Department of Planning and Environment

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South Coast Regional Water Strategy

Detailed economic and ecological analysis

June 2022

Acknowledgement of Country

The NSW Government acknowledges Aboriginal people as Australia's first people and the Traditional Owners and Custodians of the lands and waters. Aboriginal people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters. Today, they practise the oldest living cultures on earth.

The NSW Government acknowledge the Yuin people as having an intrinsic connection with the lands and waters of the South Coast Regional Water Strategy area. The landscape and its waters provide the Yuin people with essential links to their history and help them to maintain and practise their culture and lifestyle.

The NSW Government recognises that the Traditional Owners were the first managers of Country and that incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

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South Coast Regional Water Strategy

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Introduction

The NSW Government is developing 12 regional water strategies and 2 metropolitan strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The draft South Coast Regional Water Strategy, including a long list of options, was released in October 2020.[1]

This report provides the outcomes of the detailed economic and ecological assessments that were used to determine which of the long list options that influence the supply, demand or allocation of water should be considered further in the *Draft Regional Water Strategy — South Coast: Shortlisted Actions — Consultation Paper* released in May 2022.

Detailed economic and ecological assessments were only conducted on options that passed the rapid economic and ecological assessments. Options that passed the rapid assessment were then examined to understand the risks and opportunities associated with different options being considered in the consultation report. Options that passed detailed assessments then progressed to being shortlisted actions for the consultation paper.

The following South Coast long list options underwent detailed assessment:

- Combined option 1: Increase on-farm water storage and active water markets
- Combined option 2: Increase on-farm water storage, Brown Mountain Water Project, and active water markets — variant 1 (5.3 GL storage at Steeple Flat)
- Combined option 3: Increase on-farm water storage, Brown Mountain Water Project, and active water markets — variant 2 (20 GL storage at Steeple Flat).

The results of the detailed analysis supported the above options progressing for inclusion in the shortlisted option consultation paper as:

- Proposed option 3.2: Review water markets
- Proposed option 3.3: Investigate increased on-farm water storage

The options considered for detailed analysis were informed by a series of rapid cost-benefit analyses. These rapid cost-benefit analyses were evaluated based on the instrumental climate record rather than the more comprehensive stochastic, NARCliM and East Coast Low (ECL) models used for the detailed analysis. The rapid ecological assessment was applied to all relevant options that influence the supply, demand or allocation of water.

South Coast options that underwent a rapid economic assessment but did not proceed to detailed assessment were:

[1] www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/upcoming-public-exhibition/south-coast-regional-water-strategy

- Option 1: Pipeline from Brogo Dam to Bega–Tathra town water supply system
- Option 16: Increased on-farm water storage
- Option 19: Increase capacity of Brogo Dam
- Option 21: Brown Mountain Water Project (pumped hydro scheme)
- Option 34: Active and effective water markets.

All remaining options from the long list were subject to a rapid ecological assessment as described in the rapid analysis section of this report.

Purpose of the detailed economic and ecological analysis

The NSW Government is developing 12 regional water strategies and 2 metropolitan water strategies that bring together the best and latest climate evidence with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The detailed economic and ecological analysis describes the results of the hydrologic modelling for the relevant options put forward in the Draft South Coast Regional Water Strategy.[2] Combined options subject to detailed analysis are evaluated according to new hydrologic modelling to examine economic outcomes for key extractive users and this outcome is compared with a base case. In addition, a series of actions are conducted on each of the combined options, as well as a breakeven analysis that determines at what value of water the cost of the combined option equates to its benefits.

The hydrologic modelling in the South Coast region covers the observed historical, long-term paleoclimate (stochastic), climate change (NARCliM) and east coast low (ECL) model predictions. We have 10,000 years of data in each data set. This data has been split into 1,000 40-year segments. The analysis on each major water user is analysed using 1,000 40-year realisations or "windows". The average and extreme outcomes are examined in the detailed analysis.

The detailed economic and ecological analysis undertakes more detailed analysis of the selected options to examine:

- how they will influence the use of water in the region
- the economic consequences of implementing the option
- how resilient the option will be to a more variable climate, or to a dry climate change scenario
- how the option impacts different water users and classes of licences
- the extent to which changes to the key assumptions influence the outcomes of the detailed assessment
- impacts on a range of flows including average annual flows, and flows that increase from zero flows to overbank flows, which spread across floodplains or fill wetlands
- to assess whether changes to a set of flow parameters at several points were positive or negative relative to ecological water targets.

It should be noted that currently we do not have enough information to be able to include evidence about these potential impacts and benefits for Aboriginal communities in the assessment of the shortlisted actions. Our preliminary engagement with some Aboriginal communities in the South Coast region has identified that communities need specific information on how the shortlisted actions will affect them. Some of this information will not be available until we begin to do more detailed analyses of the shortlisted actions that remain in the final regional water strategy shortlist. Some of this additional analysis may be identified for early action in the strategy's implementation plan, while other work would progress as part of the strategic business case for specific options.

[3] www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/upcoming-public-exhibition/south-coast-regional-water-strategy

Overview of the detailed analysis

Options that passed through the filtering and rapid assessment processes have been assessed in a more detailed manner against long-term paleoclimate (stochastic), NSW and Australian Regional Climate Modelling (NARCliM), and east coast low (ECL) climate models.

- Stochastic modelling is based on the statistical characteristics of an extended historical climate record that has integrated weather data and data from tree rings, ice cores, cave deposits and coral growth. The modelling then enabled the generation of a dataset covering up to 10,000 years into the past, which enables us to describe patterns of natural variability and extremes (drought and flood) in our regions since the last major global climate shift with more certainty than was previously possible.
- NARCliM uses results from four broad-scale global climate models and combines these with information on local topography and coastal processes to develop finer resolution regional climate models. The regional models provide forecasts for a range of climate characteristics including temperature, rainfall and soil moisture for areas of 100 km^2. The NARCliM project is a NSW Government–led partnership that includes the ACT and South Australian governments, and the Climate Change Research Centre at the University of NSW.
- Projections based on the east coast low are based on a 13,000-year dataset. For the South Coast region, east coast lows have been shown to be important for water security. We have used a database developed by the Bureau of Meteorology, which provides information on the historical occurrence of east coast lows. In addition, NARCliM provides data on the potential changes in the frequency of east coast lows as a result of climate change. We have chosen to present the scenario where one east coast low has been removed per year, as this is the closest outcome to the most conservative result from NARCliM.

This data allows us to better estimate the resilience of options in more extreme climate scenarios. This detailed stage of the assessment, referred to as the detailed analysis, measured economic and ecological outcomes against this data.

Overview of the detailed economic analysis

For the relevant options, we undertook detailed analysis based on potential future climate conditions, using stochastic, NARCliM and east coast low models. The key information that informed the cost-benefit analysis of each option included:

- **understanding what happens if we do nothing**, which included hydrologic modelling using three different climate models. These models are sampled to each provide 1,000 40-year forecasts of the future of the region, and how much water would be available under the base case (existing conditions) and the influence of an option. More detail on the base case is available in the South Coast Economic Base Case.
- **high-level cost estimates** prepared for each option including capital and operational expenditure for infrastructure options, and implementation costs for non-infrastructure options. These costs are very broad and high-level in nature. Further investigating any option will require more detailed cost estimates
- **benefit estimates** — economic values of shortfalls of water to towns and industries have been developed and used as the primary benefit to assess the option costs against. This is referred to as the Regional Water Value Function. A summary of the value of water for each

major water user is given in the detailed economic analysis section of this report. The detail of how these values were determined is outlined the Regional Water Value Functions report.[3]

Key outcomes of the detailed economic analysis are defined using two metrics or decision criteria: the net present value and the benefit-cost ratio.

The net present value is the sum of the present-value economic outcomes of the option case, minus the total present-value economic outcomes of the base case. It is the marginal difference between the two outcomes, with the option cost (and the timing of costs and benefits) taken into account. A positive net present value indicates there is potential economic benefit from pursuing an option, while a negative net present value indicates that the option creates more costs than it generates benefits. Net present value can be expressed as Equation 1 (where PV — present value).

Equation 1. Net Present Value (NPV)

$$NPV_{proposed\ action} = (PV_{proposed\ action\ scenario} - PV_{base\ case}) - PV_{proposed\ action\ cost}$$

Benefit-cost ratio divides the incremental benefits of an option to the region by the discounted whole-of-life cost (capital expenditure and operational expenditure) of the option. A benefit-cost ratio of 1 or greater indicates that the project is economically feasible because the benefits outweigh the costs. The benefit-cost ratio is illustrated in Equation 2.

Equation 2. Benefit Cost Ratio (BCR)

$$BCR = \frac{PV_{benefits}}{PV_{costs}}$$

These decision criteria should be used as a guide only for assessing the economic viability of an option. The outcomes of the detailed assessment are a decision-support tool (as opposed to a decision-making tool), and an outcome that isn’t strictly positive (such as an outcome with a benefit-cost ratio less than 1) should not automatically prevent an option from being included in the strategy shortlist.

In addition to these decision-making tools, the economic component of the detailed analysis also considers:

- **sensitivity analysis** to identify the extent to which changes to the key assumptions influence the outcomes of the detailed analysis. The sensitivity analysis was carried out across:
  - the discount rate (3 and 10 per cent)
  - capital and operational expenditure (+30 per cent / -30 per cent)
  - the value of water assigned to each economic activity
  - reactive infrastructure solutions.

[3] See the Regional Water Value Functions (MJA, 2021).

- **distributional impacts** to look at how the option impacts different water users and classes of licences
- **breakeven analysis** to determine when the price for a megalitre of water would result in the costs being equivalent to the benefits.

It is not always possible to determine a break-even point, so some options may have no break-even analysis described.

