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Modelled downstream effects of licensing floodplain harvesting

NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys

December 2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Executive summary

This report uses numerical simulation models to quantify the potential downstream impacts of implementing the *NSW Floodplain Harvesting Policy* (hereinafter called the *Policy*) in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys.

The *Policy* establishes a framework for licensing floodplain harvesting activities and managing of diversions in a way that brings them back within statutory limits. The licensing framework will restrict the volume of water that can be taken from the floodplain providing gains to the system through foregone diversions.

Any gains in upstream systems such as the NSW Border Rivers (which provides on average 18% of Barwon-Darling inflows), Gwydir (6% of Barwon-Darling inflows), Namoi or Macquarie rivers may translate into the downstream rivers. These additional volumes originating in each of the Barwon-Darling tributary valleys contribute to connectivity across the broader northern Murray-Darling Basin (the Basin) and provision of increased flows to Menindee and into the Murray River.

The behaviour of these additional volumes can be investigated using numerical simulation models. Water management in NSW (and globally) relies on models such as these to provide robust and reliable estimates of what water is available, how it moves through the system and to assess the predicted impact of rules and management responses. The models used for this report have been developed using current best practice, utilise the best available information and have been subject to independent review.

Models simulate highly complex physical processes. These processes have many inputs, outputs, dependent factors and feedback loops. Each source of data comes with a set of limitations, assumptions and a level of uncertainty around how well this information reflects the real world.

A limitation of new river system models developed to represent overbank flows and floodplain harvesting is that they do not explicitly represent the return of flows from the floodplain to the river. This process is critical for analysing the downstream impacts and benefits of floodplain harvesting and without an established process the department was required to make two key assumptions:

1. **100% of foregone diversions return to the river** (i.e. all non-harvested water returns from the floodplain to the river)
2. **100% of that returning water contributes to end-of-system flows** (i.e. 100% of returned floodplain water flows unaltered to the end of system).

These two assumptions represent a simplification of the real world. In reality these volumes would attenuate, reducing in size as they are subject to natural floodplain and riverine processes. Simply put, the downstream effects shown in this analysis are greater than what will be realized through implementation of the Policy. Adoption of these assumptions provides insight into what would be the **maximum possible effect**.

This analysis is intended as a range-finding exercise to assess the potential scale of change after *Policy* implementation. It is not intended to provide a specific volumetric outcome that should be

expected in river. A sensitivity test (Appendix B) was undertaken to show the impact of these assumptions.

With adoption of both assumptions, modelling indicates that implementation of the *Policy* within the NSW Border Rivers will result in a 5.5 GL annual return of water to floodplains, rivers, and creeks. In addition, licensing floodplain harvesting is simulated to provide an additional 36.7 GL in the Gwydir valley, 1.8 GL in the Macquarie valley, 5.4 GL in the Namoi Valley and 1.2 GL in the Barwon-Darling valley.

The foregone diversions produced by the *Policy* travel across the floodplain before re-entering rivers and creeks, providing additional volumes toward downstream systems. As a result of policy implementation in the upstream Border-Rivers, Gwydir, Macquarie and Namoi valleys average annual inflows to the Barwon-Darling are modelled to increase by 38.2 GL. A quantity of the foregone diversions in the Gwydir (7.3 GL) will remain in the terminal Gwydir wetlands providing localized environmental benefits but not contributing to downstream outcomes. An additional 2.1 GL is lost due to model recalibration between the Gwydir and Barwon-Darling models. Similarly, 90% of foregone diversions in the Macquarie are anticipated to remain in the Macquarie Marshes with only 0.2 GL contributing to downstream outcomes.

These additional Barwon-Darling inflows are added to the modelled 1.2 GL annual savings that are produced in the Barwon-Darling system itself meaning a total extra 39.4 GL is moving through the waterway. This additional volume attenuates as it moves, reducing in size as it travels through the system towards the southern Basin. By the time these foregone diversions reach the end of the Barwon-Darling River system the model indicates that implementation of the *Policy* in the upstream Border-River, Gwydir, Macquarie, Namoi and Barwon-Darling will provide an annual average increase of up to 22.0 GL (1.6%) at Wilcannia.

The northern and southern Basin are connected by Menindee Lakes and the lower Darling River which adjoins the River Murray at Wentworth ~100km upstream of the South Australian border. *Policy* implementation is simulated to provide an annual average increase of up to 23.7 GL to Menindee inflows or 1.6% of the total. This additional volume has a negligible impact on diversion and/or allocations in the Lower Darling and Murray systems.

Any additional volumes created by the *Policy* are potentially available for extraction, contributing to water availability for downstream communities, town water supply, stock & domestic users and irrigators. The downstream effects assessment indicates that this additional volume has a negligible impact on access for A, B & C Class licence holders in the Barwon-Darling. This is due to the additional volume mostly being available during wetter years when flows are high and there are significant extraction opportunities for unregulated licences.

Annual average results are not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet conditions to create overland flows. In the wettest year on record (1955) an additional volume of up to 20 times the annual average was seen in some valleys due to implementation of the *Policy*. Conversely, in drier years very little to no floodplain harvesting takes place and little *Policy* impact is seen.

An additional sensitivity (Appendix B) was undertaken to investigate the potential impact of suspending floodplain harvesting in the Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys (the suspension) and the impact of such a suspension on flows in the NSW Southern Basin.

The suspension would contribute up to 122.5 GL (+7.9%) average annual inflow to Menindee Lakes. This increase is modelled to have a minor impact on diversions or allocations in the Lower Darling Regulated River Water Source as supplied by Menindee Lakes. The upper limit of 122.5 GL provided by the suspension attenuates in Menindee Lakes and as it flows down the Lower Darling into the Murray system leading to an increase of 68.4 GL average annual flow at Wentworth. This 68.4 GL only represents a small proportion (0.9%) of total flows at the location where the Lower Darling joins the far larger River Murray. This small proportional increase to inflows again has a minor impact on diversions or allocations in the Murray Regulated River Water Source.

1 Introduction

The *Policy* establishes a framework for the assessment and determination of floodplain harvesting water access licences. Floodplain harvesting licences define the volume of water that users can legally harvest from floodplains. Bringing floodplain harvesting into the water licensing system will enable management of diversions within the long-term average annual extraction limit (LTAAEL) and sustainable diversion limit (SDL) established in *NSW Water Sharing Plans* for each valley.

The *Policy* was introduced in 2013 and is now being implemented across five river valleys in the northern Basin.

Floodplain harvesting estimates for each valley are being updated and modelling outputs show that implementation of the *Policy* will result in a reduction in the volume of floodplain water diverted into storages. These foregone diversions will remain in the system, travelling across the floodplain, with some of that water returning to river. These upstream gains may translate into the downstream with additional volumes originating in the Barwon-Darling and its tributary valleys contributing to connectivity between the broader northern Basin system and provision of increased flows towards Menindee and into the Murray.

An estimate of the volumes of water returned to the system through foregone diversions in the Gwydir valley is displayed in Figure 1 which shows the modelled change in annual volumes of water diverted, with and without the *Policy*, over a 40-year modelling period. The water returned to the system due to policy implementation is the foregone diversion and in the left-hand side of Figure 1 is crosshatched in yellow.

The right side of Figure 1 also shows the modelled with and without *Policy* daily flows from the Gwydir into the Barwon-Darling for the year 1978 as an illustration of the connection between the annual diversion volume and daily flow.

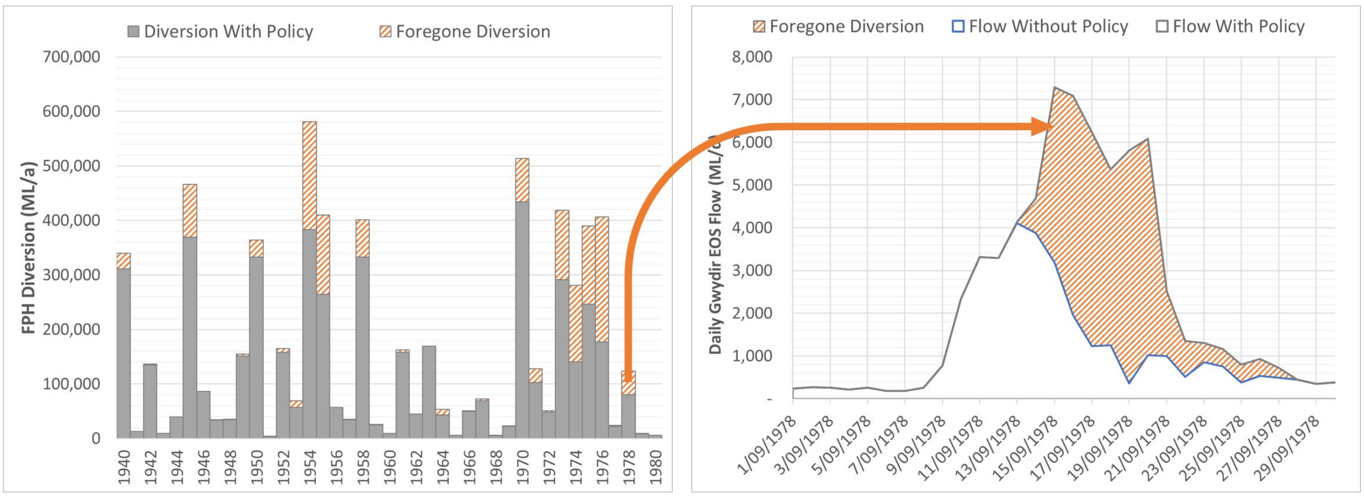

Figure 1 Modelled volumes of water (ML) returned under implementation of the *Policy* in the Gwydir valley. The chart on the left shows the modelled annual floodplain harvesting diversion and foregone diversion volumes with the *Policy* implemented over the 40-year (1940 to 1980) simulation period. The plot on the right shows the modelled without and with

Policy daily flow from the Gwydir into the Barwon-Darling over the month of September in the 1978 water year, to illustrate when the *Policy* has most effect, in this example on the rising hydrograph

1.1 Report purpose and structure

This report aims to provide an initial understanding of how reductions in upstream floodplain harvesting diversions under the Policy impact downstream water availability. The impact is associated with implementation that occurs in an individual valley, in this case the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys and on a cumulative basis.

Chapter 2 overviews the Policy and the river system modelling that has been undertaken to support the assessment of floodplain harvesting entitlements. It describes the current situation where water diverted from the rivers through floodplain harvesting exceeds statutory limits, setting the context for Chapter 3.

Chapter 3 presents the results of modelling the downstream impacts of implementing the Policy within the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys on an individual and cumulative basis. Annual average volumes and peak volumes returned to system are investigated. This analysis is extended into the southern Basin and the with the cumulative impact of implementing the Policy assessed in regard to water availability and allocations in the lower-Darling and Murray regulated rivers.

Additional information, including sensitivity analysis are included in appendices.

Formatting conventions

The report uses several formatting conventions to improve the accessibility of the text for reading software. Blue italics are used to identify terms that are specific to the model, either model terms, for example Gauge Node, or the names of model scenarios, for example Current Conditions Scenario. Standard italics identify legislation, plans, document titles and direct quotes. Bold text is used to highlight key terms and metrics, for example planted areas, as an aid for the reader to navigate through the text.

1.2 Companion reports

This report describes the downstream effects of implementing the Policy in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys. A series of companion reports exist for each valley that describe the modelling and in-valley environmental benefits of Policy implementation. These reports together serve to describe how the modelling meets the objectives of the Policy.

Some changes have been made to valley-based companion reports since this report was prepared and hence some volumes in this report no longer match the most recently published companion reports. It should be noted that these changes do not materially affect the conclusions reached in this report.

1.2.1 Companion reports for the NSW Border Rivers valley

The building of the river system model which provides the data for assessing entitlements is described in companion report Building the river system model for the Border Rivers Valley regulated river system (DPIE Water, 2020a).

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in companion report Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System: Model Scenarios (DPIE Water, 2020b).

The use of the model results for predicting potential environmental outcomes is described in companion report Environmental outcomes of implementing the Floodplain Harvesting Policy in the Border Rivers Valley (DPIE Water, 2020c).

1.2.2 Companion reports for the Gwydir valley

The building of the river system model which provides the data for assessing entitlements is described in companion report Building the river system model for the Gwydir Valley regulated river system (DPIE Water, 2022a).

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in companion report Floodplain Harvesting Entitlements for Gwydir Regulated River System: Model Scenarios (DPIE Water, 2022b).

The use of the model results for predicting potential environmental outcomes is described in companion report Environmental outcomes of implementing the Floodplain Harvesting Policy in the Gwydir Valley (DPIE Water, 2021a).

1.2.3 Companion reports for the Macquarie valley

The building of the river system model which provides the data for assessing entitlements is described in companion report Building the river system model for the Macquarie Valley regulated river system (DPIE Water, 2022e).

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in companion report Floodplain Harvesting Entitlements for Macquarie Cudgegong Regulated River System: Model Scenarios (DPIE Water, 2022f).

The use of the model results for predicting potential environmental outcomes is described in companion report Environmental outcomes of implementing the Floodplain Harvesting Policy: Macquarie Report (DPIE Water, 2021b).

1.2.4 Companion reports for the Namoi valley

The building of the river system model which provides the data for assessing entitlements is described in companion report Building the river system model for the Namoi Valley regulated river system (DPE Water, 2022a).

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in companion report Floodplain Harvesting Entitlements for Namoi Regulated River System: Model Scenarios (DPE Water, 2022b).

The use of the model results for predicting potential environmental outcomes is described in companion report Environmental outcomes of implementing the Floodplain Harvesting Policy: Macquarie Report (DPE Water, 2022c).

1.2.5 Companion reports for the Barwon-Darling valley

The building of the river system model which provides the data for assessing entitlements is described in companion report Building the river system model for the Barwon-Darling Valley unregulated river system: Conceptualisation, construction and calibration (DPIE Water, 2022c).

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in companion report Floodplain Harvesting Entitlements for Barwon-Darling River system: Model Scenarios (DPIE Water, 2022d).

2 Background

2.1 Floodplain harvesting policy

In 2013, the NSW Government introduced the Policy to manage floodplain water diversions more effectively in order to protect the environment and the reliability of water supply for downstream water users whilst ensuring compliance with the requirements of the Water Management Act 2000. The Policy also aligns with the objectives of the National Water Initiative, an intergovernmental commitment made by the Council of Australian Governments in 2004 to increase the efficiency of Australia's water use.

The Policy aims to bring floodplain harvesting under the contemporary licensing framework, issuing landholders with water access licences and water supply works approvals. The licensing framework is being rolled out in the designated floodplains of five northern inland NSW valleys; the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling. Full policy implementation is scheduled for completion before 1 July 2023.

2.2 Modelling floodplain harvesting

Water management in NSW (and globally) relies on (numerical simulation) models to provide robust and reliable estimates of what water is available, how much is needed, and how the resource can be equitably shared. The NSW Department of Planning and Environment - Water (DPE Water) manages the river system models that have been developed for this purpose. A model exists for each of the regulated valleys and the Barwon-Darling unregulated river in NSW. These models were developed to support water management and planning processes and they represent both the historical and current best understanding of catchment climate, hydrological and water use behaviours.

Floodplain harvesting simulations extend these models with a hydrological representation of the capture, diversion, storage and use of floodplain water on individual farms. This representation is based on real-world information collected and collated in association with the floodplain harvesting licence determination process and calibrated flow and irrigator behaviours.

The models used by DPE Water have been designed to support contemporary water management decisions, whether it is a rule change in a valley's Water Sharing Plan or estimating long term average water balances for components such as diversions for compliance purposes. They are now being upgraded to be used to determine volumetric entitlements for floodplain harvesting and to test the impact of changes within and between valleys.

Changes to long-term climate output or the addition of new rules for example, are used as an input into the model which then projects the outcome of those changes over an extended period. Upstream models are also connected to their downstream counterparts. These connections allow us to assess any downstream impacts of changes in one or more valleys.

The rule changes and licensing framework associated with implementation of the Policy have been incorporated into the river system models for the five northern valleys. This allows comparison between the without and with Policy implementation world including assessment of any change at local or regional scale.

2.3 Floodplain harvesting within statutory limits

Water taken from water sources in NSW must comply with the lesser of two statutory limits:

- Long-term average annual extraction limit (LTAAEL)
- Sustainable diversion limit (SDL)

These limits are described in the following sub-sections.

2.3.1 Long term average annual extraction limit (Plan limit)

The 'long-term average annual extraction limit' (LTAAEL) is a term used in NSW water sharing plans to define the limit of water that can be taken for all purposes (including domestic and stock, urban, industrial, agricultural use and held environmental water) from each water source.

The setting of the LTAAEL restricts the overall take of water in a water source to a defined volume and constrains growth to that maximum. Water in excess of the LTAAEL is reserved for the environment and is called Planned Environmental Water.

Rules to assess compliance with the LTAAEL are set out in each valley's Water Sharing Plan, and the LTAAEL is called the Plan Limit. Assessing compliance involves calculating the average of annual extractions over a specified period. In those cases where the Plan Limit is exceeded, the Minister for Water will reduce the quantity of water than can be taken by lower priority licences in accordance with established rules.

2.3.2 Sustainable diversion limit

The 'sustainable diversion limit' (SDL) is a term used in the Commonwealth's Basin Plan to define limits on total extractions for human uses from a surface water source or a group of surface water sources in the Basin. Each of the 29 river catchments and 80 groundwater areas in NSW has their own limit. The component of each valley's SDL for the regulated river systems and the Barwon-Darling unregulated river system is approximately equivalent to the respective LTAAEL. In practice, the SDL is reported with the water use associated with entitlements recovered for the environment excluded, and calculated using climate data limited to the period 1895 to 2009.

Compliance to an SDL is based on the concepts of actual and permitted take:

- actual take – the annual actual take is the volume of water extracted during a water year from a water source
- permitted take – the permitted annual take is the volume of water that can be extracted during a water year from a water source.

The difference between these two volumes is recorded on a register of take as a debit (when actual take is greater than permitted take) or a credit (when actual take is less than permitted take).

Over time, a cumulative balance accrues based on each year's credit or debit. For the first ten years of the water resource plan, if the cumulative balance reaches a debit of 20% or more of the SDL for that resource, then it is non-compliant. A reasonable excuse provision may apply in the case of non-compliance.

2.3.3 Growth in floodplain harvesting has caused an exceedance of some statutory limits

Currently floodplain harvesting occurs outside an established licensing framework. This means that water can be diverted from the floodplain without volumetric limitation. Modelling indicates that over the last two decades floodplain harvesting has grown and in some valleys this growth has caused the statutory water source limits to be exceeded.

The river system models that are used to assess Plan Limit compliance consider all water diverted from the water source, including water diverted from the floodplain. The setting of these models to describe and assess Plan Limit compliance is managed through the creation of model scenarios. Plan Limit Compliance Scenarios have been or are in the process of being developed for the Border-Rivers, Gwydir, Namoi, Macquarie, Upper Namoi and Lower Namoi regulated river systems[1] and the Barwon-Darling unregulated river system.

Modelled data is now available for the Border Rivers (DPIE Water, 2020b), Gwydir (DPIE Water, 2022b), Namoi (DPE Water, 2022b) and Macquarie (DPIE Water, 2022f) regulated river systems and the Barwon-Darling unregulated river system (DPIE Water, 2022d). This data indicates a 6.1 GL growth above the Plan Limit for the Border Rivers, 37.2 GL growth above the Plan Limit for the Gwydir, 12.7 GL growth above the Plan Limit for the Namoi, and 0.8 GL above the Plan Limit for the Barwon-Darling. Note that not all of this growth is attributed to floodplain harvesting.

Whilst there has been growth in floodplain harvesting in the Macquarie valley, it remains within its Plan Limit.

Table 1 Modelled Plan Limit and current volumes (GL/year) in the NSW Border Rivers valley regulated river system for general and high security, supplementary and floodplain harvesting licences

Development conditions	Plan Limit	Current
General & High Security	92.1	92.6
Supplementary	69.2	70.0
Floodplain harvesting[2]	38.7	43.6
Plan limit	200.0	206.1
Growth above the Plan Limit		6.1

[1] The development of the Plan Compliance Scenario for each valley is described in the companion Scenarios reports (DPIE Water, 2020b) (DPIE Water 2022b) (DPIE Water, 2022f) (DPE Water, 2022b) (DPIE Water, 2022d).

[2] Excluding exempt rainfall runoff harvesting.

Table 2 Modelled Plan Limit and current volumes (GL/year) in the Gwydir valley regulated river system for general and high security, supplementary and floodplain harvesting licences

Development conditions	Plan Limit	Current
General & High Security	215.0	217.7
Supplementary	91.1	93.0
Floodplain harvesting[3]	104.4	137.1
Plan limit	410.5	447.7
Growth above the Plan Limit		**37.2**

Table 3 Modelled Plan Limit and current volumes (GL/year) in the Macquarie valley regulated river system for general and high security, supplementary and floodplain harvesting licences

Development conditions	Plan Limit	Current
General & High Security	304.0	213.2
Supplementary	13.6	92.7
Floodplain harvesting[4]	41.0	47.2
Plan limit	350.8	324.6
Growth above the Plan Limit		Macquarie under Plan Limit

Table 4 Modelled Plan Limit and current volumes (GL/year) in the Namoi valley regulated river system for general and high security, supplementary and floodplain harvesting licences

Development conditions	Plan Limit	Current
General & High Security	144.6	144.8
Supplementary	34.4	42.1
Floodplain harvesting[5]	46.5	51.3
Plan limit	225.6	238.3
Growth above the Plan Limit		12.7

Table 5 Modelled Plan Limit and current volumes (GL/year) in the Barwon-Darling valley unregulated river system for unregulated river and floodplain harvesting licences

Development conditions	Plan Limit	Current
Unregulated river	184.5	175.2
Floodplain harvesting[6]	10.9	21.0
Plan limit	195.4	196.2
Growth above the Plan Limit		0.8

2.3.4 Outcome of returning to statutory limits

Returning the volume of water diverted within a valley to within the Plan Limit will result in more water in the river, leading to improved environmental outcomes and increased water availability in downstream systems.

