is used to create daily time step hydrological models used for integrated planning, management and operations for catchment and river systems, including demands for water from urban areas, agriculture and the environment. eWater Source™ can produce water assessments and accounts, determine water allocations according to policies, operating rules, legal agreements, and international treaties.

IQQM

The Integrated Quantity-Quality Model (IQQM) is a hydrologic river system modelling tool used by the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) and the Queensland Department of Environment, Tourism, Science and Innovation (DETSI) for the planning and management of water resources. This is a generic modelling tool in which a river system can be configured by using modelling components such as dams, river reaches, irrigation areas etc. The model carries out water allocation, accounting and hydrologic routing on a daily time step[2]. It was used extensively to model the NSW and Queensland river valleys. This model also includes an interface to Sacramento rainfall-runoff models and a range of tools to assist in data analysis and interpretation of model results.

St George

The St George model is a system specific model developed by Queensland Department of Environment, Tourism, Science and Innovation (DETSI). The model uses an individual capacity share scheme to share the water between various users rather than an announced allocation system.

Snowy

Snowy Hydro have developed a custom built monthly timestep model to help inform operations and accounting of the Snowy Hydro scheme and its obligations under the Snowy Water Licence to supply

[2] Hameed, T. and Podger, G. 2001, *Use of the IQQM simulation model for planning and management of a regulated river system*, Integrated Water Resources Management (Proceedings of a symposium held at Davis. California. April 2000). IAHS Publ. no. 272. pp.

water to the Snowy-Murray and Snowy-Tumut schemes[3]. Two versions of the Snowy Hydro model are used in the FIRM:

- Version 2 – Used for the June 2009 scenario this model represents the Snowy Water Licence consistent with the 2002 licence which was in place at June 2009
- Version 3 – Used for the Basin Plan 2024 and Fully Implemented scenarios, this model represents the contemporary management arrangements under the Snowy Water Licence including the amendments to the Snowy Water Licence that occurred in 2010, 2011 and 2020.

Coorong

The Coorong hydrodynamic model was developed by CSIRO and is a one-dimensional hydrodynamic model to simulate water level and salinity conditions in the Coorong to understand and describe the physical dynamics of the lagoon. The model includes external forcing factors such as wind speed, evaporation, and precipitation, and the sea level at the Murray Mouth. The flow into the Northern lagoon is prescribed by barrage flows and flows into the Southern lagoon from the Upper Southeast Drainage. Changes in these latter components can be influenced and thus used to change the physical conditions in the Coorong[4].

[3] NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW), "Snowy Scheme," *Water* (NSW Government website), https://www.water.dcceew.nsw.gov.au/our-work/projects-and-programs/snowy-scheme

[4] Department for Environment and Water (DEW), *Summary of Coorong hydrological, biogeochemical and ecological models* (DEW Technical report 2020/39; Government of South Australia, December 2020), PDF, https://data.environment.sa.gov.au/Content/Publications/SummaryOfCoorongHydrologicalBiogeochemicalAndEcologicalModels.pdf

Basin Plan Review reference scenarios

Each individual valley model has been run with combinations of development scenarios and hydroclimate scenarios. In summary, the development scenarios are:

- **Without development (WoD)** – intended to represent the case where there is no development of any kind in the Basin, including no dams, weirs, or extractions.
- **June 2009** – Basin Plan Review reference as at June 2009 intended to represent the development, operation, and water sharing conditions immediately prior to the Basin Plan.
- **Basin Plan fully implemented (BPFI)** – intended to represent maximum plausible future development including the full achievement/fulfilment of SDLs

Other development scenarios have been undertaken for a range of purposes such as representations of current conditions as of 2024, but the three above scenarios are the focus of the SY assessment as they best capture the long-term challenges of the full implementation of the Basin Plan.

To test the effects of different Basin Plan approaches under future climate change, three reference scenarios have been developed to show how full implementation of the Basin Plan would perform in comparison to both a without development and a pre-Basin Plan scenario. These are described further below:

Without development

This scenario is intended to represent the case where there is no development of any kind, including no dams, weirs, or extractions. It provides a baseline reference point to understand the impacts of water management interventions.

The WoD scenario is a near-natural condition model run. It either removes or disables from the river system models all the dams, irrigation and environmental infrastructure, all consumptive users (such as irrigation, town water supply and industrial water uses) and the rules governing flows such as channel capacity constraints and minimum flow requirements.

The WoD model scenario is described as 'near-natural' because it is not a true representation of pre-colonial conditions. Inflow estimates have not been corrected for land use changes and on-farm development in the catchments which are largely implicitly included in the measured flow data used to calibrate the models. Moreover, the impact of changes due to levee construction and other in-channel structures on flows in anabranch systems has not always been considered. The WoD scenario is however the best available representation of river system conditions without management intervention.

June 2009

This scenario represents the conditions in the Basin immediately prior to the Basin Plan to provide a reference point to understand the impacts of Basin Plan implementation.

The June 2009 scenario represents the water sharing arrangements that were in place in June 2009 and can be thought of as a candidate Baseline Diversion Limit (BDL) scenario. It is important to recognise that the June 2009 scenario is not agreed to as the official BDL and is not used to determine SDLs for compliance activities.

The models used to represent the June 2009 scenario may be the same as the official BDL models for some river systems, but in other systems it may be represented by an updated or new model for reasons such as:

- Updated representation in new software,
- Updated inputs, data, or model conceptualisation to improve representation of system as at June 2009, and
- Fixes or corrections to errors subsequently found in BDL models.

Other reasons the June 2009 scenario may vary from official BDL estimates is the harmonisation of the models in a whole of Basin context, where outputs from updated models may flow into downstream models. The impact of harmonisation is most likely to have the most significant impact on the Barwon-Darling and the River Murray systems due to the contribution of upstream tributaries with their own separate models.

Basin Plan Fully Implemented

This scenario represents full uptake of SDLs, which provides an understanding of the outcomes that would be expected under a plausible future where the Basin Plan is fully implemented.

These model scenarios include major policy and infrastructure changes that have occurred post 2009. Examples of the infrastructure changes include the enlargement of Cotter Dam (Upper Murrumbidgee) and Chaffey Dam (Peel) and infrastructure projects associated with the Sustainable Diversion Limit Adjustment Mechanism (SDLAM). Some of the significant policy changes included in the BPFI scenario are:

- Representation of the South Australian Storage Right (Schedule G of the Murray-Darling Basin Agreement)
- Victorian carryover policies including spillable carryover from 2012 in the Goulburn-Broken-Campaspe-Loddon and Victorian Murray
- Critical Human Water Needs (CHWN) in the Murray River system (described in the Murray-Darling Basin Agreement and Basin Plan)
- Incorporation of the Snowy Water licence changes from amendments in 2010, 2011 and 2020
- Operation of SDLAM projects expected to be completed as per modelled assumptions (Murray and Murrumbidgee)

This BPFI scenario has updated river system models to plausibly represent a whole of Basin scenario that represents:

- No relaxation of delivery constraints,
- additional Held Environmental Water (HEW) recovery to address shortfalls in Bridging the Gap (BtG) recovery that existed as of June 2024
- additional HEW recovery to represent the 450 GL. This has been assumed to have been recovered in proportion to use, based on current modelled BDL estimates which results in a split of 110 GL in the Northern Basin and 340 GL in the Southern Basin, and

- inclusion SDLAM projects expected to be included in reconciliation at 30 June 2026. This will result in a shortfall of 300 GL from the original offset of 605 GL. This shortfall will be represented as additional HEW recovery in the Southern Basin.
- Management and delivery of the HEW portfolio informed by current understanding on how it is delivered. In some cases, the modelled representation of HEW management and delivery may be simplified due to limitations in software being able to represent environmental water requirements.

The HEW recovery in the BPFI scenario targets a reduction of 2,825 GL LTDLE in diversions across the basin from the June 2009 scenario for the 1895-2009 period. To reflect this irrigation demands have been reduced where appropriate to reflect the reduced take associated with HEW recovery. This has been done by reducing the requirements of irrigation demand by either reducing planting decisions that restrict crop planted areas or limiting pump capacity.

The assumptions for the full implementation scenario are contained in **Assumptions and limitations of system representation** section, including detailing how the recovery was distributed across the basin.

Incorporating HEW into the BPFI scenario

Since the development of 2012 Basin Plan there has been an evolution in the science and knowledge used to inform the environmental water requirements of key environmental assets and key ecosystem functions across the MDB, best represented in the Environmental Water Requirements (EWRs) that were documented in the Long-Term Watering Plans (LTWPs) developed by Basin jurisdictions for each SDL unit.

Regulated HEW Demands

In parallel to the development of EWRs there has also been significant effort to be able to efficiently codify the EWR requirements into hydrological models to generate environmental water demands. This is a significant shift from the methodology used in the 2012 Basin Plan, where timeseries of environmental demands were generated externally to the hydrological models through utilising the WoD timeseries to provide all the ‘naturally occurring’ environmental events over the 114-year modelling period without any accounting or delivery constraints. An approach was then taken to reinstate selected events that could be met with the volume of environmental water anticipated to be available and be coordinated across multiple environmental sites.

In the Source modelling platform, it is possible to specify environmental water requirements at locations in the models based on the defined EWRs that are characterised through parameters such as volume, duration, seasonality and frequency (across multiple years) to generate environmental demands. These environmental demands are responsive to the model conditions, so are more flexible in dealing with different model scenarios such as the hydroclimate scenarios.

In any given model, it would be possible to specify many EWR requirements at many discrete spatial locations that may be competing simultaneously for the available HEW to meet their defined needs. In Source, the environmental flow manager functionality has been established, which represents prioritised environmental water delivery through the representation of environmental flow ‘targets’, dictating spell duration, flow thresholds and frequencies that then generate to best meet in-stream and overbank flow requirements.

The node representation of environmental flow management through an Environmental Flow Node (EFN) allows the model algorithm (resource availability, constraints consideration, ordering, and flow delivery) to be assessed at asset or reach locations and managed on a system scale using the Environmental Flow Manager accounting system. This functionality was developed as part of updates to Source in 2017, and replaced earlier representations of environmental demand nodes, which represented environmental requirements as demands through an Environmental Demand Model[5]. The Environmental Flow Node has since undergone significant updates to functionality, and while some of the river Basin models within the FIRM incorporate these updates, models submitted in earlier versions of Source or Continuous Accounting Resource systems have more limited functionality.

IQQM has the capacity to generate environmental demands at specific locations in the model which are associated with a licence volume. It does not have, or it is not easy to use a portfolio of HEW entitlements to meet multiple requirements across different locations. So, there are expected to be some limitations in the representation of environmental water delivery in these models (e.g. Macquarie, Gwydir and Lachlan).

MDBA modelling has assumed that water can be ordered from upstream storages within tributaries to address downstream requirements in the Barwon-Darling and River Murray systems. This has not yet occurred in practice due to a high uncertainty regarding losses between the storage and the downstream location and because of river operating rules in many systems.

Unregulated HEW Delivery

In the absence of large storage capacity, water resource policies in unregulated systems generally specify water access rights to each entitlement holder in the region. Water access rights across these unregulated systems are commonly expressed as allowing access to water based on local hydrographic conditions (e.g. between a local river height of 1.2 m and 1.4 m, or flows exceeding the capacity for re-regulation). Once the conditions have been met, a license holder is able to extract water in accordance with their licensed access right.

EWR’s for unregulated systems have been specified in the same manner as for regulated regions but environmental demands have not been created to represent EWRs for these regions, as water cannot be ordered from storage. Instead, the approach has been to deactivate extractions of purchased entitlements and, if required, modify the water access rights of other water users limit to extractions to the SDL.

Future modelling effort for unregulated regions would be to represent rules (if they exist) to more effectively shepherd environmental water entitlements through the system with minimal impact on other users' water rights and access. If modelled in this way, we would expect unregulated flow events to generally be enhanced in peak flow and volume; however, there is no capacity to explicitly target achievement of EWRs, and outcomes will be dependent upon the climate and hydrology of the system. In the Lower Balonne (Condamine-Balonne SDL unit), there have been instances of the CEWH purchasing environmental water from irrigators' on-farm storages to extend and enhance unregulated

[5] eWater Wiki Source Documentation 4.11, Environmental Demand Node, https://ewater.atlassian.net/wiki/spaces/SD37/pages/25598117/Environmental+demand

flows into the Narran lakes system (Event-based mechanism release in water year 2022-23). This process has not been attempted to be modelled in the scenarios used for this report.

For models across the system, it is possible for HEW to be represented as either regulated, unregulated or a combination of both. The table below summarises the representation of HEW across the river system models used for this study.

Table 1: Held Environmental Water representation in River System models

Model	Unregulated HEW	Regulated HEW
Paroo	Yes	No
Warrego	Yes	No
Nebine	Yes	No
Condamine-Balonne	Yes	No
Moonie	Yes	No
Border Rivers	Yes	Yes
Gwydir	Yes	Yes
Peel	No	Yes
Namoi	Yes	Yes
Macquarie	Yes	Yes
Barwon-Darling	Yes	No
Belubula	No	No
Lachlan	No	Yes
Upper Murrumbidgee	No	No
Murrumbidgee	Yes	Yes

Model	Unregulated HEW	Regulated HEW
Murray and Lower Darling	Yes	Yes
Goulburn-Broken-Campaspe-Loddon	No	Yes
Wimmera	No	Yes
Coorong	N/A	N/A
Snowy Hydro	N/A	N/A

Assumptions and limitations of system representation

Representation of future demands, operations and service levels

There is a range of uncertainties around how future demands, operations and service levels may be implemented to address climate change impacts across the MDB. It is likely that they will be driven by adaptation responses, behavioural and structural changes and regulatory requirements all interacting to help mitigate the way those impacts are realised across the Basin.

In this modelling, the existing management arrangements in place to meet operational needs, demands and service levels have been retained across all models wherever possible (some minor changes are sometimes necessary to ensure the models are able to be integrated). As such, the responses predicted in the river systems models are those which are a result of the changes in future inflows only, and how the existing management arrangements incorporated within the models would respond to those changes.

Representation of consumptive diversions and water recovery under the Basin Plan Full Implementation scenario

The current modelling has shown that consumptive diversions in the BPFI scenario under the historic climate sequence have been reduced by 2761 GL from the June 2009 scenario for the period July 1895 – June 2009. This is 63.1 GL less than the SDL target in the BPFI scenario of 2825 GL. The difference is dominated by increased diversions in the Victorian Murray SDL unit beyond the expected target by 53.9 GL. This is likely caused by:

- Increased inflows (130 GL/y) to the Southern Basin from the Northern Basin which are currently allocated to NSW and Victoria in the Murray system as per the water sharing rules under the Murray-Darling Basin Agreement. This increased water availability will benefit all entitlement holders in these systems,

- Assumptions on Inter Valley Trade (IVT) deliveries from the Goulburn and Murrumbidgee systems in the FIRM may differ from the assumptions used to calculate the recovery behaviour in the Murray outside the FIRM and may need further work to align with the BPFI recovery target, and
- Deliverability challenges in the BPFI scenarios, particularly due to reduced capacity through the Barmah narrows, and non-relaxed constraints levels impacting HEW deliverability.

While the total reduction in consumptive diversions is not equal to the BPFI recovery target, it is not expected to substantially alter the outcomes or findings of this report.

A key assumption in the BPFI model scenario is the representation of water recovery to achieve environmental objectives across the MDB. The table below outlines the recovery assumptions that have been made across each SDL unit to align with the assumptions agreed to by the MDBA and Basin States and documented in D25/4754 Policy assumptions for BPR modelling.

The water recovery in place as of 2024 was represented in the Basin models, and SDLs were calculated for June 2024 based on the Baseline Diversion Limits, water recovery and efficiency measures, and the settings of the Sustainable Diversion Limit Adjustment Mechanism (SDLAM) agreed to at the time of its determination.

The BPFI scenario includes additional water recovery in each additional SDL unit to meet:

- any remaining water to meet Bridging the Gap (BtG) targets
- additional water to meet the assumed 305 GL shortfall from supply contributions in SDLAM
- Assumed recovery to meet the remaining 450 GL. This has been assumed to occur in proportion to each SDL resource unit contribution to the modelled component of the BDL

The total recovery volumes for each SDL unit in the BPFI scenario are documented in the tables below. Details of how these recovery volumes are represented in each model are documented in the assumptions for each model used in the BPR reference scenarios and not within this document.

Table 2: Comparison of reduction in diversion numbers and assumed water recovery between the June 2009 and BPFI scenario

SDL Resource Unit	Total BtG Target	Progress towards 450 GL/y	Assumed Remaining 450 GL/y recovery	SDLAM supply contribution	Total BPFI recovery Target	Modelled Reduction Target (1895-2009)	Diff from Target
	(GL/y)	(GL/y LTDLE)	(GL/y LTDLE)	(GL/y LTDLE)	(GL/y LTDLE)		
	(a)	(b)	(c)	(d)	(a)+(b)+(c)-(d)		
Condamine-Balonne	100.0	0.0	28.3	-	128.3	129.3	1.0
Moonie	2.1	0.7	0.8	-	3.6	4.2	0.6
Nebine	3.8	0.1	0.3	-	4.2	4.2	0.0

Paroo	0.0	0.0	0.0	-	0.0	0.0	0.0
QLD Border Rivers	14.0	0.4	10.8	-	25.3	24.0	-1.3
Warrego	20.1	0.0	2.3	-	22.4	22.9	0.5
Northern Basin QLD Zone	140.0	1.2	42.6	-	183.9	184.6	0.7
Barwon-Darling	32.0	0.0	8.8	-	40.8	39.3	-1.5
Gwydir	49.6	5.0	11.2	-	65.8	66.2	0.4
Intersecting Streams^	13.8	0.0	0.8	-	14.6	14.6	0.0
Macquarie-Castlereagh	57.6	38.2	0.0	-	95.8	95.5	-0.3
Namoi	20.0	0.0	12.5	-	32.5	30.5	-2.0
NSW Border Rivers	7.0	0.0	8.6	-	15.6	15.0	-0.6
Northern Basin NSW Zone	180.0	43.2	42.0	-	265.2	261.1	-4.1
Northern Basin Zone Total	320.0	44.4	84.6	-	449.1	445.7	-3.4
Lower Darling*	22.3	0.9	1.2	0.0	24.4	49.2	24.8
Murrumbidgee*	597.9	7.8	72.5	81.7	596.5	583.6	-12.9
NSW Murray*	427.8	0.0	65.2	62.9	430.1	440.8	10.7
Southern Basin NSW Zone	1048.0	8.7	138.8	144.6	1051.0	1073.6	22.6
ACT Murrumbidgee	4.9	1.5	0.1	0.0	6.5	6.4	-0.1
Southern Basin ACT Zone	4.9	1.5	0.1	0.0	6.5	6.4	-0.1
Broken	1.3	0.0	0.5	0.6	1.2	0.8	-0.4
Campaspe	31.2	0.0	4.4	1.3	34.3	30.9	-3.4
Goulburn*	530.4	6.8	52.0	88.0	501.2	484.0	-17.2

Kiewa	1.1	0.0	0.4	0.7	0.9	0.9	0.0
Loddon	21.8	0.0	3.2	5.5	19.6	16.5	-3.1
Ovens	2.7	0.0	1.0	1.5	2.1	0.0	-2.1
Victorian Murray*	463.8	10.9	52.4	36.7	490.4	436.5	-53.9
Southern Basin VIC Zone	1052.3	17.7	113.9	134.2	1049.7	969.6	-80.1
Eastern Mount Lofty Ranges	0.0	0.0	0.6	0.0	0.6	0.0	-0.6
Marne-Saunders	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SA Murray*	183.8	3.7	22.1	26.2	183.4	184.5	1.1
SA Non-Prescribed Areas			0.0	0.0	0.0	0.0	0.0
Southern Basin SA Zone	183.8	3.7	22.7	26.2	183.9	184.5	0.6
Southern Basin Zone Total	2289.0	31.6	275.6	305.0	2291.2	2227.7	-63.5
Lachlan	48.0	0.0	11.2	0.0	59.2	63.4	4.2
Wimmera-Mallee	23.0	0.2	2.4	0.0	25.6	25.1	-0.5
Disconnected total	71.0	0.2	13.6	0.0	84.8	88.5	3.7
Total Basin	2680.0	76.2	373.8	305.0	2825.0	2761.9	-63.1

^ recovery in the intersecting streams has not been considered in the SDL modelling

*SDL units influenced by inter-valley trade.

Environmental Water Representation

Northern Basin HEW Coordination

The modelling currently has no coordination of HEW delivery in the Northern Basin to achieve targeted environmental outcomes in the Barwon-Darling system. For the Northern Basin valleys which have regulated HEW (Border Rivers, Gwydir, Namoi and Macquarie), the water is used to target outcomes in those valleys and outflows from these valleys will contribute to unmanaged outcomes in the Barwon-Darling.

North to South Connectivity

HEW delivery in the Northern Basin contributes to water resources in the Southern Basin in the form of increased inflows to the Menindee Lakes system. Arrangements for identifying the volume of HEW inflows to Menindee Lakes and their subsequent management are still being trialled by Basin Governments under the North-South Connectivity Trial. As these options are still in trial, they have not been included in the BPFI modelled scenario. The BPFI scenario assumes that the HEW inflows from the Northern Basin are treated in the same manner as inflows to the Menindee Lakes system and are distributed to NSW and Victoria resources under the rules set out in the Murray-Darling Basin Agreement. All entitlement holders in the Murray and Lower Darling resource allocation systems may therefore receive increased reliability of allocations because of HEW inflows to Menindee Lakes.

Southern Basin HEW Coordination

Coordination of HEW delivery in the Southern Basin is evolving in practice, but the current modelled representation has limited coordination of HEW to maximise system outcomes. Environmental demands in the Murray can pass orders to the Murrumbidgee system, but no allowance is currently made to pass Murray environmental demands into Northern Victoria (Goulburn-Broken-Campaspe-Loddon). The Victorian government has prioritised HEW in those systems to meet local environmental requirements.

Representation of prerequisite policy measures (PPMs) is represented by moving the identified HEW component at tributary outflows to the Murray system by placing a demand at the South Australian border based on the specified accounting rules in the table below. The rules align with current operational practices, but they do not guarantee that the environmental flow component will be shepherded without re-regulation through the Murray system. The rules ensure that the additional order placed at the South Australian border should be with the expected arrival of the flow from the tributaries, to minimise the impact on Lake Victoria behaviour.

Table 3: Representation of PPMs in the Murray system

HEW Flow Component	Lag (days)	Loss rate
Murray River @ DS Yarrawonga (409025)	23	environmental flow within channel has 0% loss, environmental flow overbank, first 50 GL is assumed as loss, any volume after the initial 50 GL has a 20% loss applied
Goulburn River @ McCoys Bridge (405232)	12	If Murray Flow @ Torrumbarry > 18000 ML/d, 30%, else 9%
Campaspe River @ Rochester (406202)	12	9%
Loddon River @ Appin South (407205)	12	0%

HEW Flow Component	Lag (days)	Loss rate
Billabong Creek @ Darlot (410134)	16	12%
Murrumbidgee River @ Balranald (410130)	10	Variable loss rate based on relationship between Balranald environmental flow component and flow at Murray River @ Boundary Bend (414201)
Darling River @ Weir 32 (425012)	17	If Weir 32 flow > 9000, 20% loss, else 5% loss on Lower Darling. Loss component on the Murray River is based on Murrumbidgee incremental loss rate
Darling Anabranch @ Cawndilla Outlet (425014)		60% loss on Darling Anabranch and loss on Murray River is based on Murrumbidgee incremental loss rate

Environmental Water Representation in Water Balance

Given the challenges of how environmental water is represented in different models, where it is explicitly shown within the model results, the amount has been calculated as a difference in diversions between the June 2009 and BPFI scenarios. It is understood that not all of recovered water comes from reduction in diversions between the two scenarios, but this provides a reasonable representation of the quantum of environmental water in each system and how that may be affected by the future plausible hydroclimates simulated.

Hydroclimate scenarios

The SY assessment is focused on understanding the impacts of future climate change on existing Basin Plan outcomes and the river systems modelling has incorporated a hydroclimate scaling approach (detailed in Module 1 report[6]). Results are presented for a selection of hydroclimate scenarios to represent how systems would likely behave under alternative, climate impacted historic events. The logic of these projections depicts "how things could be" under a selection of plausible climate change impacts. The selection offers a range of outcomes to present the level of uncertainty in assessing risks from one outcome.

SY 2025 considers a **plausible range** of climate futures.

'Plausible' excludes possible futures that are improbable – these are the upper and lower 10% of simulations which represent the extremes of dry and wet conditions.

Because the impacts of climate change are not certain, considering a plausible range of outcomes provides a better understanding of possible future climate to support better planning.

The plausible range of climate futures cover outcomes across 3 scenarios at 2 time horizons.

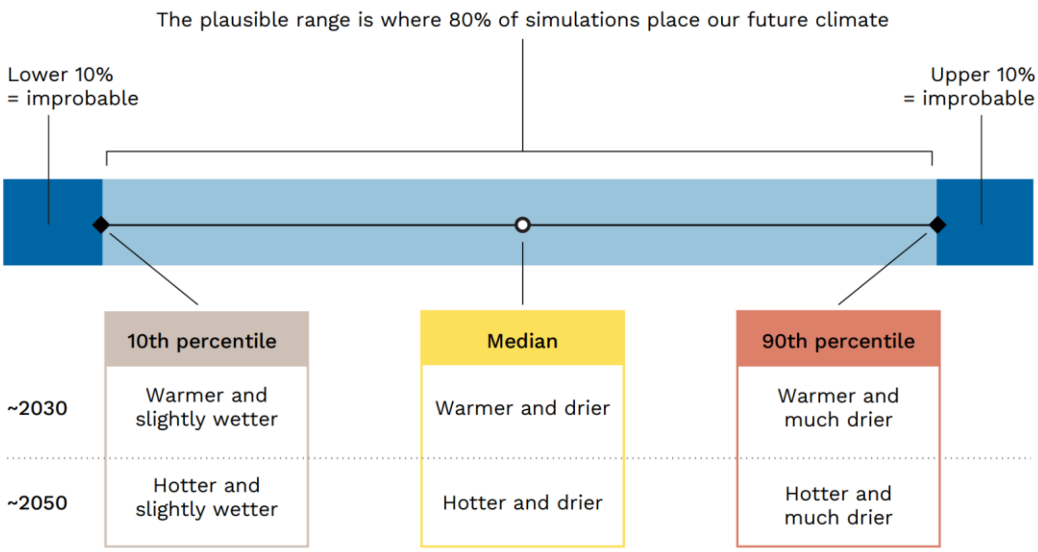


Figure 4: SY2025 range of plausible futures

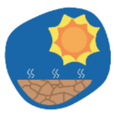
[6] Chiew FHS, Devanand A, Khan Z, Zheng H, Potter NJ, Robertson DE, Grose MR, Post DA and Fu G (2025) Hydroclimate Projections for the Murray-Darling Basin. CSIRO report from Module 1 of the MDBA Sustainable Yields Project, 131 pp.

SY 2025 has developed hydroclimate projections using the latest General Circulation Models (GCMs, also known as Global Climate Models) from the Intergovernmental Panel on Climate Change (IPCC) – the Coupled Model Intercomparison Project phase 6 (CMIP6). 120 GCM simulations from 3 Shared Socioeconomic Pathways (SSPs) were analysed (41 for SSP-2.45, 37 for SSP-3.70, 42 for SSP-5.85) at 5x5-km grid cells across the Basin. This provided projected changes in:

- temperature
- potential evapotranspiration (i.e. how readily the atmosphere evaporates water from surfaces like open water, soil or plants, which affects water availability)
- seasonal and annual rainfall
- very heavy rainfall events
- annual rainfall variability.

Rainfall-runoff modelling was developed for 5x5-km grid cells using historical and future climate series (informed by climate data), to develop projected changes in rainfall and runoff characteristics and impacts.

Six future hydroclimate scenarios have been adopted for this assessment that sit at two different time horizons (a hydroclimate centred around 2030 which represents "near-term", to support the Basin Plan Review and policy and a hydroclimate centred around 2050 which represents "long-term", to support long-term water planning). These are representative scenarios, i.e. they are not intended to show what will happen in 2030 or 2050, but to explore what future hydroclimates may be like in the near term or long term. The future hydroclimates are also compared against the existing historical climate conditions. These are described below:

	Historical – the climate conditions as recorded in the past. These are denoted with the label "S0".
	Warmer and slightly wetter – Future climate change with warmer and slightly wetter conditions. This is denoted with the labels "S1" for around 2030
	Hotter and slightly wetter – Future climate change with hotter and slightly wetter conditions. Denoted as "S4" for around 2050
	Warmer and drier – Future climate change with warmer and drier conditions, in around 2030 horizon. This is denoted with the label "S2"
	Hotter and drier – Future climate change with hotter and drier conditions, in around 2050 horizon. Denoted with the label "S5" for around 2050.
	Warmer and much drier – Future climate change with warmer and much drier conditions, in around 2030 horizon. Denoted with the label "S3" for around 2030.
	Hotter and much drier – Future climate change with hotter and much drier conditions, in around 2050 horizon. Denoted with the label "S6" for around 2050.

The hydroclimate projections come from Module 1 of SY[7]. The Module 1 hydroclimate projections are developed from rainfall-runoff modelling informed by climate change signals from 120 global climate model simulations for three greenhouse gas emission scenarios. The changes in the climate variables are expressed as change per degree global warming relative to 1990.

The Module 1 SY also considered projections to other variables (like heavy rainfall intensity, annual rainfall variability, hydrological drought, and high and low flows). Module 1 also considered different sources of climate projection data (e.g., subset of global climate models and dynamical downscaling data) and hydrological impact modelling methods (e.g., bias correction of climate model outputs, stochastic data, runoff sensitivity to climate inputs). The robustness and uncertainty, as well as limitations and future opportunities, in developing the hydroclimate projections are discussed in the Module 1 report.

The river system modelling here considers a subset of Module 1 projections, due to the complexity of putting together the various models run by the different modelling groups under state jurisdictions and ensuring reasonable consistency in the modelling and interpretation across the MDB. As the catchment inflows from the different modelling groups come from different models and methods, scaling factors are used to scale historical inflows to enable consistent treatment of climate change impact on inflows across the Basin. We note that this represents only a subset of the potential range of variability, as scaling of inflows retains their existing temporal variability, but not the full range of variability that is possible in the future. Nevertheless, river system modelling with the sub-set of scenarios is fit for the purposes of SY, to provide a broad Basin scale assessment of climate change impact on water availability and use across the Basin.

The full set of projections data from Module 1 can be accessed for more detailed modelling of local regions where required. These are available at https://data.csiro.au/collection/csiro:64826

The scenarios used for the river system modelling are the 10th percentile, median and 90th percentile of the Module 1 simulations informed by the 120 global climate model outputs. The climate change science knowledge described in Module 1, and the analyses of climate change signals from climate models and rainfall-runoff modelling in Module 1 suggest sufficient distinction to consider different projections for cool versus warm seasons (particularly in the rainfall projections) and the Northern versus Southern Basin (partly because of the climate projections and partly because of the differences in the hydrology in the North and South).

The 10th and 90th scenarios represent the plausible range of projections, where 80% of simulations place the future climate. The median scenario is a mid-point between the end member scenarios and represents the likely direction of change. Whilst many model runs group around the median, for the purposes of SY, the full range of plausibility is used, as it will more likely ensure that future planning can account for the range of plausible future water needs. The around 2030 time horizon (~1.0°C global warming relative to 1990) is modelled to support the Basin Plan Review and policy and the around 2050 time horizon (~1.5°C global warming relative to 1990) is modelled to support long-term water planning.

[7] Chiew, F.H.S., Devanand, A., Khan, Z., Zheng, H., Potter, N.J., Robertson, D.E., Grose, M.R., Post, D.A. & Fu, G., *Hydroclimate Projections for the Murray–Darling Basin* (CSIRO report from **Module 1** of the MDBA Sustainable Yields Project, **May 2025**, 131 pp.), https://www.mdba.gov.au/sites/default/files/publications/SY-hydroclimate-projections-for-the-Murray-Darling-Basin.pdf

Model veracity

Model assurance overview

The approach used in this assessment is dependent on the model performance for each of the river system models developed by state jurisdictions under accredited Water Resource Plans. These will vary according to overall modelling approach, system understanding, data availability for calibration and validation and experience and judgement of modellers.

Best available information

The modelling results in this report represent the best available information at the time of publication for the assessment of the challenges that are likely to arise under future water resources management conditions. The information presented in this report presents one of multiple lines of evidence that is available to understand current state and future climate driven risks to water availability across the Basin.

Modelling information is a key part of the evidence base used by policymakers to support emerging narratives about future climate risks and is a point-in-time assessment based on the contemporary representation of the Basin system, operating rules, water demands and climate information.

Models that are referred to in this report are subject to continual improvement and updates, as technology and scientific knowledge of climate induced water availability risks evolve. Updates to model structure, calibration, and scenario definitions are the norm, and it is important that interpretations of modelling evidence are considerate of the contemporary nature of representation of systems, rules and structures.

Comparisons to earlier SY work (such as SY 1 in 2009) should be cognisant of interim developments or advancements in scientific knowledge. SY 2009 was a major whole-of-Basin assessment used to inform the 2012 Basin Plan, and SY 2025 aims to update this evidence base to support current decision needs and will continue to be developed and refined. It is, therefore, not unlikely that results present differences in volumes or yield under predicted future conditions between this report and previous assessments. Future SY assessments and related Basin Plan Review analyses may present further numerical refinements as the evidence base and scenario set evolve.

The SY 2025 product is an early step in the current investigation cycle. SY 2025 is intended to provide critical information to inform the 2026 Basin Plan Review, alongside other lines of evidence, and the MDBA has foreshadowed that Review assessment results will be shared through a Basin Plan Review Discussion Paper in early 2026.

Model accreditation process

The models used either directly for the model scenarios or as the basis of the model scenarios developed for this project have been assessed for their suitability as part of the accreditation of the Water Resource Plans that the river system models support. In this process, the MDBA and, in some cases, independent assessor (Floodplain Harvesting models in NSW, for instance) used in this study have undergone a rigorous, criteria-based assessment led by MDBA[8]. It requires that models comply with statutory provisions and demonstrate use of the best available information[9]. It should be noted that some models submitted for this study have not been submitted to support the accreditation of Water Resource Plans, for instance the ACT and Victorian models.

Assessment is based on a set of detailed criteria covering model documentation, data quality, structure, calibration, verification, uncertainty analysis, and quality assurance. States must provide supporting evidence, and MDBA reviews the model through a bilateral process, issuing an assessment report with feedback before making a recommendation to the Minister on accreditation of the Water Resource Plan.

The process is focused on ensuring transparency, scientific robustness, cooperation with Basin state modellers, and continuous improvement, ensuring that models reflect the best available information and support compliance with sustainable water use limits.

Reviews and engagement

The development and refinement of this report is a collaborative approach between representatives from MDBA, CSIRO, and Alluvium, with guidance from the Basin State representatives of the Strategic Hydroclimate Working Group (SHWG) and the Modelling Advisory Group (MAG).

Several workshops were conducted between September and December 2025 with MDBA, CSIRO, Alluvium and with SHWG/MAG to refine the table of contents, the infographics, key messages and oversee the drafting of the preliminary results and discussion sections of this report.

Written and verbal informal feedback was requested from MDBA, CSIRO and Alluvium and integrated during the report's development. Written comments were requested from SHWG and MAG in November and December 2025 and integrated in January 2026.

All models provided by State jurisdictions and Snowy Hydro were agreed to be utilised by the MDBA in accordance with their data sharing arrangements. As part of the data sharing arrangements, all model outputs and associated report content are accessible to the State jurisdictions and Snowy Hydro on the shared central model repository.

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[8] Murray–Darling Basin Authority (MDBA), Position Statement 3C: Method for determining take (WRP Position Statement; MDBA Reference D15/15099; 20 August 2015), https://www.mdba.gov.au/sites/default/files/publications/wrp-position-statement-3c-method-for-determining-take0.pdf

[9] Basin Plan 2012 (Cth) s 10.49 ("Best available information") (Compilation No. 10, compilation date 1 July 2024, registered 30 August 2024), Federal Register of Legislation

Model sources

Three key scenarios associated with Basin Plan development have been applied to the river systems models. These represent three different configurations of the models to best represent the river systems as they would be under the planning regimes (or lack thereof) needed to evaluate different Basin Plan requirements. The scenarios are described more fully in subsequent sections, but for the purposes of model development, the three scenarios for which models have been incorporated into the FIRM include:

- **Without Development (WoD)** – intended to represent the case where there is no development of any kind, including no dams, weirs, or extractions.
- **June 2009** – Basin Plan Review reference as at June 2009, intended to represent the development, operation, and water sharing conditions immediately prior to the Basin Plan.
- **Basin Plan Fully Implemented (BPFI)** – intended to represent maximum plausible future development including the full implementation of SDLs.

The jurisdictions supplied models to the MDBA for this study under an activity schedule and either identified the models most appropriate to supply the MDBA or developed the scenarios themselves and provided them to the MDBA. In the cases where the jurisdictions supplied the most appropriate models the MDBA may have needed to adjust them slightly to be integrated into the FIRM consistent with other models.

In the FIRM, information is generally passed from upstream models to downstream models, but in some instances, particularly in the connected Southern Basin, information needs to flow from downstream models to upstream models. This requires the need to iteratively run the model scenarios to allow the information flows to sufficiently converge, so that the difference between modelled results between iterations is minimised. The volume of information passed between models increases from the WoD scenario to the June 2009 scenario to the BPFI scenario reflecting the increasing complexity of water management arrangements. The type of information that is passed between models includes:

- Flows, including components of total flow such as environmental component or inter-valley trade component
- Storage volumes
- Spill volumes from storages
- Entitlement allocations
- Water account volumes
- Activation of rules/conditions in connected valleys

WoD Models

The models used to represent the WoD scenario are listed in Table 4 and Table 5 below, including the software version. The model linkages for the WoD scenario are displayed in Figure 5. The WoD scenario is the simplest of the three scenarios outlined in this report as the linkages between the models only flow from upstream to downstream. In addition, the WoD scenario has:

- a reduced number of models representing the Condamine-Balonne system,
- An additional model representing the Menindee Lakes system as the developed representation of the Menindee Lakes in the Source Murray Model (SMM) is not easily able to be reconceptualised to its pre-developed state in that model; and

- Does not include a version of the Snowy model, as the Snowy catchment is not naturally part of the MDB. The areas of the Murrumbidgee and Murray catchments which the Snowy Hydro system harvests water from are included in the inflow estimates for those catchments respectively in the WoD scenario.

June 2009 Models

The model details used to represent the June 2009 scenario are listed in Table 4 and Table 5 below including the model file and software version. The model linkages for the June 2009 scenario are displayed in Figure 5.

As mentioned in the reference scenarios section, the June 2009 models are often the same as the models used to define the Baseline Diversion Limit (BDL); however, states have, in some cases, submitted newer versions of these models that can be considered candidate BDL models.

As the modelling being used in this study will also be used to inform assessments in the Basin Plan Review it was an opportunity for jurisdictions to transition some models that have been improved. Reasons for this transition may include:

- Updated representation in new software,
- Updated inputs, data, or model conceptualisation to improve representation of system as of June 2009, and
- Fixes or corrections to errors subsequently found in BDL models.

Most notably this is evident in Victoria where the monthly timestep REALM models for the Goulburn-Broken-Campaspe-Loddon system and the Wimmera that were used to define the BDL have been replaced by daily timestep Source models which are more appropriate for hydrograph analysis to understands the impact of Basin Plan implementation.

It is expected that changing these models will give equivalent, but not exact, outcomes to the official BDL models. The official BDL models will still be used to define the SDL and compliance outcomes.

BPFI models

The models developed for the BPFI scenario required the most development from MDBA and states to be suitable to represent a fully implemented BP as shown in Figure 5 below. River system models were in a wide range of suitability in both their representation of water recovery and their delivery and management of HEW.