Overview of the detailed ecological analysis

The analysis did not seek to monetise the costs and benefits of ecological impacts within the timeframe of the regional water strategies because these are difficult to determine and subject to several limitations. We did undertake a quantitative analysis of the impact of the options on different flows in the river. The flow metrics that were assessed were standard ecological metrics which included impacts on a range of flows, including average annual flows, no-flow (cease-to-flow) and overbank flows that spread across floodplains or fill wetlands (Figure 1). Each part of the flow regime plays an important role in supporting the health of the river.

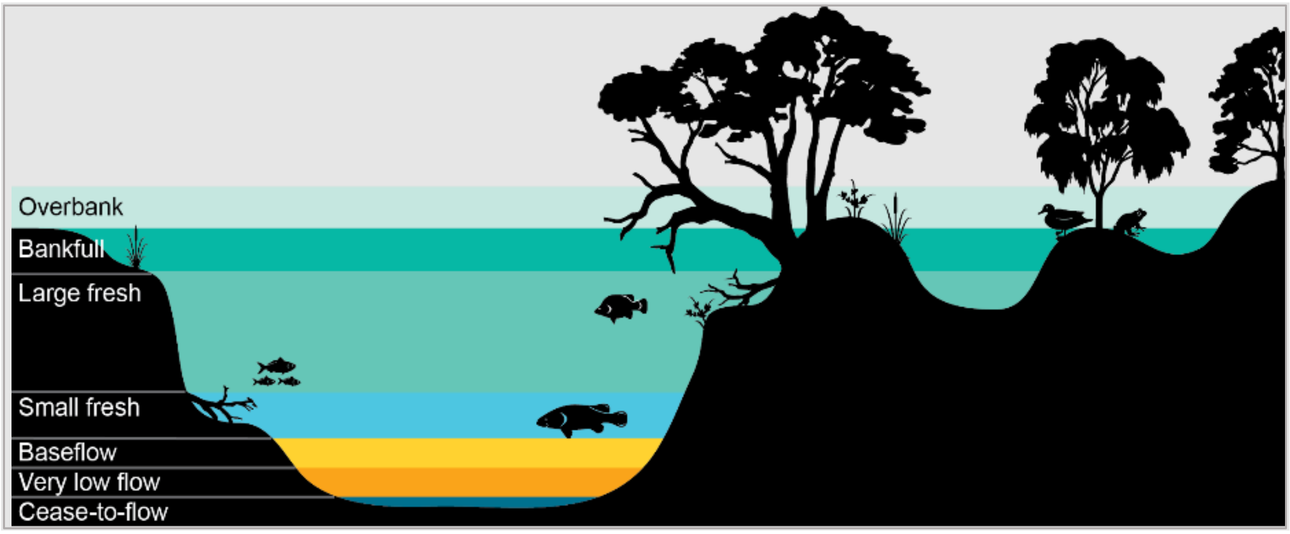


Figure 1. Conceptual model of the different components of role of different flow regimes components

These ecological metrics were combined with river hydrology models which were modified to incorporate forecasts of future flow regimes, the stochastic modelling, NARCliM and east coast low climate models. These integrated models were used to assess different options. That is, each water management option was separately modelled for all three climate scenarios, and the results compared to the base case for that climate scenario to identify changes in the delivery of water.

Each of these model runs measured impacts at different gauges along the river. In the South Coast, standard ecological metrics were used to measure changes for 20 river sites in the Bega River catchment. These gauges were chosen to represent the significant breadth of river habitat types across the region.

As with the rapid ecological assessment, the results were then categorised as having an impact from extreme improvement to extreme impact (stage 1). It uses a categorisation system to rate the potential impacts or benefits to the environment. The rapid ecological assessment uses a five-category ranking (stage 1) and the detailed assessment used an expanded 11-category ranking (stage 2, Table 1).

Table 1. Categories used in ecological assessment

Stage 1 category	Stage 2 category	Estimated percentage change in hydrology/ecology
Major/extreme impact	Extreme impact	More than 30% change in a negative direction (i.e. < –30%)
	Major impact	More than 20% change in a negative direction (i.e. < –20%)
Minor/moderate impact	Moderate impact	More than 10% change in a negative direction (i.e. < –10%)
	Minor impact	More than 3% change in negative direction (i.e. < –3%)
No/little change	Little impact	Less than 3% change in a negative direction (i.e. < 0%)
	No change	0%, rounded to the nearest whole percentage point
	Little improvement	Less than 3% change in a positive direction (> 0% and < +3%)
Minor/moderate improvement	Minor improvement	More than 3% change in a positive direction (i.e. > +3%)
	Moderate improvement	More than 10% change in a positive direction (i.e. > +10%)
Major/extreme improvement	Major improvement	More than 20% change in a positive direction (i.e. > +20%)
	Extreme improvement	More than 30% change in a positive direction (i.e. > +30%)

Detailed economic analysis

The following section outlines the key economic values used for the detailed economic analysis, and the outcomes of the analysis for each option.

The economic valuation of water for key user groups given in Table 2 has been drawn from the Regional Water Value function and is applied as $/ML supplied (or not supplied, in the case of town water supply). These values are given in Table 3 for town water supply shortfalls and in Table 4 for agricultural users.

Due to the high level of uncertainty regarding ecological valuations within a cost-benefit analysis context, no attempt has been made to include an economic ecological assessment within this cost-benefit analysis. Separate quantitative and qualitative ecological assessments have been undertaken for the relevant options.[4]

Table 2. Key water users in the South Coast region

Key water user	Water licence	Economic benefit of water use
Towns	Local water utility	Reduction in economic cost of water supply shortfalls
Perennial pasture	• general security • supplementary • rainfall harvesting • high security	• proxy of lucerne harvested as hay adopted • marginal increased yield of crop due to irrigation, compared to dryland production

Table 3. Economic cost of town water supply shortages on the South Coast

Time in water shortage	Brogo-Bermagui	Bega-Tathra	Bemboka	Tantawanglo-Kiah	Eurobodalla
Population*	3,166	6,629	12,652	12,652	35,741
System type	Regulated	Unregulated	Unregulated	Unregulated	Unregulated
0-6 months (restrictions)	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML
6 to 12 months (restrictions)	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML
Greater than 12 months	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)

[4] See South Coast Regional Water Strategy: Ecological assessment of options attachment

Time in water shortage	Brogo-Bermagui	Bega-Tathra	Bemboka	Tantawanglo-Kiah	Eurobodalla
Continued shortages (greater than 24 months)	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)	$10,000/ML (carting)	$16,000/ML (alternative water source)	$16,000/ML (alternative water source)

*2016 populations, sourced from Australian Statistical Geography Standard 2019 Local Government Authority projections (NSW, 2019) and Australian Bureau of Statistics census data

Table 4. South Coast agricultural water supply economic benefit[5]

Crop	Cropping	Water licence	Marginal economic benefit (of water) ($/ML)
Lucerne*	Perennial pasture	• General security, supplementary, uncontrolled flow, unregulated, high security	$175/ML

*Lucerne harvested as hay is assumed as a proxy to perennial pasture

Population changes have been included in accordance with the NSW Government's Common Planning Assumptions' medium-population-growth forecasts. These planning assumptions predict that towns within the southern part of South Coast region (Bega and Eurobodalla Councils) will see small reductions in population, while towns within the northern part of the South Coast (Shoalhaven Council) will see increases in populations. Towns within Shoalhaven Council have not been included in this assessment as they have an alternative water supply provided from outside the South Coast region. The analysis undertaken for the regional water strategies assumes that population levels for towns in Bega and Eurobodalla Councils will plateau, rather than fall, to ensure conservative estimates of water needs across all outputs.

Infrastructure costings

The capital expenditure and operational expenditure for the relevant options (including infrastructure) are derived from cost models built to allow consistent, comparative assessment across regions. They are not site-specific cost estimates and are not intended to be used beyond the scope of this study. The cost models rely on the physical characteristics of infrastructure, such as dam size or pipeline length, and the expected cost to construct — each category of infrastructure

[5] Note that the analysis only used values representing the highest value crop. Further values on crop type groups in the region can be seen in *Regional Water Value Functions* (MJA, 2020).

(dams, pipelines, desalination plants, etc.) has its own unique valuation method. These relationships are arrived at through analysis of past, similar projects and professional assessment.

Capital expenditure and operational expenditure costs of options were discounted to present-day values with the following assumptions:

- the option is constructed and fully operational from the start of Year 1 (that is, at Year 0), indicating that no discounting is applied to the capital expenditure.
- operational costs occur annually in annuity for the full period of the cost-benefit analysis from Year 1.

A residual value for infrastructure was considered by adding capital expenditure discounted at a linear rate at the end of the analysis period.

Policy costings

Options that include policy changes were calculated as the cost of full-time equivalent staff required to implement a policy. The costs are incurred at the beginning of Year 1 (that is, at Year 0) and there is no annual cost associated with the policy. It is assumed that there is no measurable change between the effort required to administer the region each year with or without the policy change implemented.

Combined option 1: Increase on-farm water storage and active water markets

Combined option 1 involves increasing on-farm water storage with low-flow bypasses (*Draft South Coast Regional Water Strategy,* option 16a), and improving water markets (*Draft South Coast Regional Water Strategy,* option 34). The intent is to increase agricultural production by increasing on-farm water storage, and increasing opportunities for irrigators to access water that is not being used through trade.

Table 5 provides the summary data for the modelled option. The results represent the averages of all 1,000 realisations undertaken in the analysis.

Table 5. Average results for combined option 1

Combined option	Net present cost ($m)	Stochastic NPV ($m)	NARCliM NPV ($m)	ECL NPV ($m)	Stochastic BCR	NARCliM BCR	ECL BCR
1	14	–3.5	–3.6	–4.0	0.75	0.75	0.71

The combined option was assumed to cost approximately $14 million to implement, involving private costs to improve on-farm infrastructure as well as policy costs to reform markets.