[3] Excluding exempt rainfall runoff harvesting.
[4] Excluding exempt rainfall runoff harvesting.
[5] Excluding exempt rainfall runoff harvesting.
[6] Excluding exempt rainfall runoff harvesting.

Environmental benefits

Improved environmental outcomes for floodplains is one of the key outcomes sought through implementation of the Policy. Harvesting of water from floodplains reduces the volume, frequency and duration of floods and can change the timing of flood events, impacting on the health of floodplains and downstream waterways. Floodplain harvesting can also affect connectivity between a river and its local floodplain wetlands by reducing flow volume and redirecting flood flows.

DPE Water has undertaken a valley-by-valley assessment of potential outcomes for the environment from implementing the Policy. Using modelled long-term (1895–2020) changes to the hydrology of the floodplain, each valley-specific Environmental Outcomes of Implementing the Floodplain Harvesting Policy report[7] considers the predicted ecological responses to changed floodplain harvesting volumes after licensing floodplain harvesting.

Key hydrological metrics and environmental water requirements were used to test and identify these outcomes for assets (e.g. location) and values (e.g. species) including native fish, native vegetation, waterbirds, important ecosystem functions and wetlands.

Most assessed environmental water requirements are achieved more frequently under the Plan Limit Compliance Scenario than under the Current Conditions Scenario, i.e. model without licensing of floodplain harvesting. Improvements are seen in the number of flow days, frequency and timing of floods for native fish, waterbirds and floodplain vegetation.

Increased water availability in downstream systems

Whilst the Environmental Outcomes assessment looks at changes in the volume of water at the localised, within-valley scale, implementation of the Policy is also predicted to increase the volume of water reaching downstream water sources. This volume is potentially available for extraction, contributing to water availability for downstream communities, town water supply, stock & domestic users and irrigators. Implementation of the Policy in the Barwon-Darling and four of its tributary systems will have a cumulative effect with each valley providing contributions to downstream.

[7] For example, the Border Rivers report (DPIE Water, 2020c). For more information on the key findings and recommendations, the reader is referred to each valley specific Environmental Outcomes of Implementing the Floodplain Harvesting Policy report on the DPIE Water website.

3 Assessing the downstream effects of Policy implementation

Growth in floodplain harvesting has contributed to a level of take that, in the NSW Border Rivers, Gwydir and Namoi valleys, is above statutory limits. When the licensing framework is established, floodplain harvesting licences will be subject to a volumetric limit that returns overall take to within the long-term average annual extraction limit (LTAAEL) set in each valley's Water Sharing Plan. This means that some of the water previously diverted through floodplain harvesting will be foregone. These foregone diversions will remain in the system, travelling across the floodplain, with some of the water returning to the river and continuing downstream.

This assessment explores the difference in diversions at the valley scale, considering the current unconstrained situation and what would occur post Policy implementation in each of the five northern inland valleys individually. The volumetric difference between the scenario with unconstrained floodplain harvesting (the Current Conditions Scenario) and the post policy implementation scenario (the Valley Scale Compliance Scenario) is the foregone diversions. The volume of foregone diversions in each valley is then separately input to the downstream Barwon-Darling River system model to assess the downstream impact of each valley's individual contributions, and then collectively for all valleys.

The foregone diversions from each valley are input into the Barwon-Darling model at the point(s) that each valley flows into the Barwon-Darling, together with the modelled flows from each tributary valley outlined in Figure 2. These foregone diversions pass through the Barwon-Darling adding to water availability and attenuating as they flow southwest into the Murray system.

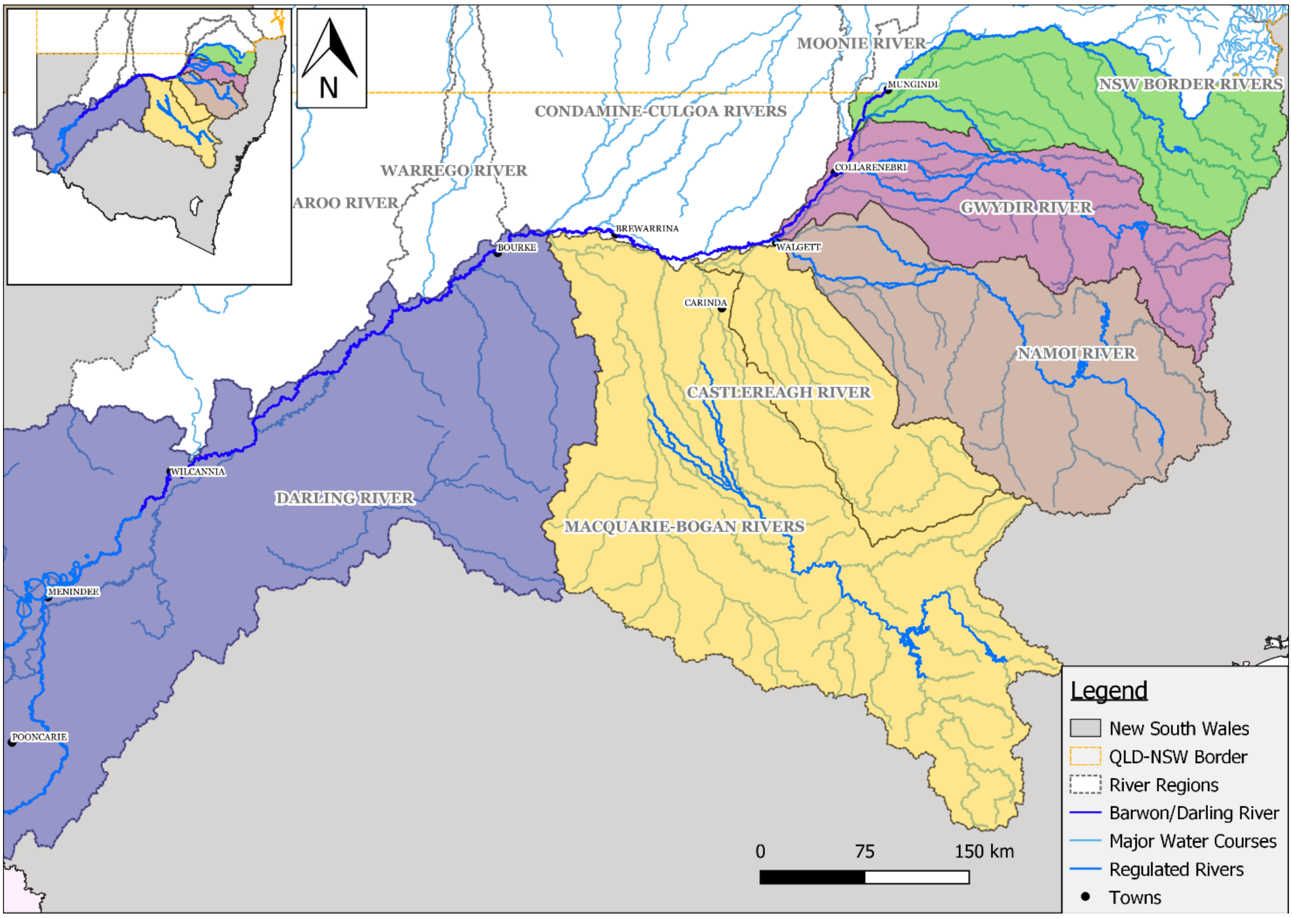

Figure 2 Map showing the Barwon-Darling tributary valley links

3.1 Inputs and assumptions

Models simulate highly complex physical processes. These processes have many inputs, outputs, dependent factors and feedback loops. Each source of data comes with a set of assumptions and a level of uncertainty around how well this information reflects the real world.

The work undertaken to support the implementation of the Policy has already substantively reduced uncertainty in the river system models. All datasets have been extensively reviewed to ensure the best quality available data are used. Multiple lines of evidence such as remote sensing and hydraulic modelling have been used, where possible, to substantiate the data, as has comparing datasets to published literature. Uncertainty can be further reduced with better information. This will require ongoing measurement and monitoring of harvesting volumes and management practices, and better representation of return flows from floodplains to river channels.

All hydrologic assessment modelling was undertaken using DPE Water's river system models developed in either the Integrated Quality and Quantity Model (IQQM) or eWater Source software. These models produce timeseries of floodplain diversion in each of valley under the Current Conditions and Valley Scale Compliance scenarios that are then input to the downstream effect's assessment model. These timeseries were provided for the period 01/07/1895 to 30/06/2009, consistent with the benchmark climate period defined in the Basin Plan.

The results presented in this report for the Barwon-Darling Valley are taken from the floodplain harvesting model first developed in 2021, consistent with the previous version of this report released in May 2022. This means that some model results will differ slightly from those reported in the Model Build and Scenario reports for the Barwon-Darling Valley.

3.1.1 Assumptions and sources of uncertainty in the river system models

The downstream effects assessment has been generated using DPE Water river system models. As described in the previous section, all care has been taken to ensure that these river system models are reliable and robust – they have been rigorously tested and refined subject to the DPE Water's risk assessment framework. As the assessment described herein utilises these river system models, it is subject to the same suite of assumptions and sources of uncertainty.

Assumptions and sources of uncertainty in the river system models are documented in the Model Build report for each valley[8] .

3.1.2 Assumptions and sources of uncertainty for downstream effects assessment

A limitation of the current river system models (mainly as a result of insufficient data) is that they do not model return flows. As a result, assumptions about return flows must be made to be able to assess downstream effects. These assumptions fall under two headings:

1. **Volume returned from the floodplain to the river**

Due to Policy implementation a quantity of diversions is foregone by each property. This water is left in systems and must travel across the floodplain before returning to rivers and creeks. As it travels across the floodplain the water attenuates and decreases in volume as it is subject to a series of complex ecological and hydrological processes, each specific to the individual location on the floodplain.

At present there is no established process or body of evidence that would enable the accurate representation of returned flows in river models. Circumstances vary broadly from property to property and from floodplain to floodplain preventing the generation of 'standard' rules or the broad application of proportional returns. There is no known model that represents these complex processes. In lieu of the ability to model this process this report assumes that **100% of foregone diversions return to the river** (i.e. all non-harvested water returns from the floodplain to the river)

2. **Contribution to end-of-system flows**

There is no established process to represent the return of flows to the river from the floodplain. Without the ability to represent this process the department is unable to accurately delineate where the foregone diversions from each property return to the river. The location of these return flows is an important consideration for the modelling. From the time the flows reach the river they are subject to in-stream attenuation, reducing in size as they move along the length of the tributary

[8] For example, the Border Rivers Model Build report (DPIE Water, 2020a). Reports for each Valley are available from the DPIE Water website.

catchments. The process for representing in-stream attenuation is established in the modelling for the five valleys where Policy implementation is taking place.

Whilst the process for in-stream flow attenuation is established we are currently unable to confidently associate foregone diversions from each property with a location from which they would be subject to attenuation losses. In lieu of the ability to accurately position these return flows in the model this report assumes that **100% of that returning water contributes to end-of-system flows** (i.e. 100% of returned floodplain water flows unaltered to the end of system).

This assumption holds up well in valleys where floodplain harvesting occurs along the length of the regulated river. In these systems foregone diversions are added to a large channel with comparatively limited in-stream losses.

In valleys where floodplain harvesting occurs away from the main channel foregone diversions may have to travel through a series of sinuous river deltas and extensive wetlands to reach the Barwon-Darling. Many of these areas are considered terminal and have little to no downstream hydrological connectivity outside large flood events.

In valleys where this situation exists a more detailed analysis of water source connectivity may be undertaken. Water sources with little to no connectivity through to the Barwon-Darling may be removed from downstream outcomes calculations. More information can be found under the valley-specific assessment section.

3.1.3 Summary

Put simply, these two assumptions mean that any additional flow associated with foregone diversion is routed directly to the end-of-valley-system outflow and added to the inflows from that valley into the Barwon-Darling River system.

This is of course a simplification of the real world. In reality, end-of-valley flows would not increase linearly with an increase in the volume of foregone diversions within each valley. Other natural processes such as evaporative losses, aquifer recharge and other local and/or catchment hydrological processes would influence the total volume and timing of flow reaching the end of the system.

These assumptions represent an upper limit estimate of the volume of additional flow reaching the Barwon-Darling providing insight into the maximum possible effect of implementing the Policy. As the downstream effects assessment is intended to provide insights into the potential scale of change after implementation of the Policy, and not to provide definitive volumetric outcomes, adoption of these assumptions is justified.

Whilst this report focuses on the maximum possible effect of Policy implementation, a sensitivity test was also undertaken to assess the impact of these assumptions on model results. The test assumed that 50% of foregone diversions return to river as opposed to 100%.

Modelling is based on the best available data and as this improves, assumptions can be refined to provide increasingly improved estimates of the changes that could be expected through implementation of the Policy.

3.2 Valley-specific assessment – NSW Border Rivers

To date, return flow impact assessment has been undertaken for the NSW Border Rivers valley under two scenarios:

- without policy implementation (Current Conditions Scenario)
- with policy implementation (Valley Scale Compliance Scenario).

The Border Rivers valley is located in southern Queensland and northern New South Wales. The valley has several rivers that straddle the Queensland and NSW border and is one of the most northern of the Basin catchments. The Macintyre River (which becomes the Barwon River downstream) forms the main trunk of the regulated river system. Its tributaries rise west of the Great Dividing Range and continue to run westward before gradually merging to form the Barwon River upstream of Mungindi.

3.2.1 Location of properties eligible for floodplain harvesting

Eligible properties in the NSW Border Rivers are located along the southern side of the Border-Rivers Regulated River. The majority of properties are concentrated in the downstream end of the valley below the confluence of the Macintyre and Dumaresq rivers. All properties are within close proximity to the regulated river main channel so connectivity between floodplain, river and downstream systems is assumed to be high.

3.2.2 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Border Rivers were provided for before and after implementation of the Policy (DPIE Water, 2020b). Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 6 provides a summary of the modelled change in annual floodplain harvesting diversions in the Border Rivers under the Policy. Results indicate a 13% reduction in average annual floodplain harvesting diversions under the Policy, with diversions reduced from about 44 to about 38 GL/year. The assumption of 100% return flows returns an additional ~5.5 GL to the Border Rivers system per year on average.

Table 6 Total annual diversions and annual end-of-system flow without and with implementation of the *Policy* in the NSW Border Rivers valley

Results	without *Policy* (GL)	with *Policy* (GL)	Change (GL)	Change (%)
Total annual FPH diversion[9]	43.6	38.0	-5.5	-12.7%
Annual end-of-system flow	538.3	543.8	+5.5	+1.0%

[9] For this valley, the total annual floodplain harvesting does not include the exempt rainfall-runoff harvesting. Including the changes in exempt rainfall runoff harvesting would slightly increase the change in total annual floodplain harvesting from 5.5 GL/year to 5.8 GL/year.

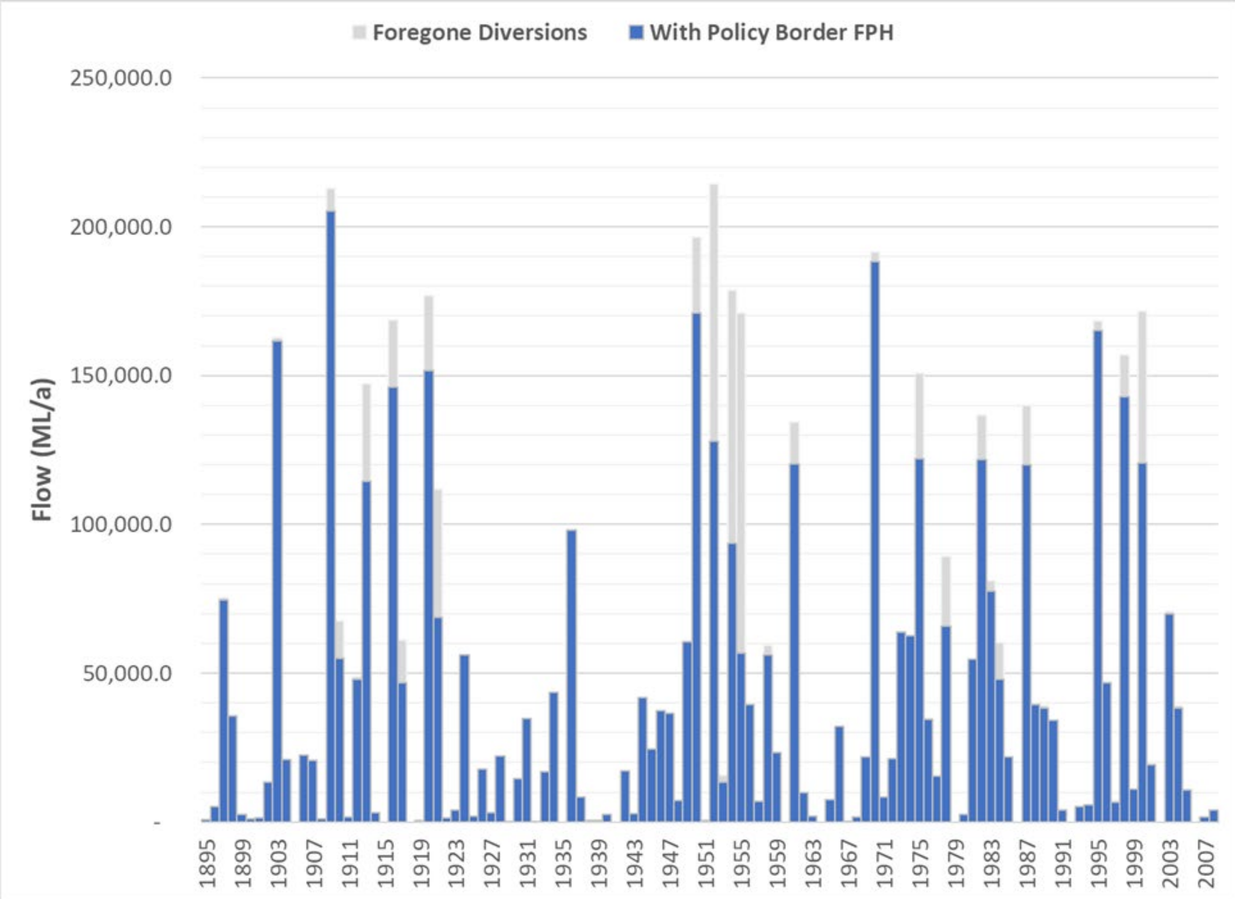

Figure 3 Modelled annual floodplain harvesting diversions with the *Policy* implemented over the 114-year climate record for the NSW Border Rivers Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the *Policy* implemented

The effect of Policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place. This variability is masked when reporting average annual results (such as in Table 6), making it important to report at annual time step.

Figure 3 shows the modelled floodplain harvesting volumes and foregone diversions with the Policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is foregone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

3.2.3 End of system flows

Floodplain harvesting diversions in the NSW Border Rivers are estimated to represent about 8.1% of total end-of-valley-system flow without Policy implementation. The chart in Figure 4 shows the modelled annual floodplain harvesting diversions and end-of-system flow volumes without the Policy being implemented, over the 114-year climate period. It can be seen from that floodplain harvesting diverts a small proportion of the total end-of-system flow in most years. The estimated 5.5 GL/year that would be returned to the river system under the Policy contributes 1.0% of the total end-of-system flow.

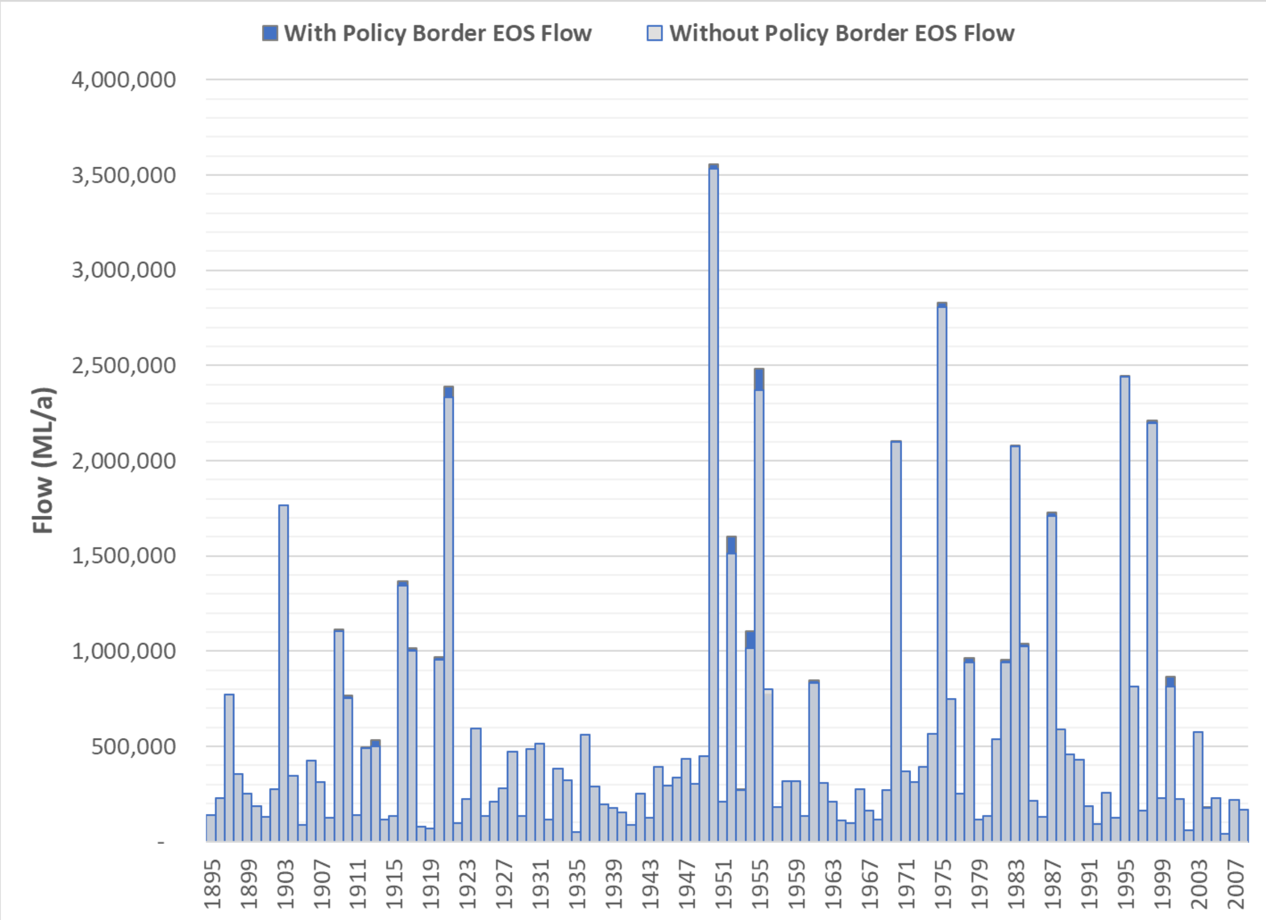

Figure 4 Modelled annual end of system (EOS) flow volume over the 114-year climate record (1895-2009) with and without the *Policy* being implemented in the NSW Border Rivers Valley

Foregone diversions are ranked (Figure 5) from largest effect to least illustrating the estimated proportion of years in which the *Policy* will have impact and the magnitude of that impact. Under the *Policy*, end-of-system flow volumes are predicted to show some increase in about 50% of years, with the largest volumetric effect in wet to very wet years and over consecutive wet years.