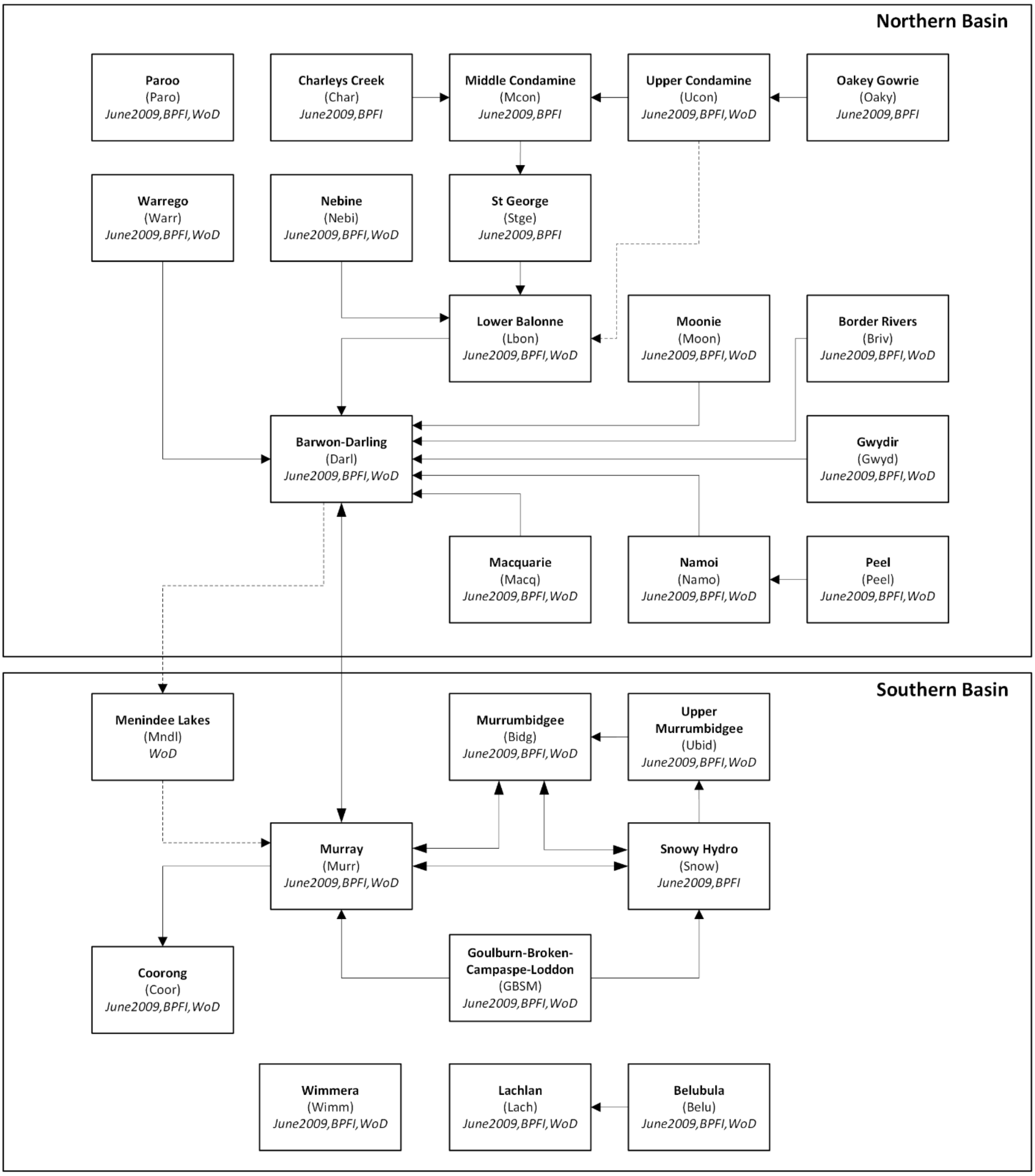


Figure 5: Linkages between river system models in FIRM for all scenarios

Table 4: Northern Basin models used for SY2 scenarios

Name (FIRM id) Supplier	Reference Scenario	Model File	Model Code	Model Version
Upper Condamine (Ucon) Queensland	June 2009	1_BaseCase_model_CON_2013_06_310a _Upper_Con_to_LoudenWeir_v4-5.rsproj	Source	4.5.0.755 2
	BPFI			
	WoD	CON_PD_2013_06_300a_St_George_v4.5 .rsproj		
Warrego (Warr) Queensland	June 2009	W1601a.sys	Iqqm	6.75.34
	WoD	WG_NAT_01.sys		
	BPFI	W1601aFI.sys		
Paroo (Parr) Queensland	June 2009	P_201a.sys	Iqqm	6.75.34
	BPFI			
	WoD	P_409b.sys		
Nebine (Nebi) Queensland	June 2009	Neb2410a.sys	Iqqm	6.75.34
	BPFI	Neb_BPFI.sys		
	WoD	N2410b.sys		
Barwon-Darling (Darl) New South Wales	June 2009	LTAAEL_2024.sqq	Iqqm	7.105.2
	WoD	bdenNt1F.sqq		
	BPFI	DarlAPT07_24curr_BPFI.sqq		
Oakey Gowrie (Oaky) Queensland	June 2009	2_BaseCase_model_CON_2013_06_301A _2_Oakey Gowrie_v4-5.rsproj	Source	4.5.0.755 2
	BPFI			
Charleys Creek (Char) Queensland	June 2009	3_BaseCase_model_CON_2013_06_304a _Charleys_Ck_model_v4-5.rsproj	Source	4.5.0.755 2
	BPFI			
St George (Stge) Queensland	June 2009	S1811FL.in	StGeorge	35-64
	BPFI[1]			
Lower Balonne (Lbon) Queensland	June 2009	Condamine Distributary Model ROP 1811F - V4.5.rsproj	Source	4.5.0.755 2
	BPFI			
	WoD	Condamine Distributary PD Model Recal 11 1889-2013- V4.5_Updated.rsproj	Source	4.5.0.755 2

Middle Condamine (Mcon) Queensland	June 2009	4_BaseCase_model_CON_2013_06_310a_Middle_Con_to_StGeorge_v4-5.rsproj	Source	4.5.0.7552
	BPFI			
Moonie (Moon) Queensland	June 2009	MoonieRiver_2020_10_13_Cap_Ext_A_2024Extension.rsproj	Source	4.11.0.10112
	WoD			
	BPFI			
Gwydir (Gwyd) New South Wales	June 2009	BDL_v27_11_2024_2a_3_final.sqq	Iqqm	7.103.0
	WoD	CC2WOD_WOD_v6_2024.sqq		
	BPFI	VSC_v27_11_2024_2a_3_HEW_v1_0_BPFI.sqq		
Namoi (Namo) New South Wales	June 2009	NAMO_APT_004_5.20.0.12549.rsproj	Source	5.20.0.12549
	WoD			
	BPFI			
Peel (Peel) New South Wales	June 2009	PeelA122.SQQ	Iqqm	7.91.6
	BPFI	PeelS052_BP2024.sqq		
	WoD	PeelN112.SQQ		7.67.4
Macquarie (Macq) New South Wales	June 2009	MACQ_BDL_20220908.sqq	Iqqm	7.101.0
	BPFI	CC_APT_20230322_BP2024.sqq		
	WoD	3501800g_pre-dev_2021.sqq		7.95.0-RC5-Rev3626
Border Rivers (Briv) New South Wales	June 2009	BorderRivers_2020_09_02.rsproj	Source	4.11.0.10112
	WoD			
	BPFI			

Table 5: Southern Basin models used for Scenarios

Name (FIRM id) Supplier	Reference Scenario	Model File	Model Code	Model Version
Belubula (Belu) New South Wales	June 2009	Belubula_4507552_WRP_001.rsproj	Source	4.5.0.7552
	BPFI			
	WoD			

Lachlan (Lach) New South Wales	June 2009	LachBD15.sqq	Iqqm	7.95.0-RC5-Rev3737
	BPFI	LachAPT123_BPFI.sqq		
	WoD	Lachlan Pre-Dev03_540013172_data_to_2024.rsproj	Source	5.40.0.13172
Menindee Lakes (Mndl) MDBA	WoD	Menindee Lakes WD 5.50.rsproj	Source	5.50.0.13365
Snowy Hydro (Snow) Snowy Hydro	June 2009	RunSnowyModel.bat	Snowy	v2
	BPFI			
Upper Murrumbidgee (Ubid) ACT	June 2009	Upper_Murrumbidgee_ACT_Planning_Model_5_50_0_V_21.rsproj	Source	5.50.0.13365
	BPFI			
	WoD			
Murrumbidgee (Bidg) New South Wales	June 2009	BIDGBDLA.iqq	Iqqm	6.104.2
	BPFI			
	WoD	Murrumbidgee_Natural-386_v5.40.rsproj	Source	5.40.0.13172
Goulburn-Broken-Campaspe-Loddon (Gbsm) Victoria	June 2009	GBCCL 2009 Conditions.rsproj	Source	5.60.0.13780
	BPFI			
	WoD	GBCCL Natural Conditions.rsproj		
Wimmera (Wimm) Victoria	June 2009	Wimmera-Glenelg.rsproj	Source	5.40.0.13130
	BPFI			
	WoD	Wimmera-Glenelg.rsproj	Source	5.16.0.12332
Murray (Murr) MDBA	June 2009	River Murray Model 5.50.0.rsproj	Source	5.50.0.13365
	BPFI			
	WoD			
Coorong (Coor) MDBA	June 2009	CHM.exe	Coorong	CHM.exe
	BPFI			
	WoD			

Understanding the results

The results of the modelling efforts that have been completed across the Basin are presented here, aggregated to key reporting locations that indicate the change in hydrologic condition of systems under each hydroclimate scenario, and the impacts on water available for different consumptive and non-consumptive uses, compared between Basin Plan Review reference scenarios.

The modelling framework is able to produce a wealth of information, at a large number of reporting points across the system. Model outputs include climatic and hydrologic features such as gauged and calculated flow volumes, storage volumes, losses (evaporative, groundwater, overbank floodplain), and demand features, such as diversions (consumptive water entitlement allocation), environmental water (held and releases), entitlement volumes, demand reliability. Due to differences in management products across the Basin, outputs are not necessarily representative of a singular concept. Efforts have been made to define the reporting metrics, such that they can represent a singular concept.

It is important to note that where there is inconsistency in definition or representation of terms, this has been considered, and where required, subject to a caveat to avoid misinterpretation.

While there are limits to the interpretation that can be drawn from model outputs, the results presented here have been defined to ensure consistency and unambiguity in drawing key messages.

Reporting metrics

The following modelling metrics have been derived from the modelling framework at key reporting points across the Basin. The metrics that are described here are defined as they relate to the interpretation of modelling results.

Metric	Definition
Climatic metrics	
Cool Season	Within this report and in the interpretation of the results, this is defined as the period between May and October.
Warm Season	As the corollary to the Cool Season, this is used as the period between November and April.
Rainfall	Measured or interpolated rainfall data accumulated to a daily or monthly timestep. Rainfall series are model inputs that have been adjusted to represent the equivalent rainfall under each of the respective hydroclimate scenarios.
Evaporation	Potential evapotranspiration (PET) estimated using other climatic factors such as recorded temperature, to define the maximum rate of evaporation that would occur if water supply were unlimited. As actual evaporation is difficult to measure, PET is used as a proxy to estimate the water requirement apportioned to evaporative loss from the system.

Temperature	Measured or interpolated temperature data, recorded as a daily or monthly average
Loss* (evaporative)	One of several types of loss of water from the surface water system. This is a metric indicating water that leaves the Basin river system through evaporation into the atmosphere.

Hydrologic metrics

Drought	Drought refers to hydrologic drought. This is measured as a period of time when flow is below the 10th percentile range of historical flow volume.
Runoff	A hydrologic metric of catchment yield from a given rainfall event. Runoff is typically calculated using Rainfall-Runoff models that take historical climatic inputs (such as rainfall and evaporation) that have been adjusted to represent the climate impacts of the respective hydroclimate scenario. Runoff is generally reported at the most downstream location of a user defined catchment, which often aligns with hydrologic features such as river confluences, storages, or streamflow gauges. Runoff is calibrated to a streamflow gauge and represents upper catchment flow into a river system model.
System inflows	A calculation of flow inputs into a reporting unit, such as SDL unit or Northern or Southern Basin unit. Inflows for a unit are representative of river flow volumes that are unimpacted by diversions or capture from storage and are measured at a location partway down the river system, downstream of inflow points and confluences.
Flow volume	Gauged or calculated streamflow volume. In node-based models this can be extracted at every key feature or reporting location within a model.
Loss* (groundwater)	One of several types of loss of water from the surface water system. This is a metric indicating water that leaves the Basin river system through flow to groundwater.
Storage volume	Modelled volume of water in storage. This is calculated as a water balance on a model timestep, which includes losses from spills or evaporation.
Storage efficiency	Storage efficiency is the ability for a storage to capture available inflows, referring to the proportion of overall inflow that the storage is able to capture, and the relative airspace within the storage that can intercept and retain water from passing downstream.
Loss* (storage)	Water that is lost from the system water balance and is unaccounted for in river operating rules, such as spills or evaporation.

Water delivery metrics

Allocation	The volume of water that licenced water users can access. Allocation is determined differently across Basin states, depending on water availability, use priority, and reliability or security requirements. The amount of water an entitlement holder is allocated depends on which state and catchment they are in, as well as the type of entitlement they hold.

Consumptive use	Water demand that is delivered through a diversion and consumed or removed from the surface water system. This includes both irrigation water use and environmental water that is delivered under an environmental entitlement but does not include incidental beneficial use of water in the river or captured in river system processes.
Diversions	Water apportioned for consumptive use. Diversions are modelled representations of water delivered to meet different types of demands. Diversion types differ across the Basin, and include consumptive uses such as irrigation, urban (town water supply), rural (stock and domestic) and delivered environmental water.
End of valley flows	Downstream flow volumes that are representative of total outflows from a reporting unit.
Entitlement	There are different types of entitlement products in each of the Basin states[10]. These products are not equivalent and cannot be compared across Basin states.
Entitlement Reliability	The amount of allocation as a proportion of the full entitlement available within the river system. This highlights how the ability of delivering entitlements will change under different climate and planning scenarios.
Environmental Water	Water delivered to meet environmental purposes. Environmental water presented in water balance represents the environmental water diversion volume, and may be represented as being within both river system process water and/or downstream flows. In this report, environmental water is not an additional component of the water balance, but contained within those other components.
Handshake flows	These are flows that are tracked throughout the system where they may be outflows from a tributary model that passes into a downstream model and are then treated as inflows. By accounting for this process through handshake equations specific to a particular model, inflows can be tracked throughout the integrated models without double counting.
Non – entitlement water	This is water that while being delivered to the river system, is not identified as being available for consumptive use. This can include losses to evaporation, transpiration and infiltration and flows downstream from the river system as well as water that cannot be captured.
Loss* (overbank floodplain)	One of several types of loss of water from the surface water system. This is a metric indicating water that leaves the Basin river system through flow over the banks of a river that is not returned to the system through runoff.
Held Environmental Water	Held Environmental Water (HEW) is water that is held in storage or restricted from being available to consumptive users in order to supply environmental watering requirements downstream.

[10] Murray–Darling Basin Authority. (2025). *Water entitlements in Basin states*. Murray–Darling Basin Authority. https://www.mdba.gov.au/water-use/allocations/water-entitlements-Basin-states

River system process water	This represents the fraction of water exiting the surface-water system by non-consumptive pathways such as through losses, pre-wetting etc, not including downstream flows. It is also referred to non-entitlement water in some cases. While river system process water represents combined system losses*, this includes water that is of beneficial use to the environment, or contributions to groundwater recharge, and therefore represents an important component of the overall system water balance.
Town Water Supply	Urban or town and industrial or high security or high reliability water, depending on the regional definition that differs by jurisdiction.

* Losses refer to loss from the surface-water system. These are represented under river system process water in results.

Reporting locations and water balance components

The assessment of hydroclimatic impacts to the MDB system under representative Basin Plan Review reference scenarios has been undertaken across all valleys within the Basin. Within the results section, a selection of reporting units, illustrative valleys and reporting locations has been identified that provide a good indication of the trends and observable impacts of each scenario. Their selection has been made to demonstrate what the majority of results indicate. Reporting units present a high-level picture of Basin wide impacts, illustrative valleys have been selected to show the spatial variability, and the key reporting locations indicate the impacts of climate hazards and management scenarios on sites that are commonly evaluated in Basin assessments.

Within each unit water balance components are apportioned based on hydrologic factors, such as river form (channel steepness, sinuosity), quantity and volume of entitlement holders, location of diversions and storages and the presence of wetlands or lakes. Figure shows the components of a water balance within a reporting unit, where inflows represent the total water available to a unit, diversions represent flow of water to consumptive uses, river system process water represents water that is lost from the surface water system, through evaporation, groundwater, and/or system watering or is otherwise unable to be captured or passed downstream. Outflows represent the end of system flows or flow out of a unit, which equates to the contribution of water that is available for downstream uses.

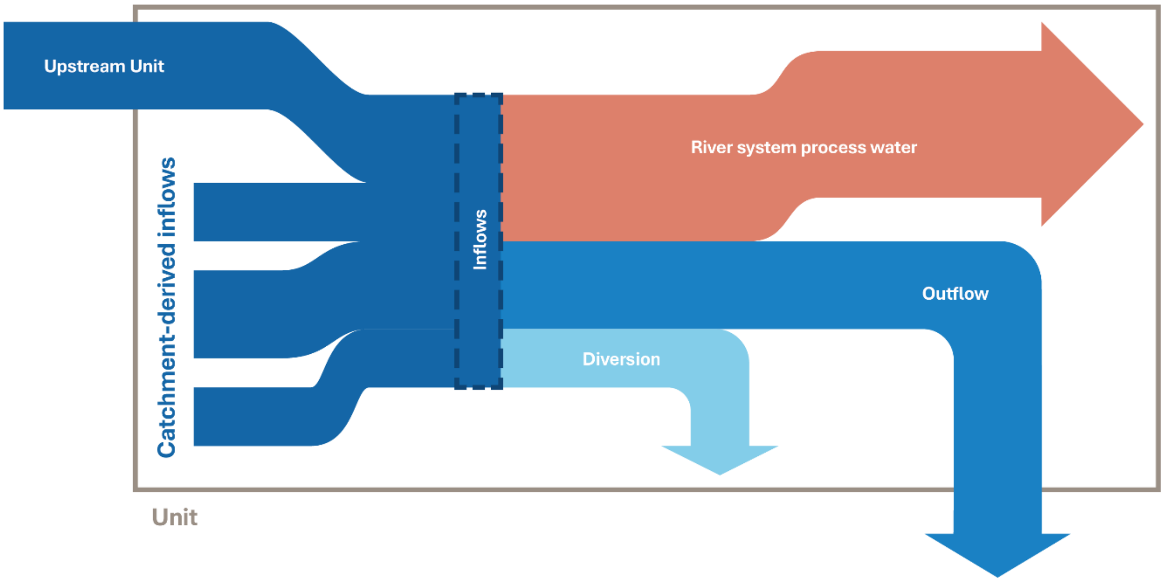


Figure 6: Conceptual water balance for interpretation of results.

Results have been presented as reporting units, which vary in spatial resolution. Reporting units range from whole of Basin scale, valley scale, down to key reporting locations that represent sites of environmental or cultural significance, such as the Menindee Lakes or the Coorong. This gives a view of key trends and insights that are illustrated on a macro-scale, and that when zooming in to a smaller scale, the overarching narrative is unchanged, but with subtleties and deeper revelations. Results are presented using an hourglass approach, that steps from broad, whole of system considerations, into finer spatial detail to explore important insights seen when looking at different scales, then zooms out to the key findings and observations in the interpretation and discussion. The models used in this assessment are approximately consistent with the surface water sustainable diversion limit (SDL) resource unit boundaries in the Basin but are sometimes combinations of these which make it difficult to extract out individual SDL results. As this report focuses largely on the impacts of climate change for water in the Basin, and not definitive SDL accounting, the results have been retained at the individual model output scale as the smallest reporting unit, and further disaggregation into individual SDL units has not been undertaken here. The SDL units and their associated river valleys are shown in Figure 7.

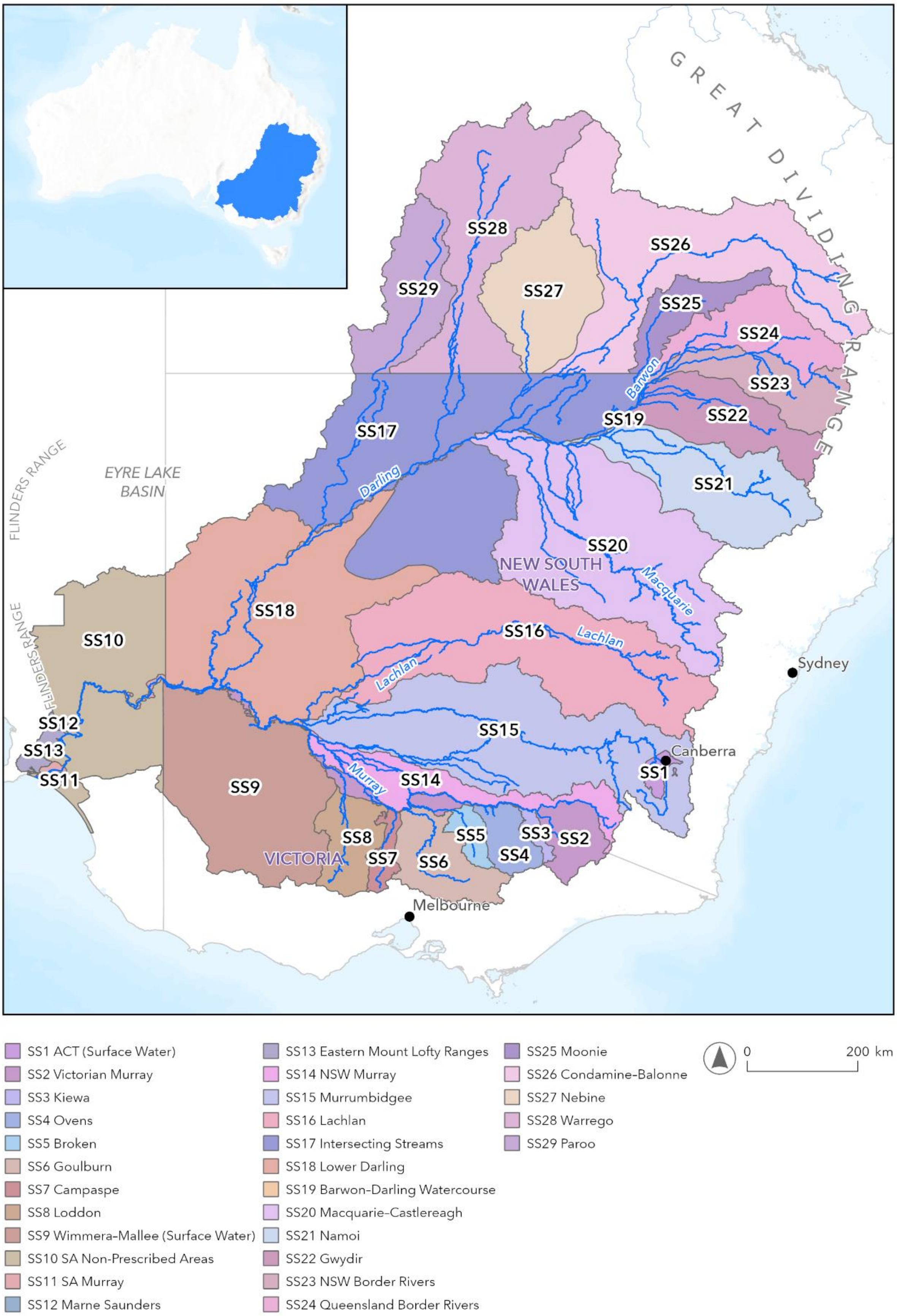


Figure 7: SDL Resource Units across the Basin.

Results

Outputs from the river system modelling framework have been synthesised to provide insights into the potential climate driven impacts on water resources across the MDB. The results presented here are intended to represent the potential impacts of future climate change by evaluating different planning scenarios (WoD, June 2009 and BPFI) under different future hydroclimates.

As noted in previous sections, the methods and results used in the report are intended to provide an understanding of those impacts, and how they may be influenced by different planning contexts. They are not designed to illustrate exact changes in key components of the water cycle, especially with regards to water available for consumptive uses or for the environment, nor are they designed to evaluate or inform climate risks on water resources for individual SDL water resource units.

Climate and runoff

Largely, the river system modelling is most influenced by the scaling of inflows used in accordance with the tables below, with the rainfall, temperature and PET scaling used in internal processes within the model (e.g. crop models).

The climate change impact assessments in SY considered 3 future scenarios at 2 different time horizons. For the river system modelling, the 1895–2024 baseline historical inflows, rainfall and PET are scaled by the change factors as shown in the tables below for the climate change impact assessment.

Table 6: Hydroclimate scenario scaling factors used in the river systems modelling for around 2030 conditions

~2030 ~1.0oC global warming relative to 1990	**S1 Warmer and slightly wetter** 	**S2 Warmer and drier** 	**S3 Warmer and much drier** 
Change in inflows Northern Basin Cool season (May–Oct) Warm season (Nov–Apr) Southern Basin Cool season (May–Oct) Warm season (Nov–Apr)	+6.0 % +18 % 0 % +5.0 %	-11 % +1 % -10 % -9 %	-21 % -13 % -20 % -17
Change in rainfall Northern Basin Cool season (May–Oct) Warm season (Nov–Apr) Southern Basin	+3.6 % +5.7 % +1.0 %	-4.4 % +0.7 % -3.5 %	-8.0 % -3.3 % -7.7 %

Cool season (May–Oct) Warm season (Nov–Apr)	+6.3 %	-0.3 %	-4.8 %
Change in temperature (°C)	+0.9 %	+1.1 %	+1.2 %
Change in PET	+2.6 %	+3.0 %	+3.6 %

Table 7: Hydroclimate scenario scaling factors used in the river systems modelling for around 2050 conditions

~2050 ~1.5oC global warming relative to 1990	S4 Hotter and slightly wetter	S5 Hotter and drier	S6 Hotter and much drier
Change in inflows Northern Basin Cool season (May–Oct) Warm season (Nov–Apr) Southern Basin Cool season (May–Oct) Warm season (Nov–Apr)	+9 % +27 % 0 +8 %	-17 % +2 % -15 % -13 %	-31 % -19 % -30 % -26 %
Change in rainfall Northern Basin Cool season (May–Oct) Warm season (Nov–Apr) Southern Basin Cool season (May–Oct) Warm season (Nov–Apr)	+5.4 % +8.6 % +1.5 % +9.4 %	-6.6 % +1.1 % -5.2 % -0.5 %	-12.0 % -5.0 % -11.5 % -7.2 %
Change in temperature	+1.3 °C	+1.6 °C	+1.8 °C
Change in PET	+3.9 %	+4.5 %	+5.4 %

Assessing outputs from the river system modelling involves evaluating the impact of different development scenarios under a selection of plausible future climate scenarios informed by the scaling of hydroclimate variables as shown above. The assessment, therefore, focuses on three scenarios that sit across a spectrum of plausible outcomes, for both a near-term and longer-term assessment, to show how climatic conditions under each projection evolve with time and over different planning contexts.

River system flows

Observing differences in river system flow metrics between scenarios shows how each development case and hydroclimate condition influences how water moves through the river system and how it is made available to individual management units. Comparing scenarios outlines the total volume of water generated within each unit under different conditions, the way that water is partitioned between consumptive users, environmental needs, river system process water representing water lost from the river system and storage operations, and the proportion of flow that continues downstream to support downstream water uses.

Inflows

Inflows provide a measure of the total volume of water generated within a river system and available for use within a system. For headwater rivers, inflows represent the runoff generated in the catchment, whereas for downstream rivers, inflows include outflows from any upstream tributaries. Methods of accounting for this using "handshake" equations. These "handshake" equations handle the passing of flows from the outflow of one model being counted as an inflow into a downstream model and are applied to ensure there is no double-counting of inflows across the whole Basin. Projected hydrologic changes have been presented as differences in average annual totals over the period of record, providing a consistent baseline for comparing changes under future climates, under different development settings. Climate change will impact parts of the flow regime differently, where there is likely to be an increase in severity and magnitude of extreme events at both ends, intensifying high-flow events under wetter conditions and deepening low-flow and drought periods under drier conditions. In this report, long-term averages give an indication of overall directional change and the magnitude of change expected at different time horizons, but do not capture the shifts in frequency or intensity of extreme events.

Across the Basin, the impacts of climate change on inflows are variable, depending on the hydroclimate scenario applied. Different projections of plausible future climates elicit different rainfall-runoff responses, leading to a wide range of plausible outcomes for water availability. For example, a hotter and wetter climate will result in similar or more water available than under historical conditions, an effect that is more pronounced in the Northern Basin in the warm season, but the drier hydroclimates show a downward trend across all relevant scenarios.

These impacts also differ spatially across the Northern and Southern Basins, reflecting the distinct climatic zones and hydrologic features. Comparing inflow volumes across the North and South provides a whole-of-Basin perspective on where climate-driven changes to inflows are likely to be most pronounced, and how regional sensitivities may shape system-wide outcomes.

Changes to catchment inflows are driven by shifts in climate, and are irrespective of development condition. Implementation of the Basin Plan influences how water is used and transmitted through the system, but does not alter the volume of water generated by the catchment under a given future climate.

Table 8: Results from model scenarios showing average annual volumes of inflows (GL) to aggregated units (Northern Basin) under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Annual Inflows (GL) – Northern Basin							
WoD	12131	13747	11651	10167	14559	11412	9190
% change from historical climate		13%	-4%	-16%	20%	-6%	-24%
June 2009	11931	13526	11463	10002	14328	11231	9045
% change from historical climate		13%	-4%	-16%	20%	-6%	-24%
BPFI	12634	14259	12151	10654	15072	11910	9666
% change from historical climate		13%	-4%	-16%	19%	-6%	-23%

Table 9: Results from model scenarios showing average annual volumes of inflows (GL) to aggregated units (Southern Basin) under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Annual Inflows (GL) – Southern Basin							
WoD	19838	20473	18166	16203	20736	17279	14333
% change from historical climate		3%	-8%	-18%	5%	-13%	-28%
Jun-09	20198	20709	18375	16389	20967	17462	14465

% change from historical climate		3%	-9%	-19%	4%	-14%	-28%
BPFI	19851	20367	18050	16091	20599	17146	14204
% change from historical climate		3%	-9%	-19%	4%	-14%	-28%

Climate change impacts available inflows across the Basin differently

- Northern Basin impacts show that generally, total annual inflows will change from +13% to -24% of historical inflows across the range of hydroclimate scenarios.
- In the Southern Basin, the range of impacts for total annual inflows are less pronounced from +3% to -28% but generally showing a greater reduction than in the Northern Basin

Under hotter and wetter conditions, increases in inflows are proportionally greater in the Northern Basin than in the Southern Basin, with increases up to +17 to +20% in total annual inflows predicted for the 2050 hydroclimate in the North, but only +1 to +3% in the South. The majority of inflow increases are seen in warm season inflows in the Northern Basin, with maximum increases of up to +27% predicted under the 2050 hydroclimate. In the Southern Basin, minimal increases are expected in total annual inflows, ranging from +3% to +5% under the hotter and wetter conditions for the 2050 hydroclimate, with cool season inflows remaining constant (0% change) and warm season inflows predicted to increase overall from between +5% to +8%.

Under hotter and drier conditions, the Southern Basin is expected to have greater proportional reductions in total annual inflows than the Northern Basin, ranging from -8% to -14% in the South, compared to -4 to -6% in the North. It is expected that in the Southern Basin, the reductions are likely to be more predominant in the cool season inflows (-10% to -15%) than in warm season inflows (-9 to -13%). In the Northern Basin, cool season inflows are also expected to show greater reductions under these conditions (-11% to -17%) than warm season inflows (+1% to +2%).

The hotter and much drier conditions show significant impacts to inflows across both Northern and Southern Basins, with maximum total annual inflow reductions of up to -24% in the Northern Basin, and -28% in the Southern Basin. In the Northern Basin, these impacts are predicted to be proportionally greatest in cool season inflows (up to -30%). Similarly, cool season inflows in the Southern Basin are predicted to reduce by up to -31% in the 2050 hydroclimate.

Overall, it is apparent from the scenarios that there will be less inflows across the Basin in the future, especially under the drier hydroclimates. This drier outcome is expected to be more prominent in the Southern Basin during cool seasons, where larger reductions are predicted in the season with higher inflows. In the Northern Basin this impact appears to be less pronounced, with warm season inflows appearing to be less affected than cool season inflows, and the majority of inflows associated with the warm season. This may result in more dominant dry periods, especially if warm season inflows are lower for a particular year.

The impacts on inflows are independent of regulation or management

Predicted climate change impacts on inflows across the Basin are largely due to the changes in rainfall conversion to runoff under future plausible hydroclimates, as simulated by the scaling factors used for inflows, and are unlikely to be influenced significantly by different planning contexts. This is simply because most planning and management actions occur downstream of points of inflows.

Balance of water within a unit

Reporting units, illustrative valleys, and key reporting locations are represented as units to show how water is partitioned within management areas at different scales. Detailed water balances are presented for illustrative valleys to show how inflows are partitioned at specific locations into key components such as diversions, system losses, storage changes, and downstream flow. This highlights the influence of regional differences in hydrologic or landform features, climate, diversions and location of major storages or lakes on the overall water balance between valleys. Comparing a selection of illustrative valleys shows how local hydrology, development intensity, and operational settings shape water availability and transmission through the system.

A detailed water balance is presented for three climate scenarios for the following systems:

Macquarie catchment – A NSW river system with large upstream storages contributing inflows to the Darling River at Bourke, upstream of Menindee Lakes.

Gwydir catchment – A NSW system with substantial diversions and the lower Gwydir wetland and floodplain complex, with sporadic interconnection to the Barwon system during high flow events.

Warrego catchment – A Queensland and NSW system spanning a flat, arid landscape with low density water users.

GBCCL Basins – A Victorian system representing the combined water across the Victorian Goulburn, Broken, Campaspe, Coliban, and Loddon River systems. These rivers contribute significant inflows to the Murray River downstream of Barmah.

Murrumbidgee catchment – A system spanning mountainous to plains landscape across NSW and is one of the biggest contributors of inflows to the Murray River system.

Murray Basin – The water balance isolates the water used within the Murray River system as compared with the inflows contributed by upstream river systems.

Wimmera catchment – A Victorian system spanning flat, arid landscape, with terminal wetlands. The Wimmera is managed to supply bulk water through a reticulated supply network, and to manage high salinity and connectedness with the groundwater system.

Northern Basin Units

The Macquarie catchment

Two major dams, Burrendong Dam and Windamere Dam, are located in the headwaters of the Macquarie catchment. Both play a key role in capturing and storing water for delivery to entitlement holders within the system.

The following results show the trends observed in many of the Northern Basin Valleys, with the Macquarie being an important system in terms of downstream contributions into the Barwon-Darling system.

Under warmer/hotter and wetter conditions, the model predictions indicate a general increasing trend in future water availability within the Macquarie catchment with more water available across all components, particularly downstream flow, which provides inflows to the Darling system.

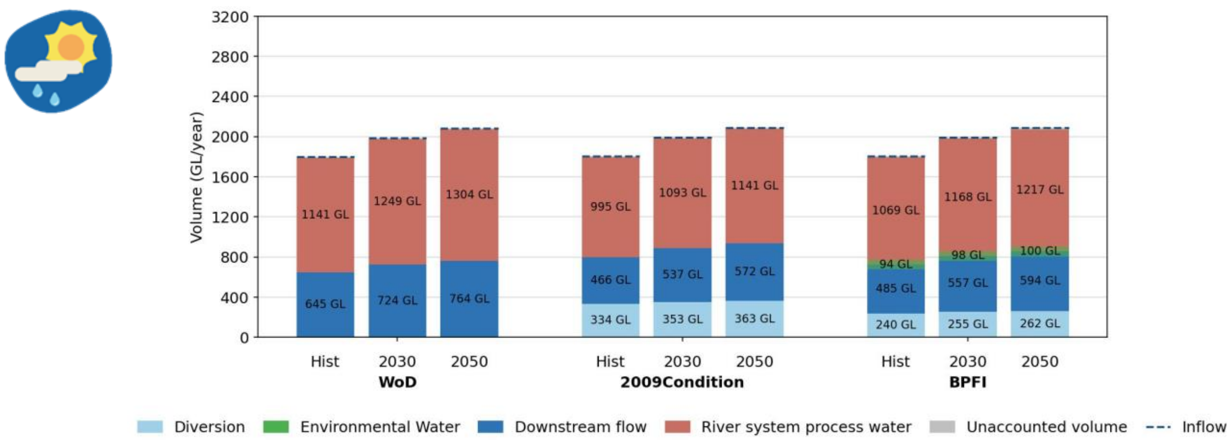


Figure 8: Stacked bar chart showing the annual total volumes of the **Macquarie catchment** under warmer/hotter and wetter climate conditions

The warmer/hotter and drier conditions show relatively similar impacts across the June 2009 and BPFI scenarios with diversions being less impacted than outflows. Environmental water is predicted to be largely unimpacted in these conditions.

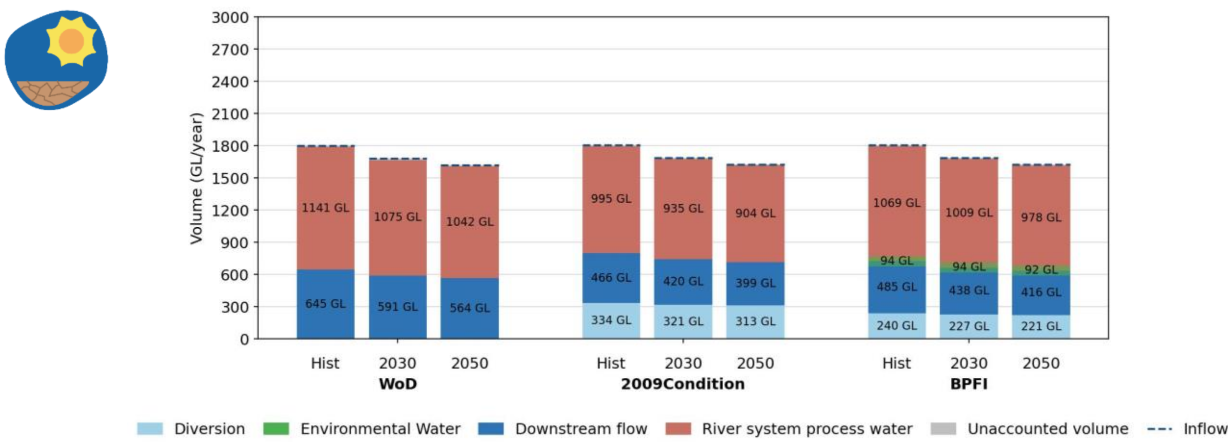


Figure 9: Stacked bar chart showing the annual total volumes of the **Macquarie catchment** under warmer/hotter and drier climate conditions

The warmer/hotter and much drier hydroclimate conditions result in significant decreases across all scenarios, but between the 2009 and BPFI scenarios, the impacts across diversions are relatively consistent, with the reduction in diversions compared to historical climate being around 18% and 20% in 2050.

Downstream flows show significant reductions in the BPFI and 2009 scenarios (-36%) from historical to the 2050 climate projections, noting that some of this water is also contained now in the environmental water component. The environmental water component also shows impacts with a predicted 14% reduction in water available.

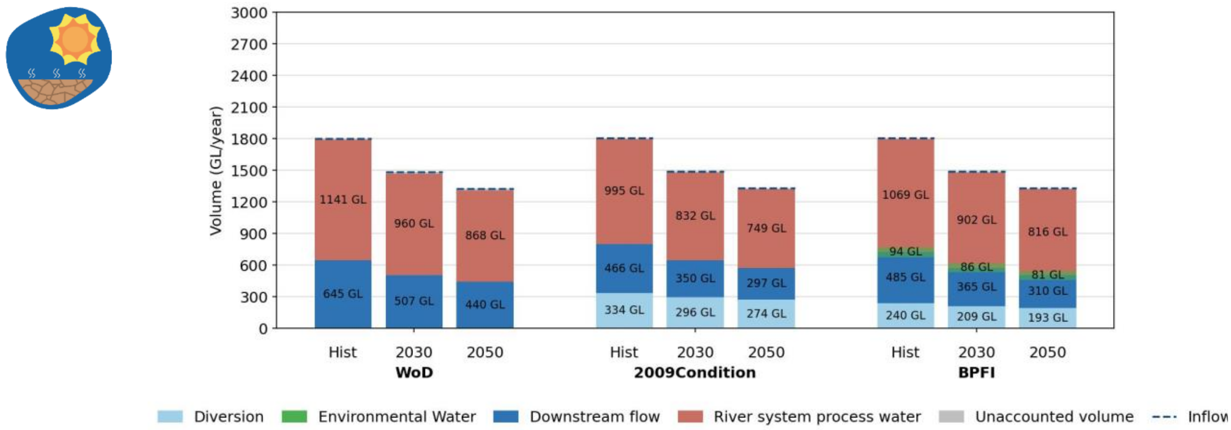


Figure 10: Stacked bar chart showing the annual total volumes of the **Macquarie catchment** under warmer/hotter and much drier climate conditions

Gwydir catchment

The Gwydir is characterised by the lower Gwydir wetland and floodplain complex, an anabranching floodplain system that soaks up much of the water flowing through the valley. The Gwydir contributes to the Barwon River system episodically, during high flow events. As such, a high proportion of water attributed to river system processes due to the downstream wetlands retaining much of the flow that passes into them.