The combined option has an average negative net present value of between $3.5 and $4.0 million in all climate datasets, with similar benefit-cost ratios — ranging from 0.71 to 0.75 — indicating that the costs of expanding on-farm water storages outweigh the economic benefits they generates, on average, over a given 40-year period.

The hydrologic record includes a great deal of variation. With 1,000 realisations of each hydrologic dataset that examine the range of potential outcomes of the option, Table 6 presents the range of possible outcomes for the option's performance over any 40-year period. The 1st percentile is effectively the worst outcome, while the 99th is the best.

The positive benefit-cost ratios present in the decile and extreme centile results show that the combined option produces some benefit under the full range of outcomes all datasets; however, this benefit is consistently less than the adopted cost of the action, with no benefit-cost ratio greater than 1 achieved. The combined option performs similarly between the stochastic and NARCliM climate datasets. Under the east coast low dataset, results are marginally lower at each percentile level and a small drop in economic performance of the combined option can be expected under these conditions.

Table 6. Decile and extreme centile results for combined option 1

Percentile	Stochastic NPV ($m)	Stochastic BCR	NARCliM NPV ($m)	NARCliM BCR
1%	–4.8	0.66	–5.4	0.61
10%	–4.2	0.7	–4.4	0.69
20%	–4	0.72	–4.1	0.71
30%	–3.8	0.73	–3.9	0.72
40%	–3.7	0.74	–3.7	0.73
50%	–3.5	0.75	–3.6	0.75
60%	–3.4	0.76	–3.4	0.76
70%	–3.3	0.77	–3.2	0.77
80%	–3.1	0.78	–3	0.79
90%	–2.8	0.8	–2.7	0.81
99%	–1.9	0.86	–1.7	0.88

The same information presented in the above tables is given in a histogram below in Figure 2, which gives the combined option outcomes of each of the 1,000 realisations across all three climate datasets. This shows that the results are consistent across all modelled climates, with the majority of net present value outcomes falling between –$6 million and –$2 million. Reinforcing the tabulated percentile information, the east coast low shows marginally lower values (with some outliers) than the other two climate datasets (with outliers present on the lower end of the distribution).

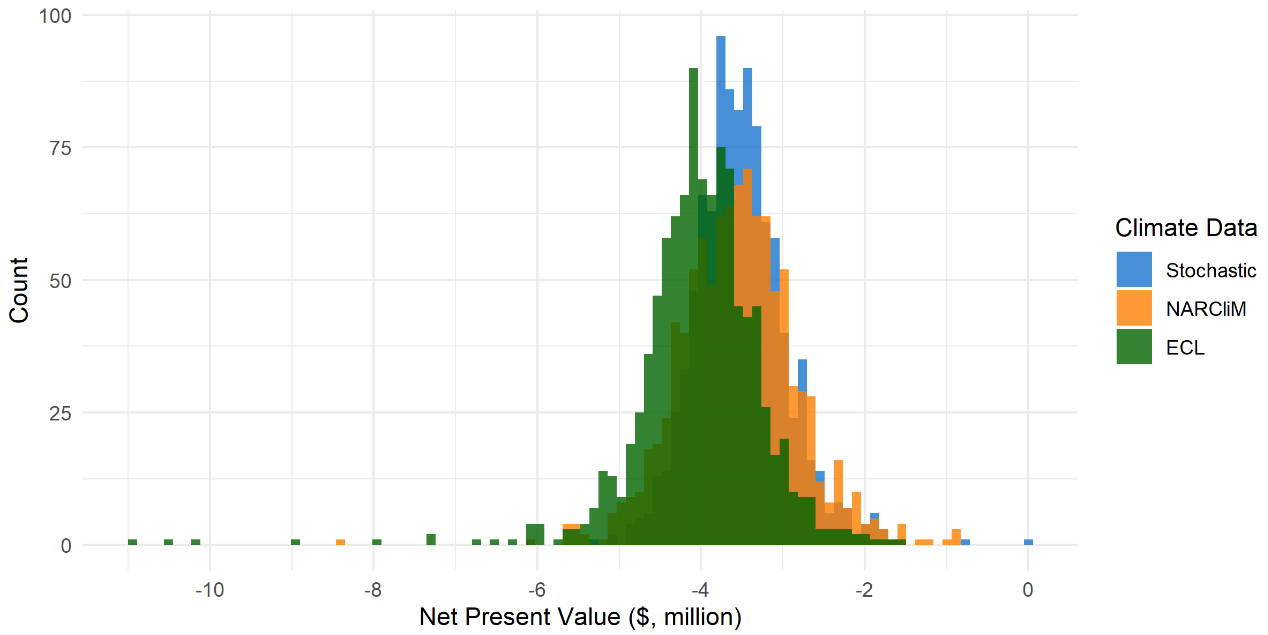


Figure **2**. Combined option 1 net present value histogram

Sensitivity analysis

Sensitivity analysis identifies the extent to which changes in the key assumptions influence the outcomes of the cost-benefit analysis. Sensitivity analysis was undertaken for the combined option, which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (–30%) option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 7 provides the summary results data for combined option 1 for the central case and sensitivity analysis across the key underlying assumptions used in this modelling.

Table 7. Sensitivity analysis on combined option 1 across the stochastic, NARCliM and east coast low datasets

Stochastic dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Central	14.0	-3.5	0.75	0.62	1.00	0
Low discount rate (3%)	14.1	3.8	1.27	1.07	1.60	100
High discount rate (10%)	13.6	-5.7	0.58	0.48	0.80	0
Option cost (+30%)	18.2	-7.7	0.58	0.48	0.77	0
Option cost (-30%)	9.8	0.7	1.07	0.89	1.43	91.6
Economic values (High)	14.0	-1.7	0.88	0.73	1.17	1.6
Economic values (Low)	14.0	-5.3	0.62	0.52	0.83	0

NARCliM dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	14.0	-3.6	0.75	0.40	0.94	0
High discount rate (10%)	14.1	3.7	1.26	0.80	1.52	99.6
Option cost (+30%)	13.6	-5.7	0.58	0.28	0.76	0
Option cost (-30%)	18.2	-7.8	0.57	0.31	0.72	0

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Economic values (High)	9.8	0.7	1.07	0.57	1.34	83.7
Economic values (Low)	14.0	−1.7	0.88	0.42	1.10	2.5
Low discount rate (3%)	14.0	−5.3	0.62	0.39	0.78	0

East coast low dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	14.0	−4.0	0.71	0.22	0.89	0
High discount rate (10%)	14.1	2.9	1.20	0.55	1.43	97.8
Option cost (+30%)	13.6	−6.1	0.55	0.10	0.72	0
Option cost (-30%)	18.2	−8.2	0.55	0.17	0.69	0
Economic values (High)	9.8	0.2	1.02	0.31	1.28	65.1
Economic values (Low)	14.0	−2.3	0.84	0.18	1.05	0.7
Low discount rate (3%)	14.0	−5.7	0.59	0.27	0.74	0

The sensitivity analysis highlights important assumptions about what would make the combined option economically viable. Under the stochastic dataset, combined option 1 produces a positive net present value and a benefit-cost ratio greater than 1, on average, when lower discount rates are adopted (3% rather than the 7% in the central analysis). Under this low discount rate, combined option 1 produces an average net present value of $3.8 million and a benefit-cost ratio of 1.27 — with even the worst outcome producing a benefit-cost ratio greater than 1.

Within the stochastic climate dataset, there are economically positive results at the average level if the costs are 30% less than the estimate used in the main analysis. Under these conditions, a positive net present value and benefit-cost ratios greater than 1 are produced 91.6% of the time. Furthermore, when higher economic cost estimates of the marginal value of water are high, positive economic outcomes are achieved in 1.6% of the stochastic realisations. This suggests that the validity of the option is highly influenced by the cost of construction.

The outcomes under the NARCliM climate dataset are similar, with average benefit-cost ratios greater than 1 occurring in the same three occasions as under the stochastic dataset. The difference is that percentage of economically positive outcomes is less under the NARCliM results than under the stochastic dataset in each of the three scenarios.

Finally, the east coast low dataset only produces average benefit-cost ratios greater than 1 in two of the sensitivity cases: when a low discount rate is adopted, and when the combined option cost is lower than the estimate adopted within this study. The percentage of realisations with positive economic outcomes that occur under the east coast low dataset is less than both stochastic and NARCliM datasets.

The distribution of the histograms achieved under the sensitivity analysis can be seen below (Figure 3). The histograms show that the net present value of the combined option is most sensitive to the discount rate and cost estimate. If the discount rate used is lower, then the majority of the realisations produce positive economic outcomes. Likewise, if the cost is lower than estimated in this analysis, then the combined option typically produces positive economic outcomes.