In about 10% of the years, equivalent to the size of a 1:10 year flood event, implementing the *Policy* is predicted to provide an increase in end-of-system flows of more than 19 GL, or more than three times the average (5.5 GL). In the top 5% of wet years, equivalent to a 1:20 year flood, implementing the *Policy* is predicted to provide an increase in end-of-system flows of more than 33 GL or more than 6 times the average. In the wettest year on record (1955) a maximum floodplain harvesting foregone diversion of about 110 GL is predicted (Figure 5).

Under consecutive years with frequent and/or large volume overland flow events, the potential exists under the *Policy* for account limits to 'cap out' during a water year. This cap may be realised before storages are completely full. These storages would have been filled in the without *Policy* scenario, i.e. the *Current Conditions Scenario*. A relative volume of free storage space then remains for use in the following water year which would not have existed otherwise.

With subsequent credit to the annual account at the beginning of the following water year and this remaining free storage volume, the potential exists for greater floodplain harvesting under subsequent flood events than would have been the case before implementation of the *Policy*.

Nevertheless, and taking this into account, total diversions over multiple years under the *Policy* are predicted to remain equivalent to or lower than modelled diversions without the *Policy* implemented.

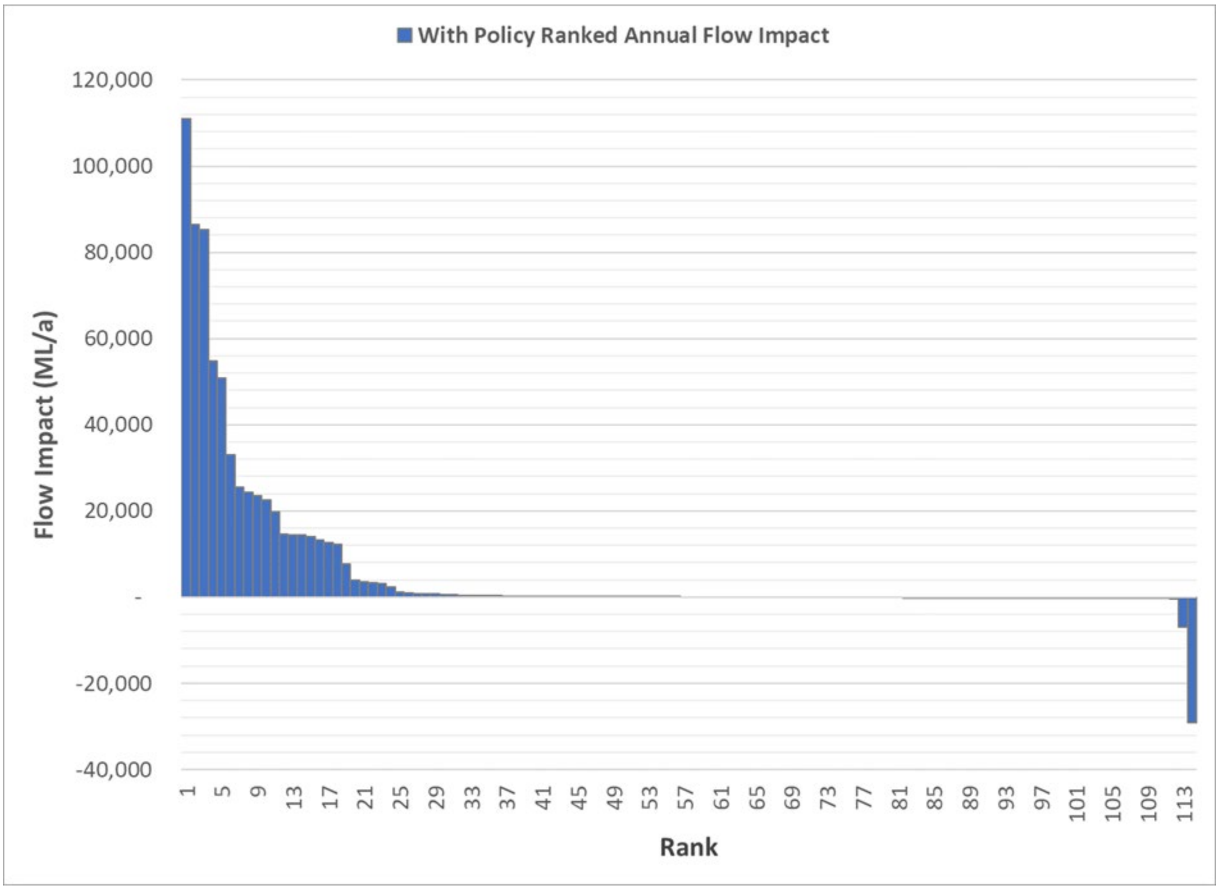

Figure 5 Modelled end of system ranked change in annual end-of-system flow volume with the *Policy* implemented for the Border Rivers valley

3.3 Valley-specific assessment – Gwydir

To date, return flow impact assessment has been undertaken for the Gwydir valley under two scenarios:

- without policy implementation (Current Conditions Scenario)
- with policy implementation (Valley Scale Compliance Scenario).

The Gwydir valley is located immediately below the Border Rivers catchment in northern New South Wales. The Gwydir River itself begins on the New England Tablelands flowing westward through steep valleys before being regulated by Copeton Dam.

Releases from Copeton flow west to Moree, where the Gwydir River widens into a flat alluvial floodplain and splits into a series of water courses. The Gingham and the lower Gwydir watercourse flow into the Gwydir wetlands where the river spreads further across the floodplain to- create a terminal delta where wetlands and swamps soak up much of the river flow.

The Gwydir Wetlands are among the most extensive and significant semi-permanent wetlands in north-west New South Wales and include four Ramsar listed sites. There is little to no hydrological connectivity between the area that encompasses the Gwydir wetlands and the Barwon-Darling.

To the north and south of the wetlands the Mehi River, Moomin Creek and Gil Gil Creek carry the bulk of the volume in the Gwydir Regulated River providing connectivity to the Barwon-Darling.

3.3.1 Location of properties eligible for floodplain harvesting

The Gwydir designated floodplain begins just east of Moree extending to the west and spreading to encompass most of the lower Gwydir.

The Gwydir diverges close to Moree into three broad water courses. The northern divergence of the Gwydir regulated river contains a series of floodplain harvesting properties located along Carole Creek and Gil Gil Creek. This system connects through to the Barwon Darling.

In the centre of the Gwydir designated floodplain there are a much smaller number of floodplain harvesting properties located across the Gingham Watercourse and Gwydir water sources. This location is a highly sinuous terminal delta associated with the Gwydir wetlands and there is little to no hydrological connectivity outside major flooding events. Water that enters the Gingham Watercourse and Gwydir water sources remains in these areas, providing benefits to local wetland ecosystems. These water sources do not connect to the Barwon-Darling and foregone diversions from these properties have not been included in the end of system flow calculations.

A larger number of floodplain harvesters exist in the southern part of the Gwydir designated floodplain along the Mehi River and Moomin Creek. There are multiple connected wetlands through the southern Gwydir however the floodplain harvesting properties in this region are largely connected to the regulated river system and have good connectivity to the downstream Barwon-Darling.

3.3.2 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Gwydir were provided for before and after implementation of the Policy (DPIE Water, 2022b). Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 7 provides a summary of the modelled change in annual floodplain harvesting diversions in the Gwydir under the Policy. Results indicate a 21.1% reduction in average annual floodplain harvesting diversions under the Policy, with diversions reduced from about 173 to about 137 GL/year. The assumption of 100% return flows from these water sources returns an additional ~37 GL to the Gwydir system per year on average.

Note - The Barwon-Darling model uses a specific flow calibration process for catchment inflows to attempt to correct higher flow events not captured by upstream gauges. The application of this flow calibration results in the estimated impact on Gwydir end of system flow due to Policy implementation decreasing from approximately 29 GL to 27 GL, a 7% reduction. The change is not material to the outcomes of the assessment.

Table 7 Total annual diversions and annual end-of-system flow without and with implementation of the *Policy* in the Gwydir valley

Results	without *Policy* (GL)	with *Policy* (GL)	Change (GL)	Change (%)
Total annual FPH diversion	173.4	136.8	-36.7	-21.1%
Annual FPH diversion in terminal water sources (do not contribute to end of system flow)	29.3	22.0	-7.3	-24.9%
Annual end-of-system flow	170.1	197.3	27.2	+16.0%

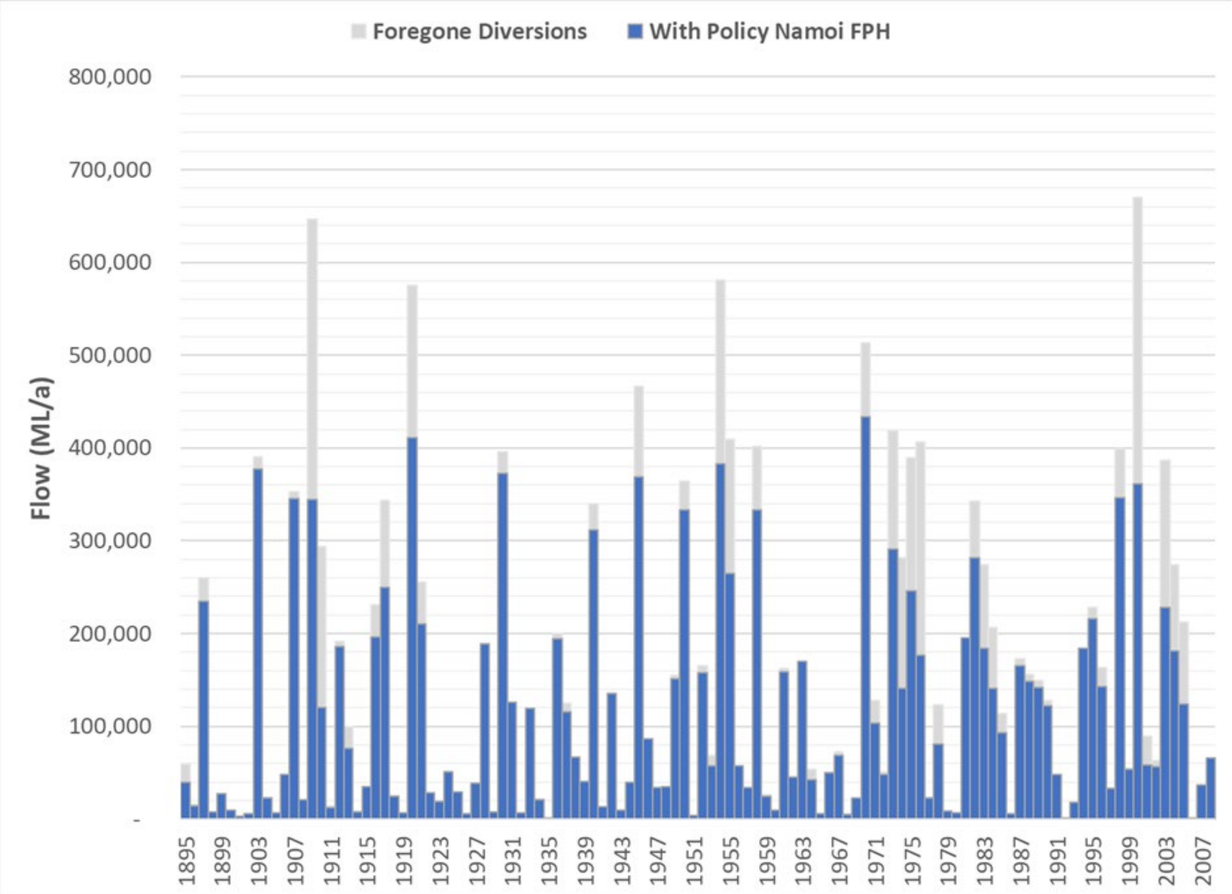

Figure 6 Modelled annual floodplain harvesting diversions with the *Policy* implemented over the 114-year climate record for the Gwydir Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the *Policy* implemented

The effect of Policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place. This variability is masked when reporting average annual results (such as in Table 7), making it important to report at annual time step.

Figure 6 shows the modelled floodplain harvesting volumes and foregone diversions with the Policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is foregone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

3.3.3 End of system flows

In the Gwydir not all water sources connect through to the downstream Barwon-Darling. The Gingham Watercourse Water Source and the Gwydir Water Source have been removed from the assessment of downstream outcomes including any calculation of end of system flow. These water sources are considered terminal wetlands and have no connectivity outside major flooding events. Any foregone diversions produced by the Policy would remain in the water source contributing to local environmental outcomes as detailed in the Environmental Benefits report (DPIE Water, 2021a).

Annual average floodplain harvesting diversions in these water sources total 29.3 GL without policy implementation (Table 7). After establishing the licensing framework analysis indicates that annual average diversions in the Gingham Watercourse Water Source and the Gwydir Water Source will be reduced by 24.9% to 22.0 GL. The additional 7.3 GL left in system due to Policy implementation would remain in the RAMSAR listed Gwydir wetlands and has not been considered as part of any further downstream analysis. These foregone diversions would not contribute to Barwon-Darling inflows.

The water sources that do connect to the Barwon-Darling also display the sinuous, delta-like characteristics of the lower Gwydir. Large volumes of water are retained in system and the Gwydir has far lower end of system flows and contributes far less to the Barwon-Darling than other similar northern Basin tributary systems. Gwydir end of system flows are more than three time smaller than that of the NSW Border Rivers whilst Gwydir floodplain harvesting diversion are approximately four times larger.

The chart in Figure 7 shows end-of-system flow volumes with and without the Policy being implemented, over the 114-year climate period. The grey also represents the volume of foregone diversions after licensing that contribute to end of system flows. It can be seen from that floodplain harvesting diverts a small proportion of the total end-of-system flow in drier years but has a more significant impact in wetter years. The estimated 27.2 GL/year annual average that would be returned to the river system under the Policy would contribute +16.0% of the total end-of-system flow.

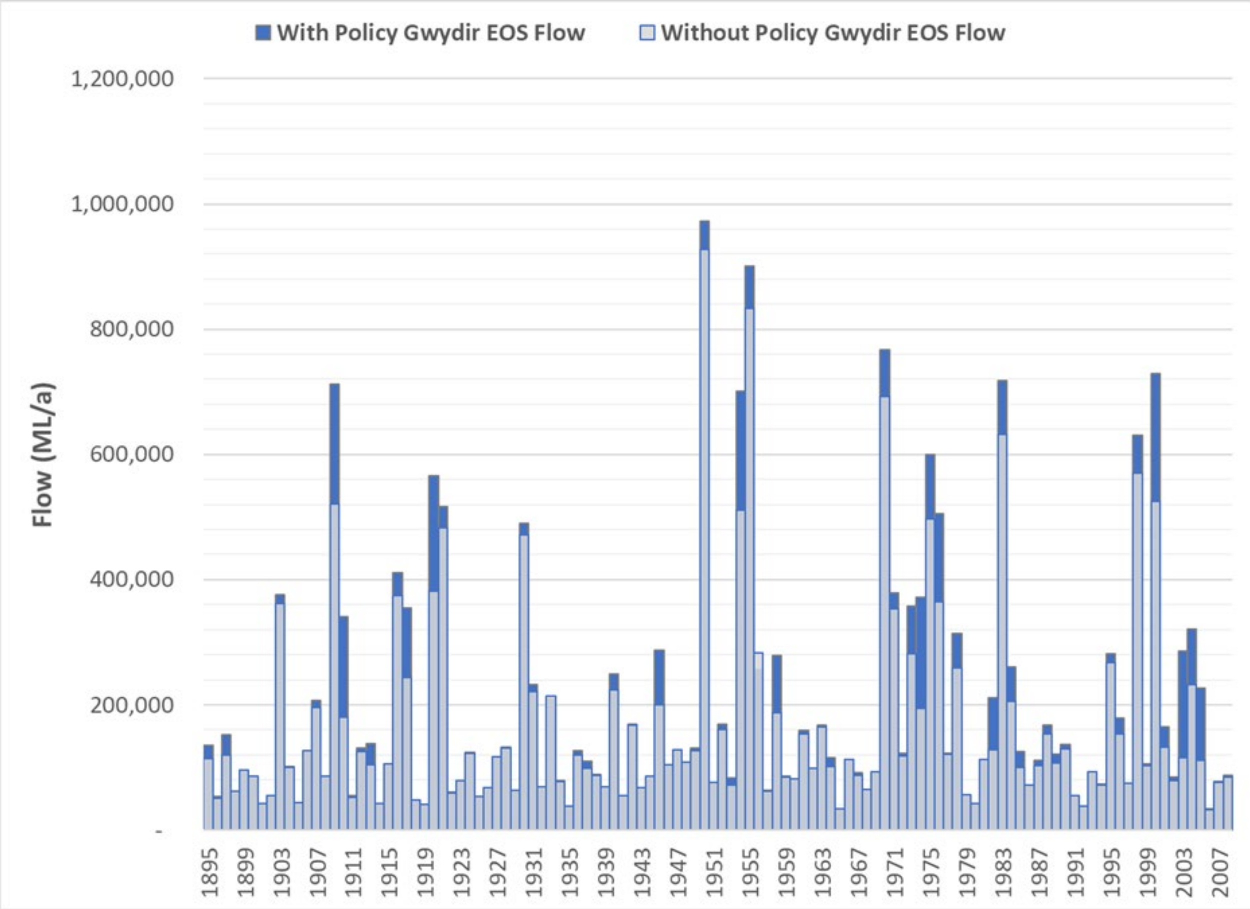

Figure 7 Modelled annual end of system (EOS) flow volume over the 114-year climate record (1895-2009) with and without the *Policy* being implemented in the Gwydir Valley

Foregone diversions are ranked (Figure 8) from largest effect to least illustrating the estimated proportion of years in which the *Policy* will have impact and the magnitude of that impact. Under the *Policy*, end-of-system flow volumes are predicted to show some increase in about 80% of years, with the largest volumetric effect in wet to very wet years and over consecutive wet years.

In about 10% of the years, equivalent to the size of a 1:10 year flood event, implementing the *Policy* is predicted to provide an increase in end-of-system flows of close to 100 GL, or nearly four times the average (27.2 GL). In the top 5% of wet years, equivalent to a 1:20 year flood, implementing the *Policy* is predicted to provide an increase in end-of-system flows of approximately 170 GL or more than 6 times the average. These flood years would see the *Policy* contribute up to 38.9% to end of system flows.