Each of the hydroclimate conditions show results which are consistent with the Macquarie catchment above, although the proportion of water flowing downstream is much lower as it is attenuated in low lying wetlands.

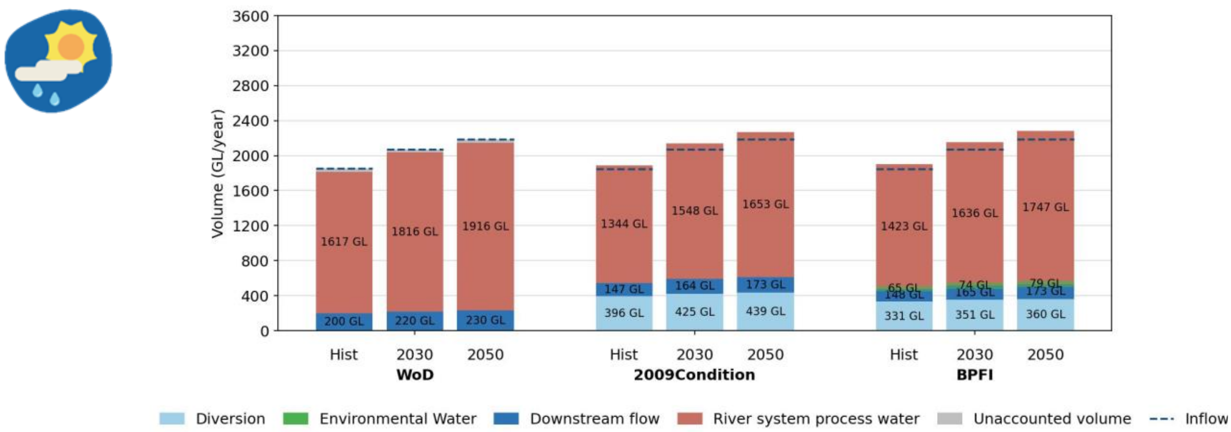


Figure 11: Stacked bar chart showing the annual total volumes of the **Gwydir catchment** under warmer/hotter and wetter climate conditions

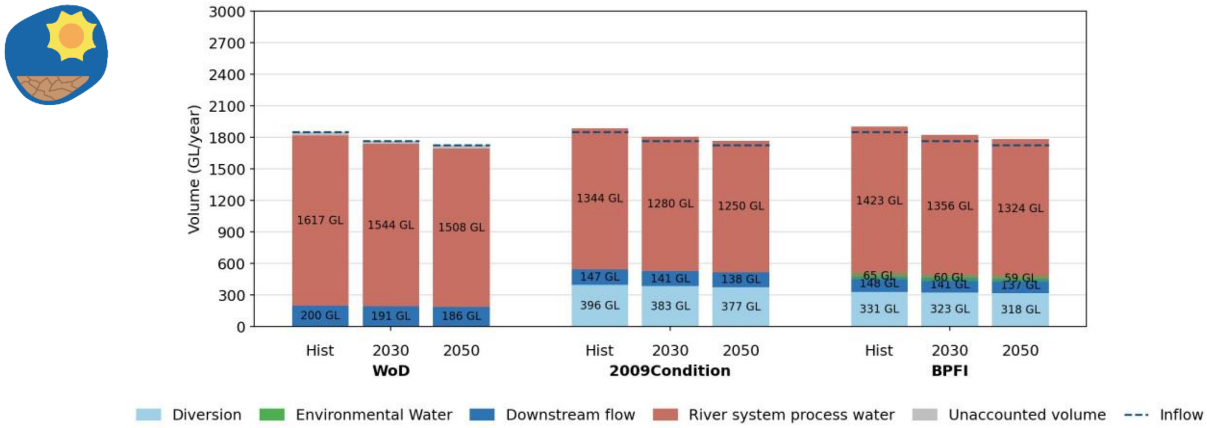


Figure 12: Stacked bar chart showing the annual total volumes of the **Gwydir catchment** under warmer/hotter and drier climate conditions

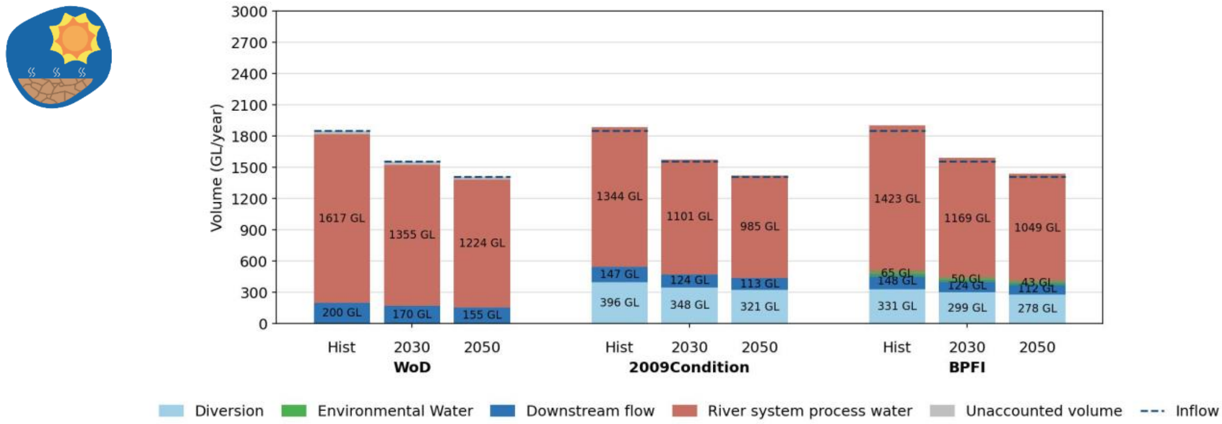


Figure 13: Stacked bar chart showing the annual total volumes of the **Gwydir catchment** under warmer/hotter and much drier climate conditions

Both the Gwydir and Macquarie catchments illustrate the likely impacts of future climate change on the Northern Basin river valleys where consumptive use is a significant component of the water balance. Under hotter and drier or hotter and much drier hydroclimates, overall water availability is likely to reduce, and the impacts of those reductions are likely to be more significant for downstream flows than on diversions and environmental water. Hotter and wetter hydroclimate results show slightly greater water availability into the future. However, given that the other hydroclimates simulated both indicate reductions, the most likely trend appears to be a reduction in total water available in these valleys.

Warrego catchment

The Warrego is in an arid region with low entitlement use. In this system, the majority of inflows are lost to river system processes leaving a small proportion for entitlements and downstream flows. The model results shown below for each of the hydroclimate scenarios shows on minimal impacts to diversions and downstream flows given the dominance of the river system process water component.

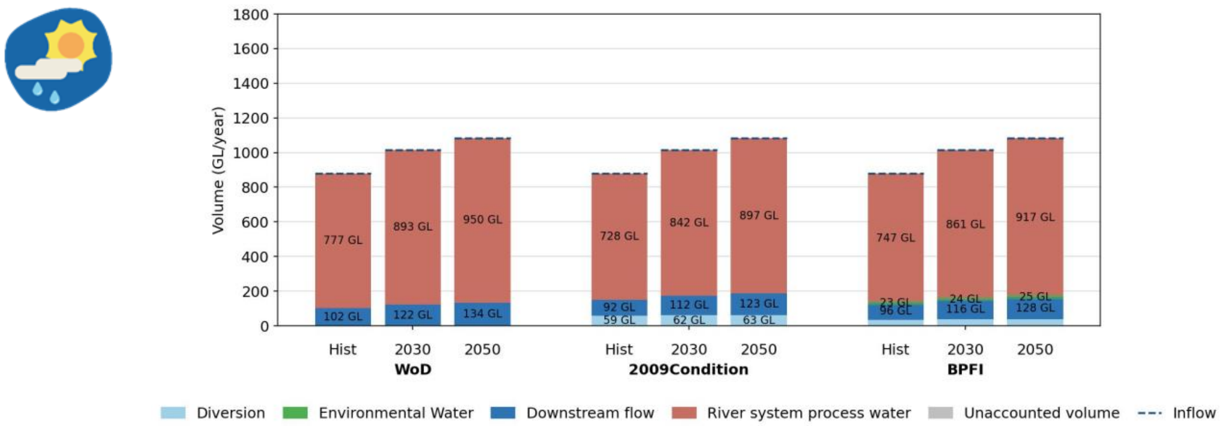


Figure 14: Stacked bar chart showing the annual total volumes of the **Warrego catchment** under warmer/hotter and wetter climate conditions

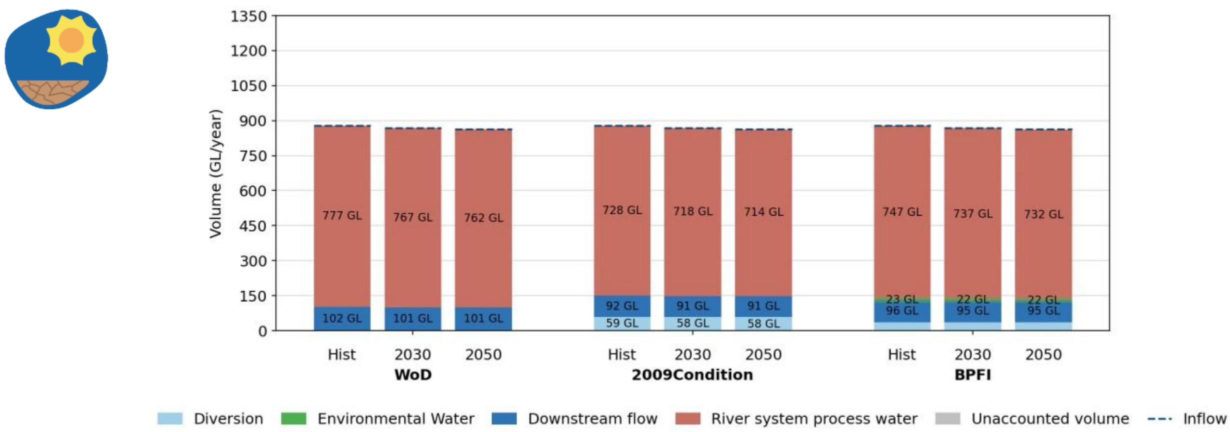


Figure 15: Stacked bar chart showing the annual total volumes of the **Warrego catchment** under warmer/hotter and drier climate conditions

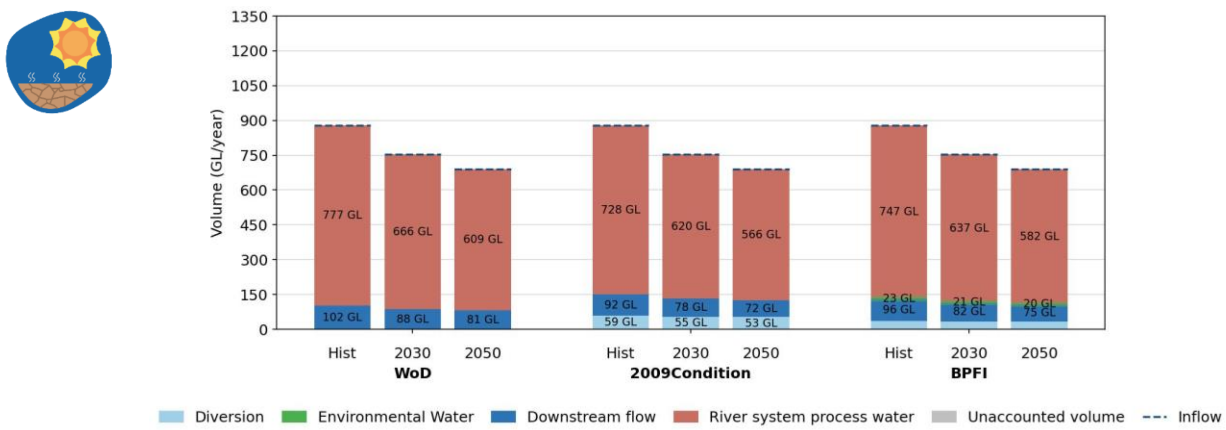


Figure 16: Stacked bar chart showing the annual total volumes of the **Warrego catchment** under warmer/hotter and much drier climate conditions

In arid Northern Basins like the Warrego, downstream flows will be less impacted overall because the majority of the water balance is in river system process water primarily composed of evaporation and infiltration losses. With both consumptive uses and environmental flows being such a small component, these are predicted to be relatively unaffected by the planning context.

Whole of Northern Basin

Outlined in the table below are the total overall volumes for each water balance component for the whole of the Northern Basin for each of the hydroclimate scenarios. These values are the aggregate of all tributary flows, although this aggregation process is calculated differently for each component. River system process water and diversions are simply added across all tributaries (including the Barwon-Darling). Inflows and downstream flows are aggregated based on more complex accounting of "handshake" values between different models (e.g. outflows from a tributary such as the Namoi become an inflow into the Barwon-Darling).

Table 10: Whole of Northern Basin results for warmer/hotter and wetter climate conditions

Whole of Northern Basin	Historical			S1 Warmer and slightly wetter ~2030			S4 Hotter and slightly wetter ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	12131	11931	12634	13747	13526	14259	14559	14328	15072
Total River System Process Water	9238	7858	8942	10474	9031	10187	11099	9629	10819
Total Downstream Flow	2617	1518	1652	2923	1777	1904	3073	1907	2031
Total Diversion	0	2414	1988	0	2551	2089	0	2610	2133
Unaccounted volume	276	142	52	350	167	79	386	183	89

Table 11: Whole of Northern Basin results for warmer/hotter and drier climate conditions

Whole of Northern Basin	Historical			S2 Warmer and slightly drier ~2030			S5 Hotter and slightly drier ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	12131	11931	12634	11651	11463	12151	11412	11231	11910
Total River System Process Water	9238	7858	8942	8900	7540	8602	8732	7387	8436
Total Downstream Flow	2617	1518	1652	2508	1430	1562	2454	1387	1518
Total Diversion	0	2414	1988	0	2390	1959	0	2371	1944
Unaccounted volume	276	142	52	243	103	28	227	89	14

Table 12: Whole of Northern Basin results for warmer/hotter and much drier climate conditions

Whole of Northern Basin	Historical			S3 Warmer and much drier ~2030			S6 Hotter and much drier ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	12131	11931	12634	10167	10002	10654	9190	9045	9666
Total River System Process Water	9238	7858	8942	7784	6501	7487	7063	5842	6776
Total Downstream Flow	2617	1518	1652	2211	1188	1323	2006	1033	1163
Total Diversion	0	2414	1988	0	2250	1853	0	2141	1768
Unaccounted volume	276	142	52	172	63	-9	121	28	-41

Southern Basin Units

Goulburn Broken Coliban Campaspe Loddon (GBCCL) Basins

The GBCCL is a combined system representation of the Goulburn, Broken, Coliban, Campaspe and Loddon rivers that are simulated in one model. The system has significant regulatory components across these rivers but is also an important contributor of flows to the Murray River.

The system illustrates typical water balance components that are present in Southern Basin river valleys, with much lower river system process water associated with evaporation compared to the Northern Basin rivers. It also has greater proportions of diversions in the 2009 planning context compared to BPFI, and a large environmental water component under BPFI.

In the GBCCL, the hotter and wetter hydroclimate shows only minimal change across the three time horizons and across the planning contexts as shown in Figure 17.

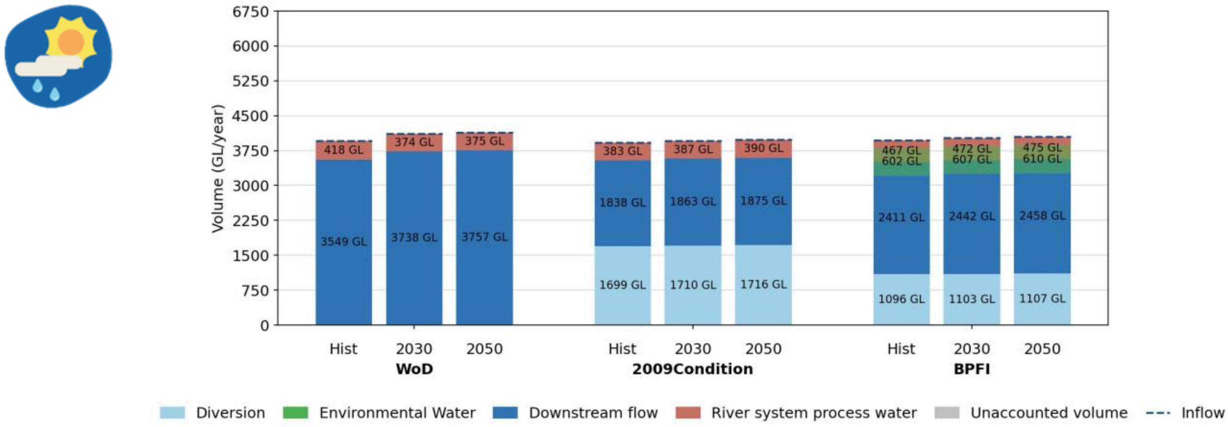


Figure 17: Stacked bar chart showing the annual total volumes of the **GBCCL Basins** under warmer/hotter and wetter climate conditions

The model results for the hotter and drier hydroclimate scenario are shown in Figure 18. It shows that there is slightly less impact on downstream flows under BPFI compared to the 2009 planning context, with a predicted reduction in downstream flows of -19% under BPFI (2050 hydroclimate) compared to -22% in the 2009 planning context. However, the BPFI scenario is intended to simulate water recovery, so it is expected that overall downstream flows should be higher in this development context. Impacts on diversions are similar in both planning scenarios, with a reduction of -8% (2050 hydroclimate).

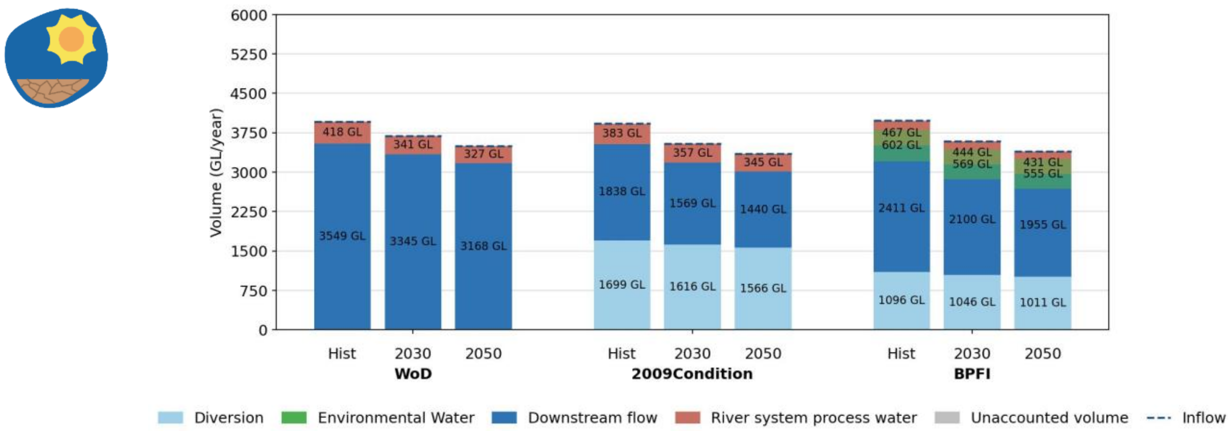


Figure 18: Stacked bar chart showing the annual total volumes of the **GBCCL Basins** under warmer/hotter and drier climate conditions

The warmer/hotter and much drier hydroclimate conditions show considerable impacts overall as seen in Figure 19, but again it is predicted that downstream flows will have the largest impact, with up to a -41% reduction in outflows in the 2009 condition, and a -38% reduction under the BPFI planning contexts.

Diversions under the different planning contexts also show interesting results under climate change. While diversions have decreased significantly in the GBCCL model results between 2009 and BPFI, the reductions in diversions predicted from climate change in the warmer/hotter and much drier hydroclimate conditions are -17% in BPFI, compared to -18% in the June 2009 planning context. These modelled results indicate that full implementation of the Basin Plan may have the potential to partly mitigate the impacts of future climate change as simulated in this work.

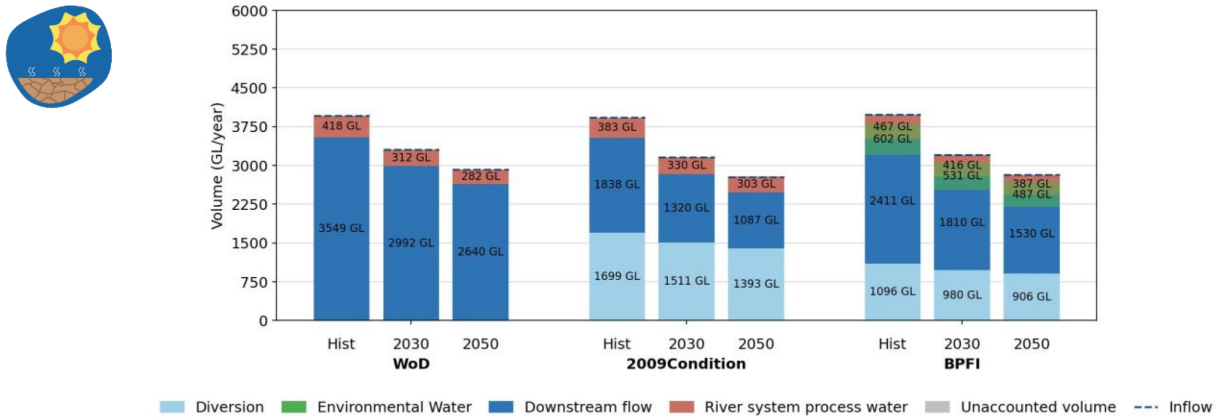


Figure 19: Stacked bar chart showing the annual total volumes of the **GBCCL Basins** under much hotter and much drier climate conditions

Murrumbidgee catchment

The Murrumbidgee catchment is also a significant contributor of flows into the Southern Basin and is highly important given that it is used for drinking water supplies to Canberra and surrounds, which is the largest urban area in the Murray-Darling system. The water balance components are different to the GBCCL in that there is more water in the river system process water component, and a larger downstream flow contribution.

It should be noted that there are differences in the overall magnitude of the water balance between the Without Development (WoD), 2009 Condition and BPFI as a result of incorporation of both the Snowy scheme (2009) and water recovery (BPFI).

In the warmer/hotter and wetter hydroclimate conditions shown in Figure 20 there is no significant improvement in Murrumbidgee water availability predicted.

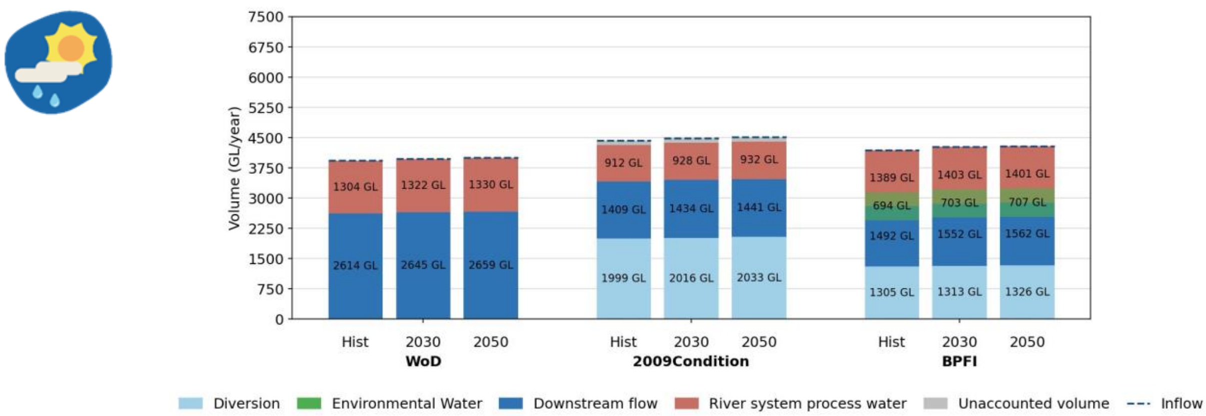


Figure 20: Stacked bar chart showing the annual total volumes of the Murrumbidge system under warmer/hotter and wetter climate conditions

In the warmer/hotter and drier scenario results shown in Figure 21, the reductions in diversions predicted for the 2050 hydroclimate are greater under the 2009 planning scenario (-8%) compared to the BPFI scenario (-6%), but the impacts on downstream flows are similar (around -18%) for both planning contexts. This supports the overall finding that impacts on downstream flows are likely to be substantial under future hydroclimates, with the planning context only making small differences in the magnitude of those impacts.

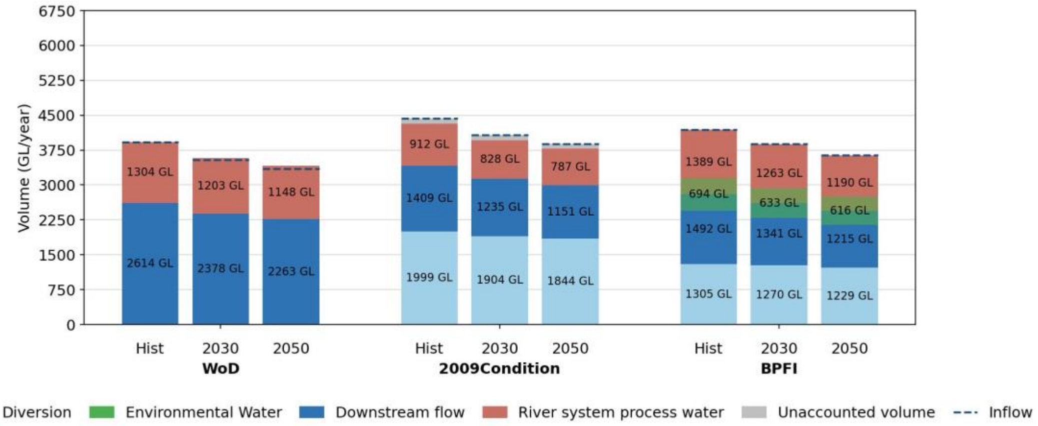


Figure 21: Stacked bar chart showing the annual total volumes of the Murrumbidge system under warmer/hotter and drier climate conditions

The impacts of climate on downstream flows under the warmer/hotter and much drier conditions are significant in the Murrumbidgee. Compared to the historical downstream flows, they are predicted to reduce in both the 2009 scenario (-33%) and the BPFI scenario (-36%). Diversions are again less impacted, but the model predictions indicate a greater reduction under the 2009 scenario (-20%) in comparison to BPFI (-17%). These results (Figure 22) again show that impacts of future climate change are likely to be more dominant on flows passing to downstream systems than for consumptive uses.

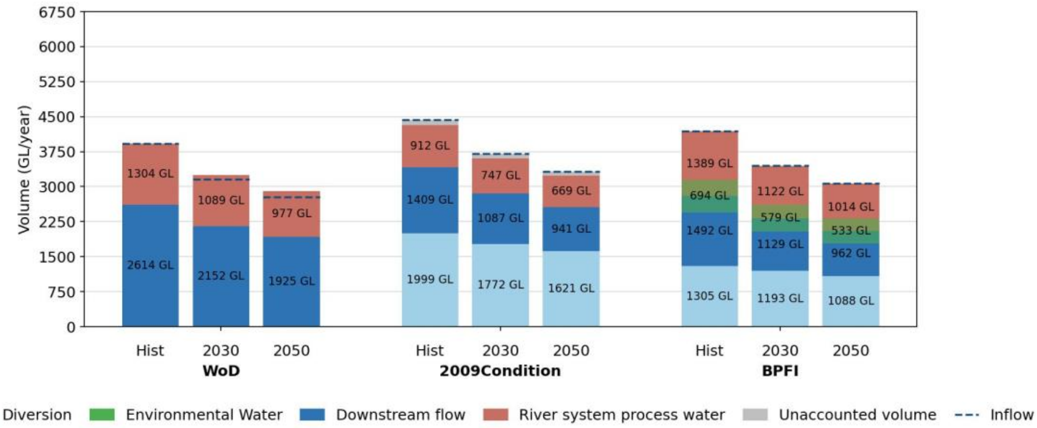


Figure 22: Stacked bar chart showing the annual total volumes of the Murrumbidge system under warmer/hotter and much drier climate conditions

Murray River Basin

The model results for the Murray River Basin include flows only within that Basin and not tributary inflows. Similar to the Murrumbidgee model inflows, there are differences in the overall magnitude of the water balance under each planning scenario, resulting from the Snowy River scheme and water recovery.

In the warmer/hotter and wetter hydroclimate conditions shown in Figure 23, there is increased water availability predicted that appears to be greater than the GBCCL and Murrumbidgee impacts, though the increase is still small in comparison to the Northern Basin under this hydroclimate scenario.

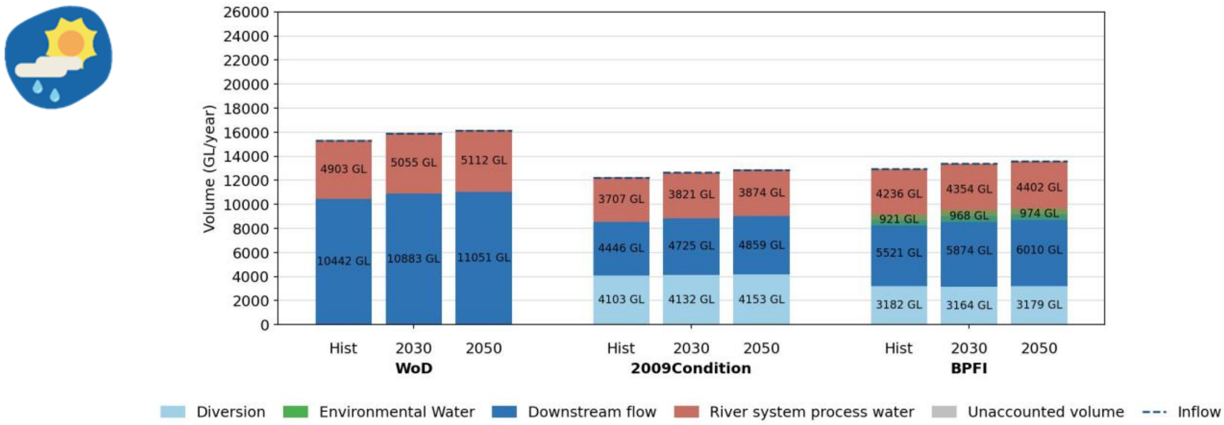


Figure 23: Stacked bar chart showing the annual total volumes of the Murray system under warmer/hotter and wetter climate conditions

For the warmer/hotter and drier scenario, the reductions in diversions in the 2050 hydroclimate are predicted to be slightly greater under the 2009 planning scenario (-9%) compared to the BPFI scenario (-6%). Similarly, the impacts on downstream flows are slightly greater under the 2009 scenario (-24%) compared to the BPFI scenario (-22%) as shown in Figure 24.

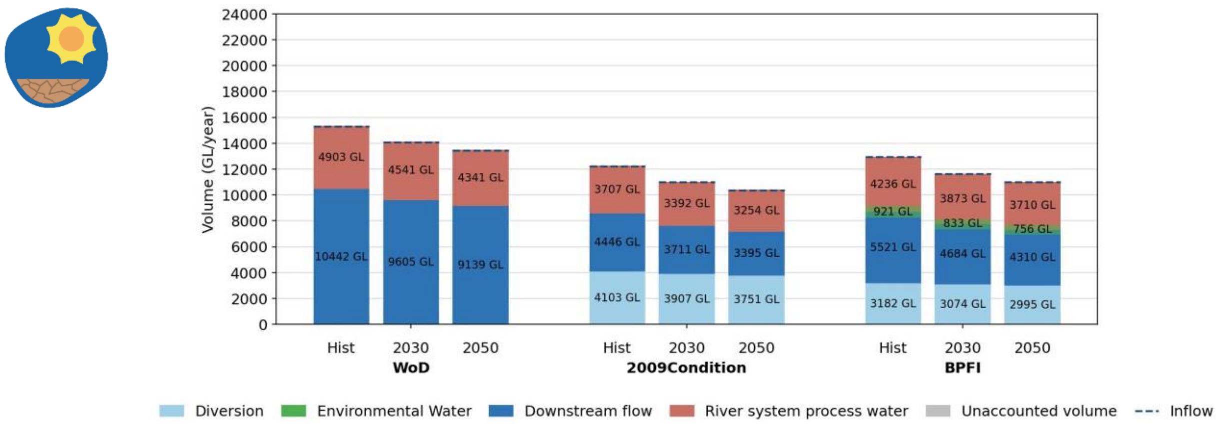


Figure 24: Stacked bar chart showing the annual total volumes of the Murray system under warmer/hotter and drier climate conditions

The impacts on downstream flows under the warmer/hotter and much drier conditions are very significant in the Murray system, driven by cumulative reductions across the contributing tributaries. The flows are predicted to reduce by nearly half under the 2009 scenario (-49%), with the BPFI scenario showing slightly lower reductions (-45%), but still substantial. Diversions are less impacted, but the model predictions indicate a greater reduction under the 2009 scenario (-20%) in comparison to BPFI (-16%). These results (Figure 25) again show that impacts of future climate change are likely to be more dominant on flows passing to downstream systems than for consumptive uses. Given the magnitude of change in this largest contributing Basin in the MDB, these impacts are likely to be one of the most significant influences on overall water balances in future hydroclimate scenarios.

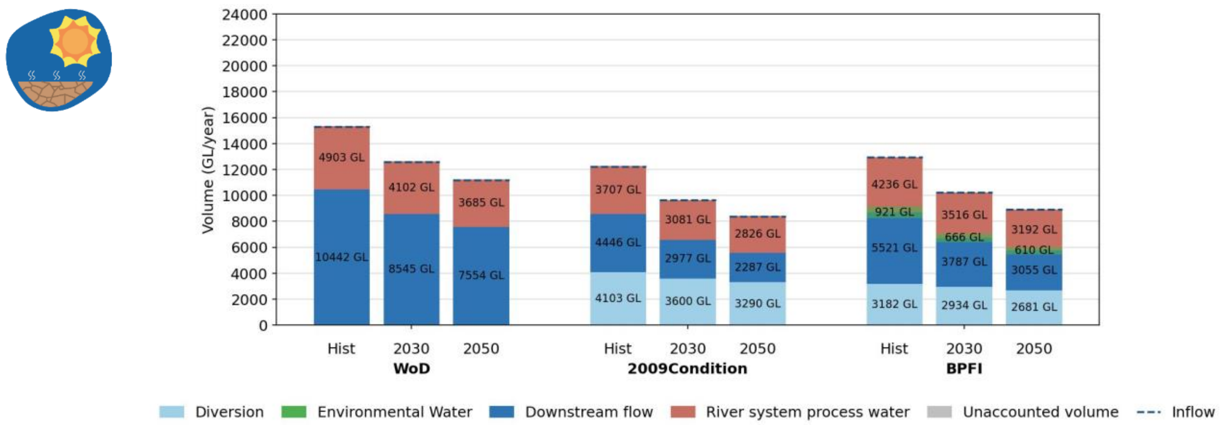


Figure 25: Stacked bar chart showing the annual total volumes of the Murray system under warmer/hotter and much drier climate conditions

Wimmera River catchment

The Wimmera River is a terminal system in Western Victoria and while it does not provide any downstream flows to the Murray River, it is considered as part of the MDB. Given that this one of the driest areas in Victoria, river system process water is the dominant component of the water balance. Differences in total amount of the water balance between each of the scenarios are due to the inclusion of interbasin transfers from the Glenelg system that are then included in the 2009 and BPFI scenarios.

Generally, future climate change impacts on this system for consumptive uses are relatively small for both the warmer/hotter drier, and wetter hydroclimate scenarios. The majority of change is likely to be in reductions in inflows and the losses associated with river system process water.

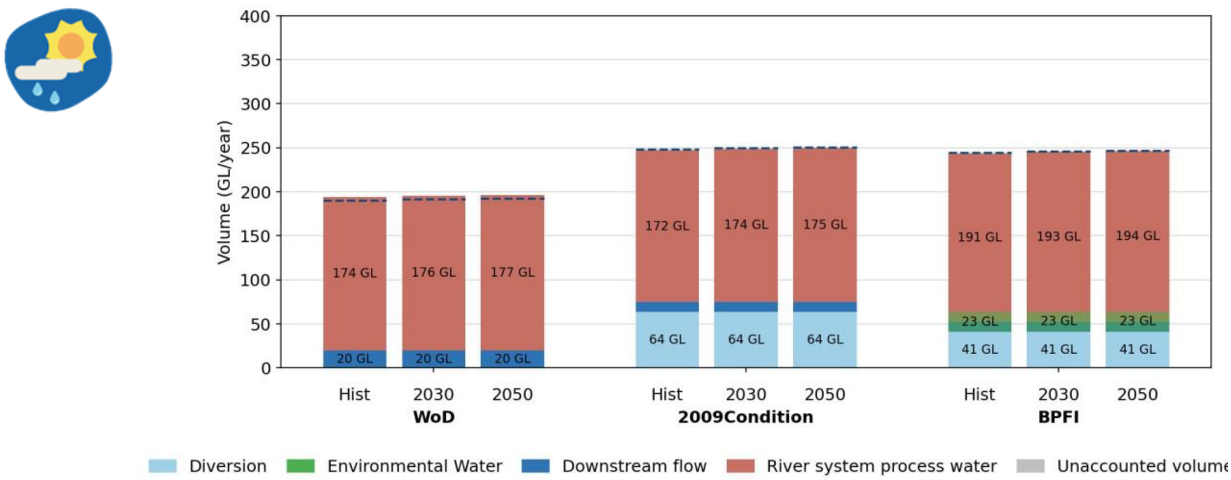


Figure 26: Stacked bar chart showing the annual total volumes of the Wimmera system under warmer/hotter and wetter climate conditions

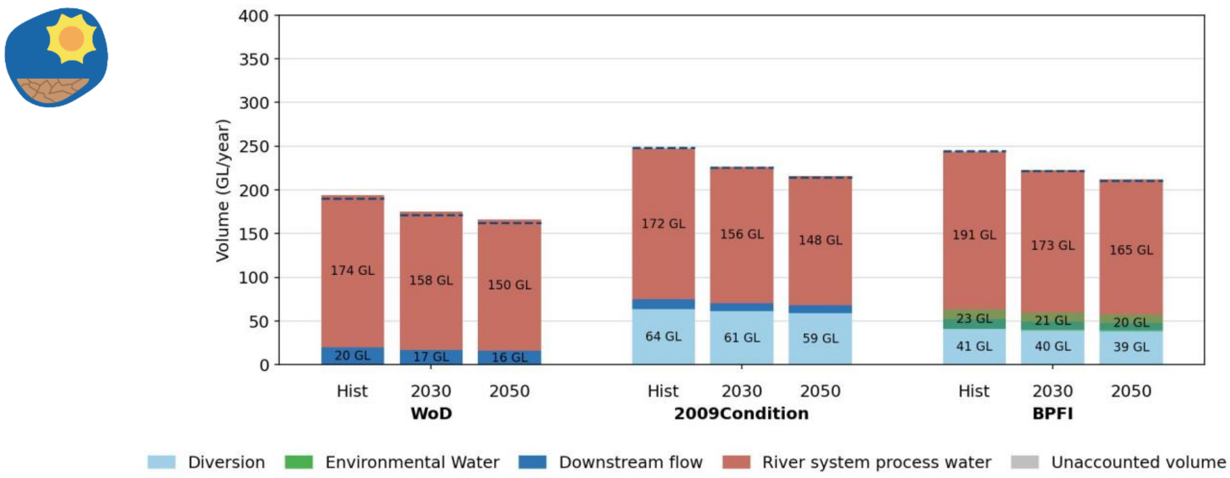


Figure 27: Stacked bar chart showing the annual total volumes of the Wimmera system under warmer/hotter and drier climate conditions

For the warmer/hotter and much drier hydroclimate scenario, the model results show that impacts under a 2009 planning context would see nearly twice the reductions in diversions (-19%) compared to the BPFI planning context (-10%) at the 2050 time period, but the reduction in environmental flows would be far greater (-35%).