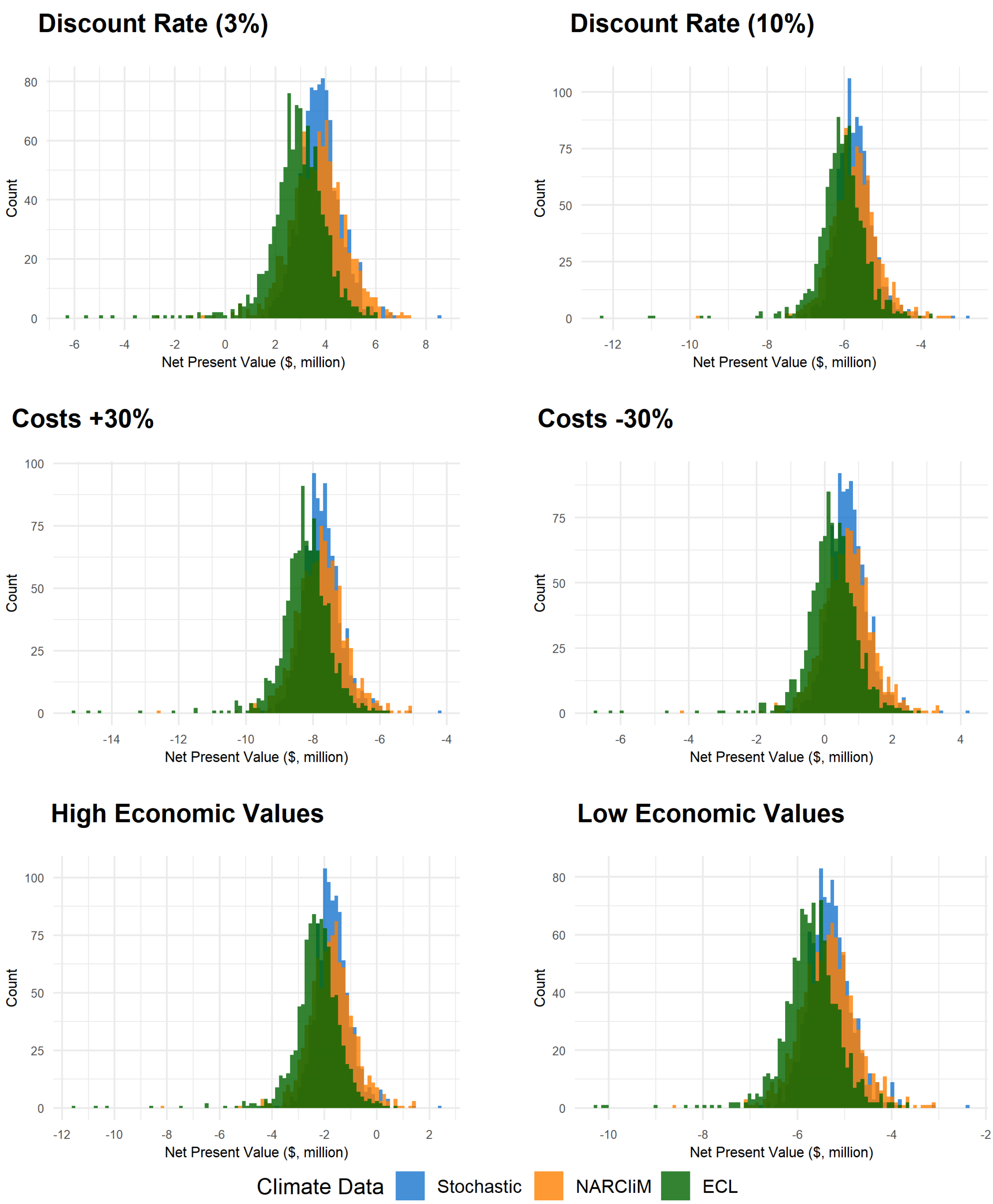


Figure 3. Combined option 1 sensitivity case net present value histograms

Distributional impacts

Table 8 shows the average distributional impacts that could be expected from introducing combined option 1 when compared to the economic base case across all datasets.

Table 8. Average distributional impacts from combined option 1

Stochastic dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–1.2	224.2	-	0	223.0
Bulk licence conversion	–1.2	234.7	-	0	223.5
Change ($m)	0	10.5	-	0	10.5
% Change	–0.4	4.7	-	31.8	4.7

NARCliM dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–6.2	218.7	-	0	212.5
Bulk licence conversion	–6.3	229.2	-	0	222.9
Change ($m)	0	10.5	-	0	10.5
% Change	–0.8	4.8	-	50.8	4.9

East coast low dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–5.3	219.1	-	0	213.8
Bulk licence conversion	–5.4	229.2	-	0	223.8
Change ($m)	–0.1	10.1	-	0	10.0

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
% Change	–1.5	4.6	-	–29.7	4.7

This table highlights the benefits of combined option 1 to the growth of perennial pasture, as seen in the average increases in economic output of approximately 5% (or $10 million) across the 40-year analysis period for each dataset. It achieves this with minimal impacts on towns, with impacts under 1.5% on average across all climate datasets.

Break-even analysis

The targeted, primary benefit of combined option 1 is to increase the agricultural activity in the region, for which the relevant price level is the marginal economic value water to pastural operations. This value was increased separately for the stochastic, NARCliM and east coast low economic analysis until the average, or expected value, of benefit-cost ratio outcomes for the 1,000 forty-year runs of each dataset was equal to, or near, 1.

In the initial analysis, it was assumed that dryland agriculture generated revenue of $824/ML, whereas irrigated agriculture generated revenue of $1,373/ML. This produced a producer surplus, or profit to the farmer, of $344 for every megalitre of water applied from rainfall (i.e. dryland agriculture) and $636 for every megalitre of water applied via irrigation. In this break-even analysis, the revenue for both dryland and irrigated water use were increased concurrently while the variable cost of each remained constant. The break-even price level for the revenue generated by each agricultural operation, and its associated producer surplus, are given in Table 9.

Table 9. Break-even price level for combined option 1

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
Stochastic	1.0	Irrigated revenue: $1,653 Irrigated producer surplus: $916 Dryland revenue: $1,104 Dryland producer surplus: $760
NARCliM	1.0	Irrigated revenue: $1,663 Irrigated producer surplus: $926 Dryland revenue: $1,114 Dryland producer surplus: $770

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
East coast low	1.0	Irrigated revenue: $1,713 Irrigated producer surplus: $976 Dryland revenue: $1,164 Dryland producer surplus: $820

The break-even analysis suggests that the combined option is near viable under the three datasets. To achieve break-even point across all realisations, the revenue received would need to increase approximately 20% for irrigated agriculture and 35% for dryland agriculture.

Combined option 2: Increase on-farm water storage, Brown Mountain Water Project, and active water markets — variant 1 (5.3 GL storage at Steeple Flat)

Combined option 2 involves increasing on-farm water storage with low-flow bypasses (Draft South Coast Regional Water Strategy option 16a) and the Brown Mountain Water Project (pumped hydro scheme). The Brown Mountain Water Project is a 5.3 GL storage at Steeple Flat (Draft South Coast Regional Water Strategy option 21a). An additional component of the option is to improve the effectiveness of water markets in the region (Draft South Coast Regional Water Strategy option 34). This combined option assumes the Bemboka River remains an unregulated river and the storage supports existing irrigation demands. This analysis does not consider any potential gains associated with electricity generation for the hydro-electric scheme.

Average economic outcomes of the combined option can be seen in Table 10 below. The results indicate that average positive net present values, or benefit-cost ratios above 1, are not achieved under any climate scenario. Given the lack of hydro-electric consideration these results are considered a lower bound estimate, although the economic value of any electricity generation under this combined option is uncertain.

Table 10. Average results for combined option 2

Combined option	Net present cost ($m)	Stochastic NPV ($m)	NARCliM NPV ($m)	ECL NPV ($m)	Stochastic BCR	NARCliM BCR	ECL BCR
1	180	–170	–170	–170	0.06	0.06	0.06

The hydrologic record includes a great deal of variation. With 1,000 realisations of each hydrologic dataset examining the range of potential outcomes of the option, Table 11 presents the range of possible outcomes for the option's performance over any 40-year period. The 1st percentile is effectively the worst outcome, while the 99th is the best.

Results across all three examined climate datasets resulted in small, positive benefit-cost ratios less than 1, and negative net present values across the full range of outcomes. This indicates the benefit realised by the combined option is consistently much lower than the cost of construction and operation. The stochastic and east coast low datasets perform similarly, with the NARCliM dataset giving marginally improved results. The spread of outcomes across the dataset is narrow, with a relatively consistent performance of the combined option.

Table 11. Decile and extreme centile results for combined option 2

Percentile	Stochastic NPV ($m)	Stochastic BCR	NARCliM NPV ($m)	NARCliM BCR	ECL NPV ($ mil)	ECL BCR
1%	–171.0	0.05	–171.3	0.05	–172.0	0.05
10%	–170.3	0.06	–170.3	0.06	–170.7	0.05
20%	–170.1	0.06	–170.1	0.06	–170.5	0.05
30%	–169.9	0.06	–169.9	0.06	–170.3	0.06
40%	–169.8	0.06	–169.7	0.06	–170.1	0.06
50%	–169.6	0.06	–169.5	0.06	–169.9	0.06
60%	–169.5	0.06	–169.3	0.06	–169.8	0.06
70%	–169.3	0.06	–169.1	0.06	–169.6	0.06
80%	–169.1	0.06	–168.8	0.06	–169.3	0.06
90%	–168.8	0.06	–168.3	0.07	–168.9	0.06
99%	–166.9	0.07	–165.9	0.08	–166.8	0.08

Figure 4 gives a visual representation of all net present value outcomes through histograms of the economic results across all three climate datasets. It shows a low level of variance in outcomes in all three datasets and reinforces the results given by the tabulated information. The stochastic climate dataset results in the worst few outcomes, with outliers at approximately –$185 million and –$177 million, both of which are rarer than the 1st percentile.