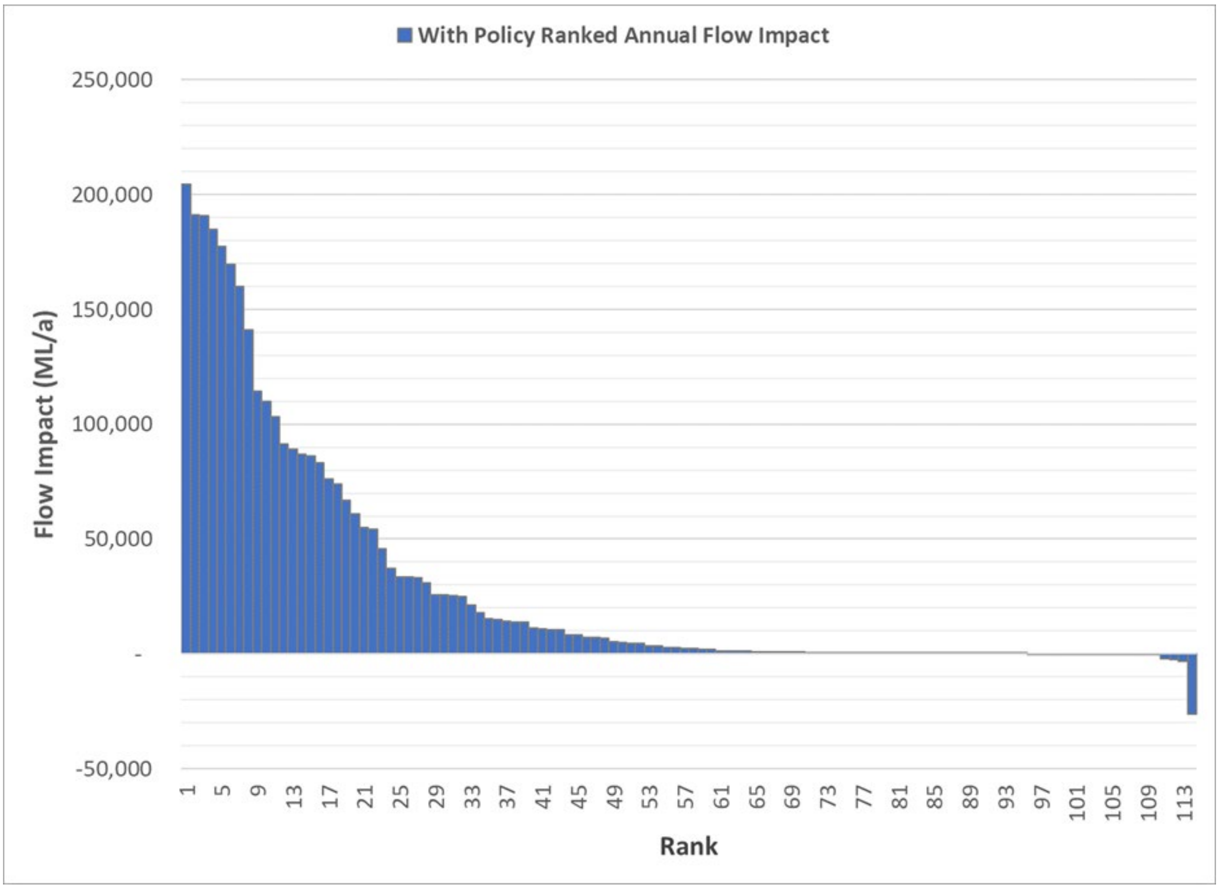

Figure 8 Modelled end of system ranked change in annual end-of-system flow volume with the *Policy* implemented for the Gwydir valley

3.4 Valley-specific assessment – Macquarie

To date, return flow impact assessment has been undertaken for the Macquarie valley under two scenarios:

- without policy implementation (Current Conditions Scenario)
- with policy implementation (Valley Scale Compliance Scenario).

The Macquarie valley is located immediately below the Namoi catchment in central-western New South Wales. In this valley three major river networks; the Castlereagh, Macquarie, and Bogan flow from the highland's northwest onto the alluvial plains and towards the Barwon River. The Castlereagh is an unregulated river with no major storages whilst the Macquarie is highly regulated with releases controlled from Burrendong Dam.

The three rivers run close to one another as they cross the plains, with flood-runners, creeks and streams providing connectivity between the Macquarie and the Bogan, the Macquarie and the Barwon, and the Castlereagh and the Barwon.

As the waterways approach the Barwon River the interconnected streams spread to form a floodplain, supporting extensive flood-dependent flora and fauna in the Ramsar-listed and nationally important Macquarie Marshes.

The Macquarie Marshes are one of the large freshwater lakes in the Murray-Darling Basin, containing many threatened and endangered species. The marshes support large numbers of waterbirds and is recognizes and one of the most important Australian bird breeding sites.

3.4.1 Location of properties eligible for floodplain harvesting

The Macquarie designated floodplain begins at Narromine extending to the northwest and broadening into a ~80km wide corridor that terminates into the Barwon-Darling.

The majority of floodplain harvesting properties in the Macquarie are located in the upstream portion of the designated floodplain associated with the Backwater Boggy Cowal and Ewenmar Creek Water Sources. Properties in these areas occupy both sides of the regulated river varying in distance from the main channel by up to 20 km.

The Macquarie Regulated River diverges ~70km downstream of Narromine into a series of northwards and eastward channels. The eastward channels soon terminate in the Lower Bogan River Water Source. There is very little floodplain harvesting occurring in this area.

The northward channels contain roughly 30% of the estimated floodplain harvesting entitlement. Floodplain harvesting properties are near the main regulated river channel. The northward channel continues into the top of the Macquarie Marshes before terminating in their centre.

3.4.2 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Macquarie were provided for before and after implementation of the Policy. Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 8 provides a summary of the modelled change in annual floodplain harvesting diversions in the Macquarie under the Policy. Results indicate a 3.9% reduction in average annual floodplain harvesting diversions under the Policy, with diversions reduced from about 47 to about 45 GL/year. The assumption of 100% return flows from these water sources returns an additional ~1.8 GL to the Macquarie system per year on average.

However, current estimates suggest that 90% of flows within the Macquarie that reach the Macquarie Marshes do not exit the system. The Marshes reticulate and retain water whilst it is taken up via several ecological processes. After applying the 90% reduction assumption modelling simulates only ~0.2 GL of additional flow reaching the Barwon River per year (average) as a result of the Policy.

Table 8 Total annual diversions and annual end-of-system flow without and with implementation of the *Policy* in the Macquarie valley[10]

Results	without *Policy* (GL)	with *Policy* (GL)	Change (GL)	Change (%)
Total annual FPH diversion	47.3	45.4	-1.8	-3.9%
Annual end-of-system flow	101.0	101.2	0.2	+0.2%

[10] These results are taken from the modelling originally published in 2021. Subsequent minor updates were made to the model in 2022 following further review of eligible infrastructure and some individual properties (DPIE 20022f), which *increased* the reduction in floodplain harvesting attributable to implementation of the Policy by 2.1 GL/year.

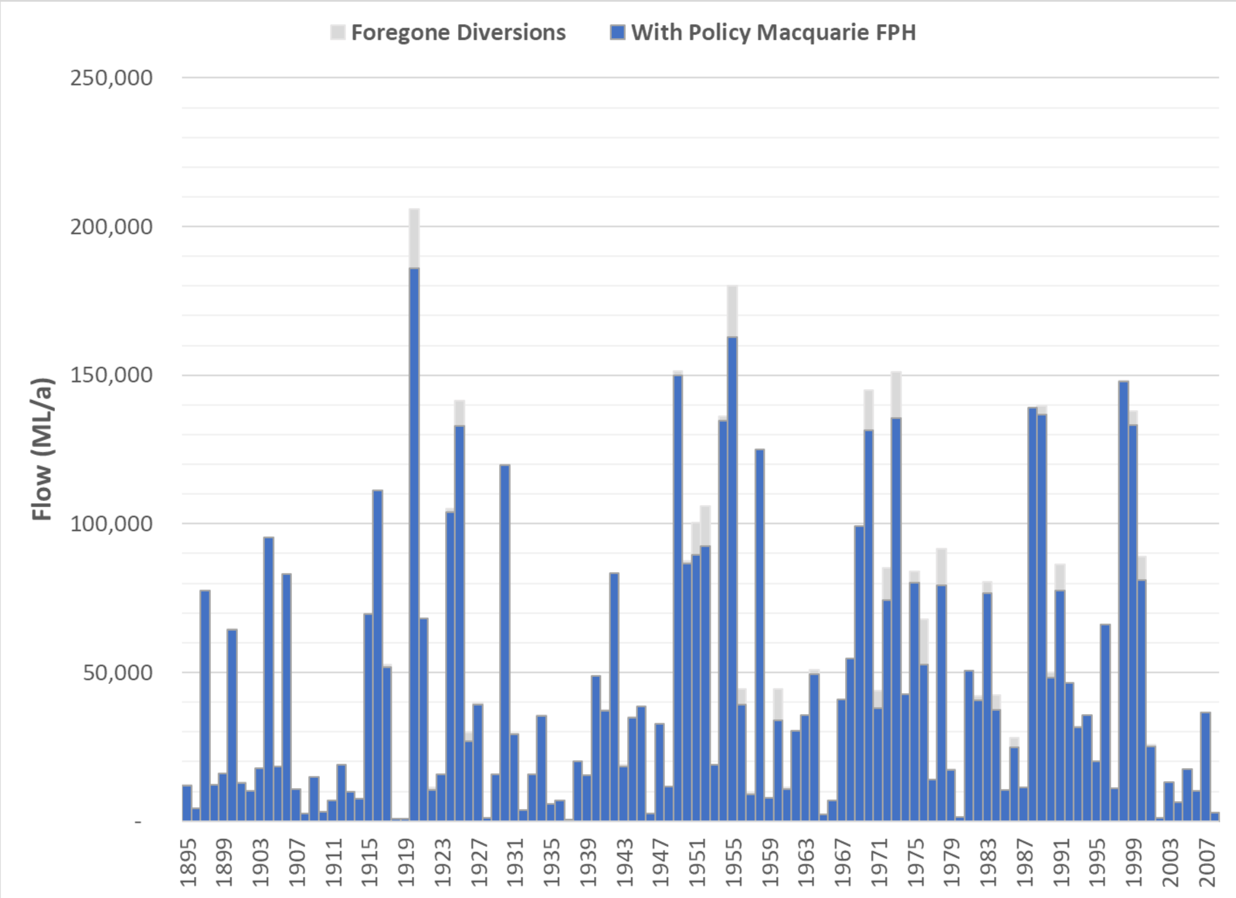

Figure 9 Modelled annual floodplain harvesting diversions with the *Policy* implemented over the 114-year climate record for the Macquarie Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the *Policy* implemented

The effect of Policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place. This variability is masked when reporting average annual results (such as in Table 8), making it important to report at annual time step.

Figure 9 shows the modelled floodplain harvesting volumes and foregone diversions with the Policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is foregone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

3.4.3 End of system flows

The vast majority of floodplain harvesting in the Macquarie occurs towards the top of the designated floodplain and is associated with the regulated river main channel. This channel terminated in the Macquarie Marshes with all water having to pass through this wetland system before connecting with the downstream Barwon-Darling. Water moves slowly through this sinuous, delta-like system with long travel times promoting the uptake of water through various ecological and hydrological processes.

Best estimates indicate that 90% of the water entering the Macquarie Marshes is retained. Any forgone diversions produced by the Policy would provide local environmental benefits but not fully translate into downstream outcomes. The estimated 1.8 GL/year annual average that would be returned to the river system under the Policy would only contribute 0.2 GL to total end-of-system flow.

The chart in Figure 10 shows end-of-system flow volumes with and without the Policy being implemented, over the 114-year climate period. The grey also represents the volume of foregone diversions after licensing that contribute to end of system flows.

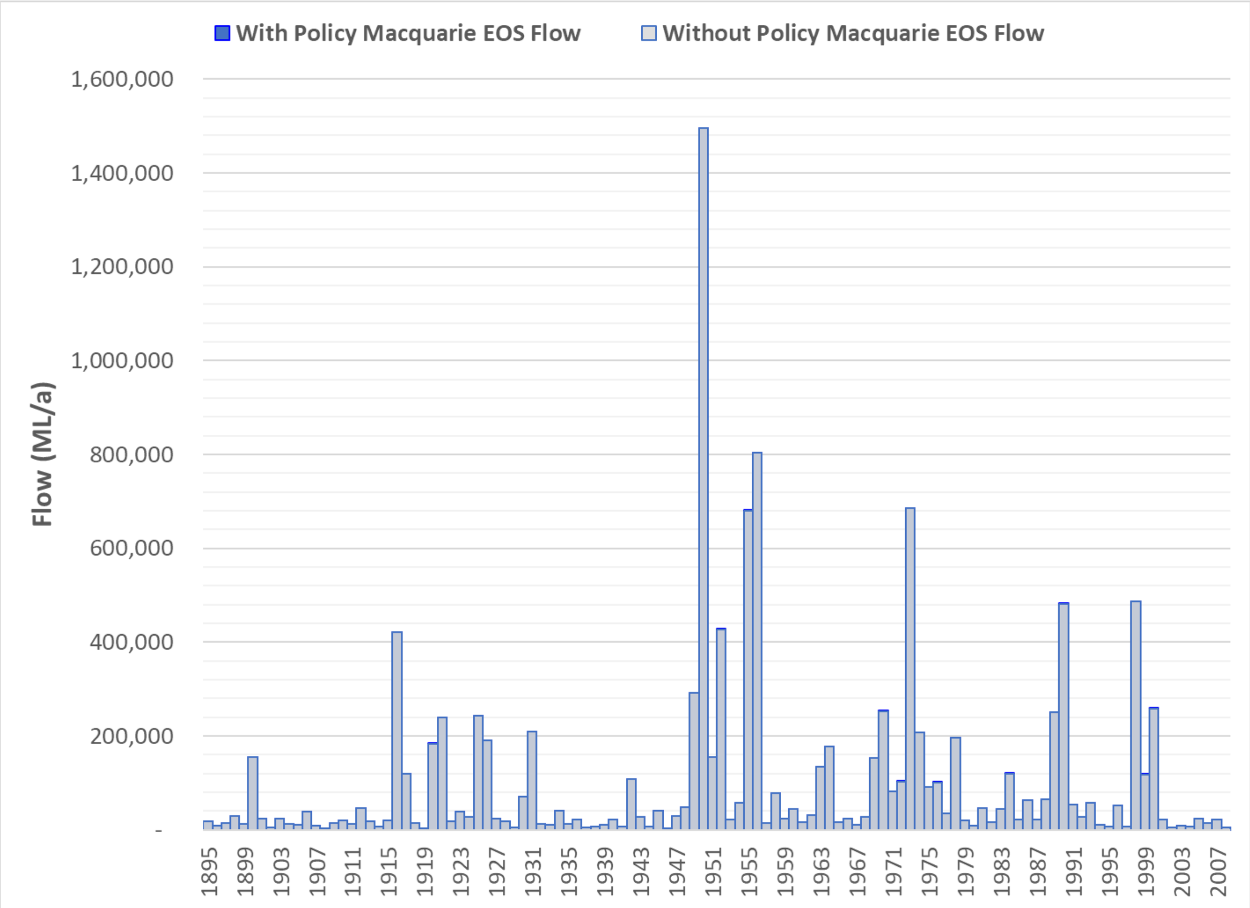

Figure 10 Modelled annual end of system (EOS) flow volume over the 114-year climate record (1895-2009) with and without the *Policy* being implemented in the Macquarie Valley

3.5 Valley-specific assessment – Namoi

3.5.1 Location of properties eligible for floodplain harvesting

The designated floodplain of the Namoi River broadens away from the Namoi River channel downstream of the confluence with the Peel River down to Boggabri, and then narrows back close to the river down to Mollee Weir. There are a small number of properties eligible for floodplain harvesting licences in this smaller floodplain area. Below Mollee Weir, the floodplain spreads out significantly, encompassing the Gunidgera-Pian Creek system. The majority of eligible properties are located in this broad lower floodplain area.

3.5.2 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Namoi regulated river system were provided for before and after (DPE Water, 2022b) implementation of the Policy. Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 9 provides a summary of the modelled change in annual floodplain harvesting diversions in the Namoi under the Policy. Results indicate a 10.3% reduction in average annual floodplain harvesting diversions under the Policy, with diversions reduced from about 52 to about 47 GL/year. The assumption of 100% return flows returns an additional ~5.3 GL to the Namoi system per year on average.

Table 9 Total annual diversions and annual end-of-system flow without and with implementation of the *Policy* in the Namoi valley[11]

Results	without *Policy* (GL)	with *Policy* (GL)	Change (GL)	Change (%)
Total annual FPH diversion	52.2	46.7	-5.4	-10.3%
Annual end-of-system flow	518.7	524.0	+5.3	+1.0%

[11] For this valley, the total annual floodplain harvesting does not include the exempt rainfall-runoff harvesting. Including the changes in exempt rainfall runoff harvesting would reduce the change in total annual floodplain harvesting from 5.4 GL/year to 2.9 GL/year.

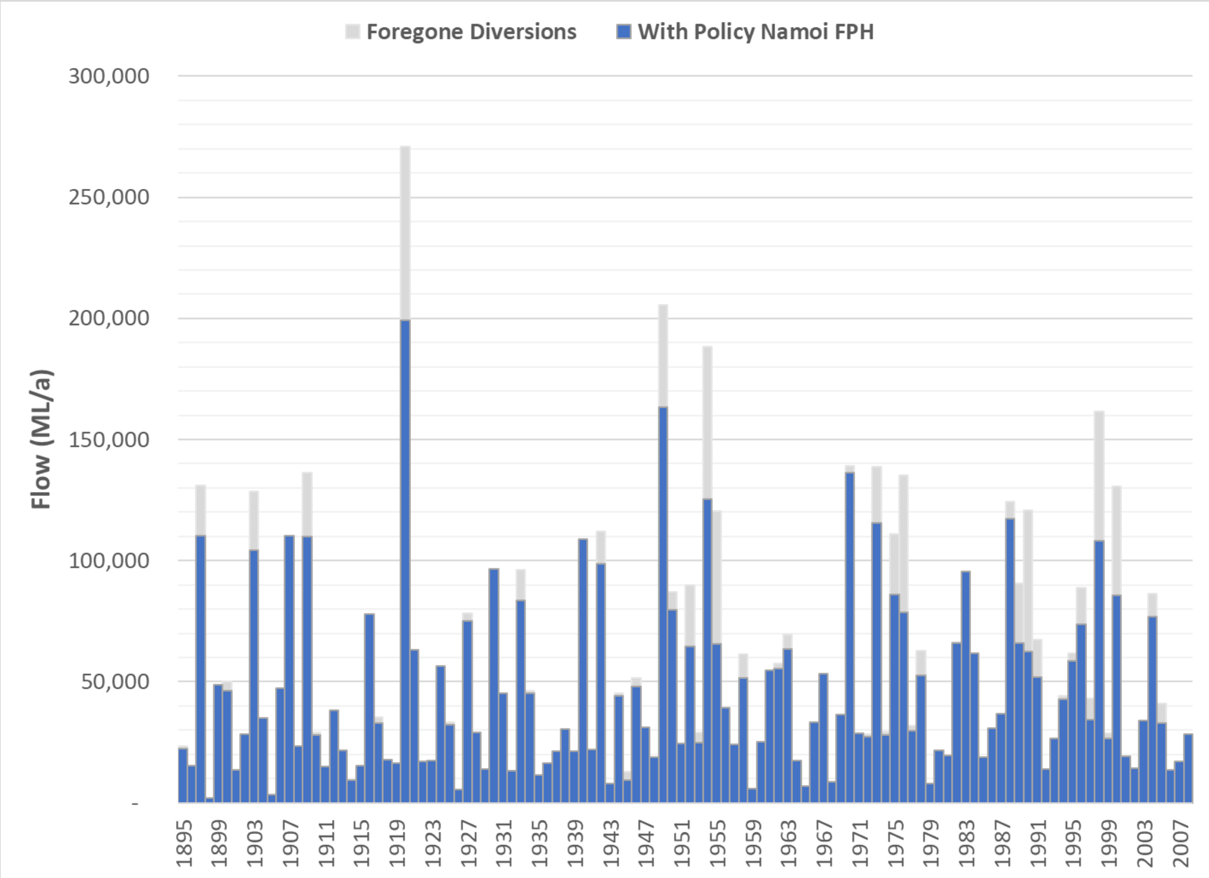

Figure 11 Modelled annual floodplain harvesting diversions with the *Policy* implemented over the 114-year climate record for the Namoi Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the *Policy* implemented

The effect of Policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place. This variability is masked when reporting average annual results (such as in Table 9), making it important to report at annual time step.

Figure 11 shows the modelled floodplain harvesting volumes and foregone diversions with the Policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is foregone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

3.5.3 End of system flows

Floodplain harvesting diversions in the Namoi are estimated to represent about 10% of total end-of-valley-system flow without Policy implementation. The chart in Figure 12 shows the modelled annual floodplain harvesting diversions and end-of-system flow volumes without the Policy being implemented, over the 114-year climate period. It can be seen from that floodplain harvesting diverts a small proportion of the total end-of-system flow in most years. The estimated 5.3 GL/year that would be returned to the river system under the Policy contributes 1.0% of the total end-of-system flow.

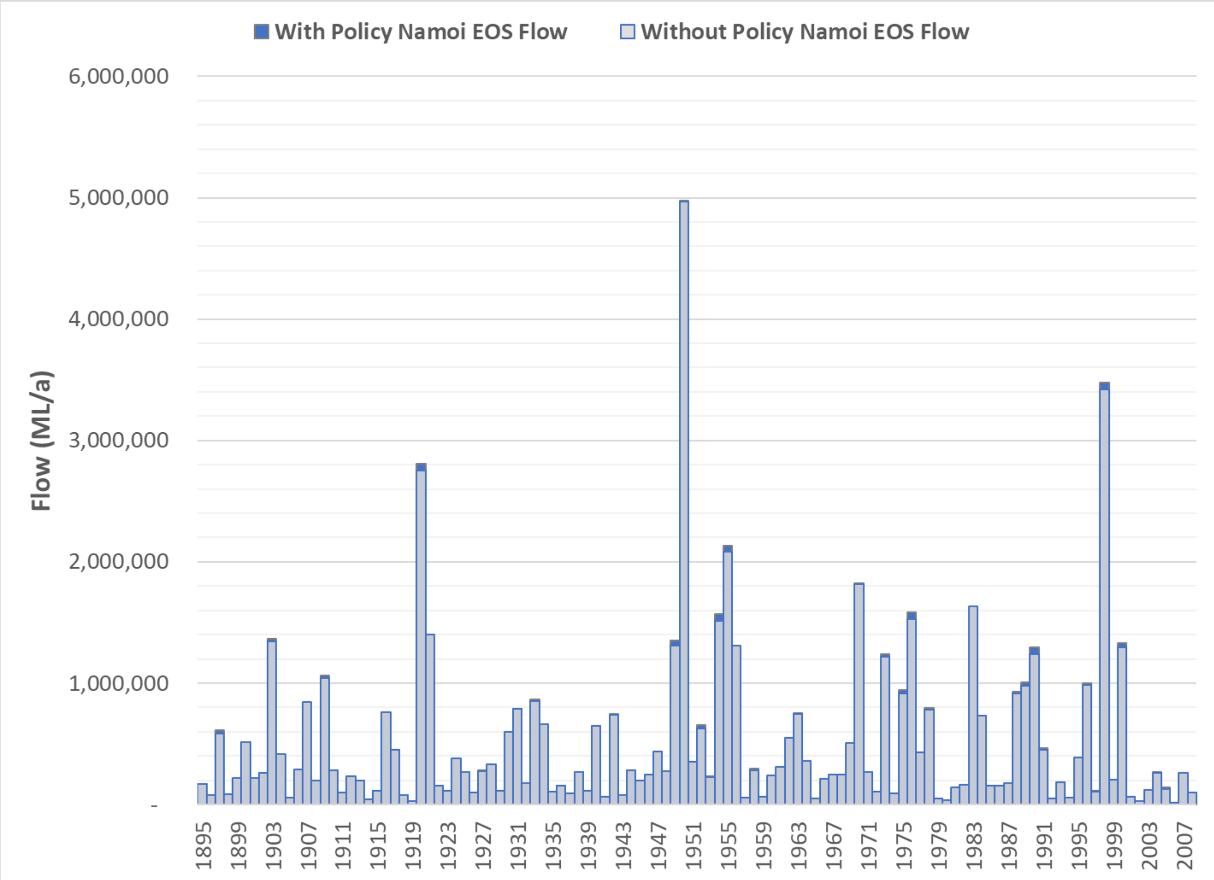

Figure 12 Modelled annual end of system (EOS) flow volume over the 114-year climate record (1895-2009) with and without the *Policy* being implemented in the Namoi Valley

Foregone diversions are ranked (Figure 13) from largest effect to least illustrating the estimated proportion of years in which the *Policy* will have impact and the magnitude of that impact. Under the *Policy*, end-of-system flow volumes are predicted to show some increase in about 45% of years, with the largest volumetric effect in wet to very wet years and over consecutive wet years.