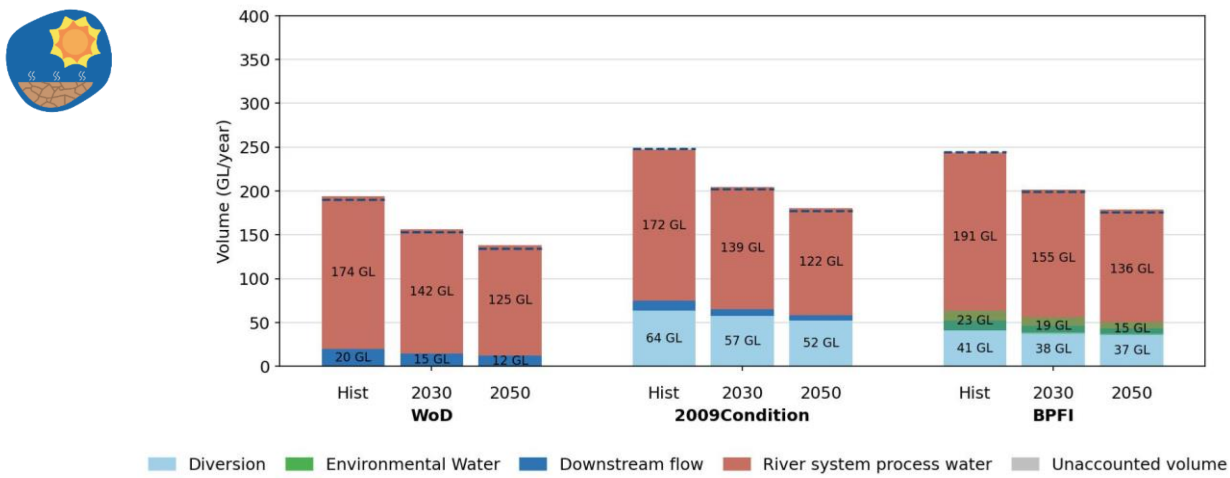


Figure 28: Stacked bar chart showing the annual total volumes of the Wimmera system under warmer/hotter and much drier climate conditions

Whole of Southern Basin

The tables below provide the flow component values for the whole of the Southern Basin for each of the hydroclimate scenarios and representing the total overall volumes for each water balance component. As for the whole of Northern Basin results, these values are the result of accumulation of all tributary flows. River system process water and diversions are simply added across all tributaries, whereas inflows and downstream flows result from more complex accounting of "handshake" values between different models.

Table 13: Whole of Southern Basin results for warmer/hotter and wetter climate conditions

Whole of Southern Basin	Historical			S1 Warmer and slightly wetter ~2030			S4 Hotter and slightly wetter ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	19838	20198	19851	20473	20709	20367	20736	20967	20599
Total River System Process Water	9394	7146	8461	9572	7309	8630	9661	7386	8695
Total Downstream Flow	10442	4446	5521	10883	4725	5874	11051	4859	6010
Total Diversion	0	7949	5886	0	8006	5888	0	8050	5921
Unaccounted volume	2	657	-17	18	669	-24	23	672	-27

Table 14: Whole of Southern Basin results for warmer/hotter and drier climate conditions

Whole of Southern Basin	Historical			S2 Warmer and slightly drier ~2030			S5 Hotter and slightly drier ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	19838	20198	19851	18166	18375	18050	17279	17462	17146
Total River System Process Water	9394	7146	8461	8604	6475	7704	8209	6163	7335
Total Downstream Flow	10442	4446	5521	9605	3711	4684	9139	3395	4310
Total Diversion	0	7949	5886	0	7570	5688	0	7303	5529
Unaccounted volume	2	657	-17	-43	620	-26	-70	601	-27

Table 15: Whole of Southern Basin results for warmer/hotter and much drier climate conditions

Whole of Southern Basin	Historical			S3 Warmer and much drier ~2030			S6 Hotter and much drier ~2050		
Development Scenario	WoD	June 2009	BPFI	WoD	June 2009	BPFI	WoD	June 2009	BPFI
	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)	(GL/yr)
Total Inflow	19838	20198	19851	16203	16389	16091	14333	14465	14204
Total River System Process Water	9394	7146	8461	7757	5819	6936	6937	5225	6229
Total Downstream Flow	10442	4446	5521	8545	2977	3787	7553.6	2287	3055
Total Diversion	0	7949	5886	0	7025	5394	0	6438	4945
Unaccounted volume	2	657	-17	-99	568	-26	-158	516	-25.3

End of system flows

End of system flows provide a measure of the volume of water that remains in the river network and is transmitted downstream beyond a catchment, Basin area, or SDL unit. End of system or downstream flow represents the difference between total water available (inflows) to a catchment, Basin, or SDL unit; and the water that is consumed, lost, or retained within the system through environmental or storage capture. End of system flows are a key indicator of river connectivity and the degree to which upstream changes propagate to downstream water users and receiving systems.

Comparing across development scenarios shows how different patterns of water use and regulation influence this downstream flow. While climate conditions determine the total volume generated within a system, development settings shape how that volume is partitioned, revealing shifts in the relative availability of water between upstream and downstream users across the Basin.

Table 16: Results from model scenarios showing average annual volumes of outflows (GL) to aggregated units (Northern Basin) under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Annual Outflows (GL) – Northern Basin							
WoD	2617	2923	2508	2211	3073	2454	2006
% change from historical climate		*12%*	*-4%*	*-16%*	*17%*	*-6%*	*-23%*
June 2009	1518	1777	1430	1188	1907	1387	1033
% change from historical climate		*17%*	*-6%*	*-22%*	*26%*	*-9%*	*-32%*
BPFI	1652	1904	1562	1323	2031	1518	1163
% change from historical climate		*15%*	*-5%*	*-20%*	*23%*	*-8%*	*-30%*

Table 17: Results from model scenarios showing average annual volumes of outflows (GL) to aggregated units (Southern Basin) under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030 	S2 Warmer and drier ~2030 	S3 Warmer and much drier ~2030 	S4 Hotter and slightly wetter ~2050 	S5 Hotter and drier ~2050 	S6 Hotter and much drier ~2050 
Total Annual Outflows (GL) – Southern Basin							
WoD	10442	10883	9605	8545	11051	9139	7553.6
% change from historical climate		4%	-8%	-18%	6%	-12%	-28%
June 2009	4446	4725	3711	2977	4859	3395	2287
% change from historical climate		6%	-17%	-33%	9%	-24%	-49%
BPFI	5521	5874	4684	3787	6010	4310	3055
% change from historical climate		6%	-15%	-31%	9%	-22%	-45%

In the models used, the final end of system is represented as the Murray River Barrages at Goolwa, South Australia. Considering changes in flows at this point gives an overview of the performance of the whole of system under both historical conditions and future hydroclimates and under different planning contexts.

Historically, the Millenium Drought resulted in no outflows past the Barrages in the latter part of the drought (2007-2009) with the model predicting this occurred under the June 2009 planning context (yellow bars). The time series does show that with BPFI in place, the models indicate that some flow (orange bars) would have still be present in that latter period, as shown in Figure 29.

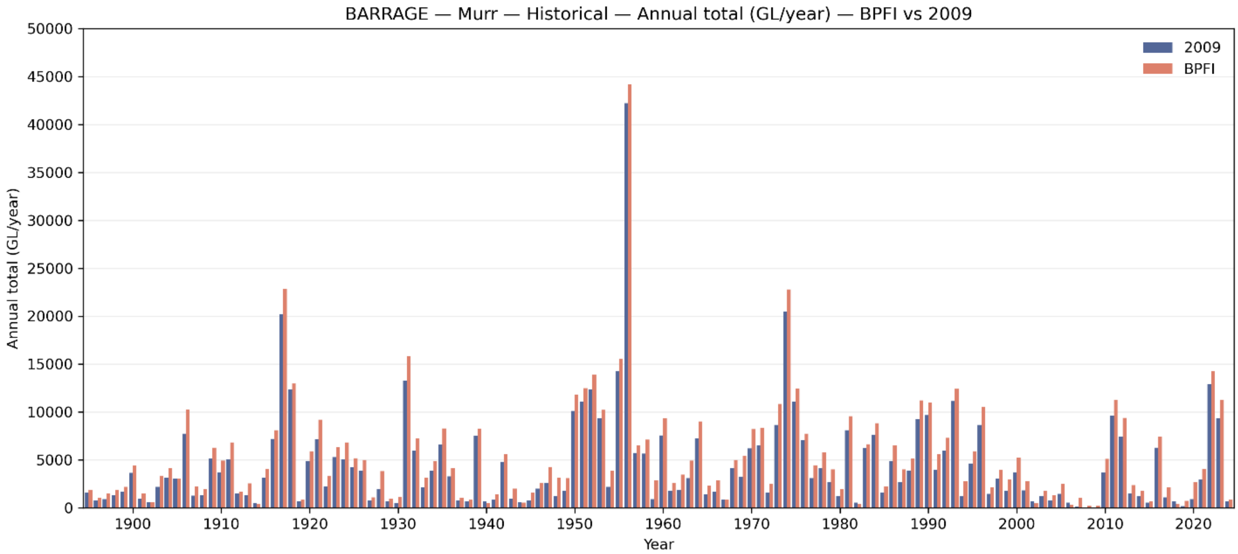


Figure 29: Annual flows at the Murray River Barrages (historical climate period)

Under the hotter and drier hydroclimate scenario (S5) for the 2050 period as shown in Figure 30, flows are maintained past the Barrages except for the 2008 year under the BPFI scenario. Overall flow reductions are consistent with other flow reductions noted in these results, with the June 2009 planning context performing as poorly as under the historical climate period. Also, note the overall reduction in the peak flow in 1956, from around 45,000GL/year in the historical climate period to around 36,000GL/year under a hotter and drier 2050 hydroclimate period.

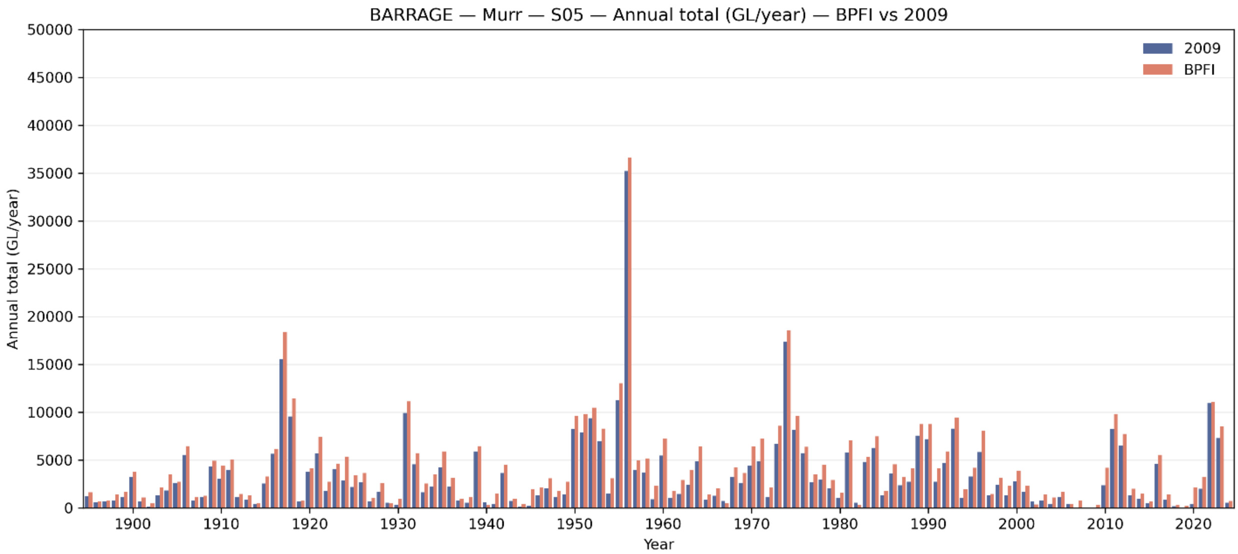


Figure 30: Annual flows at the Murray River Barrages (hotter and drier climate period)

Flow through the system

The most upstream reaches of catchments across the Basin are runoff generation zones which then propagate through tributary river valleys into downstream river systems. Examining flow propagation as it moves downstream reveals how regional impacts and operational mechanisms accumulate, interact, and transmit across the Basin.

This longitudinal view also shows how shifting climate conditions place pressure on different parts of the water balance. Under warmer/hotter and drier conditions, changes in inflows, and river system process water constrain water availability for consumptive and environmental use, which limits the share of remaining water between water users within the system and downstream receiving waterways.

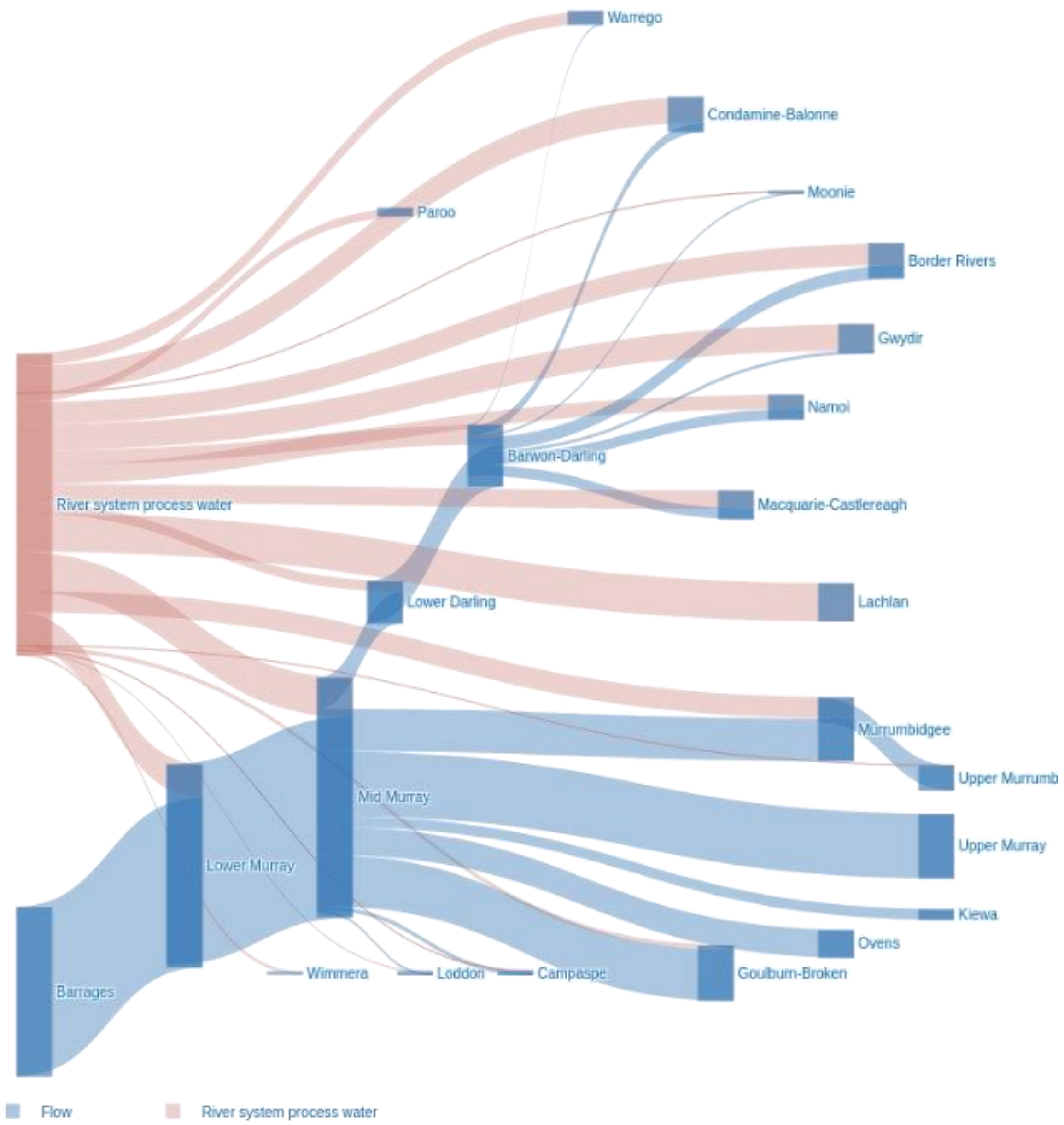
The visualisation of this is done through the use of Sankey diagrams. These visualise the contributions of each river system to the whole of basin water balance components. The diagrams can be used to map the distribution and consumption of water by visualising the cumulative impact of changes on downstream flows.

The nodes for each valley represent the summation of outflows, diversions and river system process water, approximating the inflow to each valley (differences may arise from unattributed water and change in storage terms which are minor components of the overall water balance).

Other key assumptions in the Sankey diagrams are

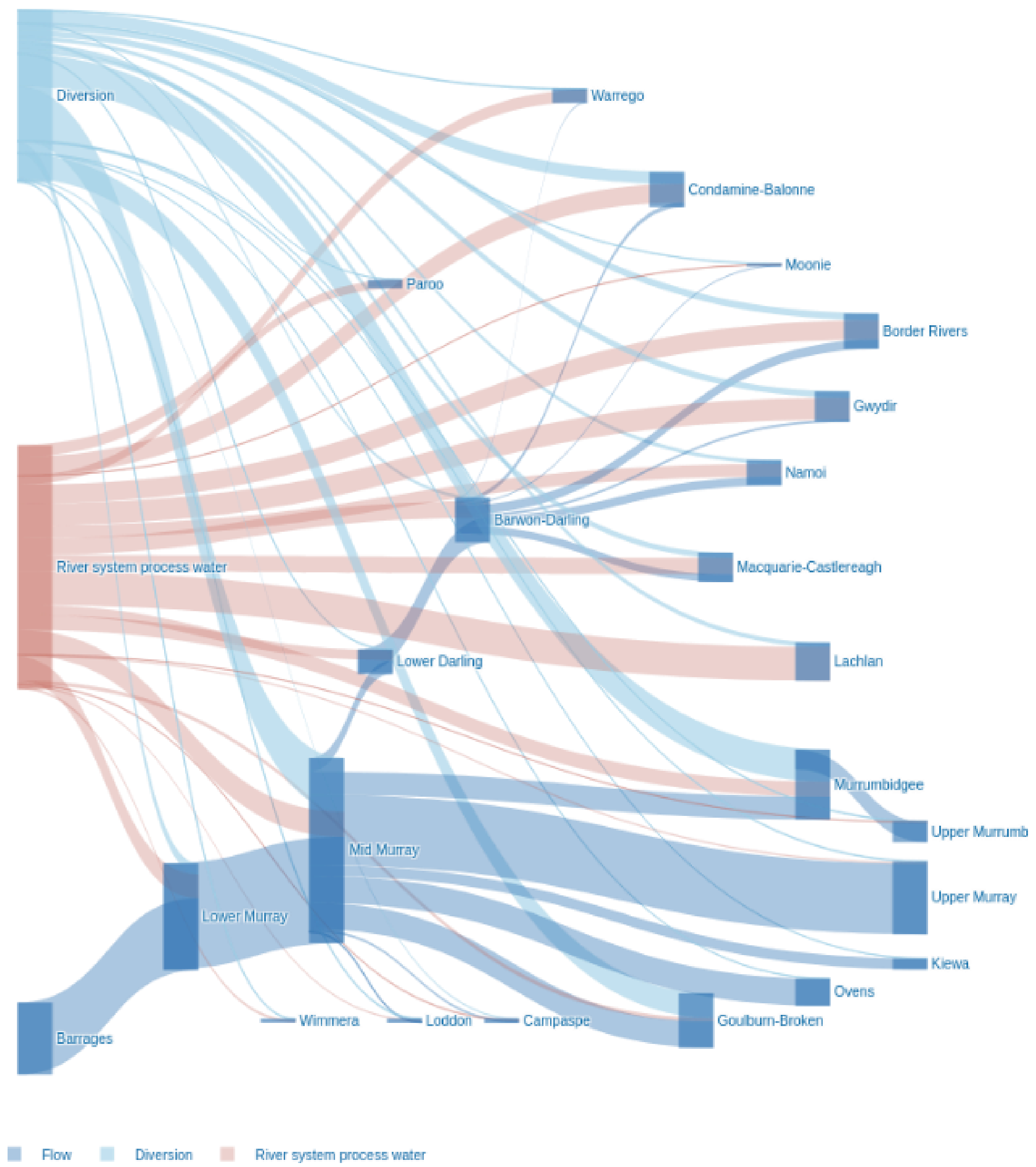
- In the disconnected valleys (Wimmera, Paroo and Lachlan), modelled end of system flows is considered as river system process water.
- As the central river in the Murray-Darling basin the Murray River is represented by multiple nodes based on the following gauged locations
  - Upper Murray -Murray River @ Heywoods (409016)
  - Mid-Murray -Murray River @ Wentworth (425010)
- Outflows from the system are considered as the modelled Barrage outflows

The figure below shows a comparison of the WoD, June 2009 and BPFI scenarios for the historic climate sequence (1895-2024). The WoD diagram shows how the inflows to the basin were distributed between river system process water and cumulatively impacted flows throughout the system. The June 2009 diagram shows the impact of development through the accumulation of diversion fluxes impacting the cumulative volume of river system process water and flows throughout the basin. The BPFI scenario approximates how the Basin Plan would redistribute the recovered volumes of diversions increase the accumulation of river system process water and flows through the system.



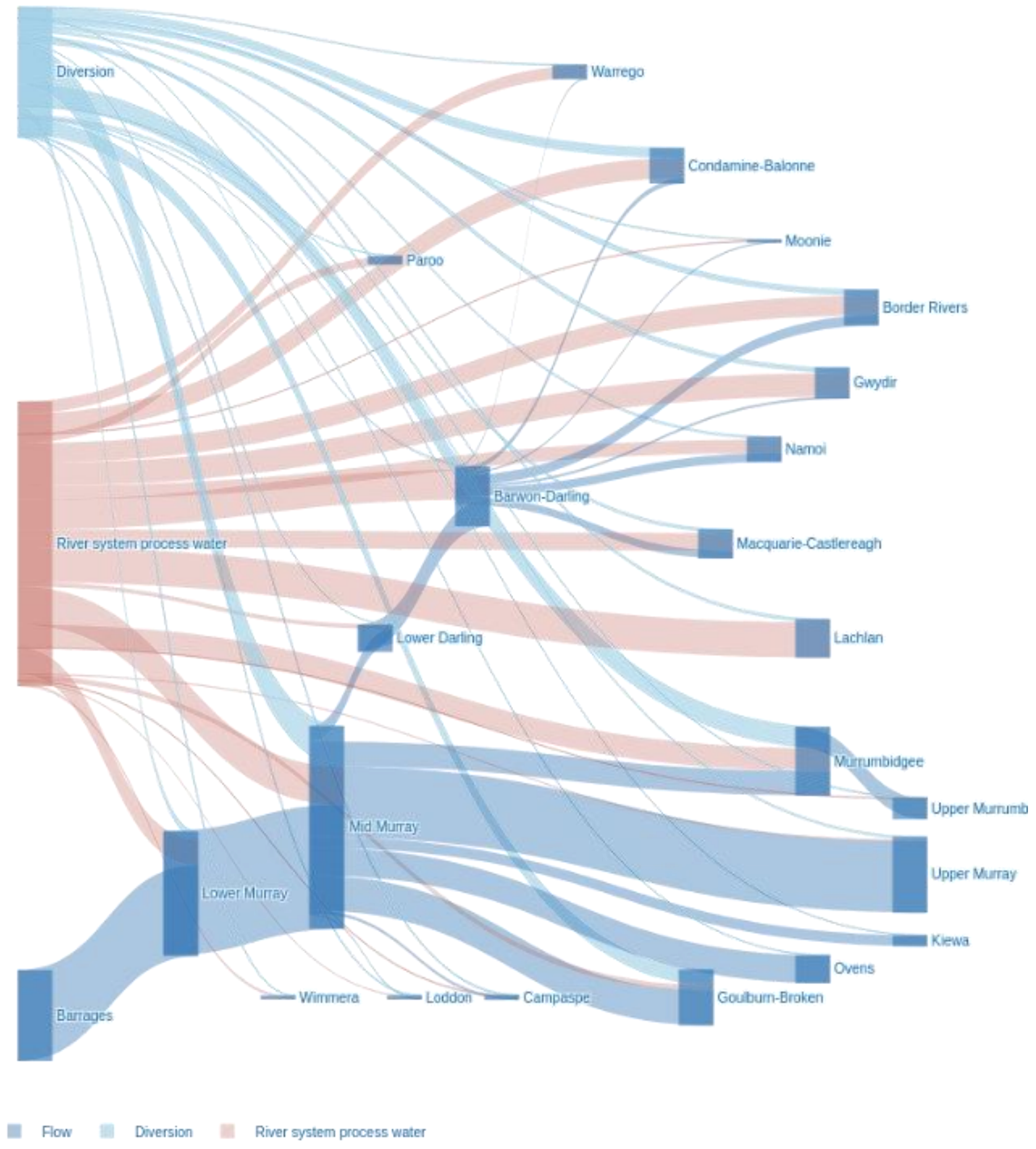
Without Development
Diversions =0 GL
River system process = 18,627 GL
Outflows (Barrages) = 10,442 GL

Figure 31. Without Development flows through the system for historical climate



June 2009
Diversions = 10,608 GL
River system process = 15,543 GL
Outflows (Barrages) = 4,446 GL

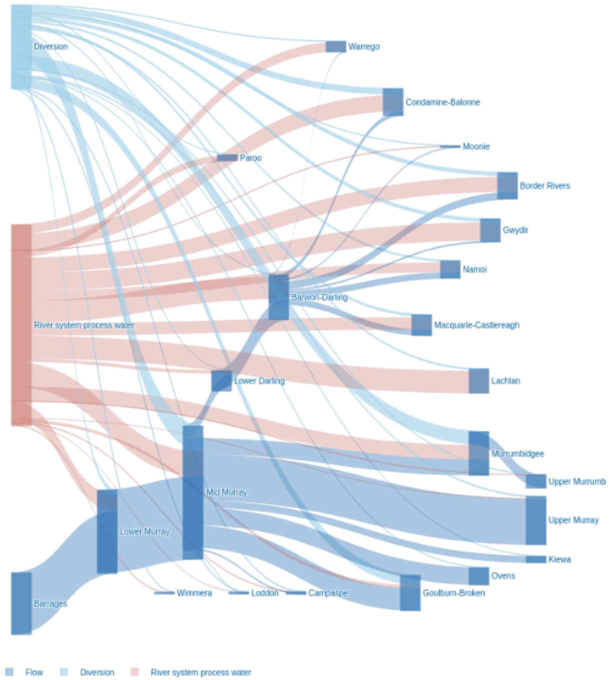
Figure 32: June2009 Condition flows through the system for historical climate



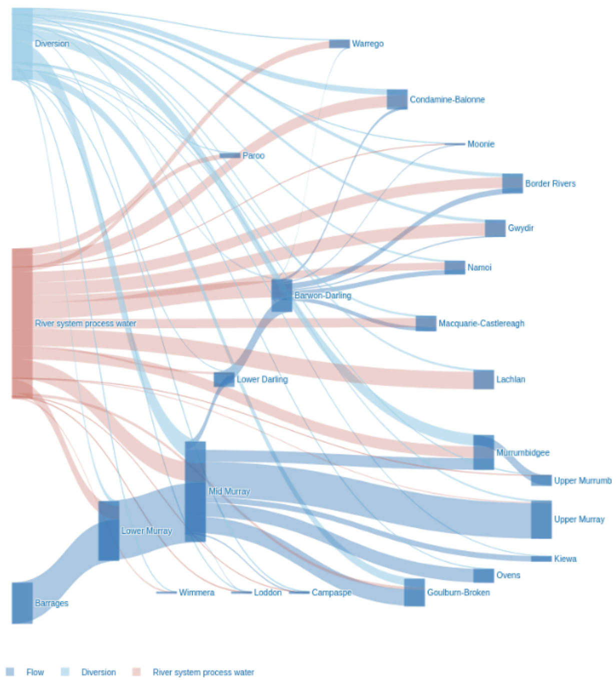
BPFI
Diversions =7874 GL
River system process =17,407
Outflows (Barrages) = 5,521 GL

Figure 33: BPFI flows through the system for historical climate

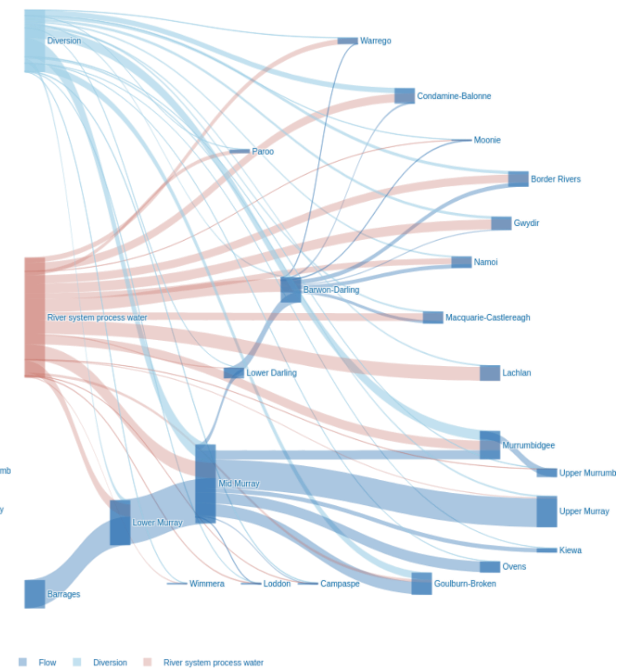
Considering how climate change under future hydroclimates might impact on flows through the MDB, the BPFI scenario has been used to highlight the changes that might be expected when compared to the historical change in Figure 33 above.



BPFI – S4 Hotter & Wetter
Diversions = 8,054 GL
River system process = 19,514 GL
Outflows (Barrages) =6,010 GL



BPFI - S5 Hotter & Drier
Diversions = 7,472 GL
River system process = 15,780 GL
Outflows (Barrages) = 4,310 GL



BPF - S6 Hotter and Much Drier
Diversions = 6,712 GL
River system process = 13,034 GL
Outflows (Barrages) = 3,055 GL

Figure 34 Comparison of BPFI historical scenarios against hydroclimate scenarios around 2050

Northern Basin

For the warmer/hotter and wetter hydroclimate conditions, the model results predict an overall increase in flows from upstream to downstream. A more significant proportion of the increase is in the river systems flow processes, with the increases in cumulative water balance from upstream to downstream more significantly represented in that component than in downstream flows and diversions.

For the Northern Basin under the warmer/hotter and drier hydroclimate conditions, the river system process water is more than 50% of the total water balance, with diversions and downstream flows being relatively evenly distributed for the remaining components moving from upstream to downstream until the contributions within the Barwon-Darling River system are added. As indicated in previous results for the Macquarie and Gwydir illustrative valleys, there is an overall reduction in the total water balance in future time horizons under this hydroclimate scenario. Although the impacts on downstream flows and diversions are relatively small proportionally when compared to the river system process water.

The warmer/hotter and much drier hydroclimate conditions result in significant overall decreases from upstream to downstream across the water balance.

Southern Basin

The Southern Basin cumulative flows from top of system to downstream show how important the rivers in this Basin are for downstream flows contributions, but also the comparative difference between the Northern and Southern diversion flows, with the Murrumbidgee, Mid-Murray and Goulburn-Broken systems all providing a significant proportion of overall flows.

In the warmer/hotter and wetter hydroclimate conditions, the model results show that there are marginal increases in flows from Southern Basin systems, with the Darling system contributing significantly to river system process water values, but not to the cumulative downstream flows or diversion values.

For the warmer/hotter and drier hydroclimate, the reductions in flows are relatively small for the Southern Basin systems given their larger contributions to the cumulative diversions and downstream flows.

The warmer/hotter and much drier hydroclimate conditions show marked reductions from upstream to downstream across each of the future time horizons, with the reductions more prevalent on the Southern Basin flow contributions in comparison to the additions from the Northern Basin.

Availability of water for use

Modelling results for the demand and delivery of flows under different development conditions show how much water is available for use under each scenario and how that availability is shared between different entitlement classes and water users across the Basin. Where changes in inflows and end of system flows are climate-driven, the changes to water availability for use observed under different development conditions show what those changes mean for users.

Entitlement reliability is assessed by comparing Basin Plan scenarios to quantify how management rules influence the portion of available water allocated to different user groups. This includes the relative shares delivered to consumptive entitlements of varying security (high reliability or high security versus general or low security.

Results described in this section present insights into how Basin Plan settings and management and delivery mechanisms such as storages shape the impacts of climate change on water availability, and how those impacts are distributed across water users within the Basin.

Entitlement reliability

The river system modelling indicates that climate change may cause widespread reductions in entitlement reliability across the MDB, with the greatest reductions emerging under the drier hydroclimate pathways. As inflows decline and runoff patterns shift, the volume of water available to meet the same pattern of demand is reduced, increasing competition between water users. This puts more pressure on operational systems to efficiently deliver water to meet priority demands, and balance remaining supply to support system function.

For some scenarios impacts on demand reliability are expected to be most pronounced for lower-security consumptive entitlements and for non-consumptive uses such as environmental water, particularly where limited supplies must be prioritised to meet critical human need like town potable water and emergency response. Under a hotter and drier climate, these impacts are more pronounced, where longer dry spells and more frequent low-flow events increase the likelihood of the system reaching risk-management thresholds or repeatedly failing to meet levels-of-service targets, triggering restrictions and potentially requiring longer-term management measures.

Under a future hotter and drier climate, the Basin is projected to experience more frequent and more severe acute water shortages. The duration of shortages may extend, driven by reduced inflow sequences, higher evaporative demand, and slower recovery of storage volumes between dry periods. This has implications for both entitlement holders through reduced allocations and for river-dependent environmental outcomes through reduced achievement of threshold events and sustained baseflows.

Entitlement reliability exceedance curves have been developed for the Macquarie and Murrumbidgee catchments and GBCCL Basins to illustrate the overall changes across the different climate scenarios and across different months corresponding to the start and end of the water year (July and June) and the different planting season commencements in the North (around October) and South (around February). This helps to indicate where future hydroclimates may have impact on different decision points for water resource use during a water year.

The results below are illustrative of the impacts of the median (warmer/hotter and drier) hydroclimate on the BPFI planning context to provide an overall understanding of the likely changes on entitlement reliability, noting that results have also been obtained for the other scenarios and hydroclimates which show both lesser (for the warmer/hotter and wetter hydroclimate) and greater (for the warmer/hotter and much drier hydroclimate) impacts on reliability.

Macquarie catchment

At the commencement of the water year under the median future hydroclimate for the BPFI planning context (warmer/hotter and drier), allocations of 100% for general security entitlement water are likely for 10 of 129 years across all climate periods (historical, 2030 and 2050). Allocations of 50% (or greater) for general security entitlement water are predicted for 35 of 129 years under the historical climate, reducing to around 30 of 129 years for both the 2030 and 2050 climates. This is illustrated in Figure 35 below.

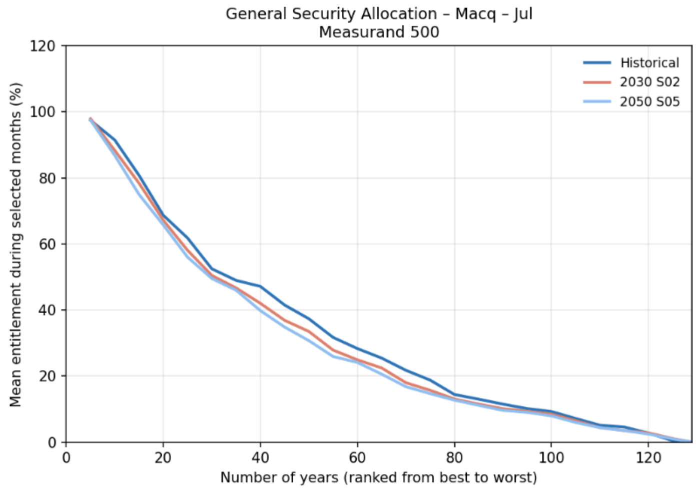


Figure 35: General security allocation at commencement of water year (Macq BPFI median hydroclimate)

High security water is shown at 100% allocations for 120 out of 129 years across all hydroclimate periods as shown in Figure 36 below.

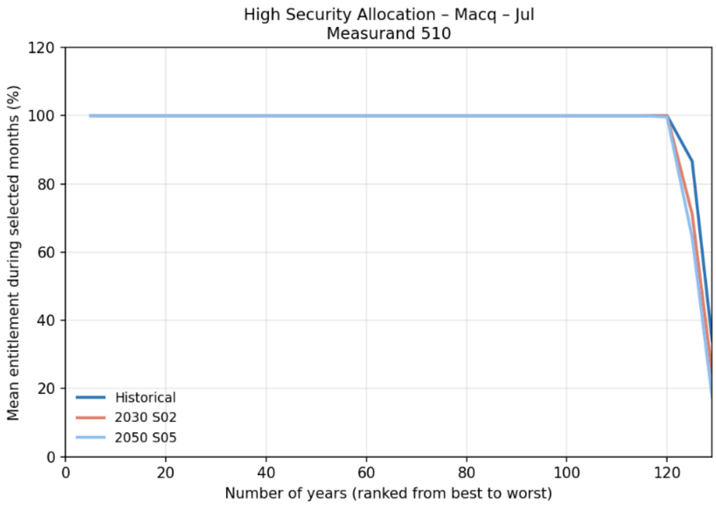


Figure 36: High security allocation at commencement of water year (Macq BPFI median hydroclimate)

In October, which corresponds to the beginning of the planting season in the Northern Basin, allocations for general security entitlement water show minimal change across all climate periods for the possibility of 100% allocations at that time (25 of 129 years for historical, 20 of 129 years for 2030 and 2050 periods). The modelling, as illustrated in Figure 37, predicts an overall decrease in the potential for allocations of 50% (or greater) with this showing a decline from around 55 of 129 years for historical climates, to 50 of 129 years for the 2030 period and around 45 of 129 years for the 2050 period.

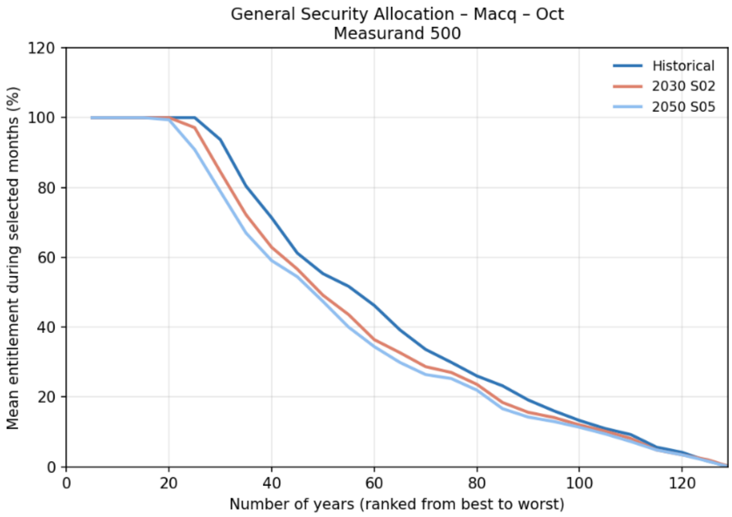


Figure 37: General security allocation at beginning of the Northern Basin planting season (Macq BPFI median hydroclimate)

While not related necessarily to planting decisions, high security entitlement water shows no change in 100% allocations with those predicted for the full 129 climate period as shown in Figure 38.

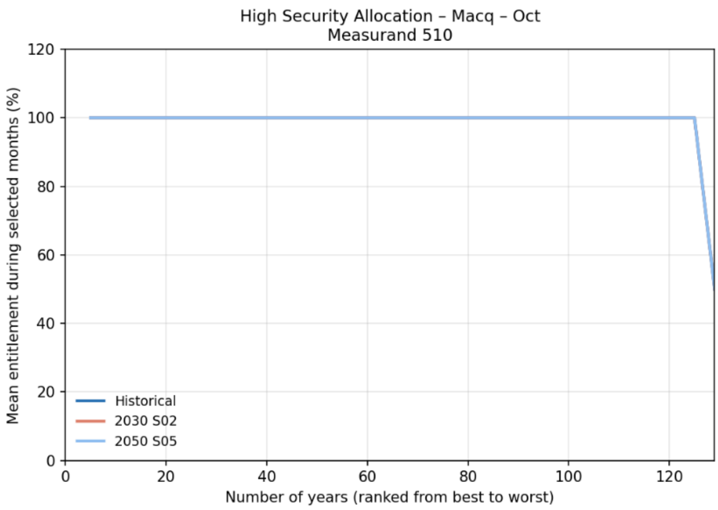


Figure 38: High security allocation at beginning of the Northern Basin planting season (Macq BPFI median hydroclimate)

At the end of the water year, the potential for allocations of 100% for general security entitlement water further improves with these expected in 40 of 129 years for the historical climate period, reducing to 35 of 129 years for 2030, and 30 of 129 years for 2050. Similarly, greater than 50% allocations are predicted to be available for 68 of 129 years historical (approximately half the time), reducing to around 60 of 129 years for the 2030 period and 57 of 129 years for the 2050 climate period, as shown in Figure 39.

As there is no change in high security entitlement water (100% allocations expected at 129 of 129 years in October and therefore also in June), this graph would be identical to Figure 38 above and is therefore omitted.