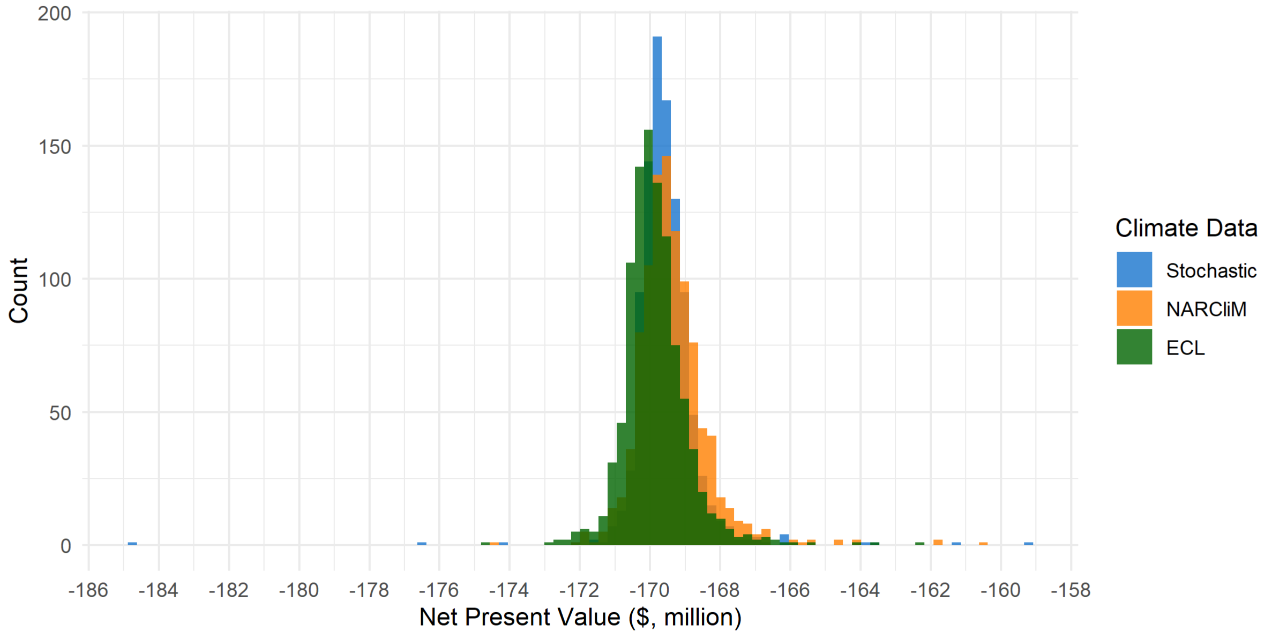


Figure 4. Combined option 2 net present value histograms

Sensitivity analysis

Sensitivity analysis identifies the extent to which changes in the key assumptions influence the outcomes of the cost-benefit analysis. Sensitivity analysis was undertaken for the action, which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (–30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

The table below provides the summary results data for combined option 2 for the central case and sensitivity analysis for the stochastic, NARCliM and east coast low datasets.

Table 12. Sensitivity analysis for combined option 2 across the datasets

Stochastic dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Central	180.3	–169.6	0.06	–0.02	0.12	0
Low discount rate (3%)	138.9	–120.7	0.13	0	0.22	0
High discount rate (10%)	187.3	–179.4	0.04	–0.03	0.09	0
Option cost (+30%)	234.4	–223.6	0.05	–0.02	0.09	0
Option cost (-30%)	126.2	–115.5	0.08	–0.04	0.17	0
Economic values (High)	180.3	–167.7	0.07	–0.04	0.14	0
Economic values (Low)	180.3	–171.4	0.05	–0.01	0.09	0

NARCliM dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	180.3	–169.4	0.06	0.03	0.11	0
High discount rate (10%)	138.9	–120.4	0.13	0.08	0.23	0
Option cost (+30%)	187.3	–179.2	0.04	0.02	0.08	0
Option cost (-30%)	234.4	–223.5	0.05	0.03	0.08	0

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Economic values (High)	126.2	–115.3	0.09	0.05	0.16	0
Economic values (Low)	180.3	–167.5	0.07	0.04	0.14	0
Low discount rate (3%)	180.3	–171.3	0.05	0.03	0.08	0

East coast low dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	180.3	–169.8	0.06	0.03	0.10	0
High discount rate (10%)	138.9	–121.3	0.13	0.09	0.18	0
Option cost (+30%)	187.3	–179.5	0.04	0.02	0.08	0
Option cost (-30%)	234.4	–223.9	0.04	0.02	0.08	0
Economic values (High)	126.2	–115.8	0.08	0.04	0.14	0
Economic values (Low)	180.3	–168.0	0.07	0.03	0.12	0
Low discount rate (3%)	180.3	–171.6	0.05	0.03	0.08	0

The sensitivity results indicate that under no combination of the conditions tested does the combined option produce benefits greater than its cost. It must be noted that no quantification of potential benefits of an attached hydropower scheme are considered in this analysis. In the event any benefits derived from the proposed hydropower scheme are included, the net present values and benefit-cost ratios would improve — although for positive results to be achieved, the realised benefits would need to be significant.

The discount rate, closely associated with weighting placed on future economic flows, has a large impact on the outcomes across all climate datasets. With a lower discount rate, more highly weighting future benefits (and costs), there is an approximately $60 million improvement to net present value. Using a higher discount rate has the opposite impact, reducing the net present value by approximately $20 million.

Varying the combined option costs has the impact of translating the distribution of outcomes by approximately –$50 million in the event that all costs are 30% greater, and by a similar amount in the positive direction when costs are 30% less. In no case do these results yield an outcome with a benefit-cost ratio greater than 1.

Considering the assumptions behind the economic valuation of water use shows a low level of sensitivity to these values. Raising economic values to their higher bound levels decreases the net present value by approximately $2 million, and lowering these values increases the net present value by nearly the same amount.

These results can be viewed for all three climate datasets in Figure 5.

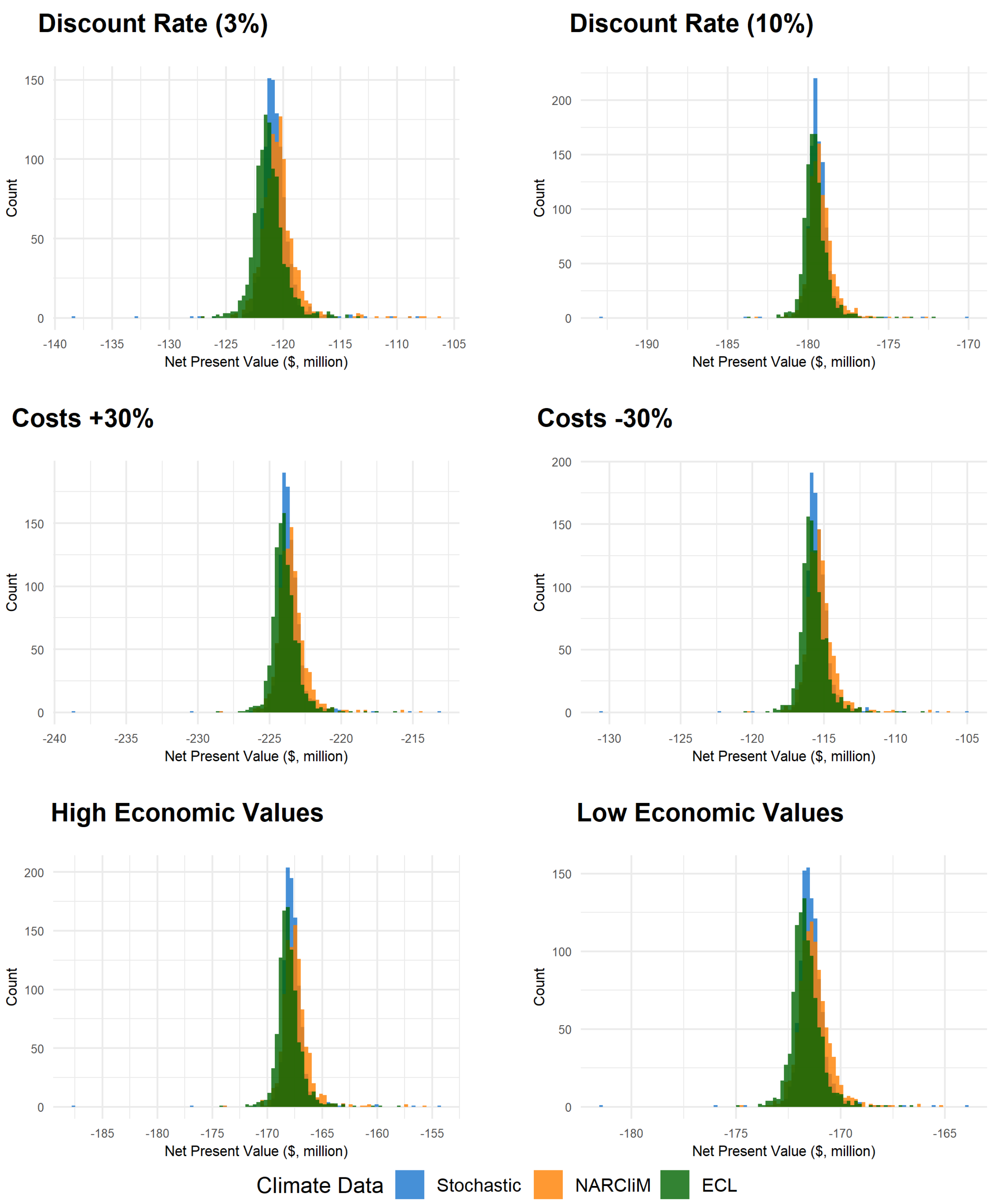


Figure 5. Combined option 2 sensitivity case net present value histograms

Distributional impacts

Table 13 highlights the distributional changes that would impact the South Coast region if combined option 2 was introduced.