In about 10% of the years, equivalent to the size of a 1:10 year flood event, implementing the *Policy* is predicted to provide an increase in end-of-system flows of more than 24 GL, or more than 4 times the average (5.3 GL). In the top 5% of wet years, equivalent to a 1:20 year flood, implementing the *Policy* is predicted to provide an increase in end-of-system flows of more than 52 GL or more than 10 times the average.

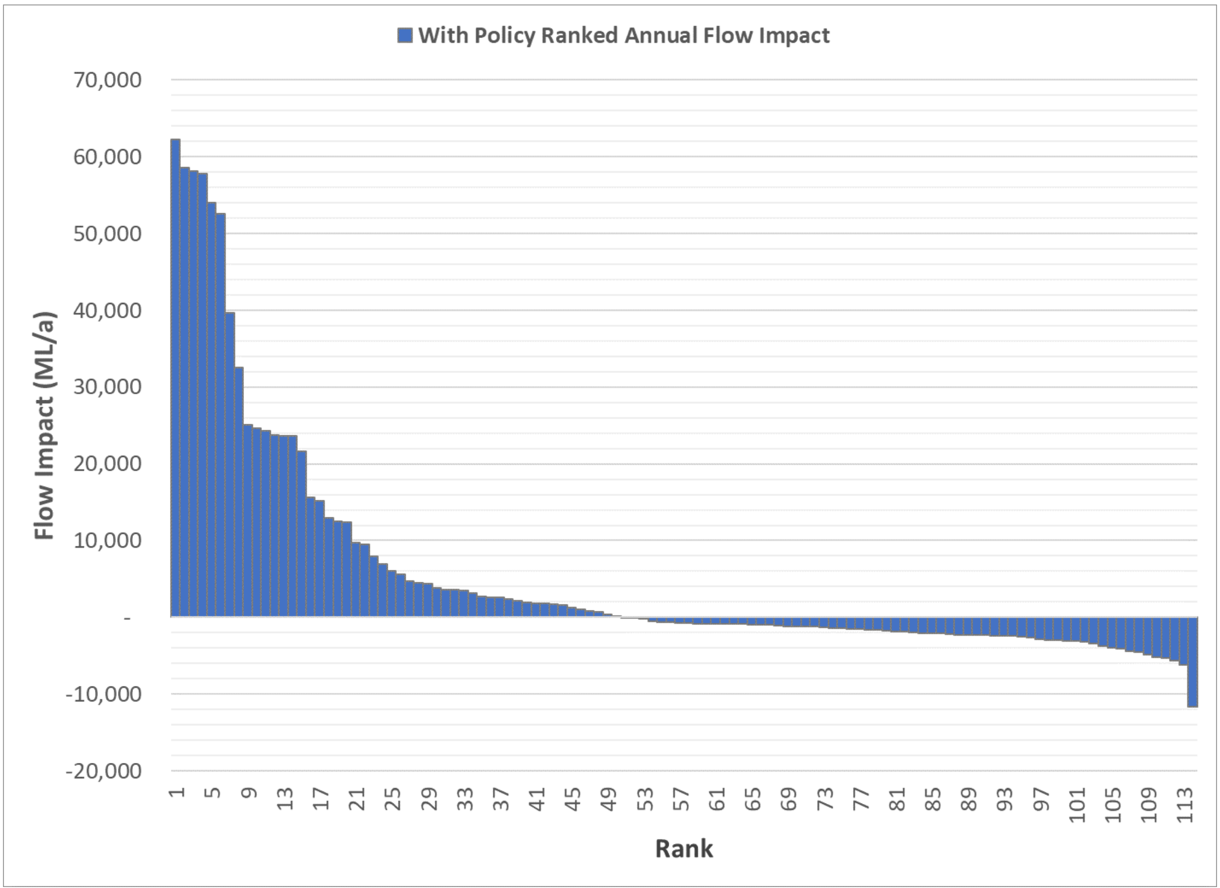

Figure 13 Modelled end of system ranked change in annual end-of-system flow volume with the *Policy* implemented for the Namoi valley

3.6 Valley-specific assessment – Barwon-Darling

To date, return flow impact assessment has been undertaken for the Barwon-Darling valley under two scenarios:

- without policy implementation (Current Conditions Scenario)
- with policy implementation (Valley Scale Compliance Scenario).

The Barwon-Darling River system begins close to the Queensland border, upstream of Mungindi at the confluence of the Macintyre and Weir rivers. The Barwon main channel is deep with excellent capacity and ability to transport flow. This corridor connects the majority of the rivers, lakes and wetlands in the northern Basin and flows all the way through to Menindee lakes and into the southern Basin.

The Barwon-Darling is an unregulated system with no major storages and is heavily reliant from inflows from tributary valleys. Flows are highly variable with this boom-and-bust nature being driven by inflows from tributary catchments including the Paroo, Warrego and Condamine–Balonne, Moonie, Border Rivers, Gwydir, Namoi, Macquarie–Castlereagh and Bogan rivers. 99% of the water flowing through the Barwon-Darling is generated in upstream catchments

3.6.1 Location of properties eligible for floodplain harvesting

The Barwon-Darling designated floodplain begins at Mungindi extending to the southwest. The floodplain is narrow and associates closely with the Barwon-Darling main channel. The designated floodplain terminates south of Bourke whilst the unregulated Barwon-Darling system continues until Wilcannia.

There are far fewer floodplain harvesting properties in the Barwon-Darling when compared to the other northern Basin valleys where the Policy is being implemented. The largest concentration of floodplain harvesting occurs around Bourke associated with the strong agricultural industry in the region. Other floodplain harvesting concentration occurs in the reach between Walgett and Brewarrina.

3.6.2 Annual average diversions

Modelled timeseries of floodplain harvesting diversions in the Barwon-Darling were provided for before and after implementation of the Policy using the initial model available in 2021[12]. Their difference allows assessment of the downstream impacts of licensing floodplain harvesting.

Table 10 provides a summary of the modelled change in annual floodplain harvesting diversions in the Barwon-Darling under the Policy. Results indicate a 3.8% reduction in average annual floodplain harvesting diversions under the Policy. Floodplain harvesting diversions are reduced from about 25 to about 24 GL/year returning 0.9 GL to the Barwon-Darling system per year on average.

As noted in Section 3.1.2, at present there is no established process or body of evidence that would enable the accurate representation of returned flows in river models, and for most valley models an assumption must be made about the proportion of any reduction in floodplain harvesting would return back to the main river.

However, many of the overbank flow breakouts in the Barwon-Darling remain close to the river itself and usually re-join the main river system. Where this occurs, the flow breakout is not separately simulated, and floodplain harvesting access by water users is simulated via use of higher flow thresholds, and any reductions in floodplain harvesting will fully contribute to downstream river flows.

Table 10 Total annual diversions and annual end-of-system flow without and with implementation of the *Policy* in the Barwon-Darling valley

Results	without *Policy* (GL)	with *Policy* (GL)	Change (GL)	Change (%)
Total annual FPH diversion	22.1	19.5	-2.5	-11.3%
Annual Wilcannia (425008) flow	1,376.8	1,376.7	-0.1	<±0.1%

[12] The final modelling published in 2022 (DPIE 2022d) indicates that the Policy would result in a reduction in floodplain harvesting of 0.9 GL/year. The results in Table 10 are for the modelling of floodplain harvesting first completed in 2021 indicated that the Policy would reduce floodplain harvesting by 2.5 GL/year.

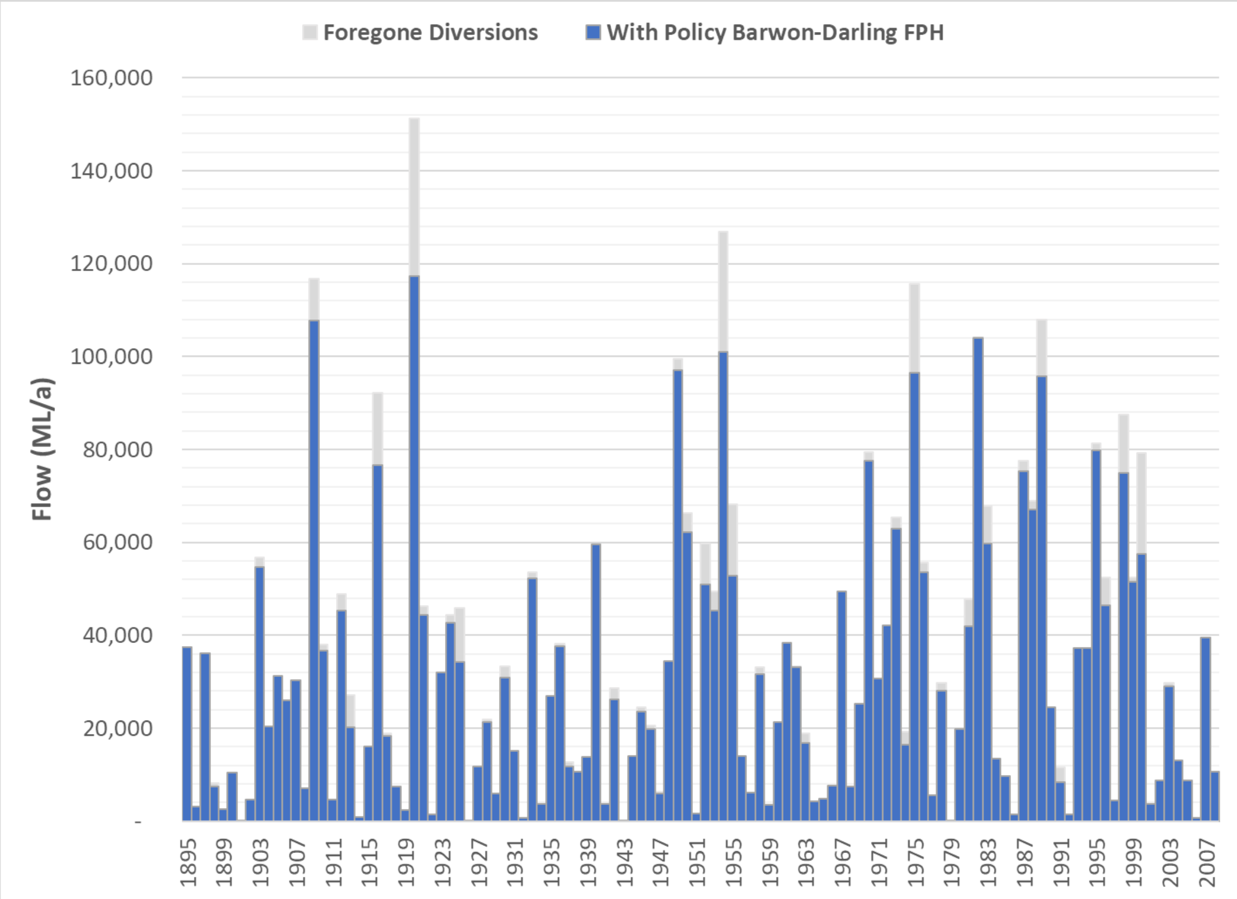

Figure 14 Modelled annual floodplain harvesting diversions with the *Policy* implemented over the 114-year climate record for the Barwon-Darling Valley. Each annual bar shows the floodplain harvesting diversions and the foregone diversions with the *Policy* implemented

The effect of Policy implementation is not shared equally between years. Floodplain harvesting is highly variable in nature, reliant on wet to very wet conditions to create overland flows. In drier years very little to no floodplain harvesting takes place. This variability is masked when reporting average annual results (such as in Table 10), making it important to report at annual time step.

Figure 14 shows the modelled floodplain harvesting volumes and foregone diversions with the Policy implemented. The blue represents the modelled annual floodplain harvesting volumes after the licensing framework is established. The grey represents the volume of diversions that is foregone after licensing. Conversely this volume can be thought of as the additional amount that would be diverted if licensing is not implemented.

3.6.3 End of system flows

Floodplain harvesting diversions in the Barwon-Darling are estimated to represent about 1.8% of total end-of-valley-system flow at Wilcannia (425008) without Policy implementation. The chart in Figure 15 shows end-of-system flow volumes with and without the Policy being implemented, over the 114-year climate period. The grey also represents the volume of foregone diversions after licensing that contribute to end of system flows. The estimated 0.9 GL/year annual average that would be returned to the river system under the Policy would contribute <±0.1% of the total end-of-system flow.

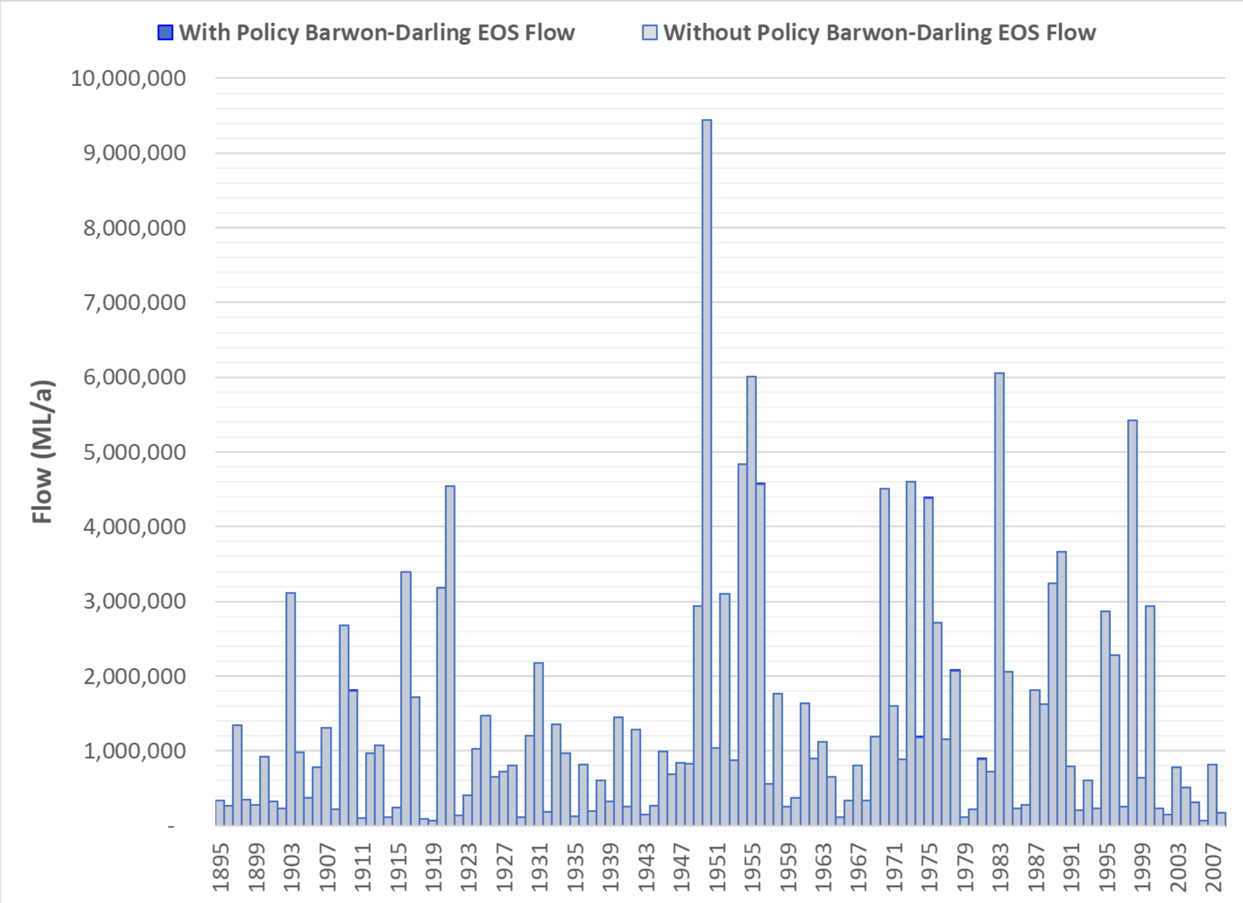

Figure 15 Modelled annual end of system (EOS) flow volume and floodplain harvesting diversions over the 114-year climate record (1895-2009) with and without the *Policy* being implemented in the Barwon-Darling Valley

Foregone diversions are ranked (Figure 16) from largest increase to least illustrating the estimated proportion of years in which the *Policy* will have impact and the magnitude of that impact. Under the *Policy*, end-of-system flow volumes are predicted to show some increase in about 47.4% of years, with the largest volumetric increase in wet to very wet years and over consecutive wet years. Largest volumetric decreases in flow occur in years that are preceded by years with large increases in flow.

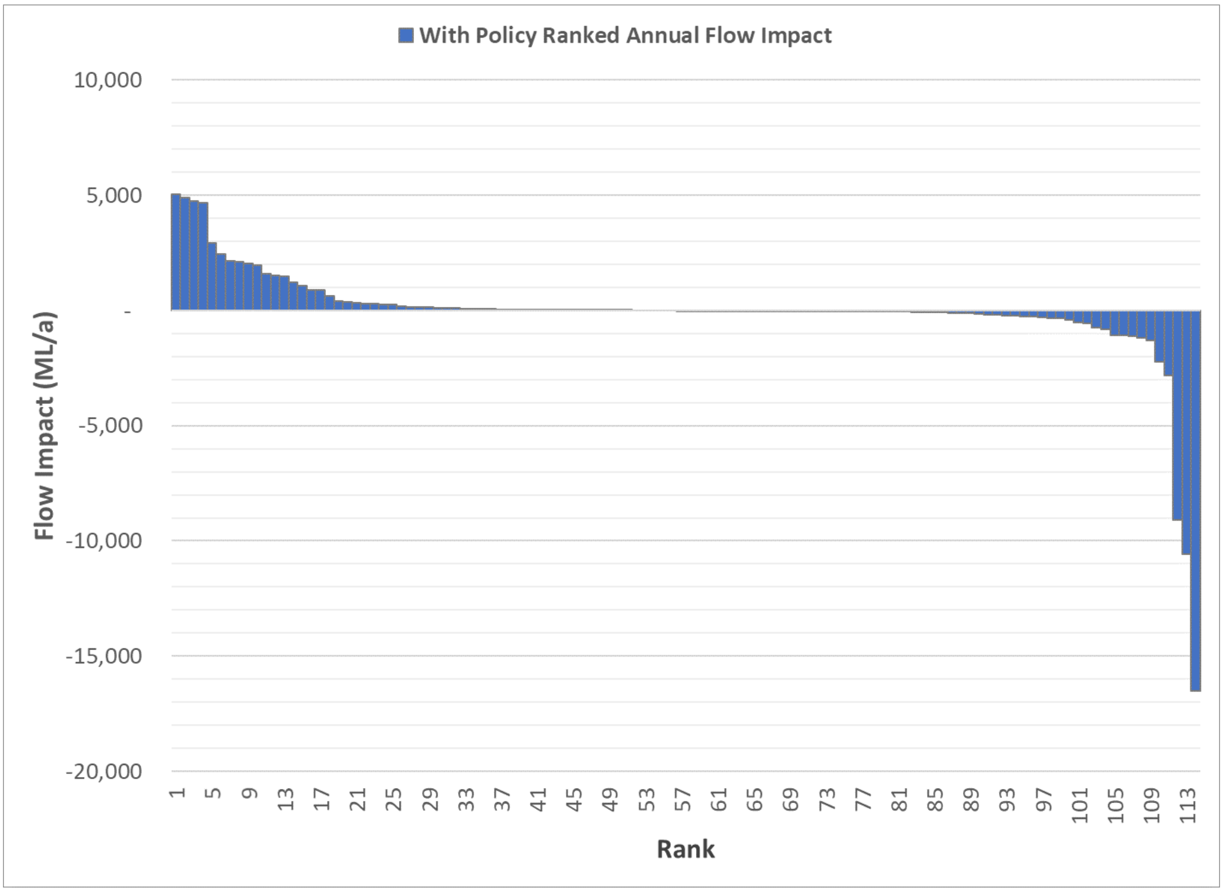

Figure 16 Modelled end of system ranked change in annual end-of-system flow volume with the *Policy* implemented for the Barwon-Darling valley

3.7 NSW Northern Basin assessment

Modelling of the Barwon-Darling River system was undertaken for a series of scenarios:

- without Policy implementation in any valley (Current Conditions Scenarios)
- with Policy implementation in the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys (Valley Scale Compliance Scenario)

This initial assessment report quantifies the impacts that licensing floodplain harvesting in the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys is predicted to have on downstream systems. The combined effects of licensing floodplain harvesting in the Barwon-Darling and the tributary valleys are then assessed along the Barwon-Darling River system.