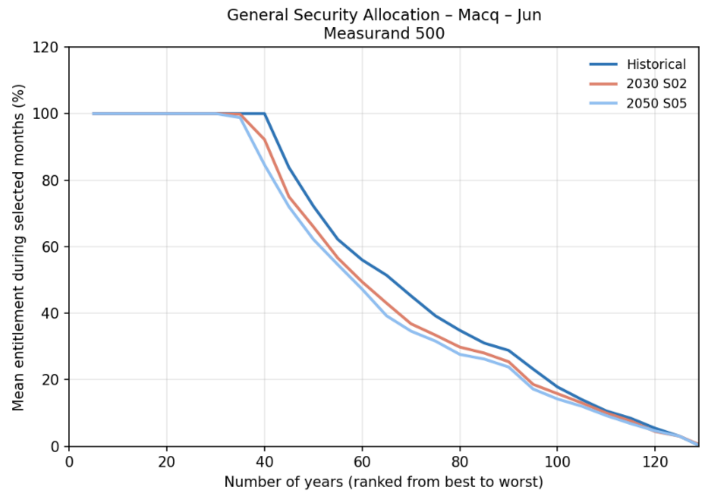


Figure 39: General security allocation at the end of the water year (Macq BPFI median hydroclimate)

Murrumbidgee catchment

Considering water allocations for the commencement of the water year in the Murrumbidgee catchment as shown in Figure 40, 100% allocations for general security entitlement water are not expected for any year over the full model run for all hydroclimate periods (historical, 2030 and 2050). 50% or greater allocations are predicted to occur for 55 out of 129 years over the historical climate period (and median hydroclimate scenario of warmer/hotter and drier and BPFI planning context), reducing to 45 of 129 years for the 2030 period, and significantly lower at only 30 of 129 years for 2050 period.

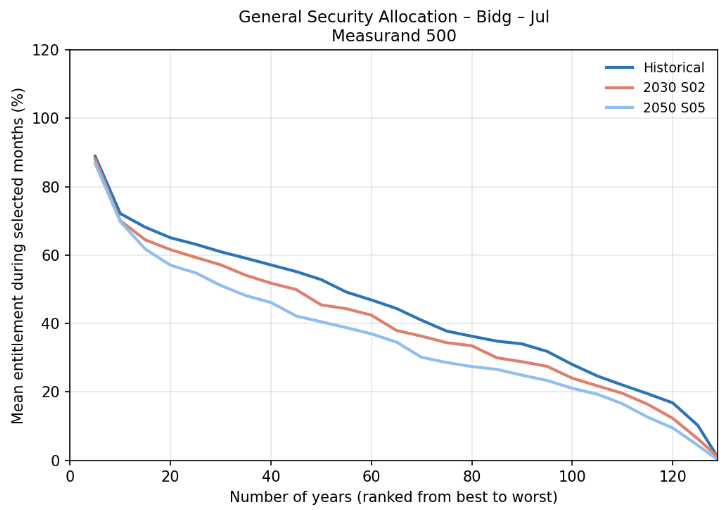


Figure 40: General security allocation at commencement of the water year (Murrumbidgee BPFI median hydroclimate)

For high security water, no significant change in water allocations is expected as shown in Figure 41, with allocations close to 100% for all water years.

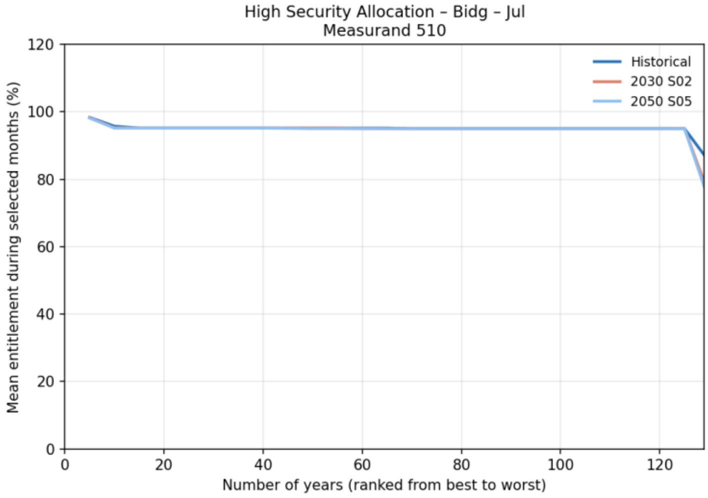


Figure 41: High security allocation at commencement of the water year (Murrumbidgee BPFI median hydroclimate)

At the beginning of the planting year in the Murrumbidgee (assumed to be around February), 100% allocations of general security entitlement water is predicted to occur in up to 40 of 129 years in the historical climate period, dropping to around 35 of 129 years for the 2030 period, and 20 of 129 years for the 2050 period as shown in Figure 42.

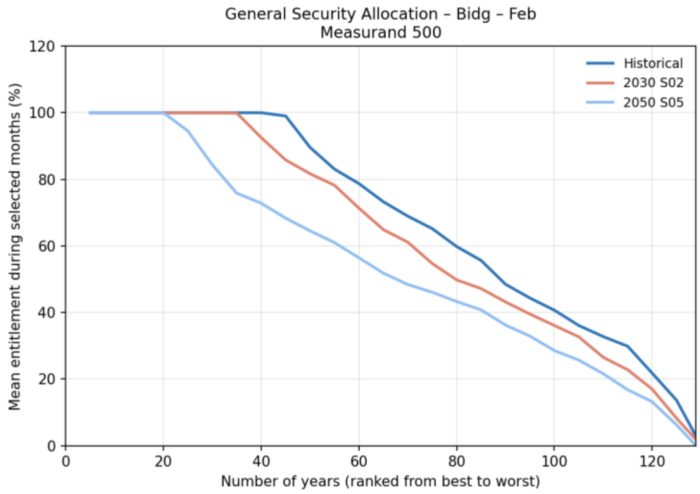


Figure 42: General security allocation at beginning of the Southern Basin planting season (Murrumbidgee BPFI median hydroclimate)

While again not related to planning decisions, high security water is shown to be at close to 100% allocations in Figure 43 for the full model run with some changes in full 100% allocations predicted (noting that this is unlikely to occur in reality given the higher priority of high security water provision).

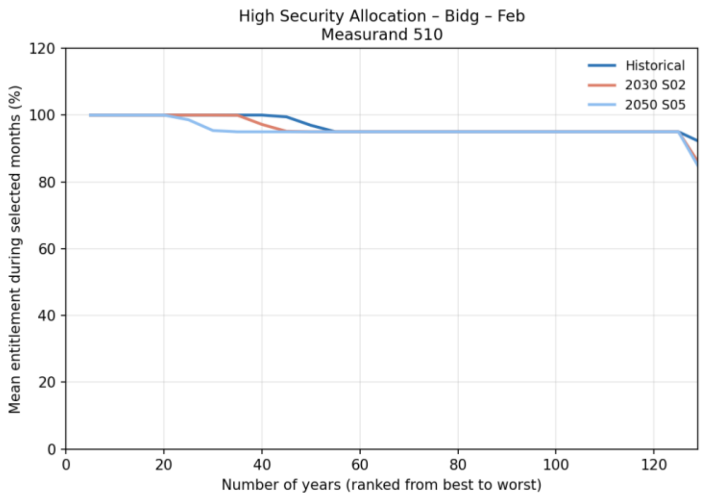


Figure 43: High security allocation at beginning of the Southern Basin planting season (Murrumbidgee BPFI median hydroclimate)

At the end of the water year in the Murrumbidgee Basin, 100% allocations are expected for general security entitlement water in 65 of 129 years over the historical period, reducing to 50 of 129 years over the 2030 period and 40 of 129 years for the 2050 period as shown in Figure 44. Greater than 50% allocations are expected to occur in 95 of 129 years for the historical period, reducing to 90 of 129 years for the 2030 period and 85 of 129 years for the 2050 period.

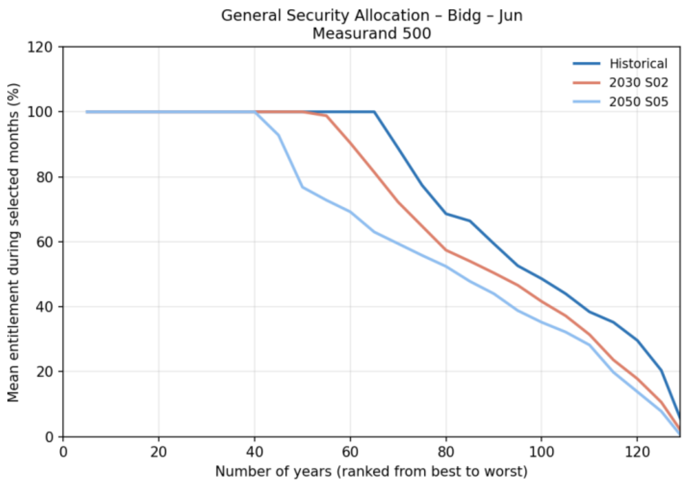


Figure 44: General security allocation at the end of the water year (Murrumbidgee BPFI median hydroclimate)

For high security entitlement water, there is further change predicted in provision of 100% allocation over the full water year, with the models predicting that the full allocations would be available for 65 of 129 years over the historical climate period, reducing to 40 of 129 years in over the 2030 period and 30 of 129 years over the 2050 period. The allocations are predicted to only drop to around 95% for the remaining years however as shown in Figure 45.

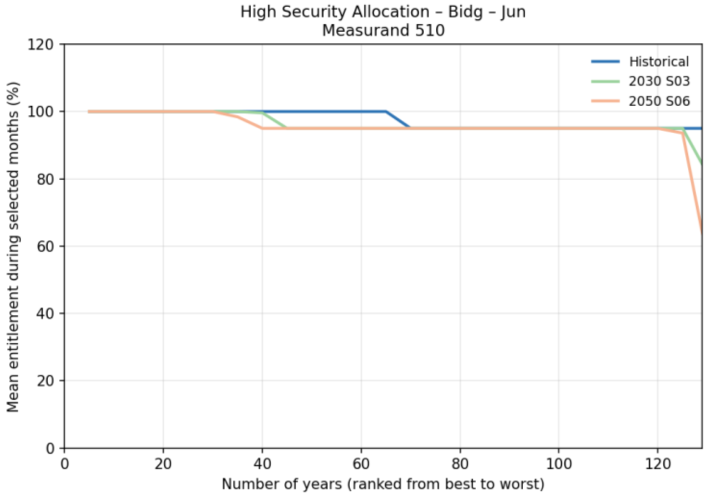


Figure 45: High security allocation at the end of the water year (Murrumbidgee BPFI median hydroclimate)

GBCCL Basin

In the GBCCL Basin at the commencement of the water year in July, low reliability water shares are expected to achieve 100% allocations for 30 of 129 years in the historical climate period, reducing to 25 of 129 years for the 2030 period, and 20 of 129 years for the 2050 period, as shown in Figure 46. 50% or greater allocations are expected to occur in 70 of 129 years over the historical period, with a reduction to around 55 of 129 years for the 2030 period, and 50 of 129 years for the 2050 period.

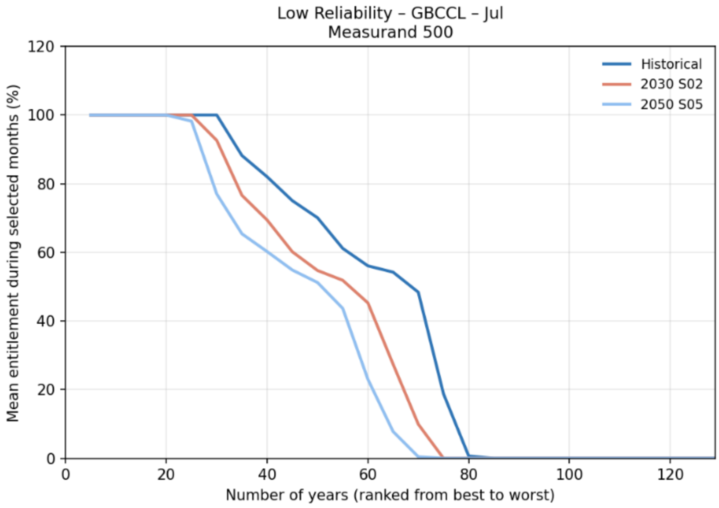


Figure 46: Low reliabilty water shares allocation at the commencement of the water year (GBCCL BPFI median hydroclimate)

High reliability water shares at the commencement of the water year, as indicated in Figure 47, are expected to be available at 100% allocations for 100 of 129 years of the historical period, reducing very slightly to 95 of 129 years in the 2030 and 2050 climate periods.

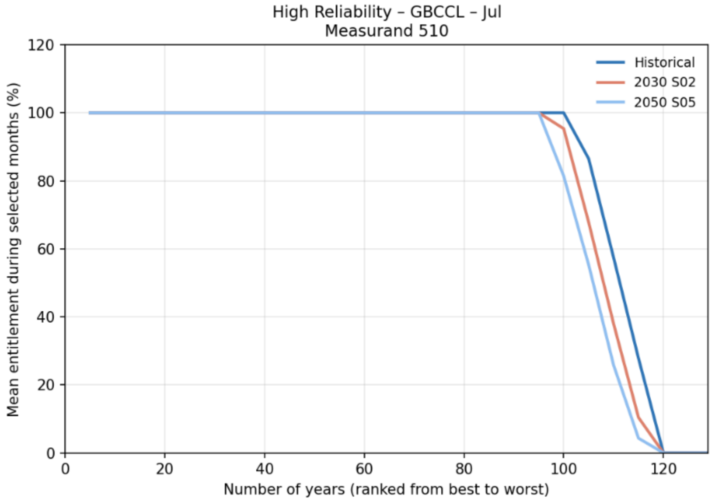


Figure 47: High reliability water shares at the commencement of the water year (GBCCL BPFI median hydroclimate)

Figure 48 shows that entitlement reliability significantly improves across the GBCCL as the water year progresses, with low reliability water shares predicted to have 100% allocations at the beginning of the Southern Basin for 80 of 129 years for the historical climate period, reducing slightly to 75 of 129 years for the 2030 period and 70 of 129 years for the 2050 period.

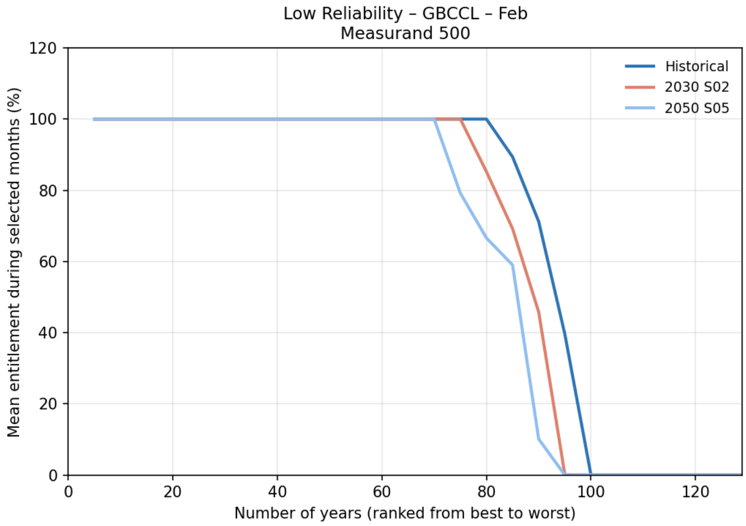


Figure 48: Low reliability water shares allocation at the beginning of the Southern Basin planting season (GBCCL BPFI median hydroclimate)

For high reliability water shares, 100% allocations are expected for around 110 of 129 years in the months of February across all climate periods as shown in Figure 49.

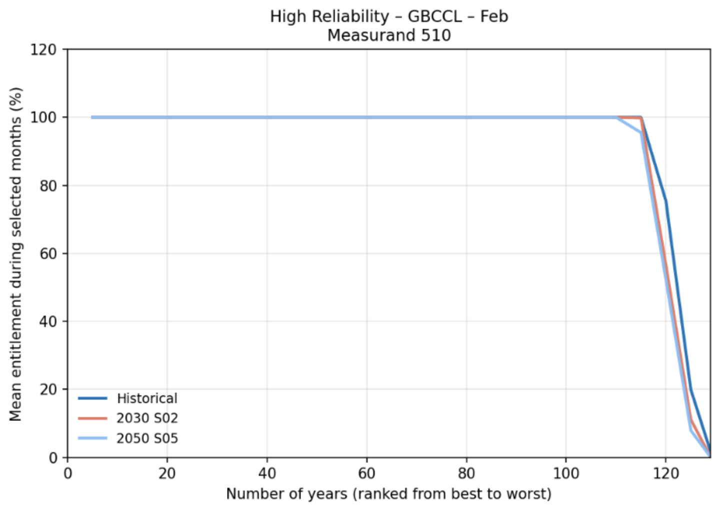


Figure 49. High reliability water shares allocation at the beginning of the Southern Basin planting season (GBCCL BPFI median hydroclimate)

At the end of the water year in the GBCCL, further improvements in allocations are predicted, with 100% allocations for low reliability water shares expected in 80 of 129 years for the historical period, dropping to 75 of 129 years for the 2030 period and around 75 of 129 years for the 2050 period as shown in Figure 50.

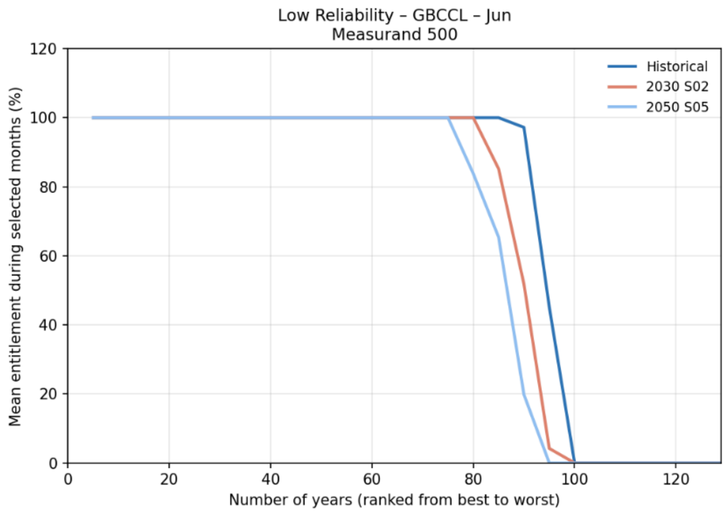


Figure 50: Low reliability water shares allocation at the end of the water year (GBCCL BPFI median hydroclimate)

As there are no further changes in the high reliability water shares at the end of the water year in comparison to those shown in Figure 50 above, the high reliability graph has been omitted.

Storages can buffer the impact from lower water availability

The presence of major storages allows water to be retained for regulated delivery, and buffer climate driven reductions in water availability in the river system. Under drier hydroclimate pathways, declining inflows mean that a greater proportion of the total runoff generated in upstream catchments is intercepted by storages. Dry conditions cause storages to operate with greater airspace and as such become more effective at capturing inflows.

Storages therefore provide enhanced control and delivery mechanisms for users within the downstream system. However, interception of inflows can also reduce the flow volumes that would otherwise pass through reaches downstream of storages to users. This impact is most acute in low flow periods and is exacerbated by drying climate conditions, while operational control becomes increasingly important under low flow conditions.

Climate impacts to available water are not shared equally, and while storage volumes can be used to supply high reliability or high priority entitlements, increased interception of diminishing water resources has a greater effect on lower-security entitlement holders, unregulated users, and environmental outcomes that depend on natural in-river flows. While storages provide an important adaptation mechanism within regulated systems, they also reshape where and how climate-driven scarcity is experienced across the river network.

Modelling of storage effectiveness was undertaken across all Basins and is summarised in the tables below for the Northern and Southern Basins. What these results indicate, is the reduction in storage volume across the hydroclimate scenarios follows a similar trend to inflows as expected, but the reductions for future drier hydroclimates (S2/S5 and S3/S6) tend to be mitigated as the storages increase in efficiency of capturing upstream runoff (i.e. there is likely to be more storage capture volume both from decreased inflow volume and increased evaporation under future climates).

Table 18: Annual average volume in storage in the Northern Basin

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Average annual volume in storage – Northern Basin							
Without development	26602	27120	26331	25602	27393	26213	25002
% change from historical		2%	-1%	-4%	3%	-1%	-6%
June 2009	92220	96956	89045	81916	99289	87505	75981
% change from historical		5%	-3%	-11%	8%	-5%	-18%
BPFI	108587	113252	105481	98383	115269	103689	91749
% change from historical		4%	-3%	-9%	6%	-5%	-16%
Average volume in storage across the warm season – Northern Basin							

Without development	13096	13345	12962	12608	13479	12902	12315
% change from historical		2%	-1%	-4%	3%	-1%	-6%
June 2009	46214	48506	44540	40990	49634	43720	38005
% change from historical		5%	-4%	-11%	7%	-5%	-18%
BPFI	54312	56585	52691	49179	57564	51764	45857
% change from historical		4%	-3%	-9%	6%	-5%	-16%
Average volume in storage across cool season – Northern Basin							
Without development	13557	13826	13419	13043	13966	13362	12735
% change from historical		2%	-1%	-4%	3%	-1%	-6%
June 2009	46185	48638	44678	41084	49847	43955	38123
% change from historical		5%	-3%	-11%	8%	-5%	-17%
BPFI	54486	56886	52995	49394	57929	52126	46070
% change from historical		4%	-3%	-9%	6%	-4%	-15%

Table 19: Annual average volume in storage in the Southern Basin

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Average annual volume in storage – Southern Basin							
Without development	15209	15157	13422	11734	15074	12433	10260
% change from historical		0%	-12%	-23%	-1%	-18%	-33%
June 2009	145149	146674	127967	112102	147369	119983	93621

% change from historical		1%	-12%	-23%	2%	-17%	-36%
BPFI	168182	168868	153807	137621	168976	145804	119104
% change from historical		0%	-9%	-18%	0%	-13%	-29%
Average volume in storage across the warm season – Southern Basin							
Without development	7876	7843	6959	6094	7800	6453	5330
% change from historical		0%	-12%	-23%	-1%	-18%	-32%
June 2009	75374	76109	66605	58424	76445	62507	48934
% change from historical		1%	-12%	-22%	1%	-17%	-35%
BPFI	85566	85859	78396	70237	85910	74335	61003
% change from historical		0%	-8%	-18%	0%	-13%	-29%
Average volume in storage across the cool season – Southern Basin							
Without development	7364	7344	6490	5664	7304	6005	4950
% change from historical		0%	-12%	-23%	-1%	-18%	-33%
June 2009	70067	70859	61620	53904	71220	57718	44876
% change from historical		1%	-12%	-23%	2%	-18%	-36%
BPFI	82947	83342	75715	67657	83399	71757	58337
% change from historical		0%	-9%	-18%	1%	-13%	-30%

Examining some specific Basins in the Northern and Southern Basin highlights how storage capacity doesn't reduce as significantly as the inflow reduction. For example, in the Northern Basin, storages in the Namoi Basin over the drier hydroclimates (warmer/hotter and drier S2/S5, warmer/hotter and much drier S3/S6) show that overall storage capacity would be greater than 50% for 45% of the time over historical climate period, reducing to 42% for the 2030 period and 40% for the 2050 period for S2/S5, and reducing to 40% for the 2030 period and 35% for the 2050 period for S3/S6. As noted in other result sections, BPFI results in less overall impact to storage capacity than for the 2009 planning context, likely to be a result of more water held for environmental uses and less available for consumptive use under the BPFI context. This is illustrated in Figure 51. It also helps to explain earlier findings in water balance results that diversions are less impacted under future drier climates in the BPFI context, as more water is available for all uses across the drier hydroclimates due to a higher storage volume across the different hydroclimates. Again, this suggests that planning context is potentially one adaption pathway for managing future climate change.

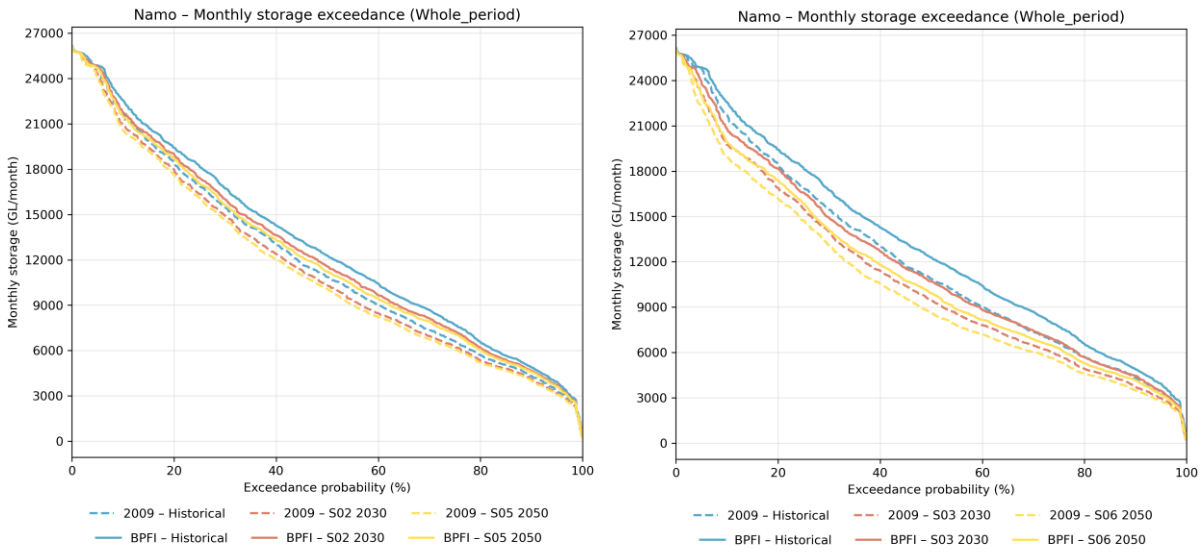


Figure 51: Namoi catchment monthly storage exceedence for hydroclimates warmer/hotter and drier S2/S5 (left) and much drier S3/S6 (right)

In the Southern Basin, the reduction in inflows is more significant in the drier hydroclimates, such that the impacts on storage capacity are more acute. Using the GBCCL as illustrative, the exceedance curve for the historical climate shows that the under the historical climate period, the model predicts that storage capacity would be more than 50% for 90% of the time, but this reduces to around 82% of the time for the warmer and drier scenario (S2 – 2030 period), and 75% of the time for the hotter and drier scenario (S5 – 2050 period). For the warmer and much drier scenario, storage capacity would be more than 50% for 72% of the time (S3 – 2030 period), and only 55% of the time for the hotter and much drier scenario (S6 - 2050 period), shown in Figure.

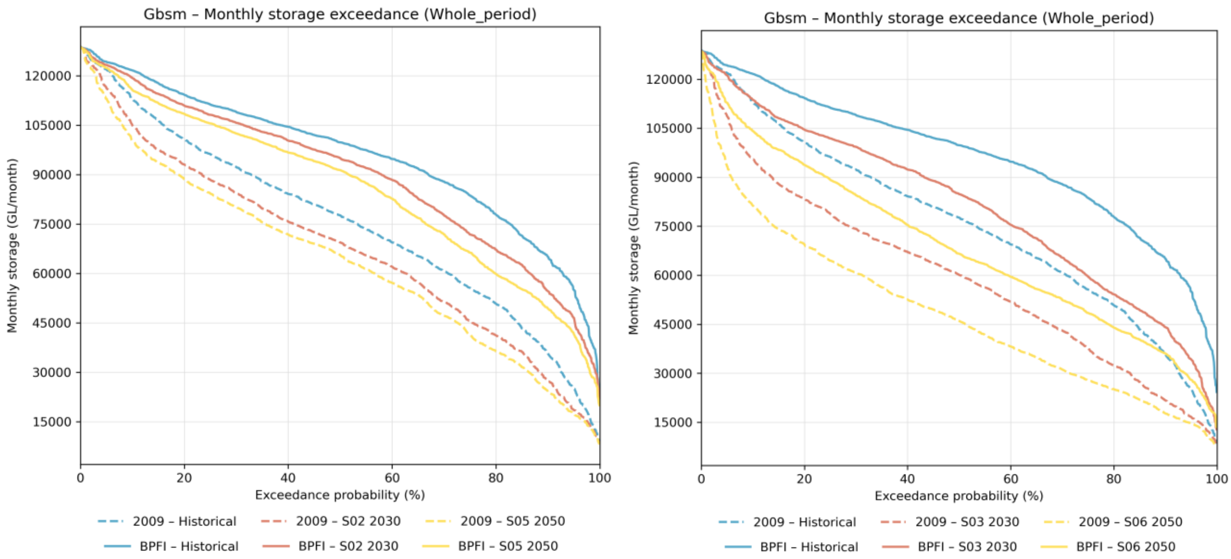


Figure 52: GBCCL monthly storage exceedence for hydroclimates warmer/hotter and drier S2/S5 (left) and much drier S3/S6 (right)

Changes in hydrologic drought

As noted in the **Modelling methodology** section, the approach used to generate future hydroclimates used scaling of seasonal inflows to approximate the influence of future climate change. Given that this scaling is applied to the existing climate time series used in the model (i.e. the historical climate period), the frequency of droughts in the future hydroclimate scenarios will replicate those in the historical record. The modelling approach therefore cannot predict changes in frequency of drought, but from the scaling approach, we can make some inferences around the length of time below certain flow thresholds when compared to the historical climate period. For example, if we used the historical 10th percentile flow as indicative of when water availability is likely to be most scarce, the scaling method used will result in more days below that historical threshold for the future hydroclimates. This helps us to understand whether there will be a significant increase in the length of time for very low flows in different parts of the Basin.

Care needs to be taken in interpretation of drought severity however, as the droughts experienced historically may or may not be the most severe encountered in the Basin, with results from assessments of palaeoclimate records indicating that droughts prior to the historical record have occurred at different frequencies and durations to those experienced during European settlement.

We have therefore mapped the changes in duration below the historical 10th percentile flow for the whole of the Basin using the catchment boundaries for each of the models assessed as shown in Figure 53. These maps show that in comparison to the historical 10th percentile flows, there is a substantial increase in the days below the threshold, particularly in the Southern Basin. This is very much consistent with the remaining results presented in this report, which impacts in the Southern Basin from reduced inflows are likely to be more significant than in the Northern Basin.

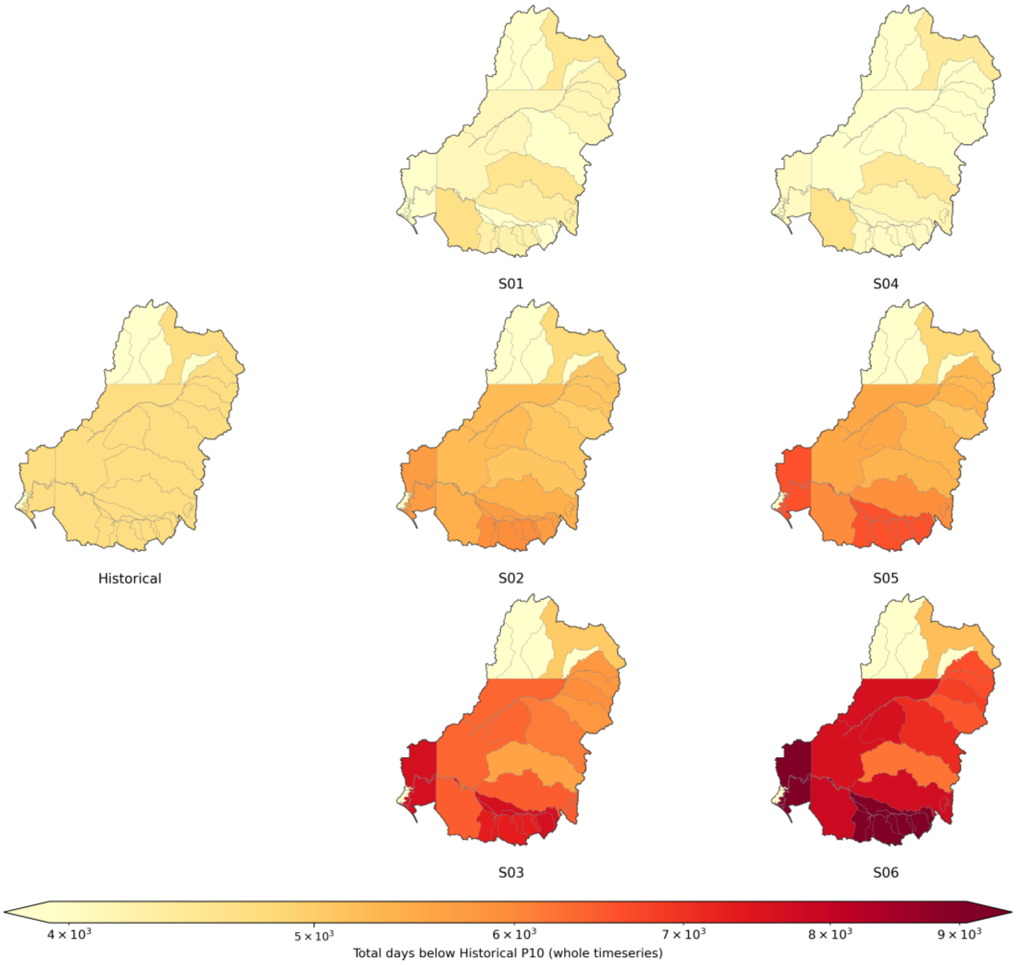


Figure 53: Changes in the number of days below the historical 10th percentile flow

The key message from this low flow assessment is that the time in drought is expected to increase in the future. It is recognised that the scaling methods have limitations in viewing this, but most importantly, these results are consistent with a large body of evidence across rivers in the Basin that have come to similar conclusions.

Given the changes in low flows, while the scaling method also doesn't show this well, there will also be changes in river connectivity, with these lower flows resulting in disconnection of stream flow in some systems, especially in the Northern Basin where there are more ephemeral rivers and streams.

Interpretation and discussion

Comparing results between hydroclimate and development scenarios from the river system modelling indicates the future outlook for the Basin under full implementation of the Basin Plan, against conditions in 2009 and without regulation or development. The focus is on understanding how different plausible hydroclimate pathways translate into changes in inflows, runoff processes, river system partitioning, and downstream transmission, and on identifying where impacts are most likely to be concentrated. Changes in climate have the biggest impact on total water availability, where Basin Plan settings impact how available water resources are shared amongst users within a valley and between upstream and downstream users.

Impacts accumulate downstream

Under future drier hydroclimate scenarios, the models predict that the reductions in downstream flows will be where the majority of impact is realised. This is likely to be occur to a larger extent in the Southern Basin than the Northern Basin.

Under full implementation of the Basin Plan, water balance components include water specifically portioned for environmental use. This water is recovered from water that has been historically designated as consumptive water and preserves volumes that are designated as end of valley flows or system outflows.

Under warmer/hotter and drier conditions, lower inflows to systems mean there is less water available to be shared amongst water uses, both to meet needs within valleys, and to pass to downstream systems. This tightening of the water balance increases trade-offs between consumptive demands, environmental requirements and water retained in the river system.

The modelling presented in this report predicts that downstream users are the most at risk of reduced water availability, because the effects of reduced inflows accumulate along the river network, and downstream availability is influenced by both climate-driven inflows and upstream extractions and operations.

Across the Northern Basin, the largest portion of water in each valley is taken up from the surface water system due to river system processes. This can be due to non-beneficial 'losses' such as evaporation, or to processes that benefit environmental values, such as floodplain or wetland watering. While water delivery efficiency is a key management concern, many of these processes are a function of the river systems and as such some climate impacts under any future climate are not able to be mitigated.

Water that is within river system processes is significantly greater in the Northern Basin than in the Southern Basin. Given this component of the water balance is more greatly influenced by climate impacts, this in turn impacts total inflows from the Darling system and Northern contributions to the Murray, meaning impacts on water availability are propagated downstream.

The different proportionality of water balance components in the South means more of the total water available is regulated. Unavoidable impacts to water availability in the North mean the system is more dependent on outflows from the South, and regulation and management of these Southern systems will have the biggest impact on total outflows to the Murray. Changes to these outflows have been shown to be particularly significant in the South and are likely to reduce greatly under the drier hydroclimate scenarios.

Storages buffer the impacts to downstream water users

Across all future hydroclimates, results from the models show that storages hold a greater proportion of inflows into the future, becoming more "efficient" in capturing upstream flows, but result in less water spilling from them downstream. In the Southern Basin, the impacts on storage capacity are much greater in the hotter and drier/much drier hydroclimates than in the Northern Basin, simply because there is a much greater storage capacity in the South, and that the reductions in inflows are also larger.

Storages are a key part of this story. Water held in storage is proportionally greater in the South, and while storages are more effective at capturing runoff under warming, drying conditions, preferentially intercepting water that would otherwise flow through the system, they allow for greater regulation and control of available water resources.

Holding water in storage allows water to be managed to meet environmental needs, supplement the system during dry periods, slow the impacts of long-term changes to water availability, provide emergency supply under drought conditions and curtail impacts of extreme flood events. Under future climate conditions, this allows greater control of water for mitigation of immediate threats, and adaptation to a changing hydroclimate.

Disparate impacts to different water users

Future, drier hydroclimates used in the models result in sometimes large reductions in downstream flows if all other components are managed as they are now (i.e. the existing management arrangements for consumptive use and environmental use). This disparate impact will need to be considered into the future such that the impacts can be more evenly spread across all water uses.

Under warmer and wetter conditions, there is likely to be more total water available and hence generally less constrained water delivery. However, because the Basin is also virtually certain to be hotter, higher rainfall may be offset by higher evaporative demand in some regions, so there will still be regional differences in how much rainfall is translated into runoff and inflows. Also, this does not consider the expected change to extreme weather events that could pose other risks to the Basin (i.e. large floods, cyclones, droughts, associated fires, infrastructure damage).

In a management context, the biggest limitations on achievement of water needs across the system are due to a warming, drying climate. Less total water available and consistent reductions in regional water availability mean entitlement reliability will be more constrained for non-consumptive uses, lower security/ reliability, and environment.

Climate impacts are not shared equally

Climate impacts are expected to be larger in the Southern connected system than in the North when modelling the existing water resource management planning contexts.

The impacts of climate change, particularly under reduced water availability conditions, are not shared equally between water user types and from North to South across the Basin. In the Southern connected system, management priorities focus on maintaining outcomes at major downstream environmental assets along the River Murray (e.g., *The Living Murray* "icon sites", including the forest/lake systems along the NSW/VIC/SA reaches of the River Murray, the Lower Lakes, Coorong and Murray Mouth).

Projected future conditions will mean decisions around trade-offs will be more common. Different entitlement products exist for this reason, and high security or high reliability water supply will be preferentially prioritised over lower security/reliability products to protect emergency water supply, town water supply and critical human and environmental water needs.

Droughts limit the water available for use in the future

The modelling approach used makes it difficult to predict future drought frequency, severity and duration. However, what it does show is that the period of time below the historical 10th percentile flow increases significantly under the future drier hydroclimates, with the effect being more predominant in the Southern Basin.

Droughts, like other climate impacts, will occur regardless of planning conditions. The warmer/drier climate scenario results show worsening drought conditions as a change in magnitude but doesn't provide any assessment of potential drought conditions under different sequencing of events or antecedent conditions. There is still significant uncertainty around the level of threat that drought behaviour will pose, in terms of drought frequency, duration, location, spatial extent and magnitude.

As such, a critical element of preparedness is system resilience, the ability to sustain critical services and recover under prolonged low inflows. Basin Plan prioritises critical human water needs and conveyance water, and if town water supply must still be met through severe drought, the residual risk is passed onto other water users, through tighter constraints on environmental outcomes, deeper drawdown of storages, and a stronger operational focus on efficiency and loss reduction (including delivery losses and avoiding non-essential releases where possible). Under drying or drought conditions, storages are unlikely to be maintained at full supply level, so there will be less incidental benefit from spills.

Climate change constrains flows passing downstream

As noted earlier, under future drier hydroclimate scenarios, the models predict that the impact on downstream flows will be where the majority of impact is realised. The planning context can make some difference to this as illustrated by the difference between the BPFI and June 2009 contexts, where BPFI tends to mitigate some of the impact of reductions in inflows.

As water moves through the Basin, the components of the water balance are partitioned differently from reach to reach. Variations in consumptive use are primarily driven by regional management rules and the density and type of licences or water users. Differences in water lost from the surface water system, captured in storage or delivered to the environment (in stream or overbank to a flood plain), described throughout this report as river system process water, are due to the location of critical infrastructure (storages and regulators) and hydrologic and geomorphic features such as waterway channel form, sinuosity or presence of wetlands that influence routing, attenuation, and losses. The regional climate has an influence on the rates of water lost from the surface water system to evaporation.

The warmer/hotter and much drier hydroclimate conditions show considerable impacts overall, but it is predicted that downstream flows will see the largest impact. Planning context can help to moderate how those impacts are distributed. Comparing modelling results from BPFI and June 2009 scenarios shows how a fully implemented Basin Plan supports more water in river and flowing to downstream relative to pre-Plan settings.

Basin Plan buffers the impacts of climate change in some circumstances

The full implementation of the Basin Plan buffers the impacts of reduced water availability, though this is usually at the expense of downstream flows. Future planning will need to consider how the impacts are most appropriately balanced across the range of water uses.