Table 13. Average distributional impacts from combined option 2

Stochastic dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–1.2	224.2	-	0	223
Bulk licence conversion	–1.1	234.8	-	0	233.7
Change ($m)	0.1	10.7	-	0	10.8
% Change	4.7	4.8	-	31.8	4.8

NARCliM dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–6.2	218.7	-	0	212.5
Bulk licence conversion	–6.1	229.4	-	0	223.3
Change ($m)	0.2	10.7	-	0	10.9
% Change	2.6	4.9	-	51.8	5.1

East coast low dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	–5.3	219.1	-	0	213.8

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Bulk licence conversion	–5.2	229.4	-	0	224.2
Change ($m)	0.1	10.3	-	0	10.4
% Change	2.7	4.7	-	–28.6	4.9

These tables identify that, on average, all users — with the possible exception of stock and domestic water users under east coast low climate conditions — will experience some benefit due to the implementation of combined option 2. The total of this benefit on average is approximately $10 million across all climate datasets, which represents a 5% increase in economic outcomes for the region.

Break-even analysis

Similar to combined option 1, this combined option seeks to increase on-farm agricultural activity via a centralised water storage facility, and activated and effective water markets. For agricultural water users, the relevant price level is the marginal economic value of water to pastural operations. This value was increased separately for the stochastic, NARCliM and east coast low economic analysis until the average, or expected value, of benefit-cost ratio outcomes for the 1,000 40-year runs of each dataset was equal to, or near, 1.

In the initial analysis, it was assumed that dryland agriculture generated revenue of $824/ML, whereas irrigated agriculture generated revenue of $1,373/ML. This produced a producer surplus, or profit to the farmer, of $344 for every megalitre of water applied from rainfall (i.e. dryland agriculture) and $636 for every megalitre of water applied via irrigation. In this break-even analysis, the revenue for both dryland and irrigated water use were increased concurrently, while the variable cost of each remained constant. The break-even price level for the revenue generated by each agricultural operation, and its associated producer surplus, are given in Table 14.

Table 14. Break-even price level for combined option 2

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
Stochastic	1.0	Irrigated revenue: $14,373 Irrigated producer surplus: $13,636 Dryland revenue: $13,824 Dryland producer surplus: $13,480

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
NARCliM	1.0	Irrigated revenue: $14,373 Irrigated producer surplus: $13,636 Dryland revenue: $13,824 Dryland producer surplus: $13,480
East coast low	1.0	Irrigated revenue: $15,373 Irrigated producer surplus: $14,636 Dryland revenue: $14,824 Dryland producer surplus: $14,480

The break-even analysis suggests that the combined option is not close to being viable in any of the datasets. For average benefit-cost ratios of 1.0, the economic value of water for agricultural users is required to be 10 times higher than that used in the initial analysis.

Combined option 3: Increase on-farm water storage, Brown Mountain Water Project, and active water markets — variant 2 (20GL storage at Steeple Flat)

This variant is the same as combined option 2 however it features a larger, 20 GL storage at Steeple Flat. Again, the analysis does not incorporate the benefit of the hydro-electric generation and, as such, the full potential economic benefits are not captured.

This combined option integrates:

- increased on-farm water storage with low-flow bypasses (Draft South Coast Regional Water Strategy option 16a)
- Brown Mountain Water Project (pumped hydro scheme), with 20 GL storage at Steeple Flat (Draft South Coast Regional Water Strategy option 21d)
- active and effective water markets (Draft South Coast Regional Water Strategy option 34).

It also assumes the Bemboka River downstream of Cochrane Dam is converted to a regulated river and that the storage supports a 10% increase in irrigation demands.

Compared with the first variant (of combined option 2), this combined option has the potential to produce greater economic output for perennial pasture under all climate scenarios due to the increased size of the dam at Steeple Flat (to 20 GL) and assumed increase in downstream demand. Additionally, in all cases the benefits to towns are improved compared to the results of the first variant.

The option performs similarly under the stochastic, NARCliM and east coast low climate scenarios, with an average net benefit to the region aggregated across all users of $24–26 million over 40 years before considering the cost of the combined option. The best results are seen in the

NARCliM climate scenario, which demonstrates a larger benefit to due to the increased security of town water supply.

Under no climate datasets considered does the combined option produce a positive net present value or a benefit-cost ratio that is greater than 1. Consistent outcomes across all climate datasets are observed, with average net present values of –$177 to –$178 million and benefit-cost ratios of 0.12 to 0.13.

Table 15. Average results for combined option 3

Combined option	Net present cost ($m)	Stochastic NPV ($m)	NARCliM NPV ($m)	ECL NPV ($m)	Stochastic BCR	NARCliM BCR	ECL BCR
3	202.7	-178	-177	-178	0.12	0.13	0.12

The hydrologic record includes a great deal of variation. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option, Table 16 presents the range of possible outcomes for the action's performance over any 40-year period. The 1st percentile is effectively the worst outcome, while the 99th is the best.

The positive benefit-cost ratios present in the decile and extreme centile results show that the combined option produces some benefit under the full range of outcomes from all datasets; however, this benefit is consistently less than the adopted cost of the combined option, with no benefit-cost ratio greater than 1 achieved. The combined option performance has a narrower range under the NARCliM climate dataset than the stochastic, performing better for the lower half of the outcome distribution and worse in the upper half of the outcome distribution. Under the east coast low dataset results, the results are more spread than for both the stochastic and NARCliM climate datasets, achieving worse results at each percentile level for outcomes that lie at less than the median (50th percentile) and better results at each percentile level above the median. The median results for all three datasets are nearly equal.

Table 16. Decile and extreme centile results for combined option 3

Percentile	Stochastic NPV ($m)	Stochastic BCR	NARCliM NPV ($m)	NARCliM BCR
1%	–202.0	0	–182.2	0.10
10%	–186.9	0.08	–178.9	0.12
20%	–183.3	0.1	–178.3	0.12
30%	–180.3	0.11	–177.9	0.12
40%	–178.6	0.12	–177.6	0.12
50%	–177.7	0.12	–177.2	0.13

Percentile	Stochastic NPV ($m)	Stochastic BCR	NARCliM NPV ($m)	NARCliM BCR
60%	–176.8	0.13	–176.9	0.13
70%	–174.8	0.14	–176.4	0.13
80%	–172.1	0.15	–175.9	0.13
90%	–167.6	0.17	–175.0	0.14
99%	–152.8	0.25	–169.1	0.17

Error! Reference source not found. represents all outcomes using histograms of the economic results across all three climate datasets. It shows the difference in spread, or variance, of across each climate scenario described in the tabulated information. The NARCliM data shows the least spread, followed by the stochastic data; finally, the east coast low data results in the greatest spread of economic outcomes for the combined option.

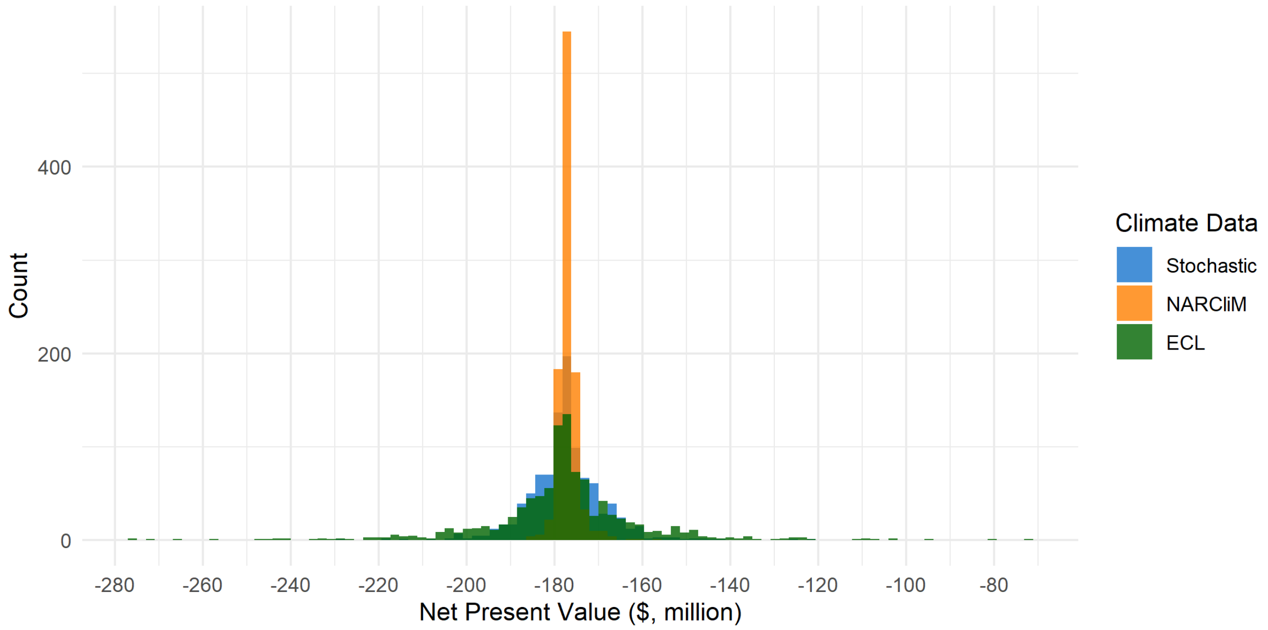


Figure 6. Combined option 3 net present value histograms

Sensitivity analysis

Sensitivity analysis identifies the extent to which changes in the key assumptions influence the outcomes of the cost-benefit analysis. Sensitivity analysis was undertaken for the action, which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (–30%) option costs

- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 17 provides the summary results data for combined option 3 for the central case and sensitivity analysis for the stochastic, NARCliM and east coast low datasets.