As each tributary river model has been redeveloped with floodplain harvesting represented, the modelled outflows from these models have progressively been used to assess the impact on flows along the Barwon-Darling River system. To maintain consistency with results in previous version of this report, the results presented in this, and subsequent sections are from the version of the Barwon-Darling model that was available in 2021.

3.7.1 Impact of Policy implementation in the NSW Border Rivers valley

Table 11 and Figure 17 provide quantification of potential changes in the Barwon-Darling due to Policy implementation in the NSW Border Rivers valley at the key gauge locations of:

- Border Rivers end-of-system (i.e. inflows to the Barwon-Darling)
- Darling River at Bourke
- Darling River at Wilcannia.

Table 11 Potential changes in annual mean flow at three key locations without and with the *Policy* implemented in the NSW Border Rivers valley. Locations are shown in Figure 17

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Border Rivers inflow	538.3	+5.5	+1.0%
Bourke (425003)	1,864.4	+4.4	+0.2%
Wilcannia (425008)	1,383.1	+2.8	+0.2%

An important message from these results is that the predicted benefits of *Policy* implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of *Policy* implementation also decreases as you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego and Paroo Rivers from the north.

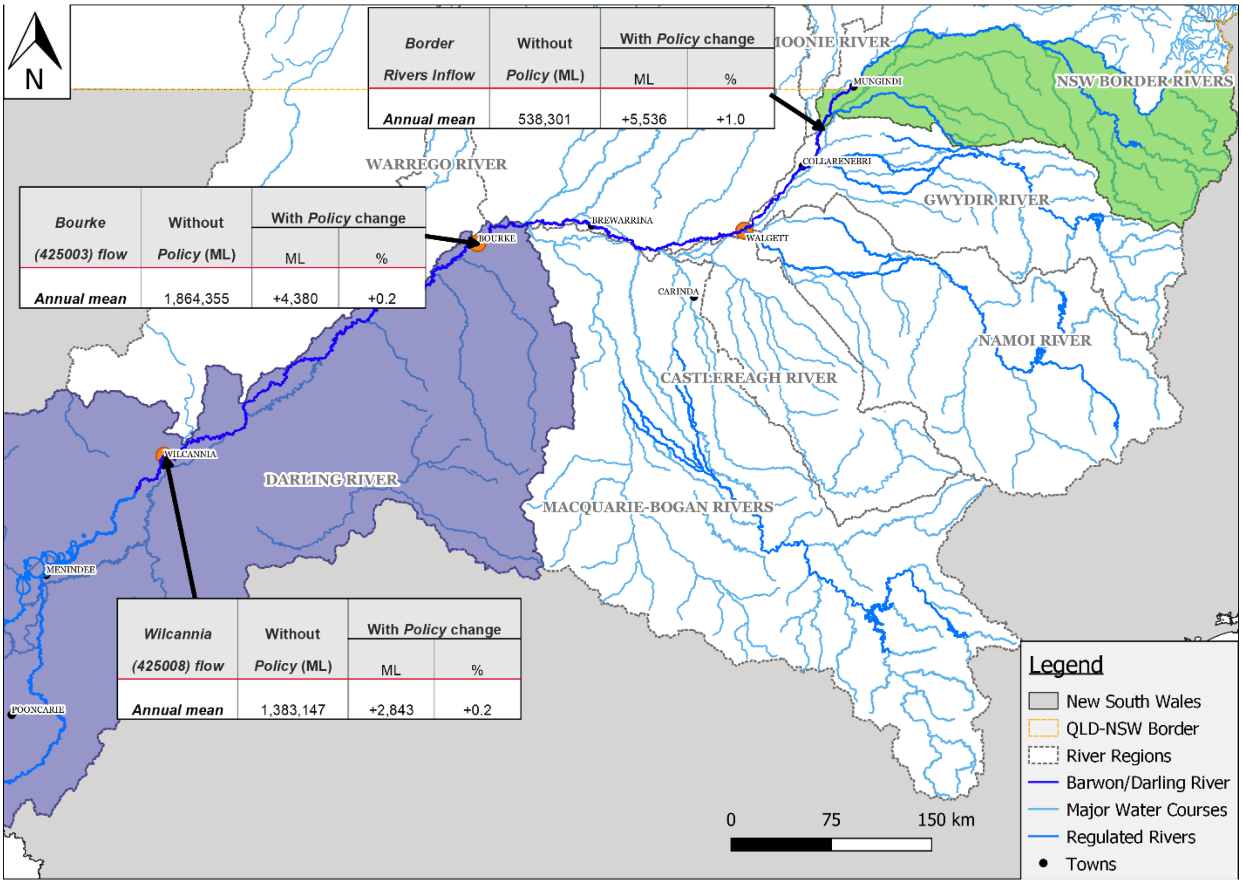

Figure 17 Map of the Barwon-Darling system, showing modelled flow metrics at 3 key locations after *Policy* implementation in the NSW Border Rivers valley

3.7.2 Impact of Policy implementation in the Gwydir valley

Table 12 and Figure 18 provide quantification of potential changes in the Barwon-Darling due to Policy implementation in the Gwydir valley at the key gauge locations of:

- Gwydir end-of-system (i.e. inflows to the Barwon-Darling)
- Barwon River at Walgett
- Darling River at Bourke
- Darling River at Wilcannia.

Foregone diversions occurring in the Gingham Watercourse Water Source and the Gwydir Water Source have been removed from this assessment as these water source have no downstream connectivity to the Baron-Darling and do not contribute to end of system flow.

Table 12 Potential changes in annual mean flow at four key locations without and with the *Policy* implemented in the Gwydir valley. Locations are shown in Figure 18

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Gwydir inflow	170.1	+27.2	+16.0%
Walgett (422001)	1,306.9	+26.3	+2.0%
Bourke (425003)	1,837.7	+22.1	+1.2%
Wilcannia (425008)	1,376.8	+16.2	+1.2%

An important message from these results is that the predicted benefits of *Policy* implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of *Policy* implementation also decreases as you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego and Paroo Rivers from the north.

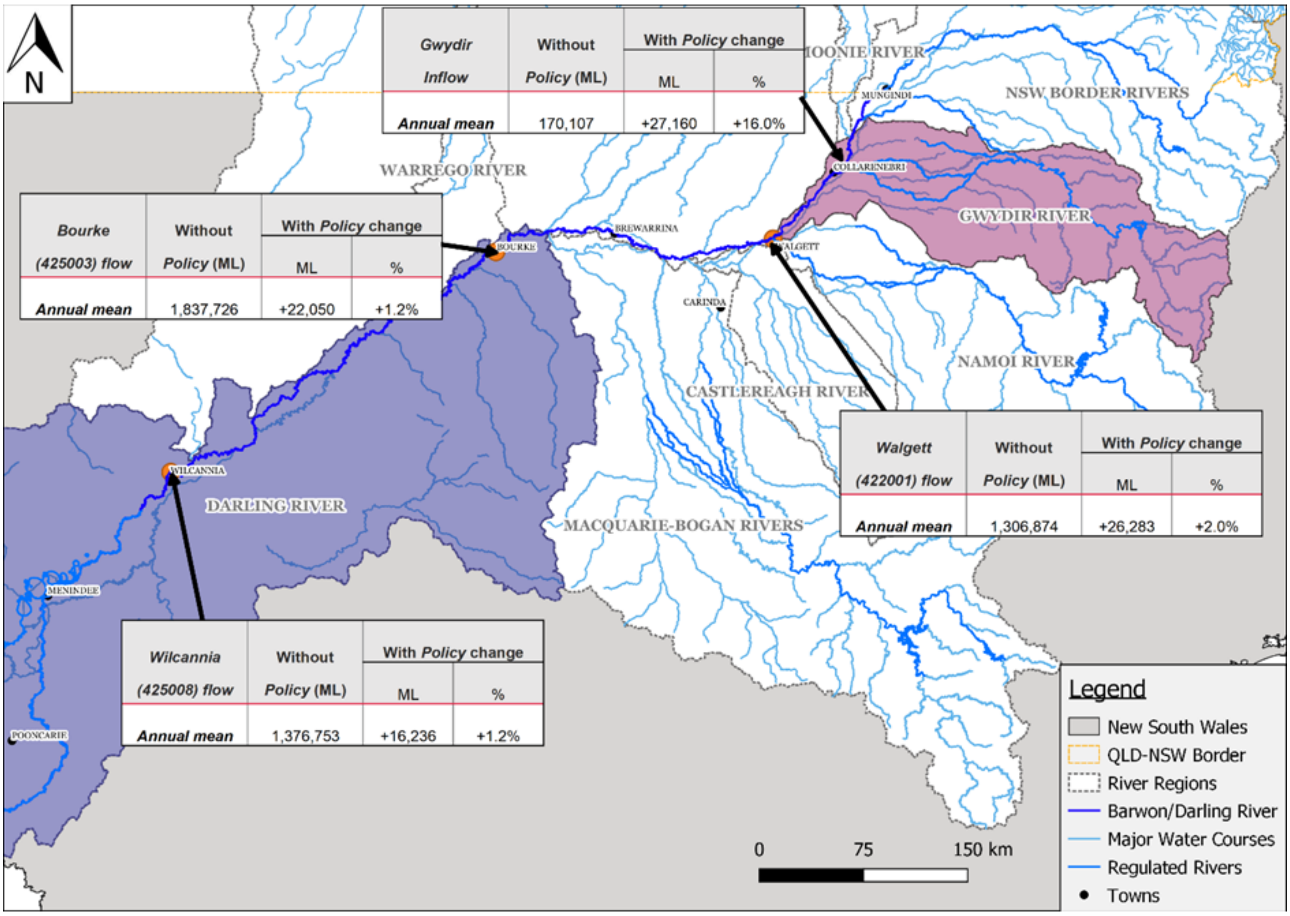

Figure 18 Map of the Barwon-Darling system, showing modelled flow metrics at 3 key locations after *Policy* implementation in the Gwydir valley

3.7.3 Impact of Policy implementation in the Macquarie valley

Table 13 and Figure 19 provide quantification of potential changes in the Barwon-Darling due to Policy implementation in the Macquarie valley at the key gauge locations of:

- Macquarie end-of-system (i.e. inflows to the Barwon-Darling)
- Darling River at Bourke
- Darling River at Wilcannia.

Table 13 Potential changes in annual mean flow at three key locations without and with the *Policy* implemented in the Macquarie valley. Locations are shown in Figure 19

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Macquarie inflow	101.0	+0.2	+0.2%
Bourke (425003)	1,837.7	+0.2	< ±0.1%
Wilcannia (425008)	1376.8	+0.1	< ±0.1%

An important message from these results is that the predicted benefits of *Policy* implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of *Policy* implementation also decreases as you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego River from the north.

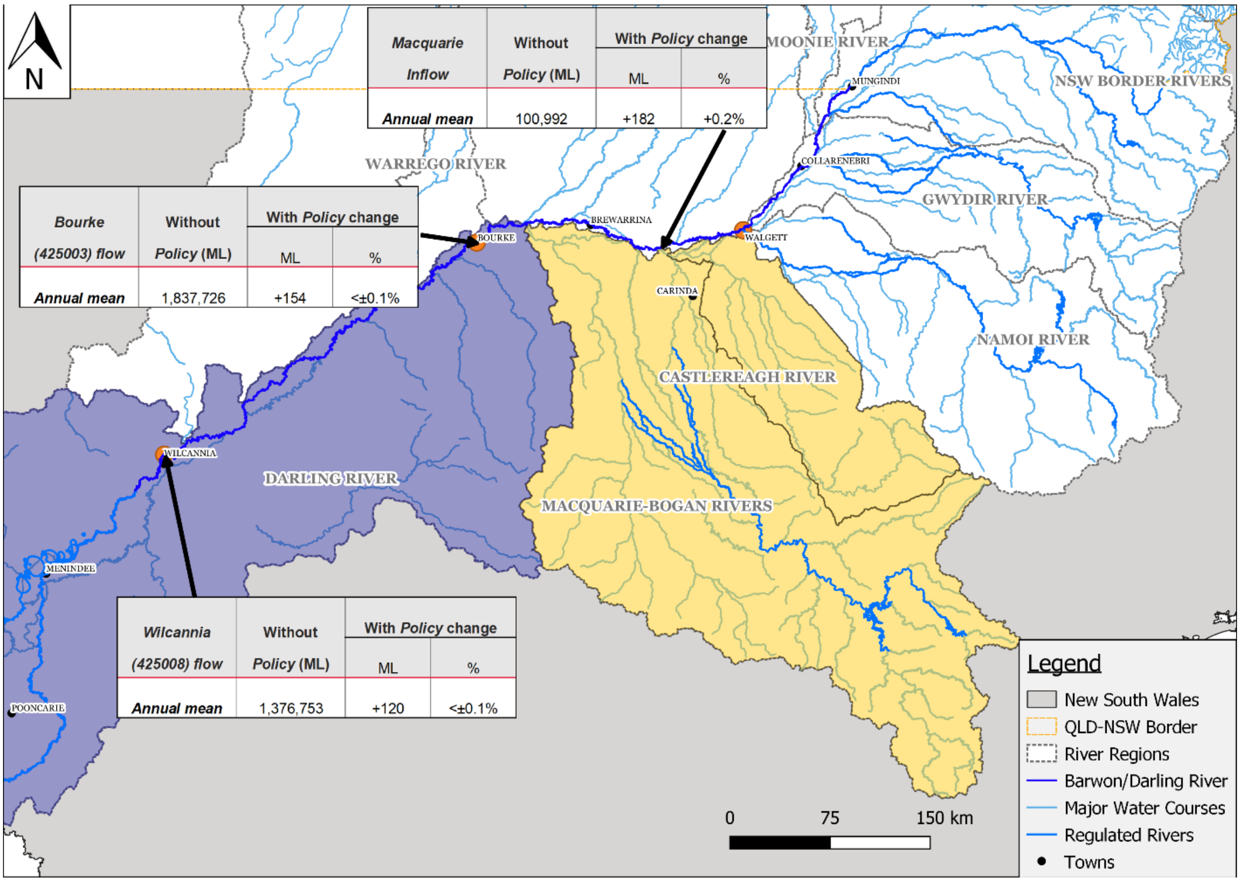

Figure 19 Map of the Barwon-Darling system, showing modelled flow metrics at 2 key locations after *Policy* implementation in the Macquarie valley

3.7.4 Impact of Policy implementation in the Namoi valley

Table 14 and Figure 20 provide quantification of potential changes in the Barwon-Darling due to Policy implementation in the Namoi valley at the key gauge locations of:

- Namoi end-of-system (i.e. inflows to the Barwon-Darling)
- Barwon River at Walgett
- Darling River at Bourke
- Darling River at Wilcannia.

Table 14 Potential changes in annual mean flow at three key locations without and with the *Policy* implemented in the Namoi valley. Locations are shown in Figure 20

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Namoi inflow	518.7	+5.3	+1.0%
Walgett (422001)	1,306.9	+5.7	+0.4%
Bourke (425003)	1,837.7	+4.8	+0.3%

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Wilcannia (425008)	1,376.8	+3.0	+0.2%

An important message from these results is that the predicted benefits of *Policy* implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of *Policy* implementation also decreases as you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego and Paroo Rivers from the north.

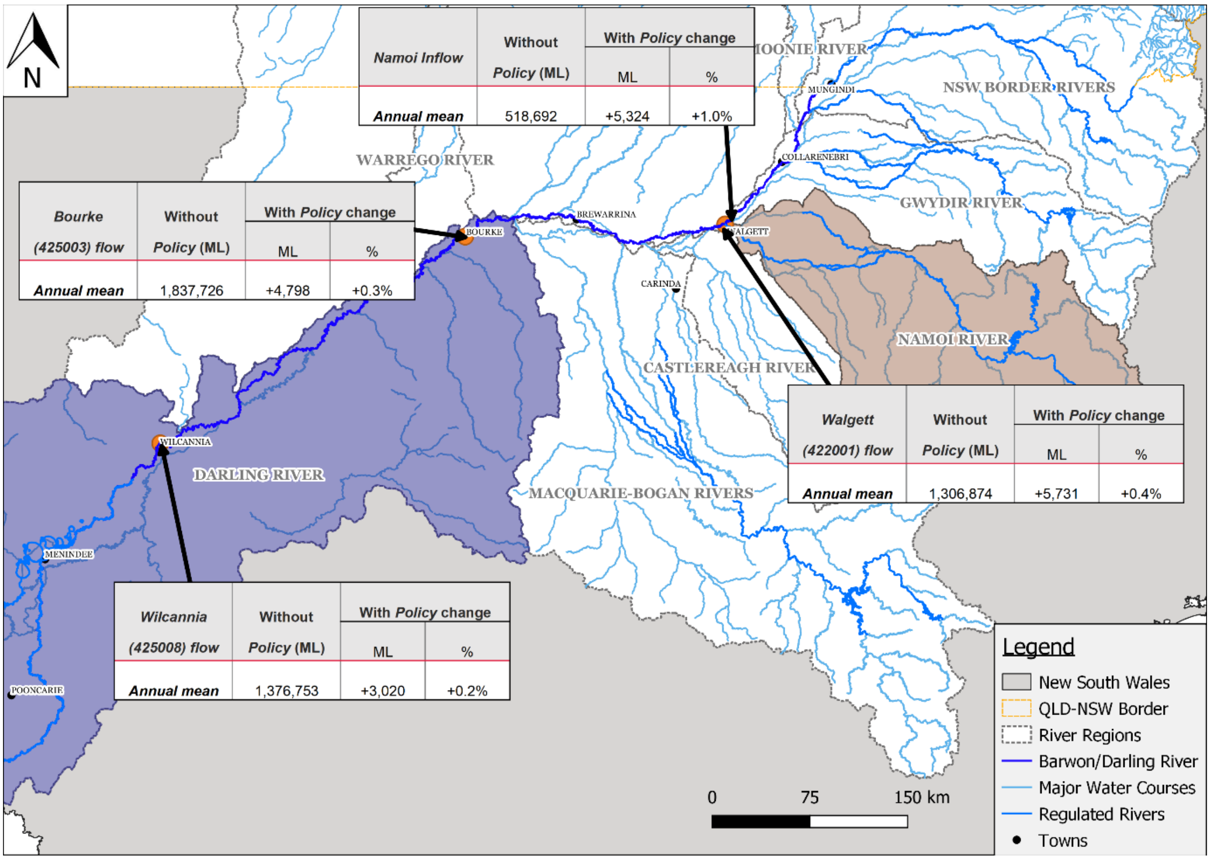

Figure 20 Map of the Barwon-Darling system, showing modelled flow metrics at 4 key locations after *Policy* implementation in the Namoi valley

3.7.5 Impact of Policy implementation in the Barwon-Darling valley

Table 15 and Figure 21 provide quantification of potential changes in the Barwon-Darling due to *Policy* implementation in the same valley at the key gauge locations of:

- Barwon River at Walgett
- Darling River at Bourke
- Darling River at Wilcannia.

Table 15 Potential changes in annual mean flow at two key locations without and with the *Policy* implemented in the Barwon-Darling valley. Locations are shown in Figure 21

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)
Walgett (422001)	1,306.9	+0.6	< ±0.1%
Bourke (425003)	1,837.7	-0.1	< ±0.1%
Wilcannia (425008)	1,376.8	-0.1	< ±0.1%

An important message from these results is that the predicted benefits of *Policy* implementation effectively decrease as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. The relative effect of *Policy* implementation also decreases as you move downstream as the same volume represents a smaller percentage of the total flow volume which has increased after contribution of inflow from other major tributaries such as flow from the Warrego River from the north.