Planning context is critical to how climate impacts are shared. The modelling results show significant differences in flow volumes across water balance components under different climate scenarios. Those differences are less apparent between management scenarios, and between 2009 and BPFI, the impacts across diversions are relatively consistent in some systems, especially in the Northern Basin. In the Southern system, BPFI tends to retain more water in storage, with less overall impact on consumptive uses.

While climate-driven declines in water availability are very likely, the Basin Plan context appears to buffer the intensity of impacts on consumptive uses within a river valley using current water management arrangements, though this results in more significant reductions in downstream flows as highlighted above. Future planning will therefore have to balance limits on consumptive take (SDLs), prioritising water for critical human needs, and reserving or returning water for environmental outcomes while protecting flows for downstream communities and ecosystems.

Conclusions and considerations for future modelling

The river system modelling provides insights into the projected range of climate driven risks to water resources across the Basin under a selection of plausible climate futures. The assessment aims to explain how inflows, runoff behaviour and river system flows are expected to change under future climate conditions, how this is expected to evolve over time, and how the rules and conditions adopted under the Basin Plan could be utilised to help mitigate some of these risks across different water users.

The assessment identifies the following key messages:

- Greater variability in the north, with modest average drying.
- Stronger and more consistent drying in the south.
- Existing management arrangements tend to:
  - Protect consumptive use within valleys.
  - Shift impacts to downstream flows.
- The most significant Basin-wide impact of climate change is the substantial reduction in downstream flows, particularly from the Southern Basin.
- Adaptation through planning helps but does not completely offset the dominant climate signal.

The assessment provides a range of temporal and spatial impacts likely to be seen across the Basin under future conditions and presents insights that frame future risks in the context of a selection of many possible outcomes. This represents an advancement on the SY 2009 analysis; however, there are a number of considerations for future modelling that would allow deeper examination of key processes and the adaptive capacity of river systems across the Basin.

Considerations for future modelling

The approach used in this work is a result of the timeframes available, and the existing capabilities of the river systems models as incorporated into the FIRM. As further modelling is undertaken associated with assessments needed for Basin Plan Review processes, and as part of future model development, improvements to the approaches adopted here are likely to be incorporated.

As part of this, previous reviews of potential methodologies undertaken by the Independent Hydroclimate Science Expert Panel (IHSEP) provided advice to the MDBA, to consider approaches and methods for assessing hydroclimate risks across the Basin into the future. Many of these recommendations have been actioned[11], and integrated into the methodology underpinning this SY assessment, while others remain aspirational and are noted here as guiding considerations, framed within a realistic and practicable context. They serve as potential guidance around how future modelling may be improved to assess the impacts of climate change and climate variability.

[11] MDBA 2025, Murray–Darling Basin Authority's response to the advice of the Independent Hydroclimate Science Expert Panel. November 2025.

Key findings of the IHSEP review of *Approaches for Generating Hydroclimate Data to Inform Water Resources Planning and Management in the Murray-Darling Basin* were:

- Determining what data and methods to use when assessing hydroclimate risks and evaluating potential responses (policies and management approaches) across jurisdictional boundaries i.e. assessing climate risks to end of system outcomes, when those outcomes depend on hydroclimate across five jurisdictions.
- Engaging with stakeholders to articulate what the science is telling us when outputs across jurisdictions are inconsistent or presented in ways that makes them look inconsistent.

Other considerations for future modelling would enable deeper exploration of river system processes in a more consistent and consolidated manner.

Methodological considerations

- In this study, the models used to assess changes under future hydroclimates model the Basin as it currently is operated and with the current demands and structures in place to allocate water across water uses needed. Under future climate change, not only will there be changes in rainfall, temperature and evaporation which may impact on water availability, but there are wholesale changes likely in agricultural systems, watering regimes, water user behaviour and regulatory regimes as a response to the impacts of the hydroclimate that results. Exploring scenarios around structural, socio-economic and behavioural change across the Basin will be needed to understand both the degree of impact and the ability to adapt to future changes. Considering a specific package of work on scenario development will be needed to craft a range of plausible futures that can then be tested by the integrated river systems models to evaluate how the Basin will respond to future climate change, not simply just from hydrologic change.
- MDB jurisdictions maintain models to explore river system processes to support water planning processes, and analysis is constrained within individual model boundaries. It is advisable that future modelling augmentation considers aggregation or outputs from models to whole of river system or valley water balance units. Reporting on water balance metrics within units or regions would enable a wide view of overall water availability and composition of different water balance components, and the interaction and contribution of flows with the wider MDB.
- The scaling of inflows approach adopted from the results of Module 1 are constrained to the 10^{th}, median and 90^{th} percentile of future hydroclimates through the scaling of inflows. This approach has allowed for consistent analysis of a set of potential future climates but does not account for the full range of existing climate variability or future climate change and a number of Basin state jurisdictions are already implementing techniques to incorporate this into modelling assessments of future climate change in their respective river systems. Further modelling at the Basin scale should therefore consider these techniques to assist in better understanding the full range of variability and change likely and to assist in quantifying potential uncertainties with the impacts of future climate change.
- Modelling practices should enable a deeper exploration of uncertainty and be configured to enable non-deterministic modelling approaches. This would allow existing modelling tools to be adapted for bottom-up investigations of system sensitivities and explore the system interactions of major hydroclimatic risks, such as investigating the shifts in frequency and intensity of extreme events.

Model application considerations

- Consistency across the Basin in river system model platform and conceptual layout of river system models and sub-model information (such as demand models, rules, delivery mechanisms and constraints, rainfall-runoff models).
- Supporting consistent model versioning protocols will enable updates to be made piecewise and be traceable.
- Maintain a consistent approach to rainfall runoff modelling, including model selection, calibration and uncertainty quantification, as well as approach to integrate calculated or gauge infilled inflows into river system models.
- Across the Basin, consistency of application of methodologies would strengthen the insights and comparisons that can be drawn from across Basin regions.
- Currently there is some coordination of environmental water delivery between the Murrumbidgee and Murray. There is room for improvement to how this is presented in the models.

Appendix 1

Total annual inflows

Table 20 : Results from model scenarios showing average annual inflow volumes from aggregated units across the Basin under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Northern Basin							
Without development	12,131	13,747	11,651	10,167	14,559	11,412	9,190
June 2009	11,931	13,526	11,463	10,002	14,328	11,231	9,045
BPFI	12,634	14,259	12,151	10,654	15,072	11,910	9,666
Border Rivers							
Without development	2,162	2,449	2,083	1,820	2,592	2,043	1,649
June 2009	2,162	2,449	2,083	1,820	2,592	2,043	1,649
BPFI	2,162	2,449	2,083	1,820	2,592	2,043	1,649
Moonie							
Without development	170	194	165	144	206	163	131
June 2009	170	194	165	144	206	163	131
BPFI	170	194	165	144	206	163	131
Condamine – Balonne							
Without development	2,180	2,512	2,135	1,852	2,679	2,112	1,688
June 2009	2,170	2,500	2,124	1,842	2,667	2,102	1,679
BPFI	2,174	2,505	2,128	1,846	2,672	2,106	1,683
Warrego							

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Without development	879	1,016	868	753	1,084	862	690
June 2009	879	1,016	868	753	1,084	862	690
BPFI	879	1,016	868	753	1,084	862	690
Paroo							
Without development	530	609	520	452	649	515	413
June 2009	530	609	520	452	649	515	413
BPFI	530	609	520	452	649	515	413
Gwydir							
Without development	1,851	2,073	1,768	1,556	2,185	1,727	1,408
June 2009	1,851	2,073	1,768	1,556	2,184	1,727	1,408
BPFI	1,851	2,073	1,768	1,556	2,184	1,727	1,408
Peel – Namoi							
Without development	1,544	1,725	1,468	1,292	1,815	1,429	1,165
June 2009	1,545	1,729	1,467	1,288	1,821	1,428	1,159
BPFI	1,542	1,726	1,465	1,286	1,819	1,426	1,157
Macquarie							
Without development	1,801	1,989	1,681	1,482	2,083	1,621	1,323
June 2009	1,807	1,995	1,687	1,487	2,089	1,627	1,328
BPFI	1,807	1,995	1,687	1,487	2,089	1,627	1,328
Darling*							
Without development	3,863	4,351	3,699	3,245	4,598	3,617	2,938

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
June 2009	2,785	3,227	2,641	2,236	3,453	2,570	1,978
BPFI	3,657	4,138	3,492	3,040	4,379	3,410	2,736
Total Southern Basin							
Without development	19,838	20,473	18,166	16,203	20,736	17,279	14,333
June 2009	20,198	20,709	18,375	16,389	20,967	17,462	14,465
BPFI	19,851	20,367	18,050	16,091	20,599	17,146	14,204
Murrumbidgee							
Without development	3,927	3,980	3,546	3,165	4,007	3,355	2,783
June 2009	4,428	4,488	4,071	3,707	4,518	3,885	3,329
BPFI	4,194	4,276	3,879	3,448	4,293	3,636	3,065
Lachlan							
Without development	2,355	2,385	2,126	1,897	2,400	2,011	1,668
June 2009	2,347	2,377	2,118	1,889	2,391	2,003	1,660
BPFI	2,349	2,379	2,120	1,891	2,394	2,005	1,662
Goulburn Broken Campaspe Coliban Loddon (GBCCL)							
Without development	3,966	4,112	3,687	3,304	4,133	3,495	2,922
June 2009	3,925	3,967	3,543	3,161	3,987	3,352	2,779
BPFI	3,979	4,022	3,593	3,207	4,044	3,400	2,821
Wimmera							
Without development	190	192	172	153	193	162	134
June 2009	248	250	225	202	251	214	177

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
BPFI	244	246	222	199	247	211	176
Murray**							
Without development	15,303	15,903	14,100	12,590	16,130	13,431	11,168
June 2009	12,237	12,661	10,986	96,29	12,870	10,375	8,368
BPFI	12,929	13,384	11,621	10,226	13,586	11,006	8,912

*Darling (Baaka) River flows modelled downstream of inflows points (at Bourke)

**Murray River flows modelled downstream of the Darling River inflow point

Total annual outflows

Table 21 : Results from model scenarios showing average annual outflow volumes from aggregated units across the Basin under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Northern Basin							
Without development	2,617	2,923	2,508	2,211	3,073	2,454	2,006
June 2009	1,518	1,777	1,430	1,188	1,907	1,387	1,033
BPFI	1,652	1,904	1,562	1,323	2,031	1,518	1,163
Border Rivers							
Without development	829	923	801	710	969	786	648
June 2009	581	665	555	476	706	541	425
BPFI	613	698	585	503	740	571	449
Moonie							
Without development	136	154	132	116	163	131	105
June 2009	102	119	99	84	128	98	75
BPFI	106	123	103	87	132	101	78
Condamine – Balonne							
Without development	560	638	548	480	677	542	439
June 2009	276	352	263	194	390	256	157
BPFI	324	398	312	246	435	306	207
Warrego							
Without development	102	122	101	88	134	101	81

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
June 2009	92	112	91	78	123	91	72
BPFI	96	116	95	82	128	95	75
Paroo							
Without development	311	358	305	264	381	302	240
June 2009	311	358	305	264	381	302	240
BPFI	311	358	305	264	381	302	240
Gwydir							
Without development	200	220	191	170	230	186	155
June 2009	147	164	141	124	173	138	113
BPFI	148	165	141	124	173	137	112
Peel – Namoi							
Without development	645	703	622	564	732	610	524
June 2009	519	576	495	438	605	483	398
BPFI	532	589	508	451	618	495	410
Macquarie							
Without development	645	724	591	507	764	564	440
June 2009	466	537	420	350	572	399	297
BPFI	485	557	438	365	594	416	310
Darling*							
Without development	2,617	2,923	2,508	2,210	3,073	2,454	2,006
June 2009	1,518	1,777	1,430	1,188	1,907	1,387	1,033

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
BPFI	1,652	1,904	1,562	1,323	2,031	1,518	1,163
Total Southern Basin							
Without development	10,442	10,883	9,605	8,545	11,051	9,139	7,554
June 2009	4,446	4,725	3,711	2,977	4,859	3,395	2,287
BPFI	5,521	5,874	4,684	3,787	6,010	4,310	3,055
Murrumbidgee							
Without development	2,614	2,645	2,378	2,152	2,659	2,263	1,925
June 2009	1,409	1,434	1,235	1,087	1,552	1,235	669
BPFI	1,492	1,552	1,341	1,129	1,562	1,215	962
Lachlan							
Without development	265	268	240	215	270	227	191
June 2009	173	175	151	130	176	140	108
BPFI	206	207	182	160	208	171	138
Goulburn-Broken Campaspe Coliban Loddon							
Without development	3,549	3,738	3,345	2,992	3,757	3,168	2,640
June 2009	1,838	1,863	1,569	1,320	1,875	1,440	1,087
BPFI	2,411	2,442	2,100	1,810	2,458	1,955	1,530
Wimmera							
Without development	20	20	17	15	20	16	12
June 2009	11	11	9	8	11	9	6
BPFI	11	12	10	8	12	9	6

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Murray**							
Without development	10,442	10,883	9,605	8,545	11,051	9,139	7,554
June 2009	4,446	4,725	3,711	2,977	4,859	3,395	2,287
BPFI	5,521	5,874	4,684	3,787	6,010	4,310	3,055

*Darling (Baaka) River flows modelled downstream of inflows points (at Bourke)

**Murray River flows modelled downstream of the Darling River inflow point

Total diversions

Table 22 : Results from model scenarios showing average annual inflow volumes from aggregated units across the Basin under climate scenarios

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Total Northern Basin							
Without development	0	0	0	0	0	0	0
June 2009	2,414	2,551	2,390	2,250	2,610	2,371	2,141
BPFI	1,988	2,089	1,959	1,853	2,133	1,944	1,768
Border Rivers							
Without development	0	0	0	0	0	0	0
June 2009	416	454	421	393	467	419	370
BPFI	376	400	372	350	411	369	332
Moonie							
Without development	0	0	0	0	0	0	0
June 2009	38	39	37	35	40	37	34
BPFI	33	35	33	31	36	33	30
Condamine – Balonne							
Without development	0	0	0	0	0	0	0
June 2009	595	614	595	574	622	594	560
BPFI	464	479	464	448	486	463	437
Warrego							

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
Without development	0	0	0	0	0	0	0
June 2009	59	62	58	55	63	58	53
BPFI	36	38	36	34	39	36	33
Paroo							
Without development	0	0	0	0	0	0	0
June 2009	0	0	0	0	0	0	0
BPFI	0	0	0	0	0	0	0
Gwydir							
Without development	0	0	0	0	0	0	0
June 2009	396	425	383	348	439	377	321
BPFI	331	351	323	299	360	318	278
Peel – Namoi							
Without development	0	0	0	0	0	0	0
June 2009	16	16	16	16	16	16	16
BPFI	16	16	16	16	16	16	16
Macquarie							
Without development	0	0	0	0	0	0	0
June 2009	334	353	321	296	363	313	274
BPFI	240	255	227	209	262	221	193
Darling*							
Without development	0	0	0	0	0	0	0

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
June 2009	196	204	197	190	208	197	185
BPFI	161	167	160	153	170	160	148
Total Southern Basin							
Without development	0	0	0	0	0	0	0
June 2009	7,949	8,006	7,570	7,025	8,050	7,303	6,438
BPFI	5,886	5,888	5,688	5,394	5,921	5,529	4,945
Murrumbidgee							
Without development	0	0	0	0	0	0	0
June 2009	1,999	2,016	1,904	1,772	2,033	1,844	1,621
BPFI	1,305	1,313	1,270	1,193	1,326	1,229	1,088
Lachlan							
Without development	0	0	0	0	0	0	0
June 2009	273	275	265	256	277	262	242
BPFI	211	216	207	197	217	203	183
Goulburn-Broken Campaspe Coliban Loddon							
Without development	0	0	0	0	0	0	0
June 2009	1,699	1,710	1,616	1,511	1,716	1,566	1,393
BPFI	1,096	1,103	1,046	980	1,107	1,011	906
Wimmera							
Without development	0	0	0	0	0	0	0
June 2009	64	64	61	57	64	59	52

Development scenario	Historical	S1 Warmer and slightly wetter ~2030	S2 Warmer and drier ~2030	S3 Warmer and much drier ~2030	S4 Hotter and slightly wetter ~2050	S5 Hotter and drier ~2050	S6 Hotter and much drier ~2050
BPFI	41	41	40	38	41	39	37
Murray**							
Without development	0	0	0	0	0	0	0
June 2009	4,103	4,132	3,907	3,600	4,153	3,751	3,290
BPFI	3,182	3,164	3,074	2,934	3,179	2,995	2,681

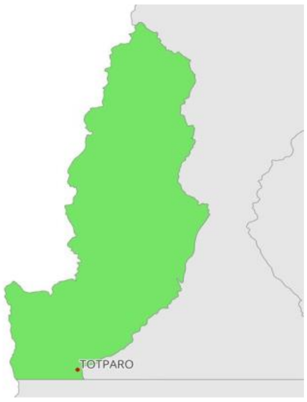
*Darling (Baaka) River flows modelled downstream of inflows points (at Bourke)

**Murray River flows modelled downstream of the Darling River inflow point

Appendix 2

Valley report cards

Paroo River – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

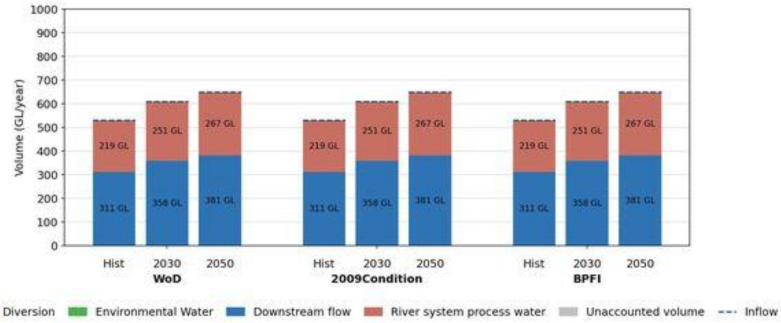


Figure R1: Stacked bar chart showing the annual total volumes of the Paroo River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	530	311	–	219	–	–
	S1	609	358	–	251	–	15
	S4	649	381	–	267	–	22
Jun-09	*Hist*	530	311	0	219	–	–
	S1	609	358	0	251	–	15
	S4	649	381	0	267	–	22
BPFI	*Hist*	530	311	0	219	0	–
	S1	609	358	0	251	0	15
	S4	649	381	0	267	0	22

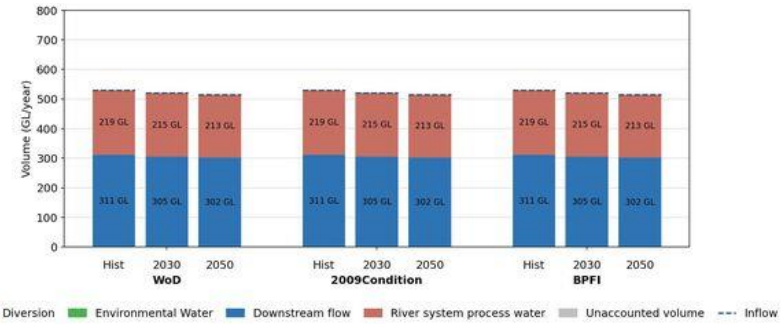


Figure R2: Stacked bar chart showing the annual total volumes of the Paroo River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	530	311	–	219	–	–
	S2	520	305	–	215	–	-2
	S5	515	302	–	213	–	-3
Jun-09	*Hist*	530	311	0	219	–	–
	S2	520	305	0	215	–	-2
	S5	515	302	0	213	–	-3
BPFI	*Hist*	530	311	0	219	0	–
	S2	520	305	0	215	0	-2
	S5	515	302	0	213	0	-3

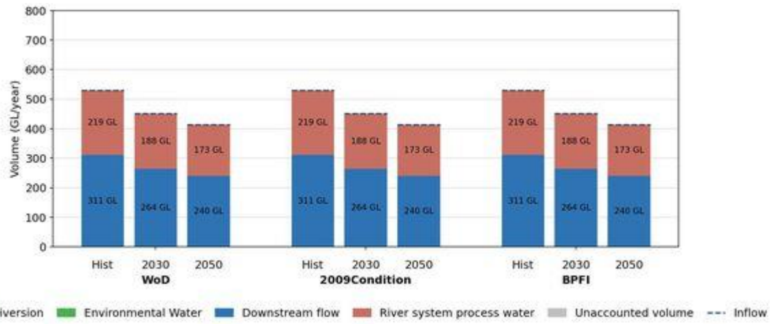


Figure R3: Stacked bar chart showing the annual total volumes of the Paroo River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	530	311	–	219	–	–
	S3	452	264	–	188	–	-15
	S6	413	240	–	173	–	-22
Jun-09	*Hist*	530	311	0	219	–	–
	S3	452	264	0	188	–	-15
	S6	413	240	0	173	–	-22
BPFI	*Hist*	530	311	0	219	0	–
	S3	452	264	0	188	0	-15
	S6	413	240	0	173	0	-22

Warrego River – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

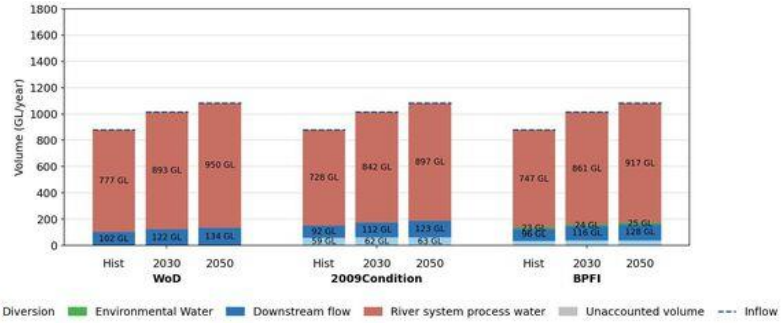


Figure R4: Stacked bar chart showing the annual total volumes of the Warrego River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	879	102	–	777	–	–
	S1	1,016	122	–	893	–	16
	S4	1,084	134	–	950	–	23
Jun-09	*Hist*	879	92	59	728	–	–
	S1	1,016	112	62	842	–	16
	S4	1,084	123	63	897	–	23
BPFI	*Hist*	879	96	36	747	23	–
	S1	1,016	116	38	861	24	16
	S4	1,084	128	39	917	24	23

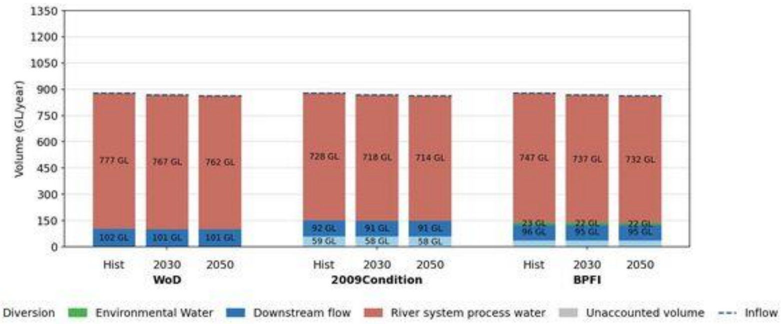


Figure R5: Stacked bar chart showing the annual total volumes of the Warrego River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	879	102	–	777	–	–
	S2	868	101	–	767	–	-1
	S5	862	101	–	762	–	-2
Jun-09	*Hist*	879	92	59	728	–	–
	S2	868	91	58	718	–	-1
	S5	862	91	58	714	–	-2
BPFI	*Hist*	879	96	36	747	23	–
	S2	868	95	36	737	22	-1
	S5	862	95	36	732	22	-2

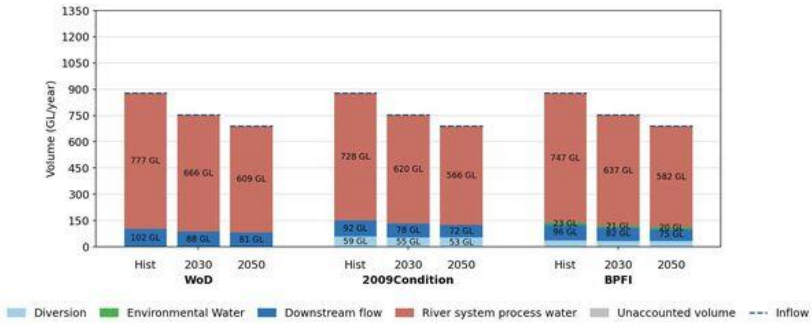


Figure R6: Stacked bar chart showing the annual total volumes of the Warrego River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	879	102	–	777	–	–
	S3	753	88	–	666	–	-14
	S6	690	81	–	609	–	-22
Jun-09	*Hist*	879	92	59	728	–	–
	S3	753	78	55	620	–	-14
	S6	690	72	53	566	–	-22
BPFI	*Hist*	879	96	36	747	23	–
	S3	753	82	34	637	21	-14
	S6	690	75	33	582	20	-22

Nebine Creek – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

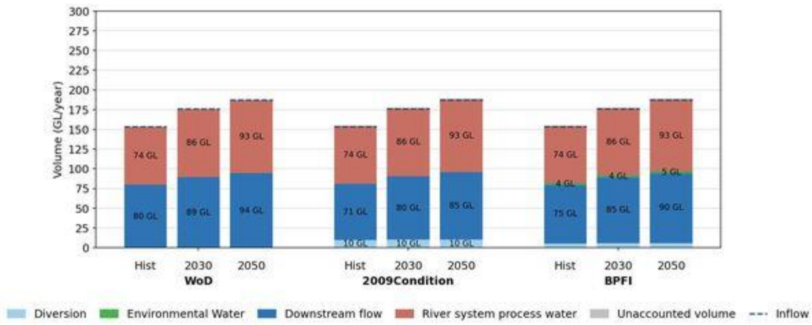


Figure R7: Stacked bar chart showing the annual total volumes of the Nebine Creek system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	153	80	–	74	–	–
	S1	176	89	–	86	–	15
	S4	187	94	–	93	–	22
Jun-09	*Hist*	153	71	10	74	–	–
	S1	176	80	10	86	–	15
	S4	187	85	10	93	–	22
BPFI	*Hist*	153	75	5	74	5	–
	S1	176	85	6	86	4	15
	S4	187	90	6	93	4	22

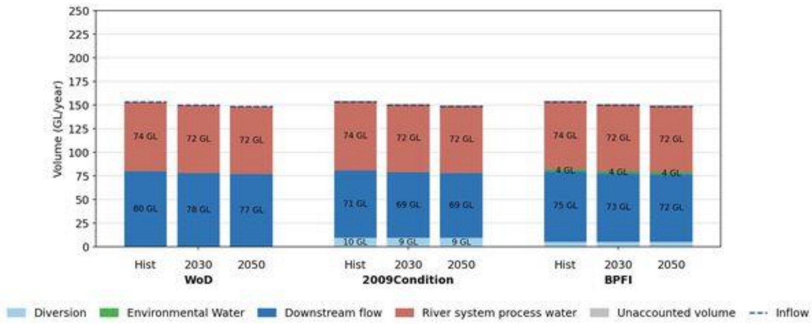


Figure R8: Stacked bar chart showing the annual total volumes of the Nebine Creek system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	153	80	–	74	–	–
	S2	150	78	–	72	–	-2
	S5	148	77	–	72	–	-3
Jun-09	*Hist*	153	71	10	74	–	–
	S2	150	69	9	72	–	-2
	S5	148	69	9	72	–	-3
BPFI	*Hist*	153	75	5	74	5	–
	S2	150	73	5	72	4	-2
	S5	148	72	5	72	4	-3

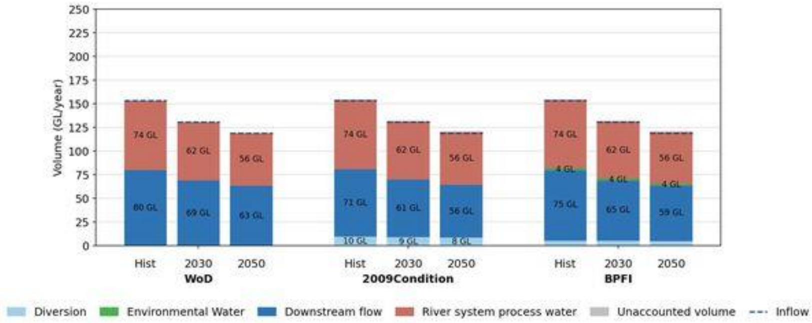
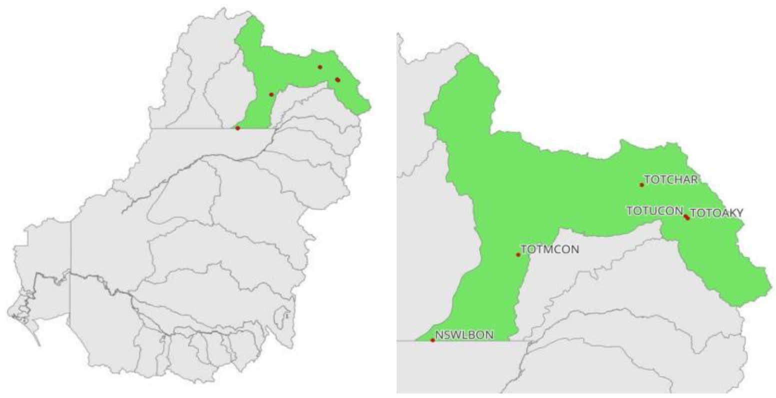


Figure R9: Stacked bar chart showing the annual total volumes of the Nebine Creek system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	153	80	–	74	–	–
	S3	130	69	–	62	–	-15
	S6	119	63	–	56	–	-22
Jun-09	*Hist*	153	71	10	74	–	–
	S3	130	61	9	62	–	-15
	S6	119	56	8	56	–	-22
BPFI	*Hist*	153	75	5	74	5	–
	S3	130	65	5	62	4	-15
	S6	119	59	5	56	3	-22

Condamine-Balonne Whole of Basin – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

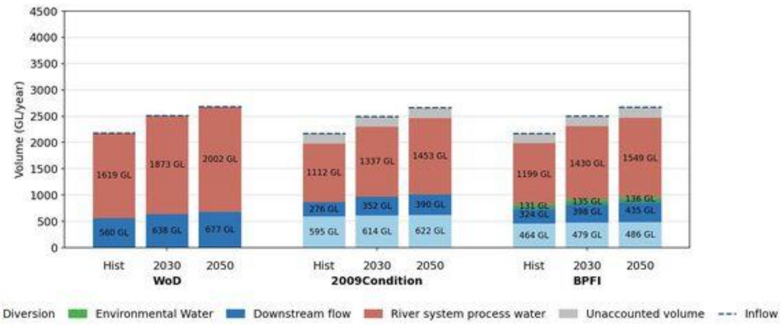


Figure R10: Stacked bar chart showing the annual total volumes of the Condamine Balonne Basin system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,180	560	–	1,619	–	–
	S1	2,512	638	–	1,873	–	15
	S4	2,679	677	–	2,002	–	23
Jun-09	*Hist*	2,170	276	595	1,112	–	–
	S1	2,500	352	614	1,337	–	15
	S4	2,667	390	622	1,453	–	23
BPFI	*Hist*	2,174	324	464	1,199	131	–
	S1	2,505	398	479	1,430	135	15
	S4	2,672	435	486	1,549	136	23

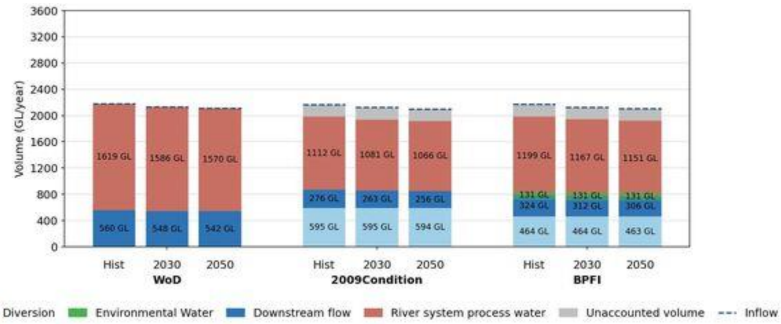


Figure R11: Stacked bar chart showing the annual total volumes of the Condamine Balonne Basin system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,180	560	–	1,619	–	–
	S2	2,135	548	–	1,586	–	-2
	S5	2,112	542	–	1,570	–	-3
Jun-09	*Hist*	2,170	276	595	1,112	–	–
	S2	2,124	263	595	1,081	–	-2
	S5	2,102	256	594	1,066	–	-3
BPFI	*Hist*	2,174	324	464	1,199	131	–
	S2	2,128	312	464	1,167	131	-2
	S5	2,106	306	463	1,151	131	-3

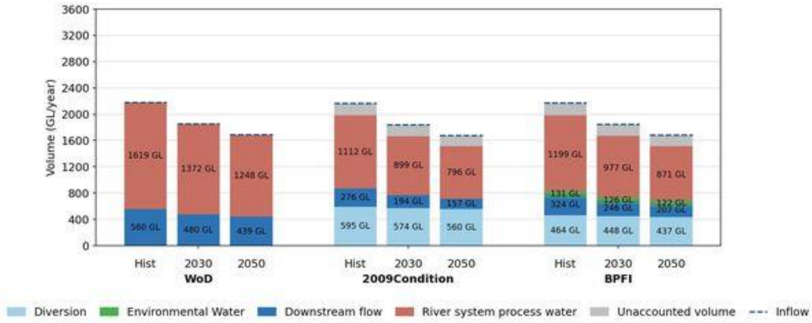
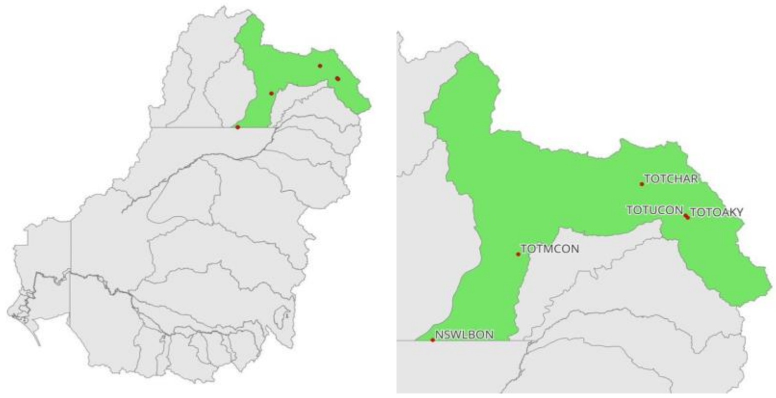


Figure R12: Stacked bar chart showing the annual total volumes of the Condamine Balonne Basin system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	2,180	560	–	1,619	–	–
	S3	1,852	480	–	1,372	–	-15
	S6	1,688	439	–	1,248	–	-23
Jun-09	*Hist*	2,170	276	595	1,112	–	–
	S3	1,842	194	574	899	–	-15
	S6	1,679	157	560	796	–	-23
BPFI	*Hist*	2,174	324	464	1,199	131	–
	S3	1,846	246	448	977	126	-15
	S6	1,683	207	437	871	123	-23

Upper Condamine River (part of the Condamine-Balonne Basin) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

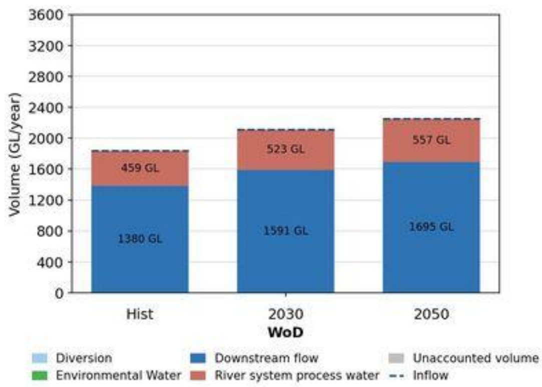


Figure R13: Stacked bar chart showing the annual total volumes of the Upper Condamine River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,838	1,380	–	459	–	–
	S1	2,114	1,591	–	523	–	15
	S4	2,252	1,695	–	557	–	23
Jun-09	*Hist*	–	–	–	–	–	–
	S1	–	–	–	–	–	–
	S4	–	–	–	–	–	–
BPFI	*Hist*	–	–	–	–	–	–
	S1	–	–	–	–	–	–
	S4	–	–	–	–	–	–

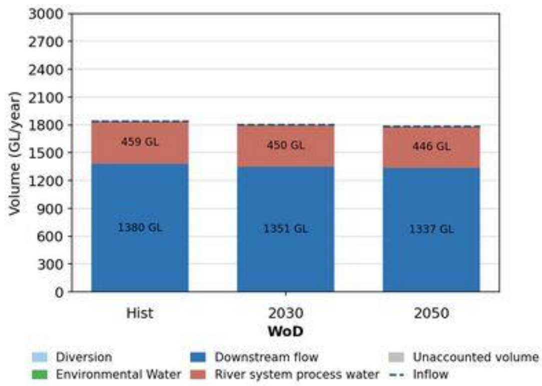


Figure R14: Stacked bar chart showing the annual total volumes of the Upper Condamine River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,838	1,380	–	459	–	–
	S2	1,801	1,351	–	450	–	-2
	S5	1,783	1,337	–	446	–	-3
Jun-09	*Hist*	–	–	–	–	–	–
	S2	–	–	–	–	–	–
	S5	–	–	–	–	–	–
BPFI	*Hist*	–	–	–	–	–	–
	S2	–	–	–	–	–	–
	S5	–	–	–	–	–	–

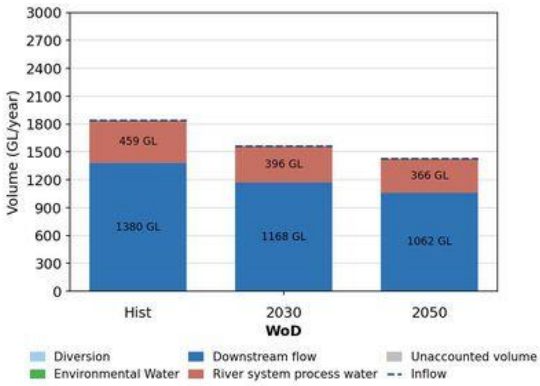
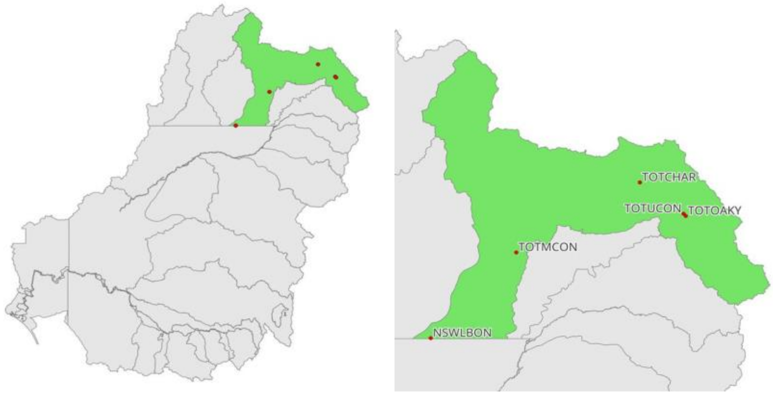


Figure R15: Stacked bar chart showing the annual total volumes of the Upper Condamine River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,838	1,380	–	459	–	–
	S3	1,564	1,168	–	396	–	-15
	S6	1,428	1,062	–	366	–	-22
Jun-09	*Hist*	–	–	–	–	–	–
	S3	–	–	–	–	–	–
	S6	–	–	–	–	–	–
BPFI	*Hist*	–	–	–	–	–	–
	S3	–	–	–	–	–	–
	S6	–	–	–	–	–	–

Oakey Gowrie Creek (part of the Condamine-Balonne Basin) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

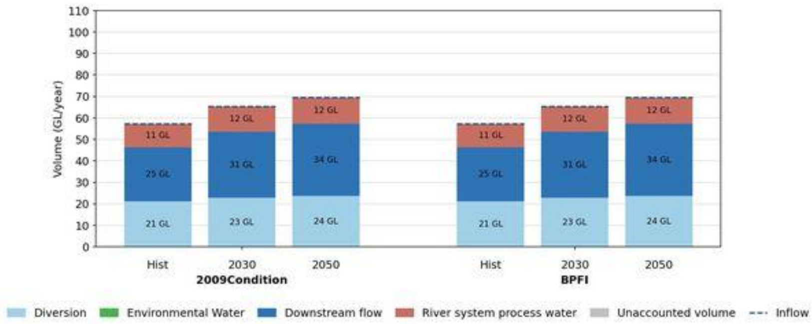


Figure R16: Stacked bar chart showing the annual total volumes of the Oakey Gowrie Creek system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S1	–	–	–	–	–	–
	S4	–	–	–	–	–	–
Jun-09	*Hist*	57	25	21	11	–	–
	S1	65	31	23	12	–	14
	S4	70	34	24	12	–	23
BPFI	*Hist*	57	25	21	11	0	–
	S1	65	31	23	12	0	14
	S4	70	34	24	12	0	23