Table 17. Sensitivity analysis on combined option 3 across the datasets

Stochastic dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Central	202.7	–177.6	0.12	–0.13	0.40	0
Low discount rate (3%)	158.4	–118.9	0.25	–0.13	0.64	0
High discount rate (10%)	209.9	–190.1	0.09	–0.12	0.34	0
Option cost (+30%)	263.5	–238.4	0.10	–0.10	0.31	0
Option cost (-30%)	141.9	–116.8	0.18	–0.18	0.57	0
Economic values (High)	202.7	–173.2	0.15	–0.17	0.49	0
Economic values (Low)	202.7	–181.9	0.10	–0.09	0.31	0

NARCliM dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	202.7	–177.0	0.13	0.08	0.23	0
High discount rate (10%)	158.4	–118.1	0.25	0.16	0.40	0
Option cost (+30%)	209.9	–189.6	0.10	0.06	0.19	0

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Option cost (-30%)	263.5	−237.8	0.10	0.06	0.18	0
Economic values (High)	141.9	−116.2	0.18	0.12	0.33	0
Economic values (Low)	202.7	−172.4	0.15	0.10	0.28	0
Low discount rate (3%)	202.7	−181.5	0.10	0.07	0.17	0

East coast low dataset

Sensitivity case	PV Capital Cost ($m)	NPV ($m)	BCR Average	BCR Minimum	BCR Maximum	% of BCR with BCR > 1
Low discount rate (3%)	202.7	−178.0	0.12	−0.37	0.64	0
High discount rate (10%)	158.4	−120.0	0.24	−0.78	1.08	0.2
Option cost (+30%)	209.9	−190.3	0.09	−0.31	0.55	0
Option cost (-30%)	263.5	−238.8	0.09	−0.28	0.49	0
Economic values (High)	141.9	−117.2	0.17	−0.52	0.92	0
Economic values (Low)	202.7	−173.7	0.14	−0.47	0.80	0
Low discount rate (3%)	202.7	−182.3	0.10	−0.27	0.48	0

Very few of the scenarios have results that produce a positive net present value or a benefit-cost ratio that is greater than 1, even under the best realisations in the climate datasets. The exception to this state is the best-case scenario using a low (3%) discount rate under the east coast low climate dataset. The results indicate that in the event the hydro-electric dam was built solely for the use of the stored water by downstream users, that it would not be viable under the considered climate scenarios subjected to the ranges of sensitivities. However, similarly to combined option 2, if further benefits associated with power generation were considered, the average benefit-cost ratio would rise dependent on the magnitude of that benefit. The economic benefits of the power generation would need to be significant.

Applying a higher (10%) discount rate has the impact of decreasing the average net present value by $12–13 million across all datasets, highlighting the impact of the large initial capital cost through the relative change of less than 10% in average net present value from the central case. The lower discount rate of 3%, allowing for future benefits (and costs) to be more highly weighted, improves the average net present value by approximately $40–50 million when compared to the central case. Although a considerable improvement to the net present value, it is evident that the decrease in the present value cost of the combined option is a large share of this improvement (about 14%). This is due to the improved discounting applied to the residual value of the infrastructure after the 40-year analysis period.

Changing the costs of the combined option has the impact of changing the distribution of outcomes — moving them by approximately –$60 million in the event that all costs are 30% greater, and by a similar amount in the positive direction when costs are 30% less. In no case do these results yield an outcome with a benefit-cost ratio greater than 1.

The assumptions behind the economic valuation of water use show a low level of sensitivity to these values for outcomes that lie near to the median in the central case. Outcomes on the tails of the respective climate distributions show a much higher sensitivity to the economic valuations used.

These results can be viewed for all three climate datasets in Figure 7.

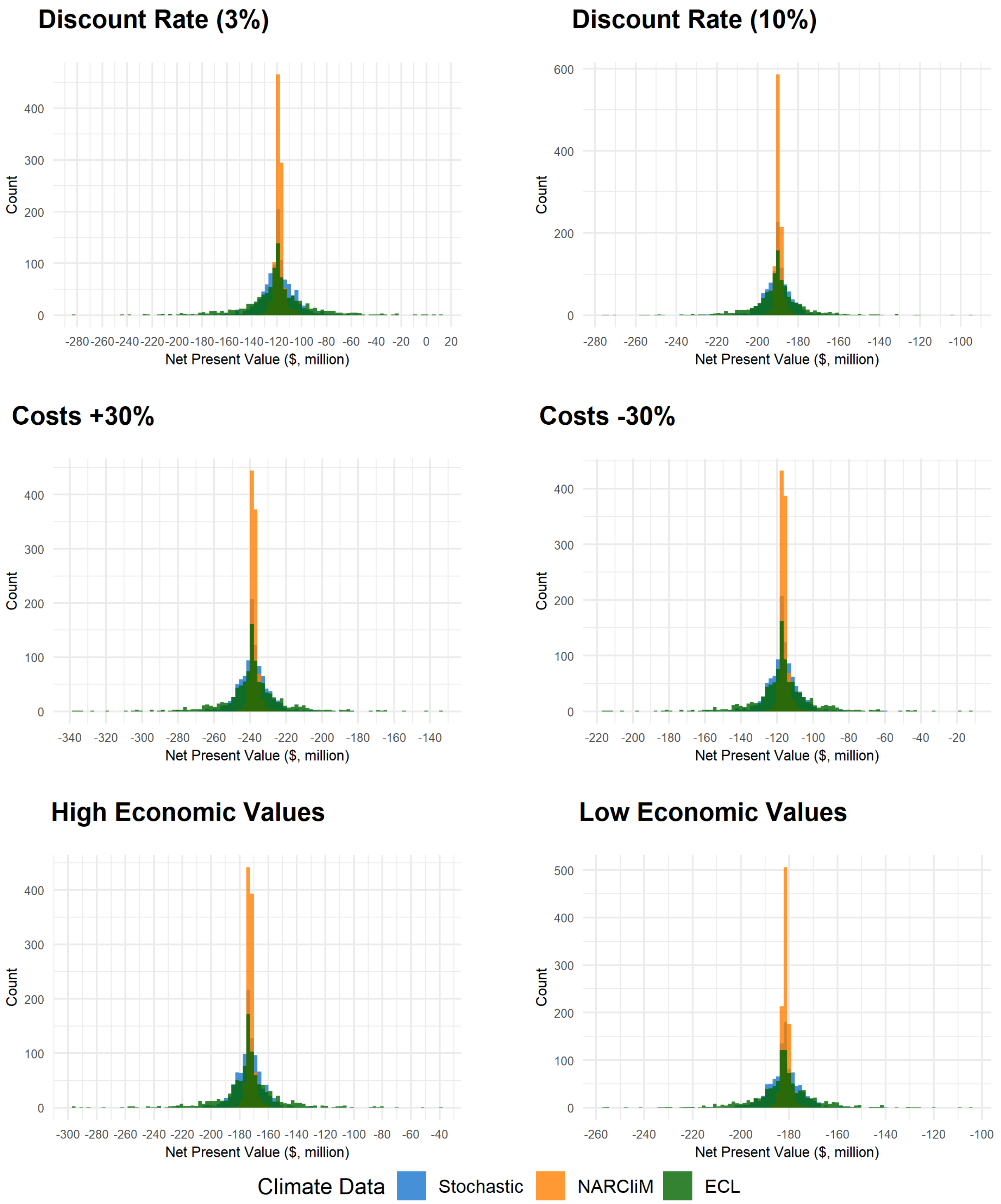


Figure 7. Combined option 3 sensitivity case NPV histograms

Distributional impacts

Table 18 below highlights the distributional changes that would impact the South Coast region if combined option 3 was to be introduced. The combined option typically results in benefits across all user groups under all climate datasets analysed, with towns marginal losses within the NARCliM dataset (at a loss of 0.8%) and permanent agriculture losses within the ECL dataset (at a loss of 1.8%) being the only exceptions.

The increase in dam size results in strong average improvements to the economic outcomes of towns across most datasets. An average benefit of $0.2 million is achieved for the stochastic climate set, which is a 17.7% increase; for the east coast low climate dataset the average benefit totals $0.6 million, which is a 10.9% increase; and an additional 12.4% benefit is realised under the NARCliM dataset.

Average benefits to agricultural outcomes are generally double those realised under combined option 2, which features a smaller hydropower dam and no increase to agricultural demand. The benefits are similar under all climate datasets with average agricultural improvements of between $24 to $25 million (~11%).

These user group improvements aggregate to an average increase in economic outcomes for the region of approximately $25 million under all climate datasets considered, equating to 11% to 12% improvement across an average 40-year period.

Table 18 Average distributional impacts from combined option 3

Stochastic dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	-1.2	224.2	-	0	223
Bulk licence conversion	-1	249.1	-	0	248.1
Change ($m)	0.2	24.9	-	0	25.1
% Change	17.7	11.1	-	31.8	11.3

NARCliM dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	-6.2	218.7	-	0	212.5
Bulk licence conversion	-5.4	243.6	-	0	238.2
Change ($m)	0.8	24.9	-	0	25.7
% Change	12.4	11.4	-	51.7	12.1

East Coast low dataset

	Towns ($m)	Perennial pasture ($m)	Permanent crops ($m)	Stock and domestic crops ($m)	Totals ($m)
Economic base case	-5.3	219.1	-	0	213.8
Bulk licence conversion	-4.7	243.1	-	0	238.4
Change ($m)	0.6	24.1	-	0	24.7
% Change	10.9	11	-	-29.2	11.6

Breakeven analysis

As in combined options 1 and 2, this combined action seeks to increase on-farm agricultural activity via a centralised water storage facility of 20 GL, increased on farm storages, and activated water markets. For agricultural water users the relevant price level is the marginal economic value of water to pastural operations. This value was increased separately for the stochastic, NARCliM, and ECL economic analyses until the average, or expected value, of BCR outcomes for the 1,000 40-year runs of each dataset was equal to, or near, 1.