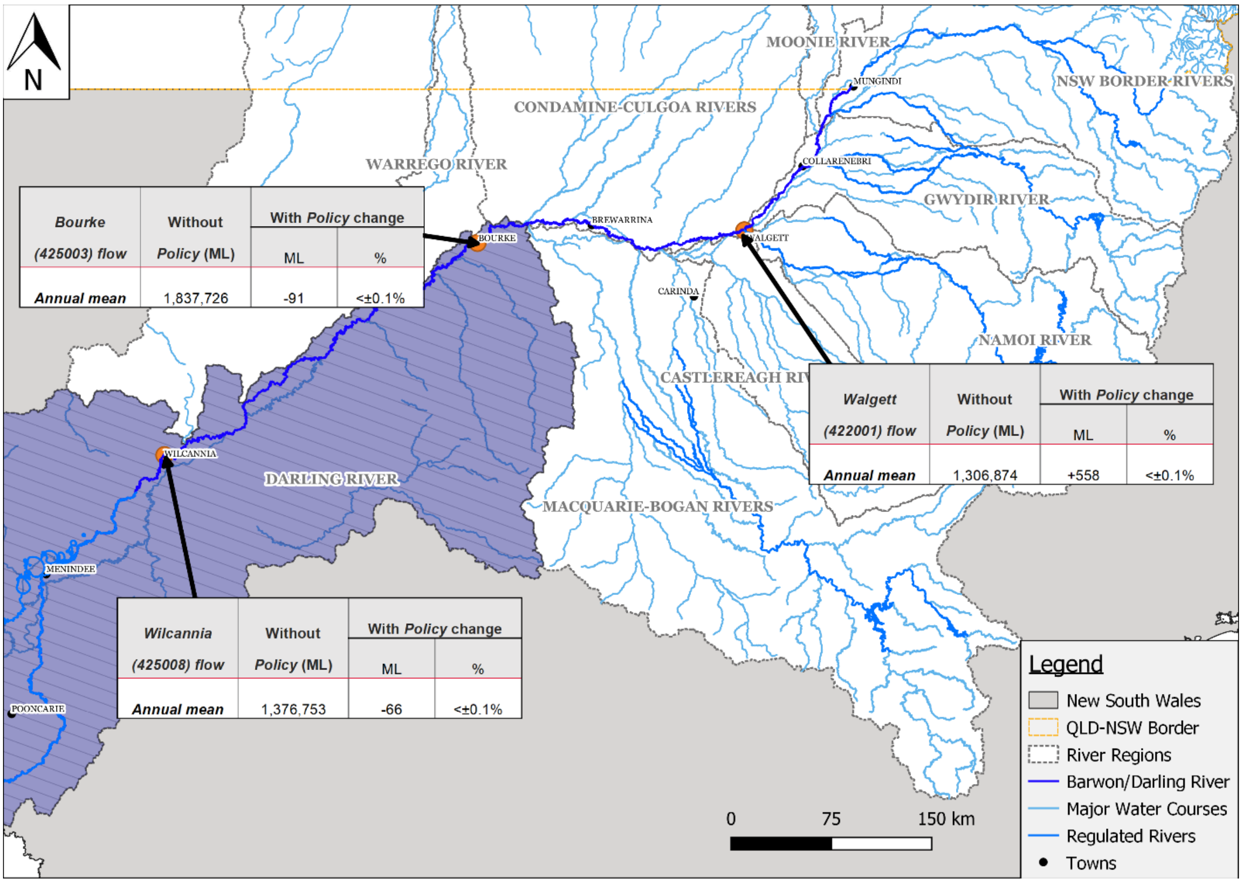

Figure 21 Map of the Barwon-Darling system, showing modelled flow metrics at 3 key locations after *Policy* implementation in the Barwon-Darling valley

3.7.6 Cumulative impact of Policy implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys

Two sets of metrics are used to quantify the potential impact:

1. Annual flows at key locations

2. Water availability in the Barwon-Darling disaggregated by licence type.

Impact on flows by location

Table 16 and Figure 22 provide quantification of potential changes in the Barwon-Darling due to *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys at the key gauge locations of:

- Border Rivers inflow
- Gwydir inflow
- Namoi inflow
- Barwon River at Walgett
- Macquarie inflow
- Darling River at Bourke
- Darling River at Wilcannia.

Border River provides an addition annual average of 5.5 GL into the northern section of the Barwon River above Collarenebri after *Policy* implementation. This is joined by an additional 27.2 GL annual average from the Gwydir and 5.3 GL from the Namoi from streams above Walgett and 0.2 GL from the Macquarie between Walgett and Brewarrina. Once these inflows join the larger Barwon-River they make up a smaller portion of the larger whole and are added to the 2.5 GL saving created through *Policy* implementation in the Barwon-Darling itself.

The additional 37.5 GL annual average provided by *Policy* implementation in the NSW Border River, Gwydir, Macquarie, Namoi and Barwon-Darling represents 2.9% of the total at the Walgett gauge. As this volume travels further down the system it attenuates, reducing to 31.1 GL (1.7%) at Bourke and 22.0 GL (1.6%) reaching Wilcannia at the bottom of the Barwon-Darling.

Table 16 Potential changes in annual mean flow without and with the *Policy* implemented in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling at key locations in the Barwon-Darling. Some locations are shown in Figure 22

Location	Without *Policy* annual mean flow (GL)	With *Policy* annual mean flow change (GL)	With *Policy* annual mean flow change (%)	With *Policy* annual max flow change (GL)	With *Policy* flow change in max year (%)
Border Rivers inflow	538.3	+5.5	+1.0	+111.1	+4.7%
Gwydir inflow	170.1	+27.2	+16.0	+204.4	+38.9%
Namoi inflow	518.7	+5.3	+1.0	+62.2	+4.1%
Walgett (422001)	1,306.9	+37.5	+2.9	+328.0	+8.2%
Macquarie inflow	100.9	+0.2	+0.2	+2.3	+0.5%
Bourke (425003)	1,837.7	+31.1	+1.7	+289.9	+4.0%
Wilcannia (425008)	1,376.8	+22.0	+1.6	+166.8	+14.1%

The year of maximum effect vary from location to location based on a series of local hydrological and climatic factors. For example, *Policy* was simulated to have maximum effect at Wilcannia in 1974 whilst 1954 saw the most change at Bourke. Comparison between location may therefore not be like for like.

In the Gwydir year of maximum effect, end of system annual flow changed by 39% with an additional 204.4 GL modelled as a result of foregone diversions. This is approximately 7 times the average benefit seen at this location. Similar maximum volume changes (289.9 GL) are seen further downstream at Bourke however this only represents 4.0% of the total volume in that year at that location.

An important message from these results is that the predicted benefits of *Policy* implementation are maximized immediately downstream of the tributary valleys subject to *Policy* implementation and vary from year to year. Annual average benefits are modeled to decrease (as a proportion and volume) as flow moves down through the system, with natural channel losses such as local aquifer recharge, seepage and evaporation/riparian evapotranspiration and consequent reduction in the effect on flow outcomes at downstream locations. Savings from the NSW Border Rivers, Gwydir, Macquarie and Namoi input into the northern Barwon-Darling were reduced by 42% by the time they reach Wilcannia.

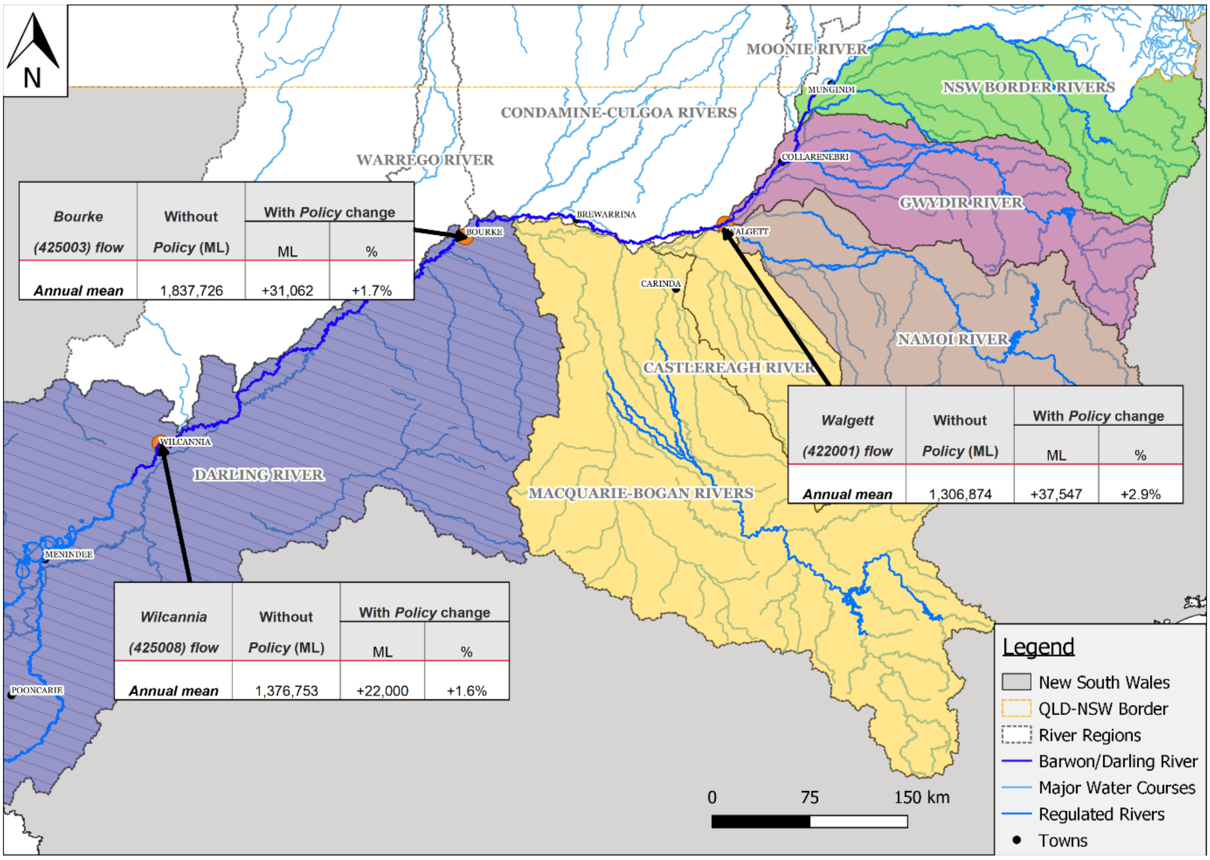

Figure 22 Map of the Barwon-Darling system, showing modelled flow metrics at 3 key locations for potential downstream outcomes of *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys

Water availability for Barwon-Darling licences

The additional volume produced by *Policy* implementation in each of the Barwon-Darling tributary valleys is potentially available for extraction in the Barwon-Darling, contributing to water availability for downstream communities, town water supply, stock & domestic users and irrigators.

The previous downstream effects assessment prior to completion of upgrades to the Barwon-Darling valley model indicates that this additional volume has a negligible impact on A, B & C Class licence holders in the Barwon-Darling. This is due to the additional volume mostly being available during wetter years when flows are high and extraction opportunities for unregulated licences are already maximised. This will be re-assessed following the completion of floodplain harvesting modelling for the Namoi Valley.

3.8 NSW Southern Basin assessment

Modelling of the Southern Basin was undertaken for two scenarios:

- without *Policy* implementation in any valley (*Current Conditions Scenarios*)
- with *Policy* implementation in the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys (*Valley Scale Compliance Scenario*)

This initial assessment quantifies the impacts that licensing floodplain harvesting in the Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys is predicted to have on flows in the NSW Southern Basin. To calculate these impacts with and without *Policy* results from the Barwon-Darling model were provided to the Murray-Darling Basin Authority and used as an input into their Murray model. This model is used to calculate diversion and allocations in the Lower Darling and Murray systems.

Murray and Lower Darling system

The northern and southern sections of the NSW Murray-Darling Basin are connected through the lower Darling River. Just as the Barwon-Darling connects the northern tributary valleys to Menindee Lakes so does the lower Darling connect Menindee to the River Murray. Only a small amount of run-off is generated within the lower Darling catchment and nearly all the water seen in system is a result of flows originating in the Barwon–Darling and its upstream valleys.

Below the Menindee Lakes, the river has 2 large and distinct channels — its main channel, the lower Darling River, and the Great Darling Anabranch. The lower Darling continues south for 530 kilometers connecting to the Murray at Wentworth. The Great Darling Anabranch runs parallel to the lower Darling and has a number of overflow lakes that can hold water for prolonged periods following a flood. It branches from the main channel of the river about 55 km south of Menindee and joins the River Murray just a few kilometers downstream of Wentworth.

At this point the waters of the northern and southern Basin combine and the River Murray travels for approximately 100km before crossing the border into South Australia.

3.8.1 Impact of Policy Implementation on the Lower Darling Regulated River

The additional volume produced by *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys contributes 23.7 GL average annual inflow to Menindee Lakes. This volume represents a minimal annual average increase of 1.6%.

This small proportional increase to inflows has a negligible impact on diversions or allocations in the Lower Darling Regulated River Water Source as supplied by Menindee Lakes. Modelling actually indicates a small reduction in diversions and allocations after these additional inflows. These small changes are within the model's error tolerances and may be the result of model artefacts. The analysis shows no effective impact of *Policy* implementation on annual average diversions or allocations in the Lower Darling over the modelled timescale.

Table 18 Potential changes in annual metrics in the Lower Darling without and with the *Policy* implemented in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys.

	Without *Policy*	With *Policy*	With *Policy* annual mean change	With *Policy* annual mean change (%)
Menindee Lakes Inflow (GL)	1,519.3	1,543.0	+23.7	+1.6%
Net Diversions (GL)	55.4	55.1	-0.3	-0.5%
General Security Allocation (30th June)	96.7	97.1	+0.4	+0.4%

Whilst the analysis shows no effective long-term average impact of *Policy* implementation on Lower Darling General Security Allocations there are some years in the timeseries that see change. In only 3 of the 114 years (around 3% of years) we see an improvement of greater than 0.1% in General Security allocations because of *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys (Figure 23).

This seemingly small change to Lower Darling General Security Allocations may be attributed to the large proportion of years when the system is fully allocated (100%). In these years any change in volume would not translate to additional allocations. Only 7 years in the 114-year time series show a General Security Allocation of less than 100% i.e. an opportunity to improve through *Policy* implementation. In one of those years allocations are modelled to improve from approximately 50% to 100% due to additional upstream volumes provided by *Policy*.

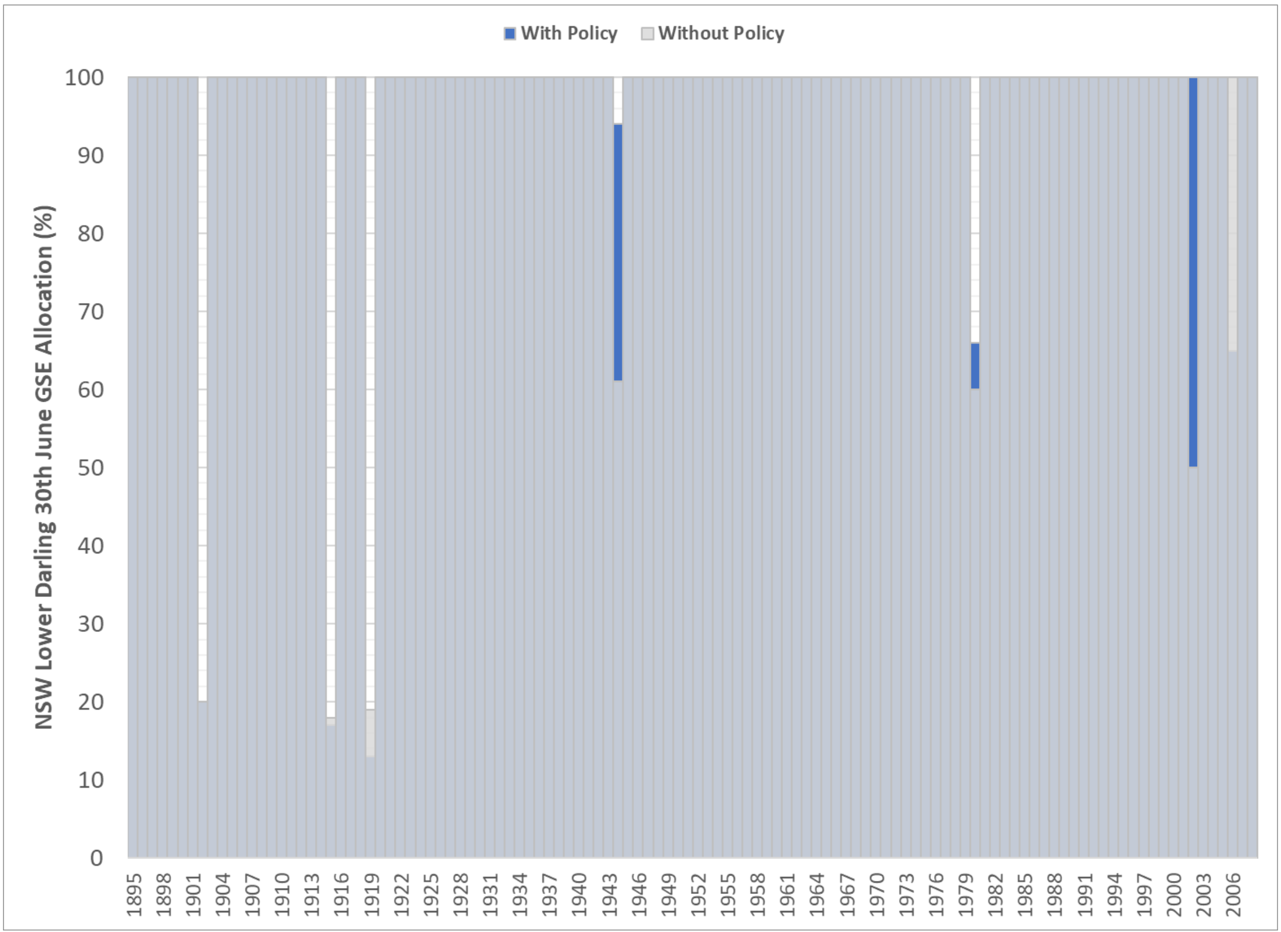

Figure 23 Lower Darling General Security Allocations on 30th June with and without *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys

3.8.2 Impact of Policy Implementation on the NSW Murray Regulated River

The additional volume produced by *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys contributes 3.2 GL average annual flow at Wentworth. The model indicates a very minimal attenuation as water flows down the Lower Darling into the Murray system.

This 3.2 GL only represents a very small proportion (<0.1%) of total flows at the location where the Lower Darling joins the far larger River Murray. This volume remains similar as it moves the small distance and flows across the border at South Australia.

This small proportional increase to inflows has a negligible impact on diversions or allocations in the Murray Regulated River Water Source. Modelling indicates a small increase in allocations after these additional inflows. These small changes are within the model's error tolerances and may be the result of model artefacts. The analysis shows no effective impact of *Policy* implementation on annual average diversions or allocations in the Murray over the modelled timescale.

Table 19 Potential changes in annual metrics in the Murray without and with the *Policy* implemented in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys.

	Without *Policy*	With *Policy*	With *Policy* annual mean change	With *Policy* annual mean change (%)
Wentworth Flow (GL)	7,752.5	7,755.8	+3.2	<±0.1%
Flow to South Australia (GL)	7,190.2	7,195.7	+5.6	+0.1%
Net Diversions (GL)	1,402.0	1,405.8	+3.8	+0.3%
General Security Allocation (30th June)	85.3	85.9	+0.6	+0.7%

In approximately 17 of the 114 years (around 15% of years) we see improvement in General Security allocations because of *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys (Figure 24).

Whilst these 17 years see positive change there are a number of years that see a minor negative impact and as a whole the analysis shows no effective long-term average impact of *Policy* implementation on Murray allocations.

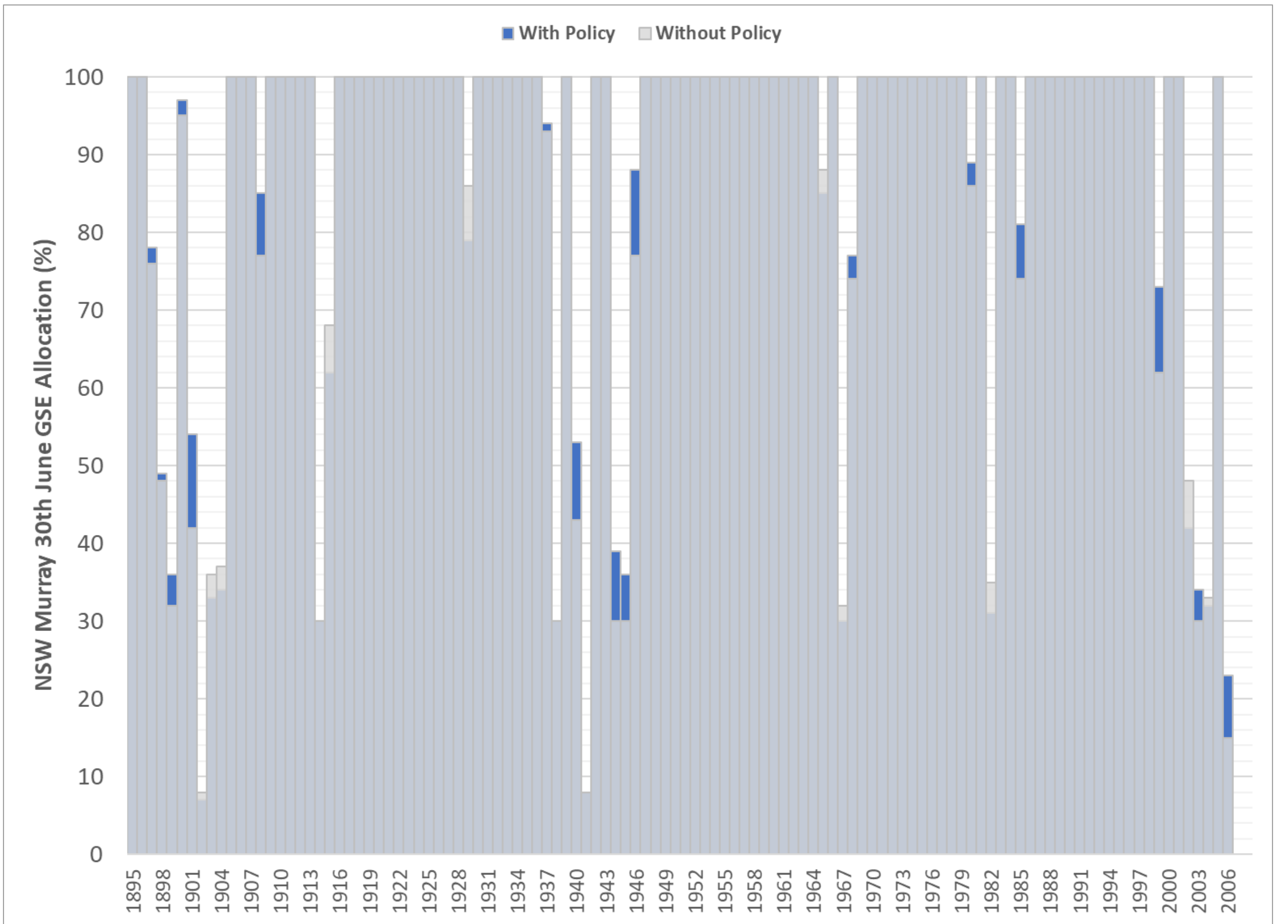

Figure 24 Murray General Security Allocations on 30th June with and without *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie, Namoi and Barwon-Darling valleys

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DPIE Water (2022d) *Floodplain Harvesting Entitlements for Barwon-Darling River system: Model Scenarios*. NSW Department of Planning, Industry and Environment.