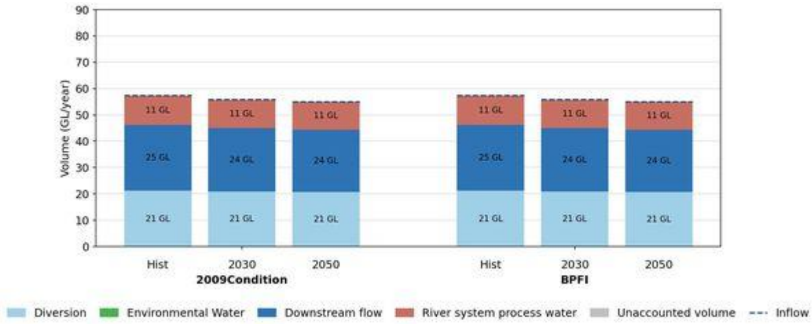


Figure R17: Stacked bar chart showing the annual total volumes of the Oakey Gowrie Creek system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S2	–	–	–	–	–	–
	S5	–	–	–	–	–	–
Jun-09	*Hist*	57	25	21	11	–	–
	S2	56	24	21	11	–	-2
	S5	55	24	21	11	–	-4
BPFI	*Hist*	57	25	21	11	0	–
	S2	56	24	21	11	0	-2
	S5	55	24	21	11	0	-4

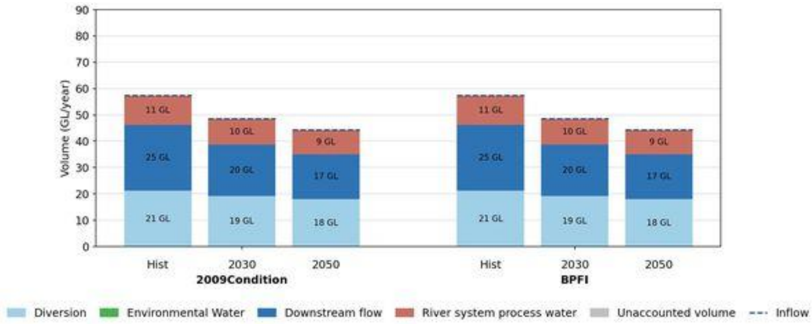
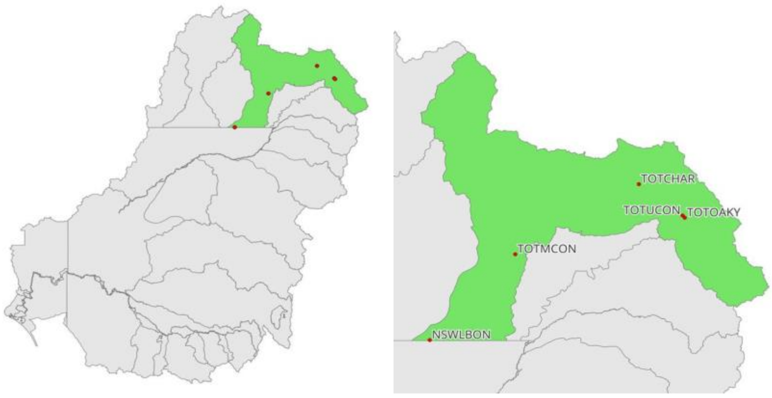


Figure R18: Stacked bar chart showing the annual total volumes of the Oakey Gowrie Creek system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	–	–	–	–	–	–
	S3	–	–	–	–	–	–
	S6	–	–	–	–	–	–
Jun-09	*Hist*	57	25	21	11	–	–
	S3	49	20	19	10	–	-14
	S6	44	17	18	9	–	-23
BPFI	*Hist*	57	25	21	11	0	–
	S3	49	20	19	10	0	-14
	S6	44	17	18	9	0	-23

Charleys Creek (part of the Condamine-Balonne Basin) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

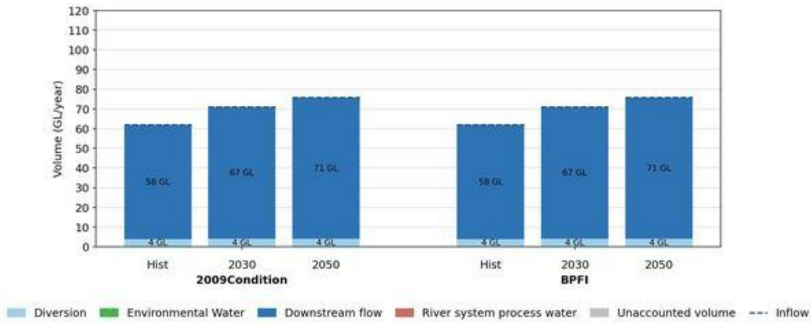


Figure R19: Stacked bar chart showing the annual total volumes of the Charleys Creek system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S1	–	–	–	–	–	–
	S4	–	–	–	–	–	–
Jun-09	*Hist*	62	58	4	0	–	–
	S1	71	67	4	0	–	15
	S4	76	71	4	0	–	23
BPFI	*Hist*	62	58	4	0	0	–
	S1	71	67	4	0	0	15
	S4	76	71	4	0	0	23

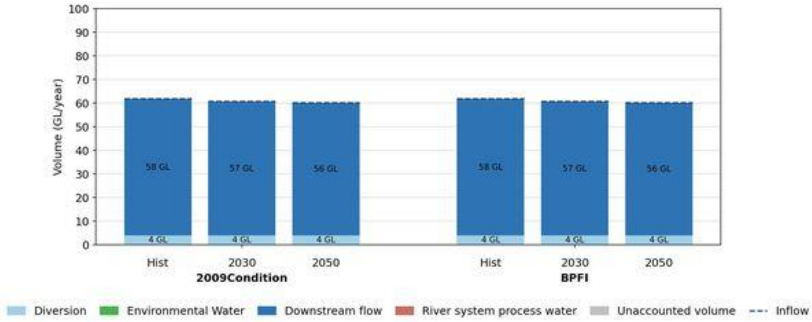


Figure R20: Stacked bar chart showing the annual total volumes of the Charleys Creek system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S2	–	–	–	–	–	–
	S5	–	–	–	–	–	–
Jun-09	*Hist*	62	58	4	0	–	–
	S2	61	57	4	0	–	-2
	S5	60	56	4	0	–	-3
BPFI	*Hist*	62	58	4	0	0	–
	S2	61	57	4	0	0	-2
	S5	60	56	4	0	0	-3

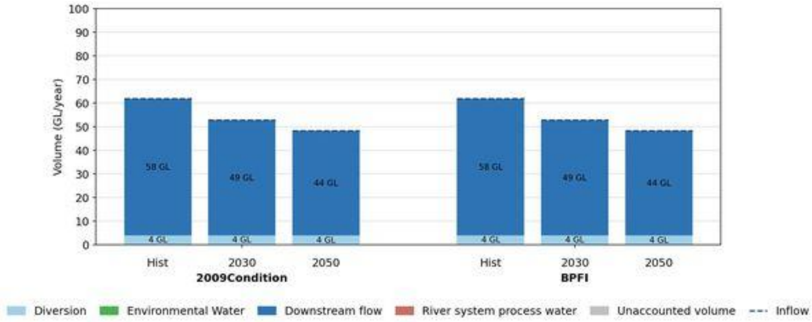
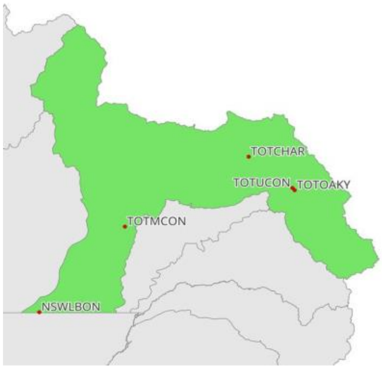


Figure R21: Stacked bar chart showing the annual total volumes of the Charleys Creek system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S3	–	–	–	–	–	–
	S6	–	–	–	–	–	–
Jun-09	*Hist*	62	58	4	0	–	–
	S3	53	49	4	0	–	-15
	S6	48	44	4	0	–	-23
BPFI	*Hist*	62	58	4	0	0	–
	S3	53	49	4	0	0	-15
	S6	48	44	4	0	0	-23

Lower Balonne River (part of the Condamine-Balonne Basin) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

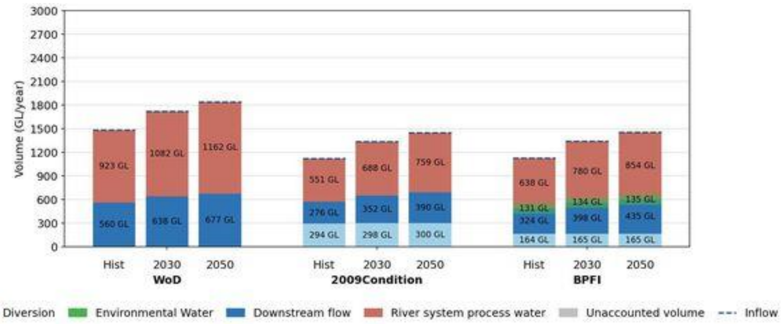


Figure R22: Stacked bar chart showing the annual total volumes of the Lower Balonne River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,484	560	–	923	–	–
	S1	1,721	638	–	1,082	–	16
	S4	1,840	677	–	1,162	–	24
Jun-09	*Hist*	1,121	276	294	551	–	–
	S1	1,338	352	298	688	–	19
	S4	1,449	390	300	759	–	29
BPFI	*Hist*	1,125	324	164	638	130	–
	S1	1,343	398	165	780	133	19
	S4	1,454	435	165	854	135	29

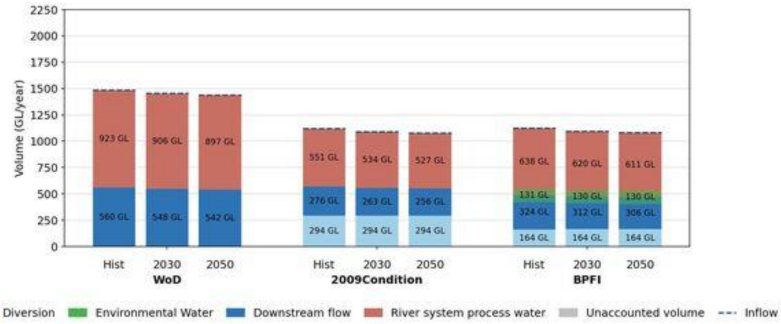


Figure R23: Stacked bar chart showing the annual total volumes of the Lower Balonne River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,484	560	–	923	–	–
	S2	1,454	548	–	906	–	-2
	S5	1,440	542	–	897	–	-3
Jun-09	*Hist*	1,121	276	294	551	–	–
	S2	1,092	263	294	534	–	-3
	S5	1,078	256	294	527	–	-4
BPFI	*Hist*	1,125	324	164	638	130	–
	S2	1,096	312	164	620	130	-3
	S5	1,082	306	164	611	130	-4

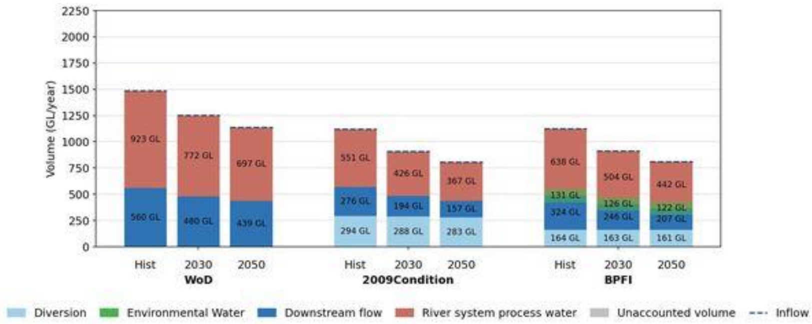
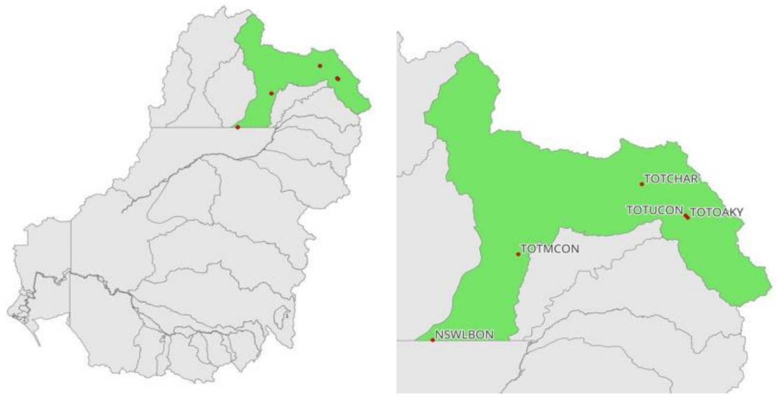


Figure R24: Stacked bar chart showing the annual total volumes of the Lower Balonne River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,484	560	–	923	–	–
	S3	1,252	480	–	772	–	-16
	S6	1,137	439	–	697	–	-23
Jun-09	*Hist*	1,121	276	294	551	–	–
	S3	909	194	288	426	–	-19
	S6	806	157	283	367	–	-28
BPFI	*Hist*	1,125	324	164	638	130	–
	S3	913	246	163	504	125	-19
	S6	810	207	161	442	122	-28

Middle Condamine River (part of the Condamine-Balonne Basin) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

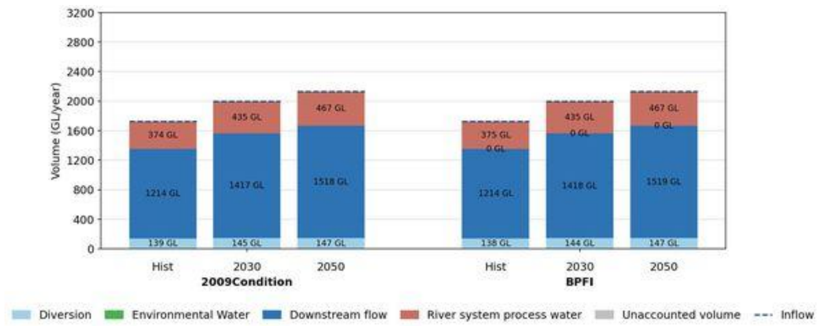


Figure R25: Stacked bar chart showing the annual total volumes of the Middle Condamine River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	–	–	–	–	–	–
	S1	–	–	–	–	–	–
	S4	–	–	–	–	–	–
Jun-09	Hist	1,727	1,214	139	374	–	–
	S1	1,997	1,417	145	435	–	16
	S4	2,132	1,518	147	467	–	23
BPFI	Hist	1,728	1,214	138	375	1	–
	S1	1,997	1,418	144	435	1	16
	S4	2,132	1,519	147	467	0	23

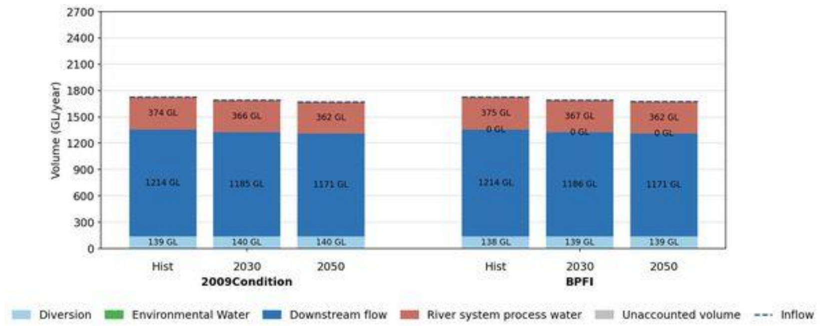


Figure R26: Stacked bar chart showing the annual total volumes of the Middle Condamine River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	–	–	–	–	–	–
	S2	–	–	–	–	–	–
	S5	–	–	–	–	–	–
Jun-09	Hist	1,727	1,214	139	374	–	–
	S2	1,691	1,185	140	366	–	-2
	S5	1,673	1,171	140	362	–	-3
BPFI	Hist	1,728	1,214	138	375	1	–
	S2	1,691	1,186	139	367	1	-2
	S5	1,673	1,171	139	362	1	-3

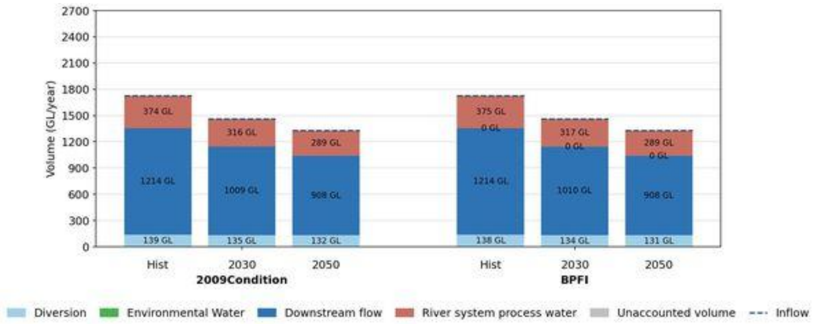
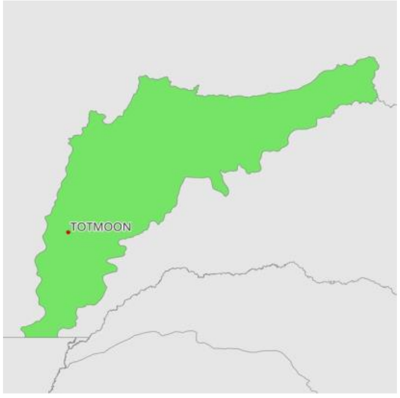


Figure R27: Stacked bar chart showing the annual total volumes of the Middle Condamine River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	–	–	–	–	–	–
	S3	–	–	–	–	–	–
	S6	–	–	–	–	–	–
Jun-09	*Hist*	1,727	1,214	139	374	–	–
	S3	1,461	1,009	135	316	–	-15
	S6	1,328	908	132	289	–	-23
BPFI	*Hist*	1,728	1,214	138	375	1	–
	S3	1,461	1,010	134	317	1	-15
	S6	1,329	908	131	289	1	-23

Moonie River – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

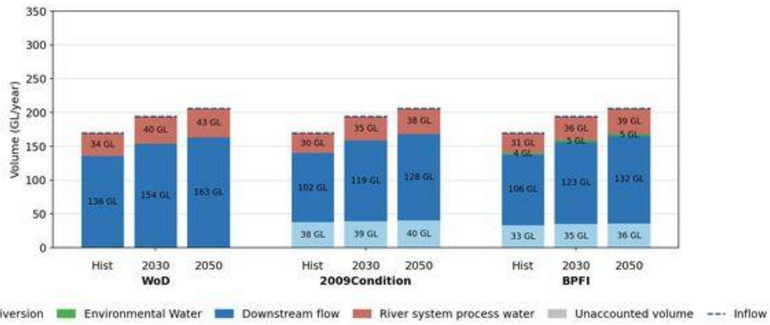


Figure R28: Stacked bar chart showing the annual total volumes of the Moonie River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	170	136	0	34	–	–
	S1	194	154	0	40	–	14
	S4	206	163	0	43	–	21
Jun-09	*Hist*	170	102	38	30	–	–
	S1	194	119	39	35	–	14
	S4	206	128	40	38	–	21
BPFI	*Hist*	170	106	33	31	5	–
	S1	194	123	35	36	4	14
	S4	206	132	36	39	4	21

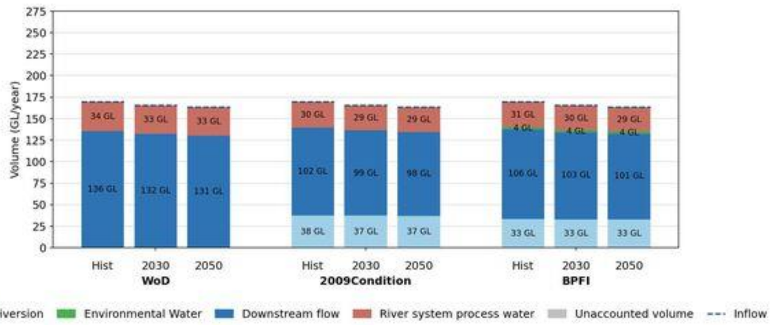


Figure R29: Stacked bar chart showing the annual total volumes of the Moonie River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	170	136	0	34	–	–
	S2	165	132	0	33	–	-3
	S5	163	131	0	33	–	-4
Jun-09	*Hist*	170	102	38	30	–	–
	S2	165	99	37	29	–	-3
	S5	163	98	37	29	–	-4
BPFI	*Hist*	170	106	33	31	5	–
	S2	165	103	33	30	4	-3
	S5	163	101	33	29	4	-4

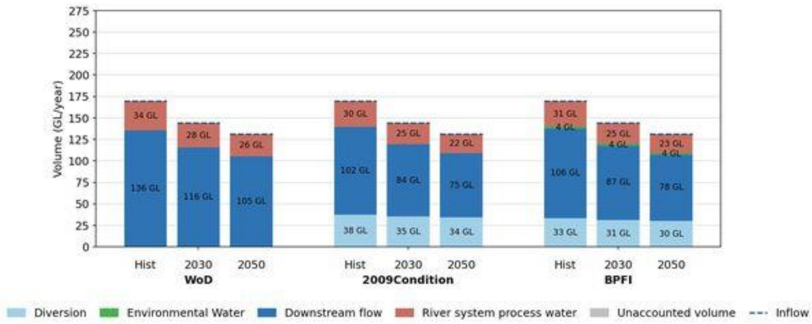
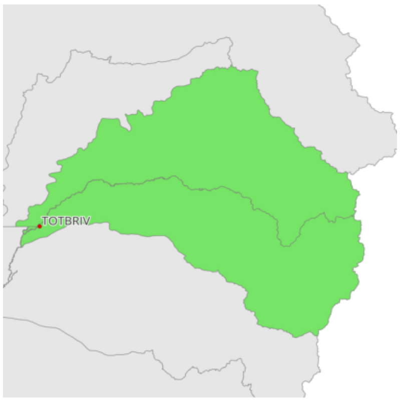


Figure R30: Stacked bar chart showing the annual total volumes of the Moonie River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	170	136	0	34	–	–
	S3	144	116	0	28	–	-15
	S6	131	105	0	26	–	-23
Jun-09	*Hist*	170	102	38	30	–	–
	S3	144	84	35	25	–	-15
	S6	131	75	34	22	–	-23
BPFI	*Hist*	170	106	33	31	5	–
	S3	144	87	31	25	4	-15
	S6	131	78	30	23	4	-23

Border Rivers – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

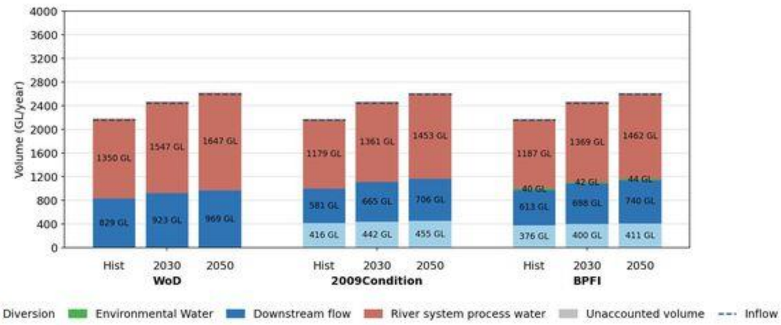


Figure R31: Stacked bar chart showing the annual total volumes of the Border River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,162	829	0	1,350	–	–
	S1	2,449	923	0	1,547	–	13
	S4	2,592	969	0	1,647	–	20
Jun-09	*Hist*	2,162	581	416	1,179	–	–
	S1	2,449	665	442	1,361	–	13
	S4	2,592	706	455	1,453	–	20
BPFI	*Hist*	2,162	613	376	1,187	40	–
	S1	2,449	698	400	1,369	42	13
	S4	2,592	740	411	1,462	44	20

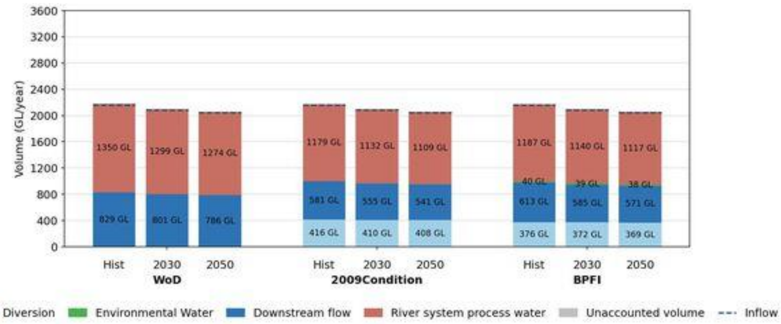


Figure R32: Stacked bar chart showing the annual total volumes of the Border River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,162	829	0	1,350	–	–
	S2	2,083	801	0	1,299	–	-4
	S5	2,043	786	0	1,274	–	-6
Jun-09	*Hist*	2,162	581	416	1,179	–	–
	S2	2,083	555	410	1,132	–	-4
	S5	2,043	541	408	1,109	–	-6
BPFI	*Hist*	2,162	613	376	1,187	40	–
	S2	2,083	585	372	1,140	38	-4
	S5	2,043	571	369	1,117	39	-6

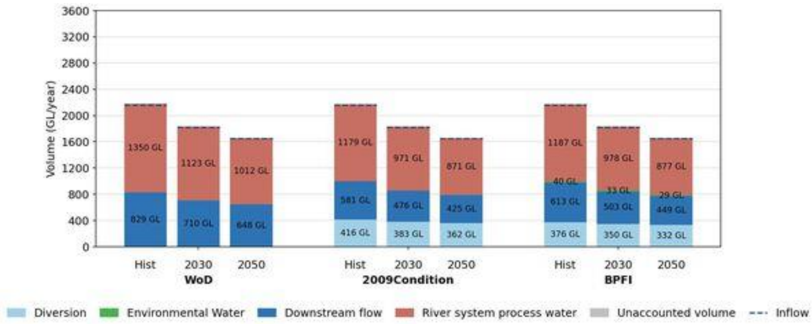
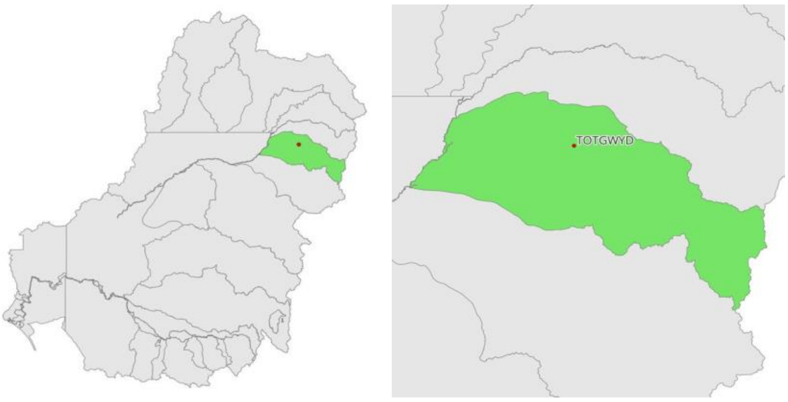


Figure R33: Stacked bar chart showing the annual total volumes of the Border River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,162	829	0	1,350	–	–
	S3	1,820	710	0	1,123	–	-16
	S6	1,649	648	0	1,012	–	-24
Jun-09	*Hist*	2,162	581	416	1,179	–	–
	S3	1,820	476	383	971	–	-16
	S6	1,649	425	362	871	–	-24
BPFI	*Hist*	2,162	613	376	1,187	40	–
	S3	1,820	503	350	978	33	-16
	S6	1,649	449	332	877	30	-24

Gwydir River – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

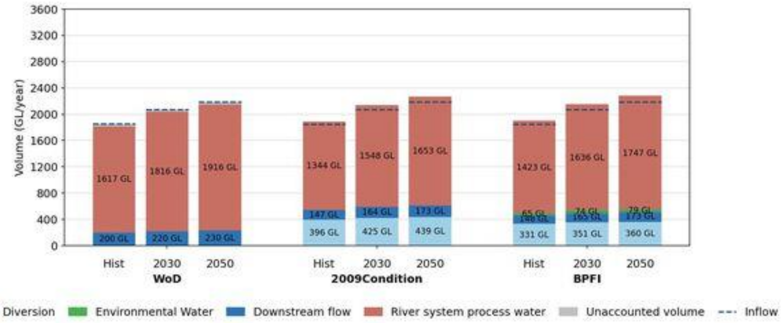


Figure R34: Stacked bar chart showing the annual total volumes of the Gwydir River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,851	200	–	1,617	–	–
	S1	2,073	220	–	1,816	–	12
	S4	2,185	230	–	1,916	–	18
Jun-09	*Hist*	1,851	147	396	1,344	–	–
	S1	2,073	164	425	1,548	–	12
	S4	2,184	173	439	1,653	–	18
BPFI	*Hist*	1,851	148	331	1,423	65	–
	S1	2,073	165	351	1,636	74	12
	S4	2,184	173	360	1,747	79	18

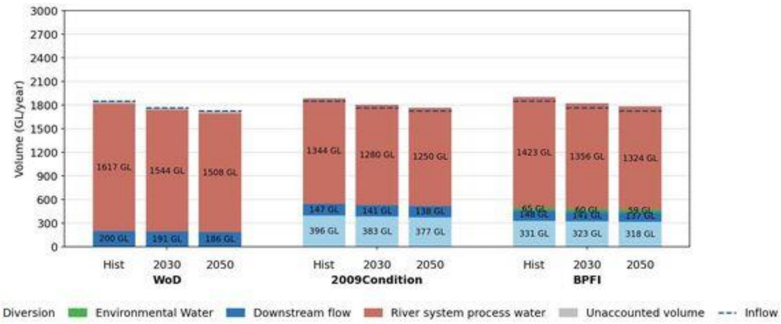


Figure R35: Stacked bar chart showing the annual total volumes of the Gwydir River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,851	200	–	1,617	–	–
	S2	1,768	191	–	1,544	–	-4
	S5	1,727	186	–	1,508	–	-7
Jun-09	*Hist*	1,851	147	396	1,344	–	–
	S2	1,768	141	383	1,280	–	-4
	S5	1,727	138	377	1,250	–	-7
BPFI	*Hist*	1,851	148	331	1,423	65	–
	S2	1,768	141	323	1,356	60	-4
	S5	1,727	137	318	1,324	59	-7

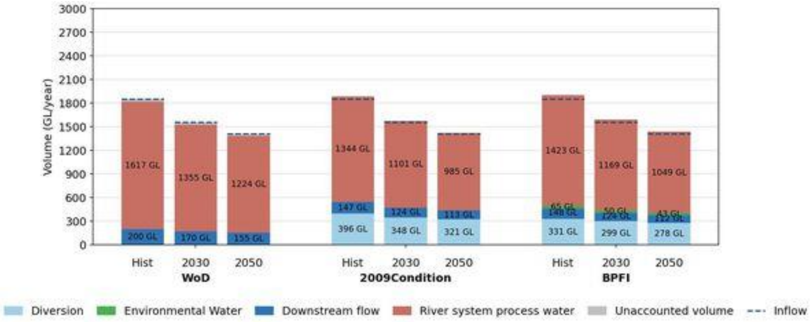


Figure R36: Stacked bar chart showing the annual total volumes of the Gwydir River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	1,851	200	–	1,617	–	–
	S3	1,556	170	–	1,355	–	-16
	S6	1,408	155	–	1,224	–	-24
Jun-09	*Hist*	1,851	147	396	1,344	–	–
	S3	1,556	124	348	1,101	–	-16
	S6	1,408	113	321	985	–	-24
BPFI	*Hist*	1,851	148	331	1,423	65	–
	S3	1,556	124	299	1,169	49	-16
	S6	1,408	112	278	1,049	43	-24

Namoi River (including Peel River) – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

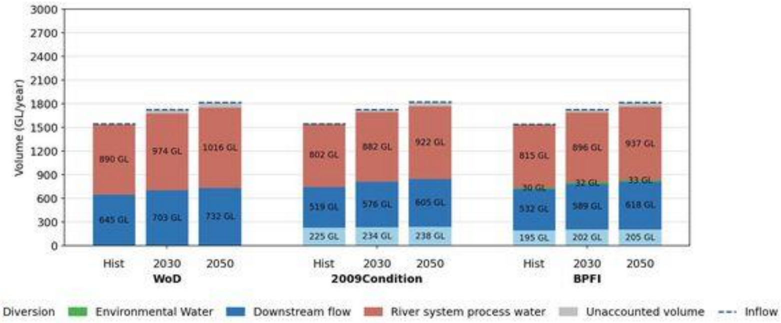


Figure R37: Stacked bar chart showing the annual total volumes of the Namoi River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,544	645	0	890	–	–
	S1	1,725	703	0	974	–	12
	S4	1,815	732	0	1,016	–	18
Jun-09	*Hist*	1,545	519	225	802	–	–
	S1	1,729	576	234	882	–	12
	S4	1,821	605	238	922	–	18
BPFI	*Hist*	1,542	532	195	815	30	–
	S1	1,726	589	202	896	32	12
	S4	1,819	618	205	937	33	18

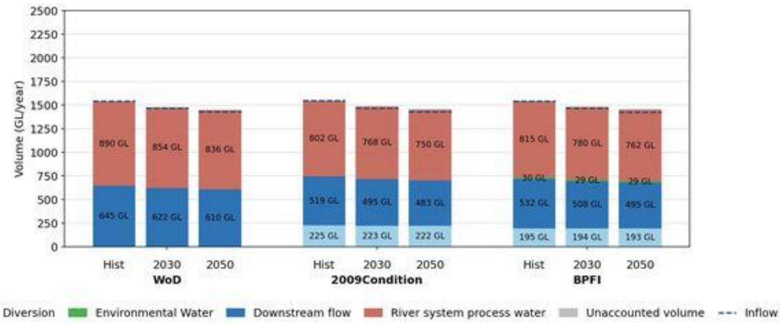


Figure R38: Stacked bar chart showing the annual total volumes of the Namoi River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,544	645	0	890	–	–
	S2	1,468	622	0	854	–	-5
	S5	1,429	610	0	836	–	-7
Jun-09	*Hist*	1,545	519	225	802	–	–
	S2	1,467	495	223	768	–	-5
	S5	1,428	483	222	750	–	-8
BPFI	*Hist*	1,542	532	195	815	30	–
	S2	1,465	508	194	780	29	-5
	S5	1,426	495	193	762	29	-8

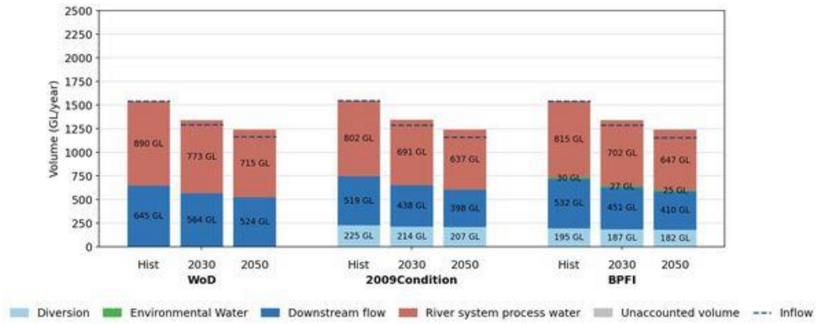


Figure R39: Stacked bar chart showing the annual total volumes of the Namoi River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,544	645	0	890	–	–
	S3	1,292	564	0	773	–	-16
	S6	1,165	524	0	715	–	-25
Jun-09	*Hist*	1,545	519	225	802	–	–
	S3	1,288	438	214	691	–	-17
	S6	1,159	398	207	637	–	-25
BPFI	*Hist*	1,542	532	195	815	30	–
	S3	1,286	451	187	702	27	-17
	S6	1,157	410	182	647	25	-25

Peel River – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

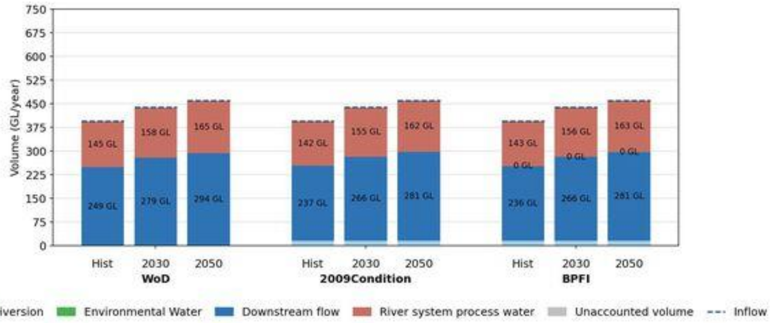


Figure R40: Stacked bar chart showing the annual total volumes of the Peel River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	395	249	–	145	–	–
	S1	438	279	–	158	–	11
	S4	460	294	–	165	–	16
Jun-09	*Hist*	395	237	16	142	–	–
	S1	438	266	16	155	–	11
	S4	460	281	16	162	–	16
BPFI	*Hist*	395	236	16	143	0	–
	S1	438	266	16	156	0	11
	S4	460	281	16	163	0	16

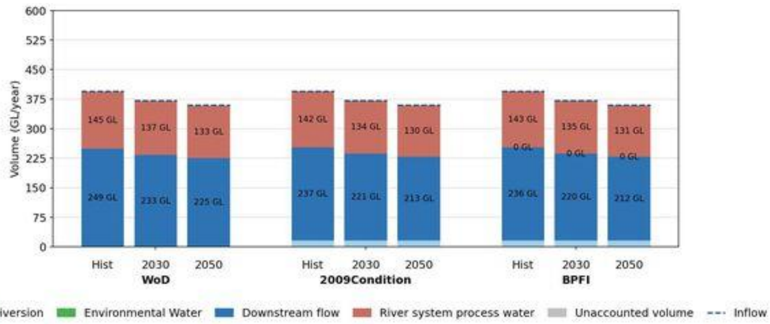


Figure R41: Stacked bar chart showing the annual total volumes of the Peel River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	395	249	–	145	–	–
	S2	372	233	–	137	–	-6
	S5	360	225	–	133	–	-9
Jun-09	*Hist*	395	237	16	142	–	–
	S2	372	221	16	134	–	-6
	S5	360	213	16	130	–	-9
BPFI	*Hist*	395	236	16	143	0	–
	S2	372	220	16	135	0	-6
	S5	360	212	16	131	0	-9

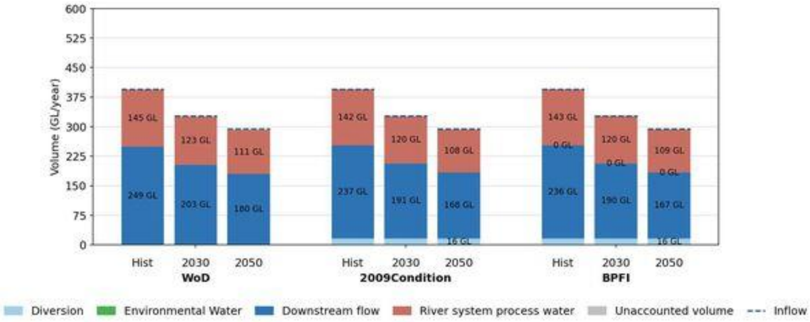


Figure R42: Stacked bar chart showing the annual total volumes of the Peel River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	395	249	–	145	–	–
	S3	328	203	–	123	–	-17
	S6	294	180	–	111	–	-26
Jun-09	*Hist*	395	237	16	142	–	–
	S3	328	191	16	120	–	-17
	S6	294	168	16	108	–	-26
BPFI	*Hist*	395	236	16	143	0	–
	S3	328	190	16	120	0	-17
	S6	294	167	16	109	0	-26

Macquarie River – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

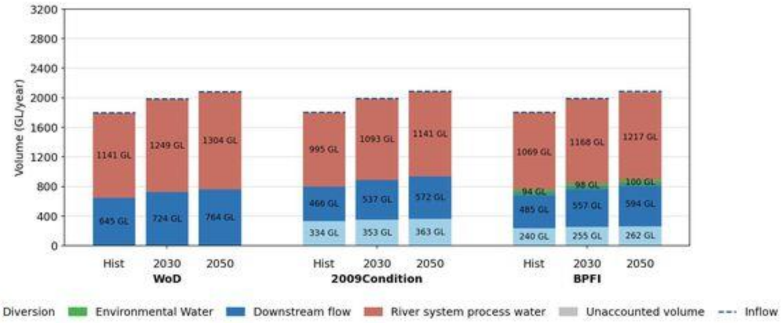


Figure R43: Stacked bar chart showing the annual total volumes of the Macquarie River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,801	645	–	1,141	–	–
	S1	1,989	724	–	1,249	–	10
	S4	2,083	764	–	1,304	–	16
Jun-09	*Hist*	1,807	466	334	995	–	–
	S1	1,995	537	353	1,093	–	10
	S4	2,089	572	363	1,141	–	16
BPFI	*Hist*	1,807	485	240	1,069	94	–
	S1	1,995	557	255	1,168	98	10
	S4	2,089	594	262	1,217	101	16