Appendix A: Sensitivity testing

A high-level sensitivity assessment was undertaken with results under base (100%) and sensitivity (50%) assumptions for end of system flow volumes. Results provide initial insights into the scale of impact that local effects such as aquifer recharge, vegetation and evaporation, local floodplain connectivity and river channel routing could have on the estimated/expected outcomes of floodplain harvesting policy implementation.

As noted in Section 3.6.2 many of the overbank flow breakouts in the Barwon-Darling remain close to the river itself and usually re-join the main river system. Where this occurs, the flow breakout is not separately simulated, and floodplain harvesting access by water users is simulated via use of higher flow thresholds, and any reductions in floodplain harvesting are configured to fully contribute to downstream river flows for this model. For this reason, there is only a 100% return flow assumption for the Barwon-Darling Valley.

Table 20 Modelled average annual end of system flow volumes without the *Policy* and with the *Policy* under assumptions of 100% and 50% return flows for the NSW Border Rivers valley

Scenario	Average annual end-of-system flow (GL/year)	Floodplain harvesting reduction (i.e. foregone diversion) (GL/year)
Without *Policy* (current)	538.3	Not applicable
With *Policy* and 100% return flow assumption	543.8	5.5
With *Policy* and 50% return flow assumption	541.1	2.8

Table 21 Modelled average annual end of system flow volumes without the *Policy* and with the *Policy* under assumptions of 100% and 50% return flows for the Gwydir valley

Scenario	Average annual end-of-system flow (GL/year)	Floodplain harvesting reduction (i.e. foregone diversion) (GL/year)
Without *Policy* (current)	170.1	Not applicable
With *Policy* and 100% return flow assumption	197.3	36.7 (29.4)
With *Policy* and 50% return flow assumption	184.9	18.4 (14.7)

Table 22 Modelled average annual end of system flow volumes without the *Policy* and with the *Policy* under assumptions of 100% and 50% return flows for the Macquarie valley

Scenario	Average annual end-of-system flow (GL/year)	Floodplain harvesting reduction (i.e. foregone diversion) (GL/year)
Without *Policy* (current)	101.0	Not applicable

Scenario	Average annual end-of-system flow (GL/year)	Floodplain harvesting reduction (i.e. foregone diversion) (GL/year)
With *Policy* and 100% return flow assumption	101.2	1.8 (0.2)
With *Policy* and 50% return flow assumption	101.1	0.9 (0.1)

Table 23 Modelled average annual end of system flow volumes without the *Policy* and with the *Policy* under assumptions of 100% and 50% return flows for the Namoi valley

Scenario	Average annual end-of-system flow (GL/year)	Floodplain harvesting reduction (i.e. foregone diversion) (GL/year)
Without *Policy* (current)	518.7	Not applicable
With *Policy* and 100% return flow assumption	524.0	5.3
With *Policy* and 50% return flow assumption	521.3	2.7

Table 24 Modelled average annual flows without the *Policy* and with the *Policy* implemented in the Border Rivers, Gwydir, Macquarie and Namoi valleys under assumptions of 100% and 50% return flows at Walgett

Scenario	Average annual flow (GL/year)	Average annual flow increase (GL/year)
Without *Policy* (current)	1,306.9	Not applicable
With *Policy* and 100% return flow assumption	1,344.4	37.5
With *Policy* and 50% return flow assumption	1,327.0	20.1

Table 25 Modelled average annual flows without the *Policy* and with the *Policy* implemented in the Border Rivers, Gwydir, Macquarie and Namoi valleys under assumptions of 100% and 50% return flows at Bourke

Scenario	Average annual flow (GL/year)	Average annual flow increase (GL/year)
Without *Policy* (current)	1,837.7	Not applicable
With *Policy* and 100% return flow assumption	1,868.8	31.1
With *Policy* and 50% return flow assumption	1,854.1	16.3

Table 26 Modelled average annual flows without the *Policy* and with the *Policy* implemented in the Border Rivers, Gwydir, Macquarie and Namoi valleys under assumptions of 100% and 50% return flows at Wilcannia

Scenario	Average annual flow (GL/year)	Average annual flow increase (GL/year)
Without *Policy* (current)	1,376.8	Not applicable
With *Policy* and 100% return flow assumption	1,401.7	24.9
With *Policy* and 50% return flow assumption	1,390.4	13.6

Appendix B: NSW Southern Basin sensitivity assessment

An additional sensitivity assessment was undertaken to investigate the potential impact of suspending floodplain harvesting in the Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys. This assessment was undertaken prior to completion of modelling of the Policy in the Namoi Valley and does not include the effects of suspending floodplain harvesting access in the Namoi Valley.

This assessment explores the difference in diversions at the valley scale, considering the previously assessed post *Policy* implementation and what would occur if floodplain harvesting were to instead be suspended in each of those catchments. The volumetric difference between the scenario with constrained floodplain harvesting (the *Valley Scale Compliance Scenario*) and the suspended floodplain harvesting scenario (the *Valley Scale Suspension Scenario*) is the **foregone diversions**. The volume of foregone diversions in each valley is then an input to the downstream Barwon-Darling River system model to assess the downstream impact of these contributions.

Modelling of the Southern Basin was undertaken for a series of scenarios:

1. With *Policy* implementation in the Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys (*Valley Scale Compliance Scenario*)
2. With suspension of floodplain harvesting in the Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys (*Valley Scale Suspension Scenario)*

This initial assessment quantifies the impacts that suspending floodplain harvesting in the Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys is predicted to have on flows in the NSW Southern Basin. To calculate these impacts with and without floodplain harvesting suspension results from the DPIE Barwon-Darling model were provided to the Murray-Darling Basin Authority and used as an input into their Murray model. This model is used to calculate diversion and allocations in the Lower Darling and Murray systems. Future extensions to this report will include the modelled impacts of licensing in the remaining Namoi valley.

Inputs and assumptions

Modelling was undertaken in a manner consistent with *Policy* assessment. That is, foregone diversions generated by suspending floodplain harvesting from the upstream catchments were routed directly to the end-of-valley system outflow and added to the inflows from that valley into the Barwon-Darling River system.

As in *Policy* assessment, suspension assessment was undertaken under the following assumptions:

- **100% of foregone diversions return to the river** (i.e. all non-harvested water returns from the floodplain to the river)
- **100% of that returning water contributes to end-of-system flows** (i.e. 100% of returned floodplain water flows unaltered to the end of system).

Impact of Floodplain Harvesting Suspension on the Lower Darling Regulated River

The additional volume produced by floodplain harvesting suspension in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys contributes 122.5 GL average annual inflow to Menindee Lakes. This volume represents an annual average increase of 7.9%.

This proportional increase to inflows has a relatively minor impact on diversions or allocations in the Lower Darling Regulated River Water Source as supplied by Menindee Lakes. These small changes are within the model's error tolerances and may be the result of model artefacts. The analysis shows no effective impact of floodplain harvesting suspension on annual average diversions or allocations in the Lower Darling over the modelled timescale.

Table 27 Potential changes in annual metrics in the Lower Darling with *Policy* and without FPH diversion in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys.

	With *Policy*	Without FPH	Without FPH annual mean change	Without FPH annual mean change (%)
Menindee Lakes Inflow (GL)	1,546.0	1,668.4	+122.5	+7.9%
Net Diversions (GL)	54.9	55.7	+0.8	+1.4%
General Security Allocation (30^{th} June)	96.5	97.0	+0.6	+0.6%

Whilst the analysis shows no effective long-term average impact of floodplain harvesting suspension on Lower Darling General Security Allocations there are some years in the timeseries that see change. In only 5 of the 114 years (~4% of years) we see an improvement of greater than 0.1% in General Security allocations because of floodplain harvesting suspension in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys (Figure 25).

This seemingly small change to Lower Darling General Security Allocations may be attributed to the large proportion of years when the system is fully allocated (100%). In these years any change in volume would not translate to additional allocations. Only 7 years in the 114-year time series show a General Security Allocation of less than 100% i.e. an opportunity to improve through floodplain harvesting suspension. In one of those years allocations are modelled to improve from around 35% to 100% due to additional upstream volumes provided by floodplain harvesting suspension.

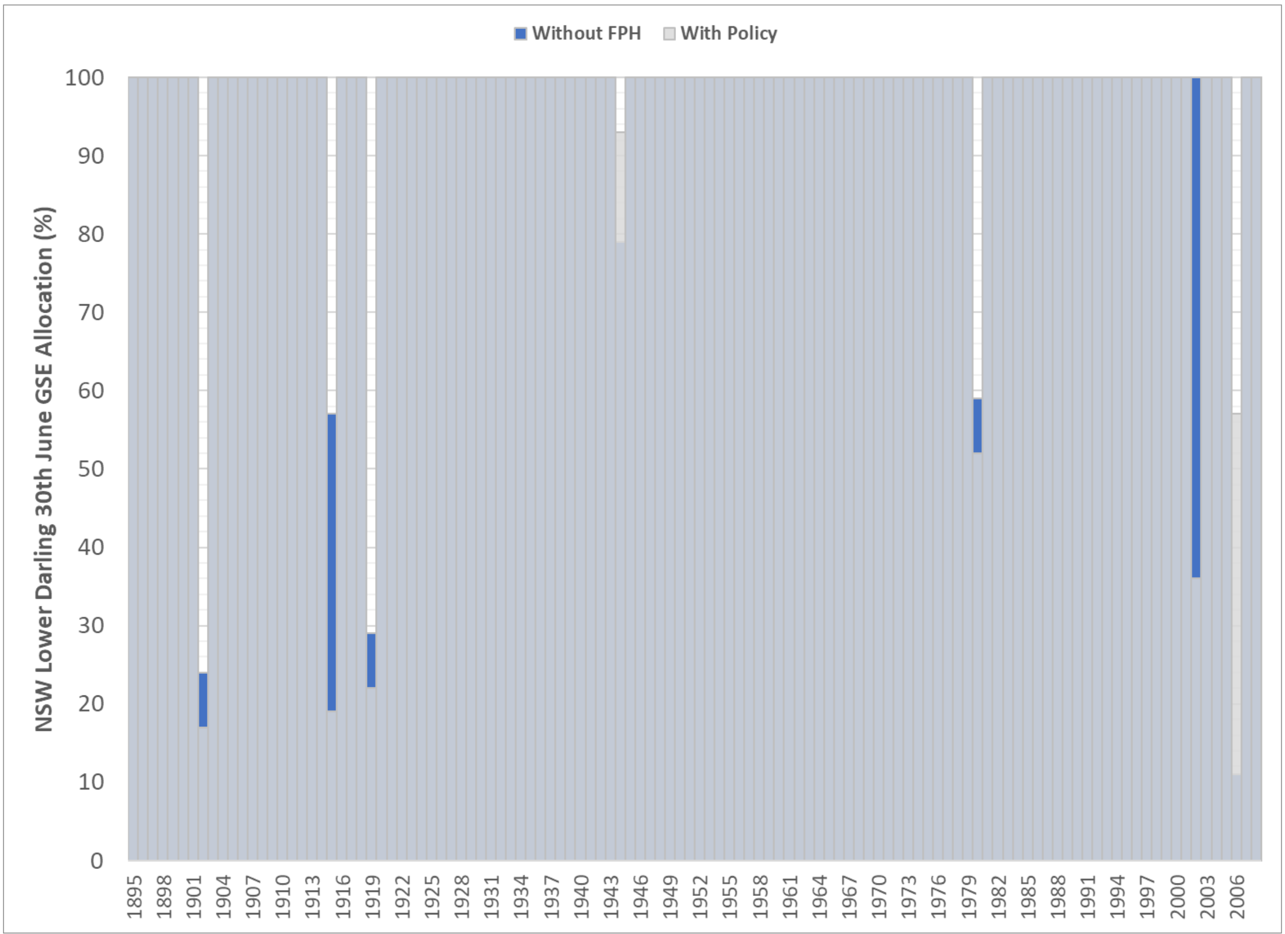

Figure 25 Lower Darling General Security Allocations on 30th June with and without FPH diversion in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys

Impact of Floodplain Harvesting Suspension on the NSW Murray Regulated River

The additional volume produced by floodplain harvesting suspension in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys contributes 68.4 GL average annual flow at Wentworth. The model indicates a very minimal attenuation as water flows down the Lower Darling into the Murray system.

This 68.4 GL only represents a small proportion (0.9%) of total flows at the location where the Lower Darling joins the far larger River Murray (see Figure 26). This volume remains similar as it moves the small distance and flows across the border at South Australia.

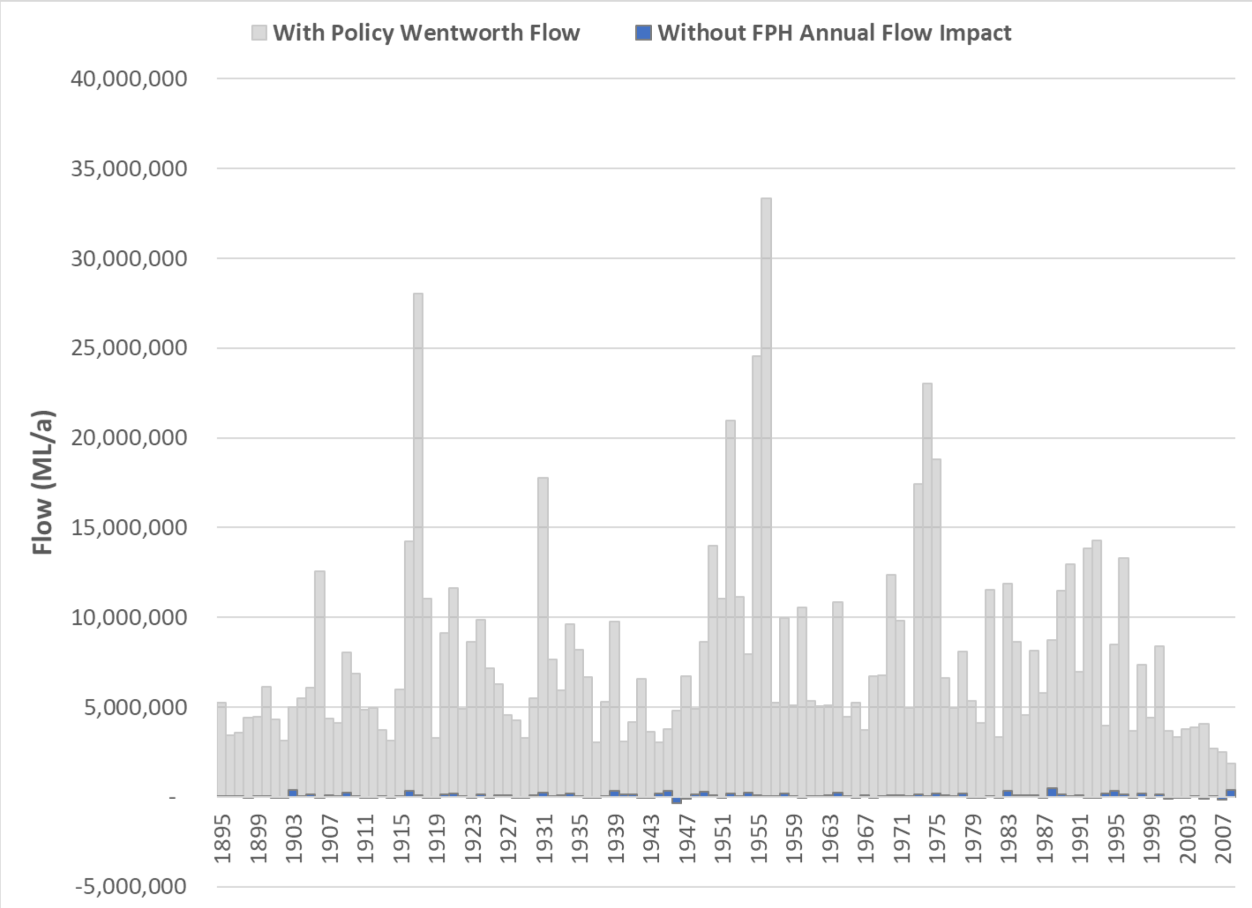

Figure 26 Modelled annual flow volume at Wentworth with and without FPH diversion in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys

This small proportional increase to inflows again has a minor impact on diversions or allocations in the Murray Regulated River Water Source. Modelling indicates a small increase in allocations after these additional inflows. These small changes are within the model's error tolerances and may be the result of model artefacts. The analysis shows no effective impact of floodplain harvesting suspension on annual average diversions or allocations in the Murray over the modelled timescale.

Table 28 Potential changes in annual metrics in the NSW Murray Valley with and without FPH diversion in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys.

	With *Policy*	Without FPH	Without FPH annual mean change	Without FPH annual mean change (%)
Wentworth Flow (GL)	7,762.0	7,830.4	+68.4	+0.9%
Flow to South Australia (GL)	7,201.5	7,273.5	+72.0	+1.0%
Net Diversions (GL)	1,405.8	1,418.3	+12.4	+0.9%
General Security Allocation (30th June)	86.0	86.5	+0.5	+0.6%

In approximately 18 of the 114 years (around 16% of years) we see improvement in General Security allocations because of *Policy* implementation in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys (Figure 27).

Whilst these 18 years see positive change there are a number of years that see a minor negative impact and as a whole the analysis shows no effective long-term average impact of floodplain harvesting suspension on Murray allocations.

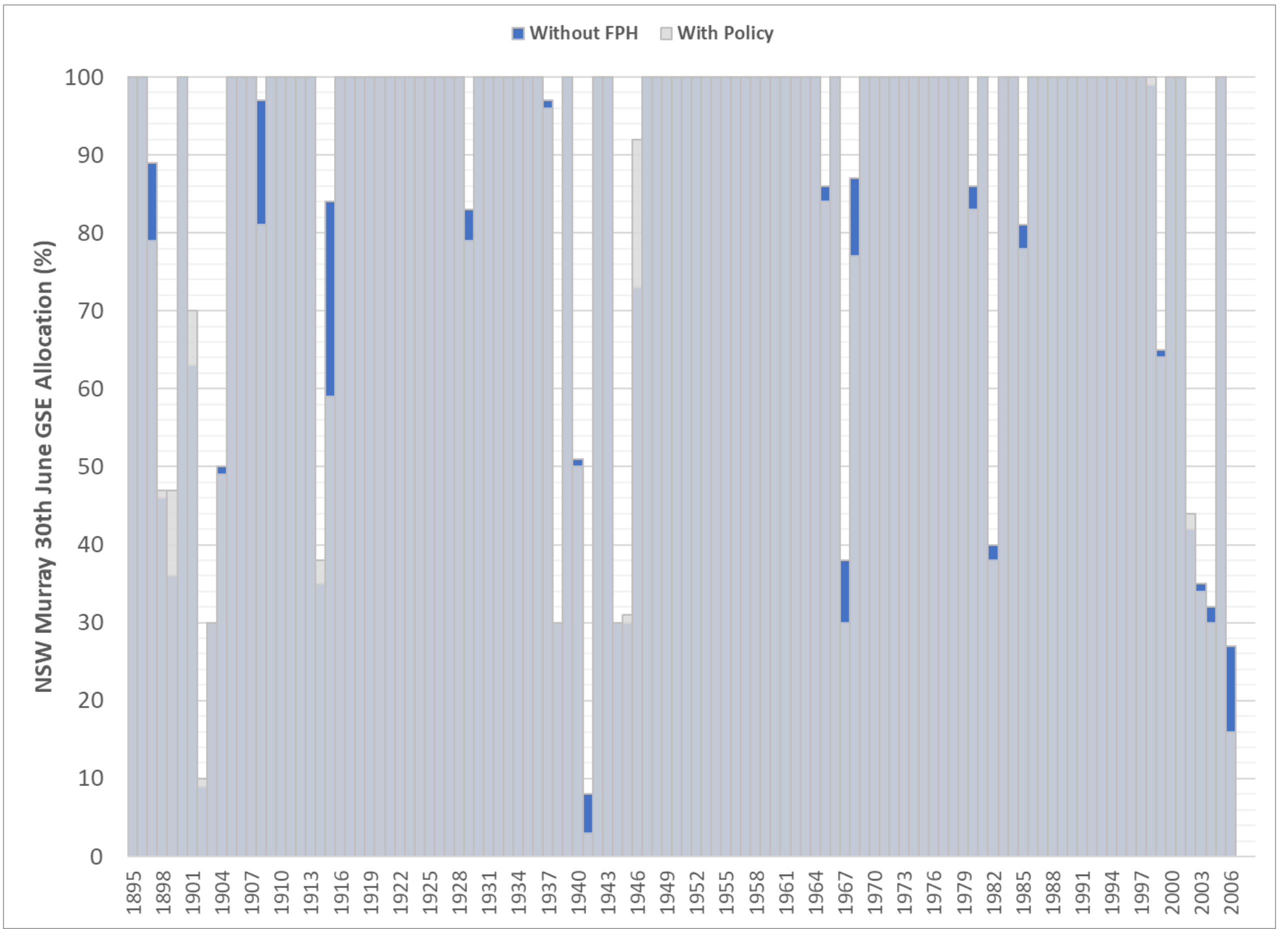

Figure 27 Murray General Security Allocations on 30th June with and without FPH diversion in the NSW Border Rivers, Gwydir, Macquarie and Barwon-Darling valleys