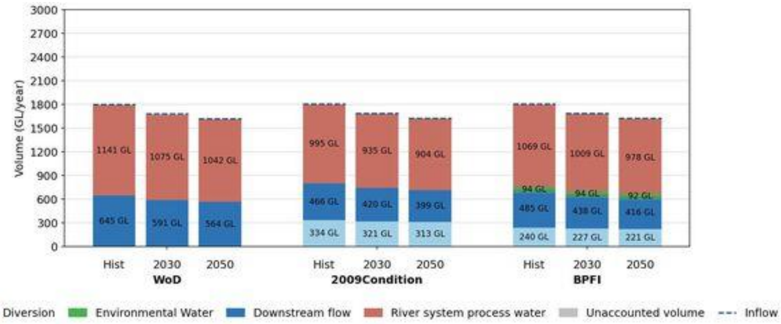


Figure R44: Stacked bar chart showing the annual total volumes of the Macquarie River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,801	645	–	1,141	–	–
	S2	1,681	591	–	1,075	–	-7
	S5	1,621	564	–	1,042	–	-10
Jun-09	*Hist*	1,807	466	334	995	–	–
	S2	1,687	420	321	935	–	-7
	S5	1,627	399	313	904	–	-10
BPFI	*Hist*	1,807	485	240	1,069	94	–
	S2	1,687	438	227	1,009	94	-7
	S5	1,627	416	221	978	92	-10

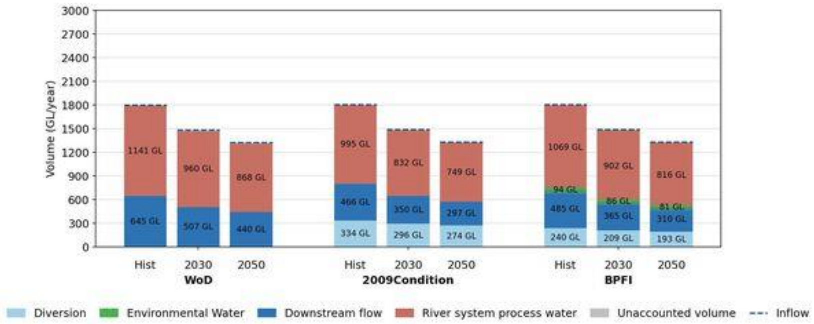
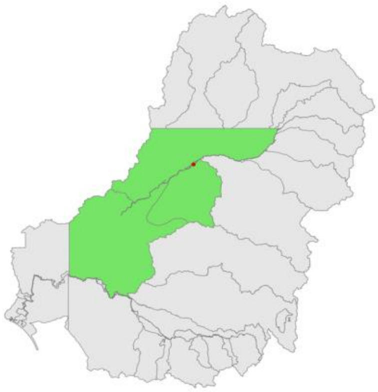
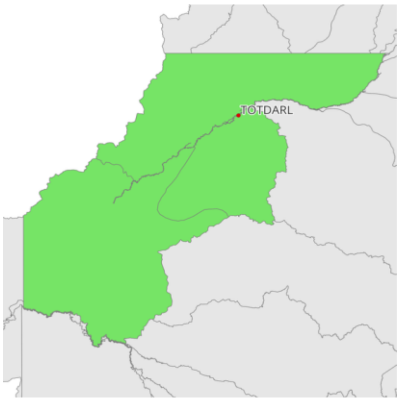


Figure R45: Stacked bar chart showing the annual total volumes of the Macquarie River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	1,801	645	–	1,141	–	–
	S3	1,482	507	–	960	–	-18
	S6	1,323	440	–	868	–	-27
Jun-09	*Hist*	1,807	466	334	995	–	–
	S3	1,487	350	296	832	–	-18
	S6	1,328	297	274	749	–	-27
BPFI	*Hist*	1,807	485	240	1,069	94	–
	S3	1,487	365	209	902	87	-18
	S6	1,328	310	193	816	81	-27

Darling River – Water Balance Report Card





Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

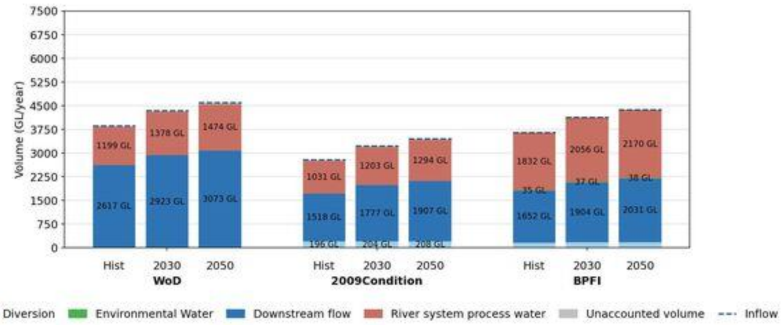


Figure R46: Stacked bar chart showing the annual total volumes of the Darling River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	3,863	2,617	–	1,199	–	–
	S1	4,351	2,923	–	1,378	–	13
	S4	4,598	3,073	–	1,474	–	19
Jun-09	Hist	2,785	1,518	196	1,031	–	–
	S1	3,227	1,777	204	1,203	–	16
	S4	3,453	1,907	208	1,294	–	24
BPFI	Hist	3,657	1,652	161	1,832	35	–
	S1	4,138	1,904	167	2,056	37	13
	S4	4,379	2,031	170	2,170	38	20

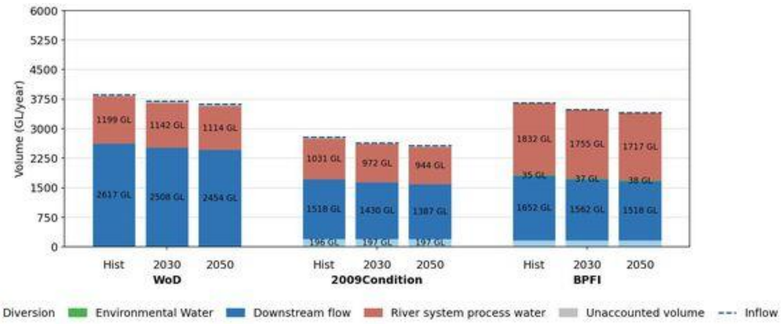


Figure R47: Stacked bar chart showing the annual total volumes of the Darling River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	3,863	2,617	–	1,199	–	–
	S2	3,699	2,508	–	1,142	–	-4
	S5	3,617	2,454	–	1,114	–	-6
Jun-09	Hist	2,785	1,518	196	1,031	–	–
	S2	2,641	1,430	197	972	–	-5
	S5	2,570	1,387	197	944	–	-8
BPFI	Hist	3,657	1,652	161	1,832	35	–
	S2	3,492	1,562	160	1,755	37	-5
	S5	3,410	1,518	160	1,717	37	-7

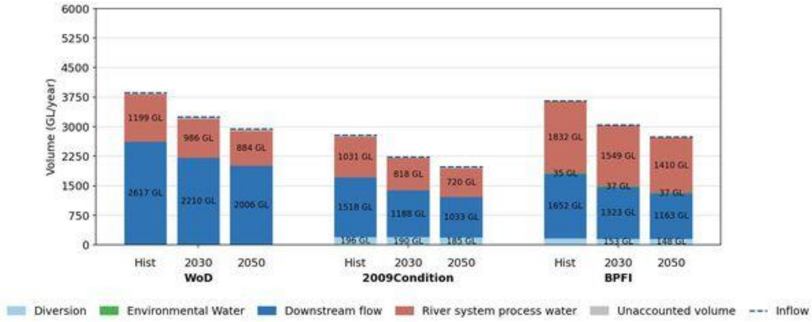


Figure R48: Stacked bar chart showing the annual total volumes of the Darling River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,863	2,617	–	1,199	–	–
	S3	3,245	2,210	–	986	–	-16
	S6	2,938	2,006	–	884	–	-24
Jun-09	*Hist*	2,785	1,518	196	1,031	–	–
	S3	2,236	1,188	190	818	–	-20
	S6	1,978	1,033	185	720	–	-29
BPFI	*Hist*	3,657	1,652	161	1,832	35	–
	S3	3,040	1,323	153	1,549	37	-17
	S6	2,736	1,163	148	1,410	37	-25

Belubula River (part of the Lachlan River) – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

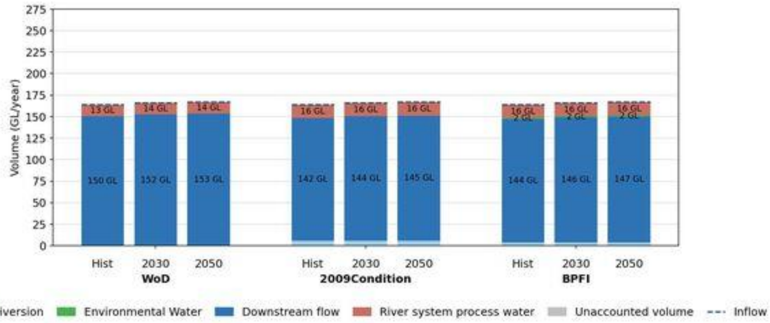


Figure R49: Stacked bar chart showing the annual total volumes of the Belubula River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	164	150	0	13	–	–
	S1	166	152	0	14	–	1
	S4	167	153	0	14	–	2
Jun-09	Hist	164	142	6	16	–	–
	S1	166	144	6	16	–	1
	S4	167	145	6	16	–	2
BPFI	Hist	164	144	4	16	2	–
	S1	166	146	4	16	2	1
	S4	167	147	4	16	2	2

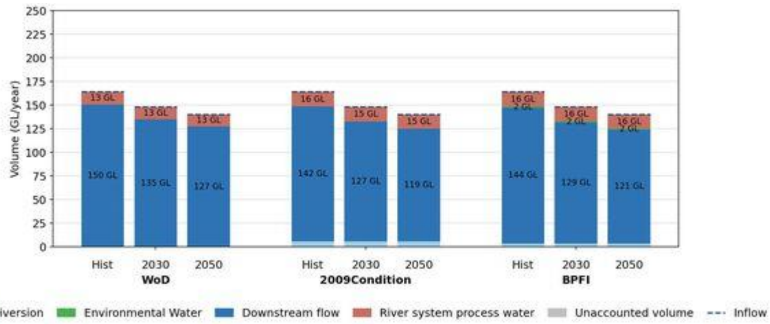


Figure R50: Stacked bar chart showing the annual total volumes of the Belubula River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	Hist	164	150	0	13	–	–
	S2	148	135	0	13	–	-10
	S5	140	127	0	13	–	-15
Jun-09	Hist	164	142	6	16	–	–
	S2	148	127	6	15	–	-10
	S5	140	119	6	15	–	-15
BPFI	Hist	164	144	4	16	2	–
	S2	148	129	3	16	3	-10
	S5	140	121	3	16	3	-15

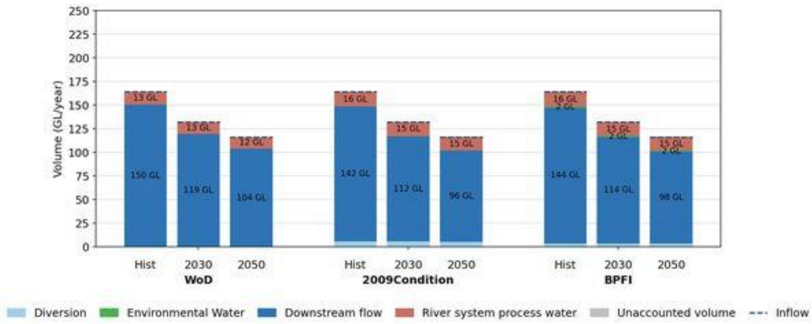


Figure R51: Stacked bar chart showing the annual total volumes of the Belubula River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	164	150	0	13	–	–
	S3	132	119	0	13	–	-20
	S6	116	104	0	12	–	-29
Jun-09	*Hist*	164	142	6	16	–	–
	S3	132	112	6	15	–	-20
	S6	116	96	5	15	–	-29
BPFI	*Hist*	164	144	4	16	2	–
	S3	132	114	3	15	3	-20
	S6	116	98	3	15	2	-29

Lachlan River (including Belubula River) – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

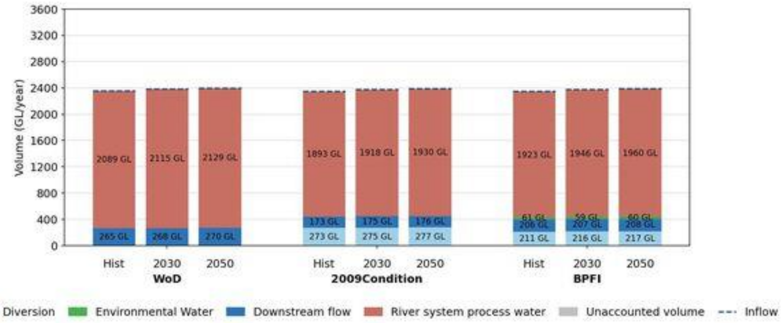


Figure R52: Stacked bar chart showing the annual total volumes of the Lachlan River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,355	265	–	2,089	–	–
	S1	2,385	268	–	2,115	–	1
	S4	2,400	270	–	2,129	–	2
Jun-09	*Hist*	2,347	173	273	1,893	–	–
	S1	2,377	175	275	1,918	–	1
	S4	2,391	176	277	1,930	–	2
BPFI	*Hist*	2,349	206	211	1,923	62	–
	S1	2,379	207	216	1,946	59	1
	S4	2,394	208	217	1,960	60	2

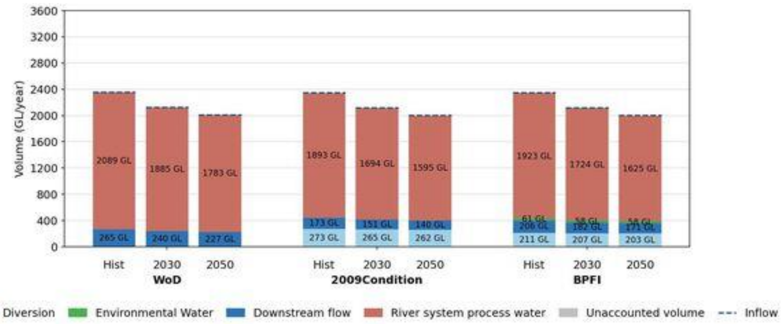


Figure R53: Stacked bar chart showing the annual total volumes of the Lachlan River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	2,355	265	–	2,089	–	–
	S2	2,126	240	–	1,885	–	-10
	S5	2,011	227	–	1,783	–	-15
Jun-09	*Hist*	2,347	173	273	1,893	–	–
	S2	2,118	151	265	1,694	–	-10
	S5	2,003	140	262	1,595	–	-15
BPFI	*Hist*	2,349	206	211	1,923	62	–
	S2	2,120	182	207	1,724	58	-10
	S5	2,005	171	203	1,625	59	-15

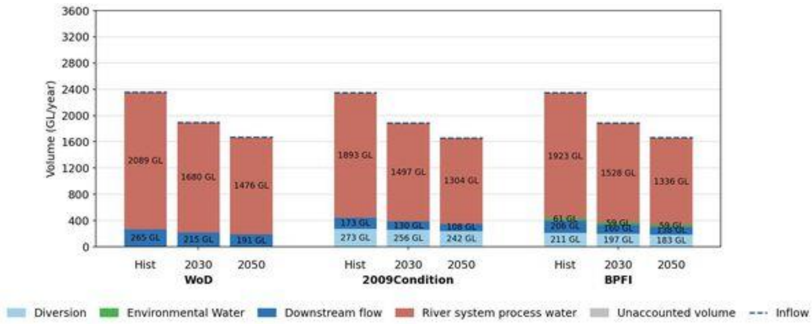


Figure R54: Stacked bar chart showing the annual total volumes of the Lachlan River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	2,355	265	–	2,089	–	–
	S3	1,897	215	–	1,680	–	-19
	S6	1,668	191	–	1,476	–	-29
Jun-09	*Hist*	2,347	173	273	1,893	–	–
	S3	1,889	130	256	1,497	–	-20
	S6	1,660	108	242	1,304	–	-29
BPFI	*Hist*	2,349	206	211	1,923	62	–
	S3	1,891	160	197	1,528	59	-19
	S6	1,662	138	183	1,336	59	-29

Wimmera River – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

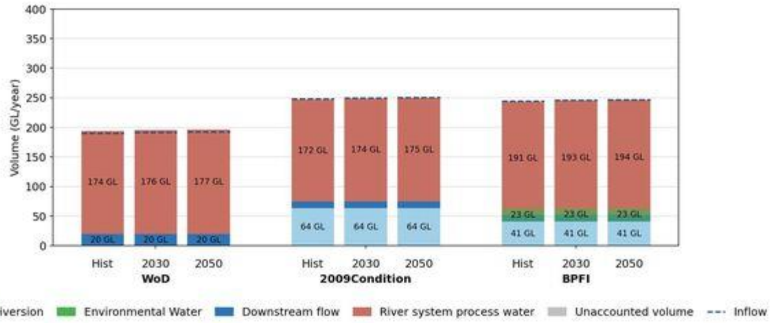


Figure R55: Stacked bar chart showing the annual total volumes of the Wimmera River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	190	20	–	174	–	–
	S1	192	20	–	176	–	1
	S4	193	20	–	177	–	2
Jun-09	*Hist*	248	11	64	172	–	–
	S1	250	11	64	174	–	1
	S4	251	11	64	175	–	1
BPFI	*Hist*	244	11	41	191	23	–
	S1	246	12	41	193	23	1
	S4	247	12	41	194	23	1

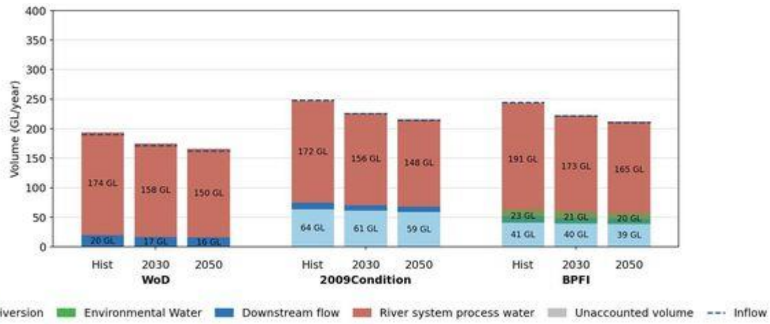


Figure R56: Stacked bar chart showing the annual total volumes of the Wimmera River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	190	20	–	174	–	–
	S2	172	17	–	158	–	-9
	S5	162	16	–	150	–	-15
Jun-09	*Hist*	248	11	64	172	–	–
	S2	225	9	61	156	–	-9
	S5	214	9	59	148	–	-14
BPFI	*Hist*	244	11	41	191	23	–
	S2	222	10	40	173	21	-9
	S5	211	9	39	165	20	-14

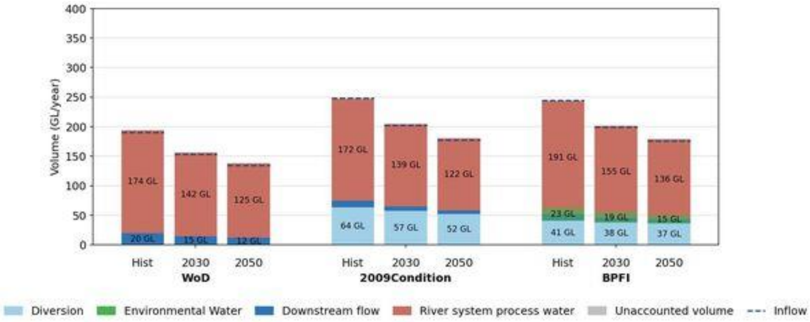


Figure R57: Stacked bar chart showing the annual total volumes of the Wimmera River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	190	20	–	174	–	–
	S3	153	15	–	142	–	-19
	S6	134	12	–	125	–	-29
Jun-09	*Hist*	248	11	64	172	–	–
	S3	202	8	57	139	–	-19
	S6	177	6	52	122	–	-29
BPFI	*Hist*	244	11	41	191	23	–
	S3	199	8	38	155	19	-18
	S6	176	6	37	136	15	-28

Murrumbidgee River – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

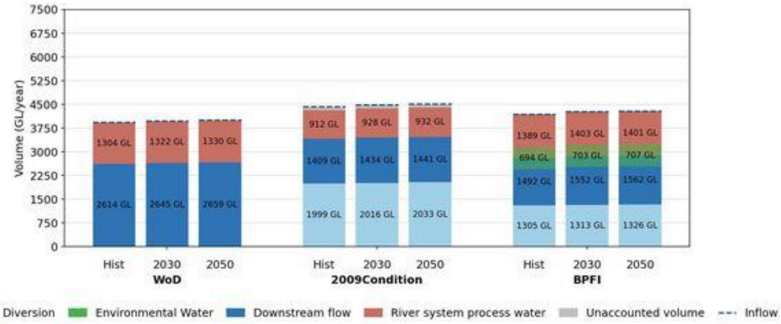


Figure R58: Stacked bar chart showing the annual total volumes of the Murrumbidgee River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,927	2,614	–	1,304	–	–
	S1	3,980	2,645	–	1,322	–	1
	S4	4,007	2,659	–	1,330	–	2
Jun-09	*Hist*	4,428	1,409	1,999	912	–	–
	S1	4,488	1,434	2,016	928	–	1
	S4	4,518	1,441	2,033	932	–	2
BPFI	*Hist*	4,194	1,492	1,305	1,389	694	–
	S1	4,276	1,552	1,313	1,403	703	2
	S4	4,293	1,562	1,326	1,401	707	2

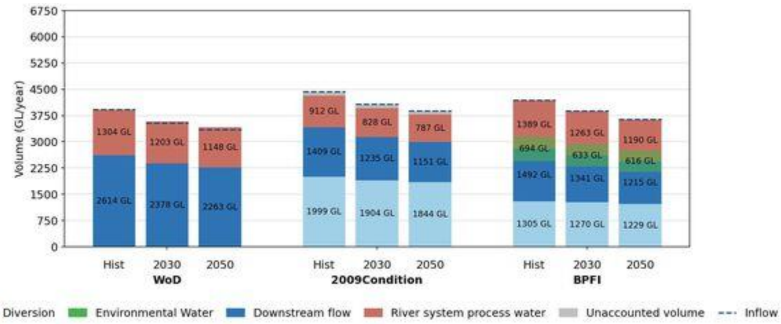


Figure R59: Stacked bar chart showing the annual total volumes of the Murrumbidgee River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,927	2,614	–	1,304	–	–
	S2	3,546	2,378	–	1,203	–	-10
	S5	3,355	2,263	–	1,148	–	-15
Jun-09	*Hist*	4,428	1,409	1,999	912	–	–
	S2	4,071	1,235	1,904	828	–	-8
	S5	3,885	1,151	1,844	787	–	-12
BPFI	*Hist*	4,194	1,492	1,305	1,389	694	–
	S2	3,879	1,341	1,270	1,263	634	-8
	S5	3,636	1,215	1,229	1,190	615	-13

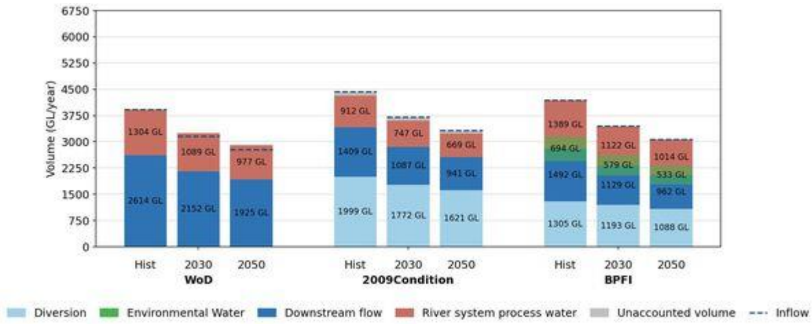
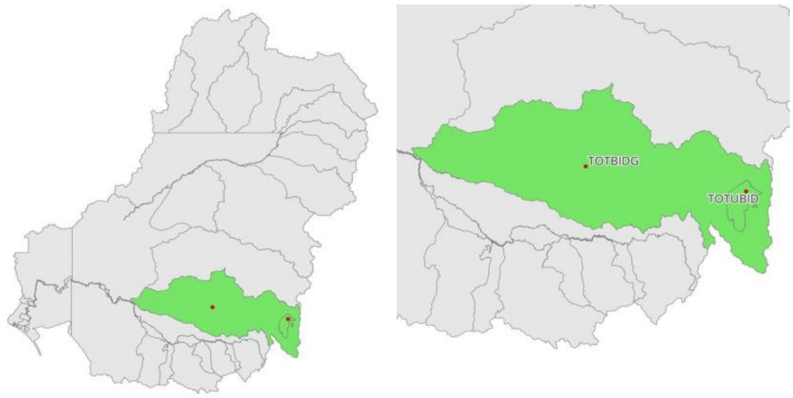


Figure R60: Stacked bar chart showing the annual total volumes of the Murrumbidgee River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,927	2,614	–	1,304	–	–
	S3	3,165	2,152	–	1,089	–	-19
	S6	2,783	1,925	–	977	–	-29
Jun-09	*Hist*	4,428	1,409	1,999	912	–	–
	S3	3,707	1,087	1,772	747	–	-16
	S6	3,329	941	1,621	669	–	-25
BPFI	*Hist*	4,194	1,492	1,305	1,389	694	–
	S3	3,448	1,129	1,193	1,122	579	-18
	S6	3,065	962	1,088	1,014	533	-27

Upper Murrumbidgee River (part of Murrumbidgee River) – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

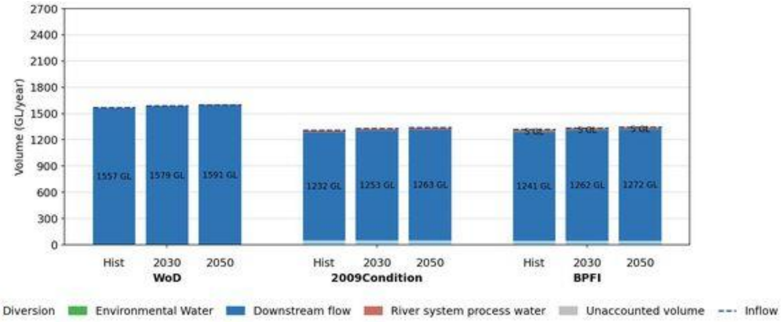


Figure R61: Stacked bar chart showing the annual total volumes of the Upper Murrumbidgee River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,568	1,557	1	8	–	–
	S1	1,590	1,579	1	12	–	1
	S4	1,602	1,591	1	11	–	2
Jun-09	*Hist*	1,310	1,232	52	20	–	–
	S1	1,331	1,253	52	20	–	2
	S4	1,341	1,263	52	20	–	2
BPFI	*Hist*	1,320	1,241	47	22	5	–
	S1	1,337	1,262	47	24	5	1
	S4	1,347	1,272	47	24	5	2

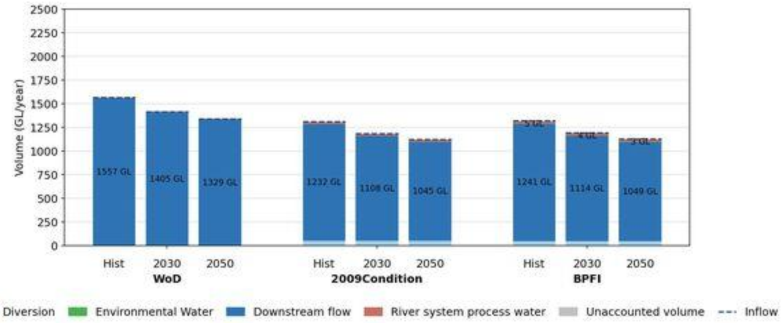


Figure R62: Stacked bar chart showing the annual total volumes of the Upper Murrumbidgee River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	1,568	1,557	1	8	–	–
	S2	1,417	1,405	1	13	–	-10
	S5	1,341	1,329	1	13	–	-14
Jun-09	*Hist*	1,310	1,232	52	20	–	–
	S2	1,185	1,108	51	21	–	-10
	S5	1,123	1,045	51	21	–	-14
BPFI	*Hist*	1,320	1,241	47	22	5	–
	S2	1,191	1,114	47	26	4	-10
	S5	1,127	1,049	48	27	3	-15

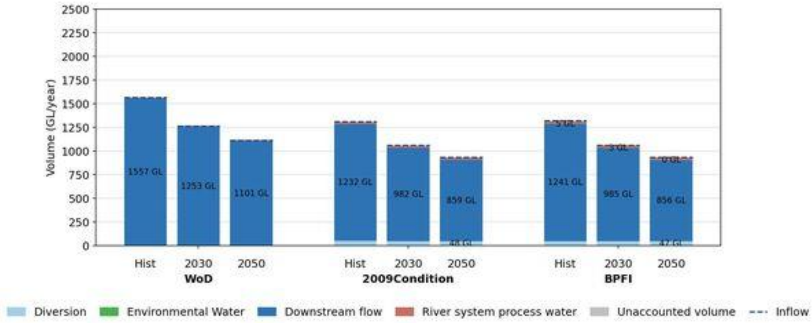
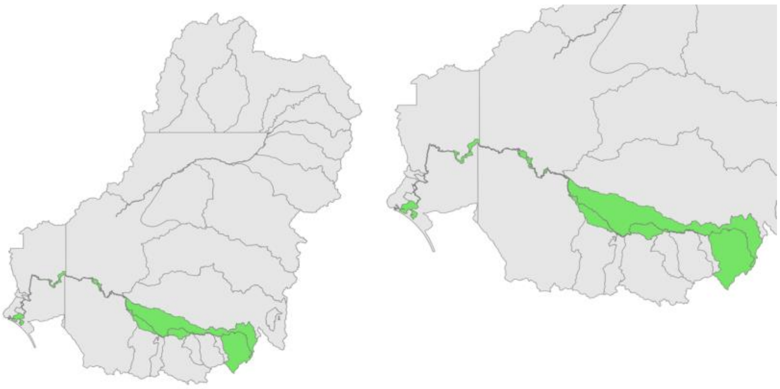


Figure R63: Stacked bar chart showing the annual total volumes of the Upper Murrumbidgee River system under S3 and S6 climate conditions

Dev scenario		**In**	**Out**	**Div**	**RSPW**	**EW**	**% Hist**
WoD	*Hist*	1,568	1,557	1	8	–	–
	S3	1,266	1,253	1	13	–	-19
	S6	1,115	1,101	1	14	–	-29
Jun-09	*Hist*	1,310	1,232	52	20	–	–
	S3	1,059	982	50	22	–	-19
	S6	934	859	48	23	–	-29
BPFI	*Hist*	1,320	1,241	47	22	5	–
	S3	1,064	985	48	27	2	-19
	S6	936	856	47	29	1	-29

Murray River – Water Balance Report Card



Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

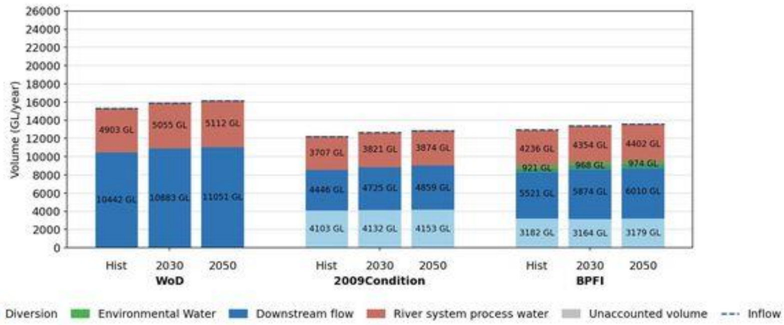


Figure R64: Stacked bar chart showing the annual total volumes of the Murray River system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	15,303	10,442	0	4,903	–	–
	S1	15,903	10,883	0	5,055	–	4
	S4	16,130	11,051	0	5,112	–	5
Jun-09	*Hist*	12,237	4,446	4,103	3,707	–	–
	S1	12,661	4,725	4,132	3,821	–	3
	S4	12,870	4,859	4,153	3,874	–	5
BPFI	*Hist*	12,929	5,521	3,182	4,236	921	–
	S1	13,384	5,874	3,164	4,354	968	4
	S4	13,586	6,010	3,179	4,402	974	5

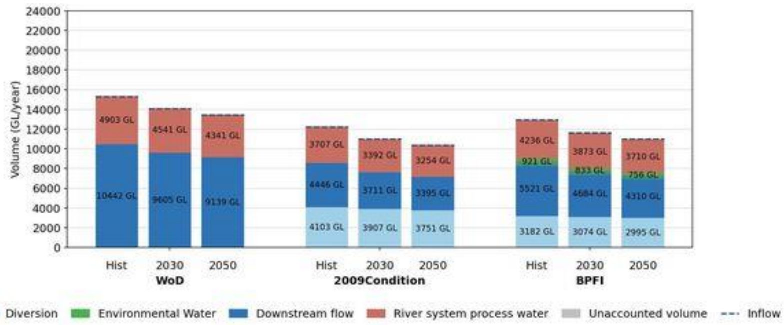


Figure R65: Stacked bar chart showing the annual total volumes of the Murray River system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	15,303	10,442	0	4,903	–	–
	S2	14,100	9,605	0	4,541	–	-8
	S5	13,431	9,139	0	4,341	–	-12
Jun-09	*Hist*	12,237	4,446	4,103	3,707	–	–
	S2	10,986	3,711	3,907	3,392	–	-10
	S5	10,375	3,395	3,751	3,254	–	-15
BPFI	*Hist*	12,929	5,521	3,182	4,236	921	–
	S2	11,621	4,684	3,074	3,873	833	-10
	S5	11,006	4,310	2,995	3,710	756	-15

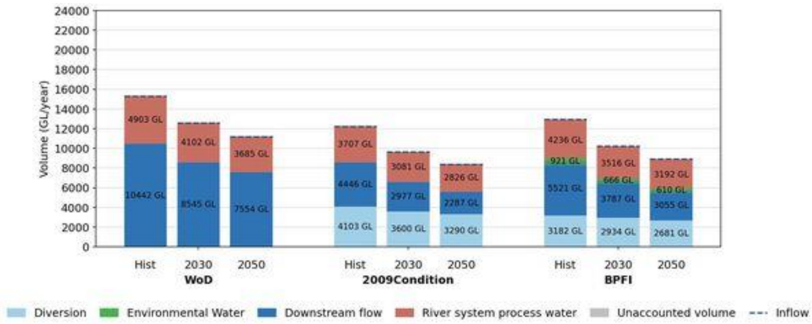


Figure R66: Stacked bar chart showing the annual total volumes of the Murray River system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	15,303	10,442	0	4,903	–	–
	S3	12,590	8,545	0	4,102	–	-18
	S6	11,168	7,554	0	3,685	–	-27
Jun-09	*Hist*	12,237	4,446	4,103	3,707	–	–
	S3	9,629	2,977	3,600	3,081	–	-21
	S6	8,368	2,287	3,290	2,826	–	-32
BPFI	*Hist*	12,929	5,521	3,182	4,236	921	–
	S3	10,226	3,787	2,934	3,516	666	-21
	S6	8,912	3,055	2,681	3,192	609	-31

Goulburn, Broken, Campaspe, Coliban River and Loddon Creek – Water Balance Report Card

Descriptions

- Historical: Hist
- Warmer and slightly wetter: S1
- Warmer and drier: S2
- Warmer and much drier: S3
- Hotter and slightly wetter: S4
- Hotter and drier: S5
- Hotter and much drier: S6
- Without development: WoD
- June 2009 Condition: Jun-09
- Basin plan fully implemented: BPFI

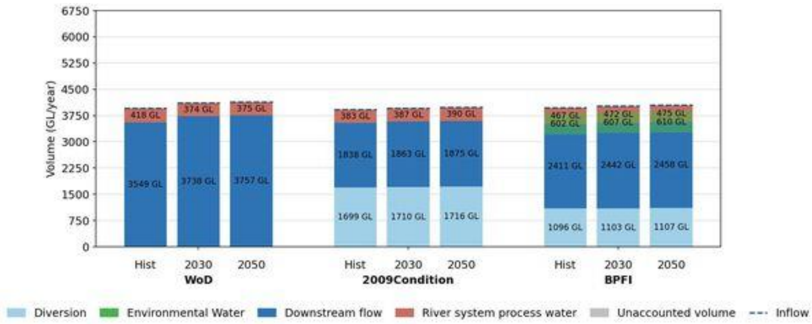


Figure R67: Stacked bar chart showing the annual total volumes of the Goulburn, Broken, Campaspe, Coliban River and Loddon Creek system under S1 and S4 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,966	3,549	–	418	–	–
	S1	4,112	3,738	–	374	–	4
	S4	4,133	3,757	–	375	–	4
Jun-09	*Hist*	3,925	1,838	1,699	383	–	–
	S1	3,967	1,863	1,710	387	–	1
	S4	3,987	1,875	1,716	390	–	2
BPFI	*Hist*	3,979	2,411	1,096	467	603	–
	S1	4,022	2,442	1,103	472	607	1
	S4	4,044	2,458	1,107	475	609	2

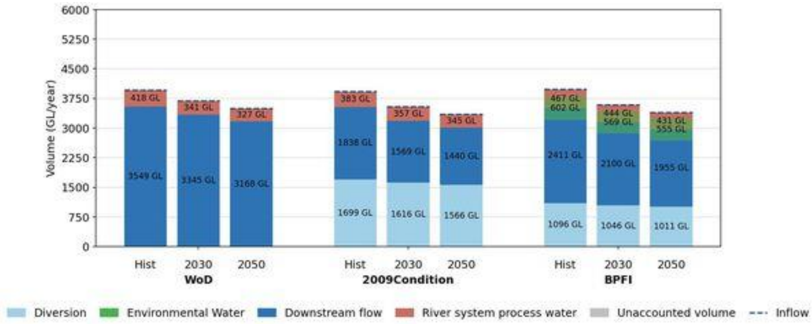


Figure R68: Stacked bar chart showing the annual total volumes of the Goulburn, Broken, Campaspe, Coliban River and Loddon Creek system under S2 and S5 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,966	3,549	–	418	–	–
	S2	3,687	3,345	–	341	–	-7
	S5	3,495	3,168	–	327	–	-12
Jun-09	*Hist*	3,925	1,838	1,699	383	–	–
	S2	3,543	1,569	1,616	357	–	-10
	S5	3,352	1,440	1,566	345	–	-15
BPFI	*Hist*	3,979	2,411	1,096	467	603	–
	S2	3,593	2,100	1,046	444	570	-10
	S5	3,400	1,955	1,011	431	555	-15

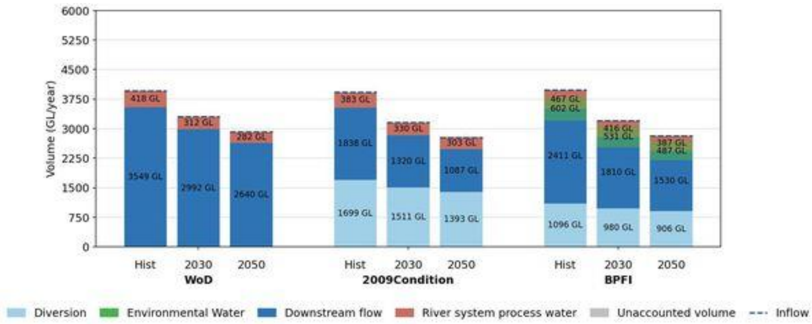


Figure R69: Stacked bar chart showing the annual total volumes of the Goulburn, Broken, Campaspe, Coliban River and Loddon Creek system under S3 and S6 climate conditions

Dev scenario		In	Out	Div	RSPW	EW	% Hist
WoD	*Hist*	3,966	3,549	–	418	–	–
	S3	3,304	2,992	–	312	–	-17
	S6	2,922	2,640	–	282	–	-26
Jun-09	*Hist*	3,925	1,838	1,699	383	–	–
	S3	3,161	1,320	1,511	330	–	-19
	S6	2,779	1,087	1,393	303	–	-29
BPFI	*Hist*	3,979	2,411	1,096	467	603	–
	S3	3,207	1,810	980	416	531	-19
	S6	2,821	1,530	906	387	487	-29

Office locations – *First Nations Country*
Adelaide – *Kaurna Country*
Albury – *Wiradjuri Country*
Canberra – *Ngunnawal Country*
Goondiwindi – *Bigambul Country*
Griffith – *Wiradjuri Country*
Mildura – *Latji Latji Country*
Murray Bridge – *Ngarrindjeri Country*

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