In the initial analysis, it was assumed that dryland agriculture generated revenue of $824/ML, whereas irrigated agriculture generated revenue of $1,373/ML. This produced a producer surplus, or profit to the farmer, of $344 for every megalitre of water applied through rainfall (ie. dryland agriculture) and $636 for every megalitre of water applied via irrigation. In this breakeven analysis the revenue for both dryland and irrigated water use were increased concurrently whilst the variable cost of each remained constant. The breakeven price level for the revenue generated of each agricultural operation and its associated producer surplus are given in Table 19.

Table 19 Breakeven price level combined option 2

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
Stochastic	1.0	Irrigated Revenue: $7,373 Irrigated Producer Surplus: $6,636 Dryland Revenue: $6,842 Dryland Producer Surplus: $6,480
NARCliM	1.0	Irrigated Revenue: $7,373 Irrigated Producer Surplus: $6,636 Dryland Revenue: $6,842 Dryland Producer Surplus: $6,480

Climate Dataset	BCR Average	Required economic value of high security entitlements ($/ML)
East coast low	1.1	Irrigated Revenue: $7,873 Irrigated Producer Surplus: $7,136 Dryland Revenue: $7,324 Dryland Producer Surplus: $6,980

The breakeven analysis suggests that this combined option is more viable than combined option 2, although it remains uneconomical. To reach a favourable outcome, the marginal economic value of water would be required to be five times that adopted for the central case, as opposed to the ten times required in combined option 2.

Detailed ecological analysis

Key ecological values and assets

The South Coast region is a highly significant and diverse ecological area.[6] The connected river, estuarine and marine ecosystems require a range of flows. These flows ensure maintenance during low flow periods; and through larger flows that enable fish and plant recruitment along rivers via the dispersal of seeds, eggs, young fish, reproductive fish and nutrients. Several native fish species rely on specific flow regimes in the from tributaries to the estuaries, and then the sea.[7]

The Bega, Clyde and Shoalhaven rivers support the Australian grayling which is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Grayling spend their first six months at sea, and the adult spawning that starts this cycle is thought to be initiated by an increase in river flow from seasonal rains. Adult Cox's gudgeon require fast-flowing upland streams. Australian bass range from tributaries to the estuaries, and possibly need river freshes[8] to recruit. Empire gudgeon prefer lowland habitat with aquatic plants; and spawn during spring to summer, and then their larvae drift down to estuaries.

The South Coast is also home to many state and nationally significant wetlands and swamps, supporting large areas of mangrove, saltmarsh and seagrasses.[9] The reach of the Bega River between Bega township and the Bega River estuary supports a small floodplain that includes paleochannels[10] and wetlands,[11] and areas that have been modified for irrigation. The lower Bega River estuary is in a relatively natural state, with extensive forest cover on the slopes of the immediate catchment, and areas of wetland and saltmarsh in generally good condition. Connected to the estuary are several lagoons, which would be influenced by the Bega River flow regime, particularly floods.

Method for assessing the ecological effects of water management options

An ecohydrological assessment approach was developed to use generic ecological metrics to assess the effects of any combined water management option across a representative suite of river sites in each NSW region. For the South Coast, these measures were applied for the long-term historical climate projections (stochastic), under a future dry climate change scenario (NARCliM) and for a modelled future where water produced from east coast lows is reduced.

[6] Department of Environment, Climate Change and Water (or DECCW 2010a), South Coast Regional Conservation Plan, Department of Environment, Climate Change and Water, Sydney, and Department of Planning, Industry and Environment - Environment, Energy and Science (or EES, 2022). River Health | NSW State of the Environment (at: www.soe.epa.nsw.gov.au/all-themes/water-and-marine/river-health; Accessed 24 Feb 2022).

[7] Morris, S, A., Pollard, P.A., Gehrke, P. C. & J.J. Pogonoski (2001). Threatened and potentially threatened freshwater fishes of coastal New South Wales and the Murray-Darling Basin, and NSW DPI (2006). Reducing the Impact of Weirs on Aquatic Habitat - New South Wales Detailed Weir Review. Southern Rivers CMA

[8] Freshes are larger flows that inundate the sides of the banks and any in-channel bars and benches that may be present. These typically travel as a pulsed flow down the system. Freshes transport organisms and nutrients and as such are required to support in-stream processes and biota in a similar way as bankfull and overbank flows.

[9] EES (2022), DECCW (2010b). State of the catchments 2010. Southern Rivers region. Estuaries and coastal lakes

[10] A remnant of an inactive river or stream channel that has been filled or buried by younger sediment

[11] Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or (mostly slow, sic.) flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (see www.ramsar.org/sites/default/files/documents/library/info2007-01-e.pdf).

Once the flow scenarios had been developed, the next step was to assess how the flow regime had changed. This was achieved by identifying key characteristics of the flow regime and comparing these characteristics against the base case which, in this case, was the do-nothing portfolio. This approach resulted in 20 hydrologic metrics, including mean annual flow and the number of years with a cease-to-flow event. Preliminary analyses indicated a shortlist of nine metrics that collectively tended to show much the same 'story' as the full list of 20 metrics, many of which were interdependent.

In coastal regions, the use of ecological water requirement metrics was not applied as has been applied for inland regions, as such metrics are not currently available. Ecological water requirements that are best suited to these regional water strategy assessments need to be developed collaboratively with agency experts. Ecological water requirements partly address the challenge that flow-dependent species and communities have different and detailed ecological water requirements. There will, however, always be external and long-term hydrologic and ecological effects associated with river management that neither the generic metrics or ecological water requirements cannot capture, and that will affect the viability of aquatic species and their populations.

The current generic metrics attempt to capture the same intent as the ecological water requirements for:

- **cease-to-flow** or **no-flow** events which are known to be a major influence on physical habitat for aquatic biota, water quality and water availability for vegetation
- **freshes** that influence riparian habitat, food-web dynamics and opportunities for fish movement and (for pulse specialists) recruitment
- **overbank flows** that provide critical connectivity with the floodplain, sustain wetland habitats and floodplain vegetation communities, and provide large-scale productivity pulses in the river channel. It was assumed that the threshold for overbank flows for any particular reach is likely to be within the 2.5-year to 10-year return interval.

Water management options for the South Coast Regional Water Strategy that were nominated for ecohydrologic assessment are shown in Table 20.

Table 20. The South Coast region's modelled combined options

Combined option number	Description
1	Increase on-farm water storage and activate water markets
2	Increase on-farm, centralised water storage (5.3 GL dam); and activate water markets — variant 1
3	Increase on-farm, centralised water storage water storage (20 GL dam); and activate water markets — variant 2

The assessment rating system is based upon that used by the Department of Planning and Environment — Environment, Energy and Science to assess the potential ecological outcomes from implementing individual daily extraction limits in the Barwon–Darling system.[12] It uses a categorisation system to rate the potential impacts or benefits to the environment. Stage one uses a five-category ranking and stage two an expanded 11-category ranking (Table 21). An effect was generally only considered significant if there was a change in the metric at 3% or higher, in either a positive or negative direction.

Table 21. Categories used in ecological assessments

Stage 1 category	Stage 2 category	Estimated percentage change in hydrology/ecology
Major/extreme impact	Extreme impact	More than 30% change in a negative direction (i.e. < –30%)
	Major impact	More than 20% change in a negative direction (i.e. < –20%)
Minor/moderate impact	Moderate impact	More than 10% change in a negative direction (i.e. < –10%)
	Minor impact	More than 3% change in negative direction (i.e. < –3%)
No/little change	Little impact	Less than 3% change in a negative direction (i.e.< 0%)
	No change	0%, rounded to the nearest whole percentage point
	Little improvement	Less than 3% change in a positive direction (> 0% and < +3%)
Minor/moderate improvement	Minor improvement	More than 3% change in a positive direction (i.e. > +3%)
	Moderate improvement	More than 10% change in a positive direction (i.e. > +10%)
Major/extreme improvement	Major improvement	More than 20% change in a positive direction (i.e. > +20%)
	Extreme improvement	More than 30% change in a positive direction (i.e. > +30%)

[12] Department Planning, Industry and Environment (2019). Potential ecological outcomes from the implementation of IDELs in the Barwon – Darling River: Preliminary Assessment

Summary of ecological results

This section summarises the impacts of the stochastic, NARCliM and east coast low modelling for each of the three combined options respectively, which were all for the Bega River.

Impact of combined options on standard flow metrics

Combined option 1: Increase on-farm water storage and activate water markets

The main ecological impact identified for this option was on the number of days at or below low flows. Low flows are defined as the flow exceeded 90 percent of the time under baseline conditions at each gauge, or the 90% percentile[13]. In particular, the typical (median) number of days below the low flow threshold (22, 18 and 18 ML/day under Stochastic, NARCliM and East Coast low base case) per year doubled for Bega River at Warraguburra (from 2 to 4, 7 to 13, and 6 to 12 days under the stochastic, east coast low and NARCliM scenarios respectively)[14]. Bega River at Warraguburra (WaterNSW gauge 219026), although now a decommissioned river gauge, can be considered a proxy for the end-of-system flows as it is downstream of the confluence of the Brogo and the Bega rivers.

An increase in the number of low-flow days can have many ecological implications. It can reduce the amount of available river habitat for aquatic plants and animals, reduce long-term sediment control and can increase the likelihood of poor water quality. It can also inhibit fish movement and increase predation because of fewer refuge habitats.

In this instance, these increases are still not long periods of low flow, and the greatest risk is probably that the river is more prone to the risk of more frequent, short no-flow periods. This site is about one-third of the way along the Bega River from the Bega township to where the river discharges into the sea. It is also located in the floodplain area where there is more obvious floodplain agricultural development, which explains the impacts on low flows. This emphasises the need to ensure that local extraction does not overly draw down the river overall, over time and along the river in general, but also specifically at this location if this option is pursued.

[13] This is more accurately referred to as percentage exceedance, not a percentile, using definitions from the Australian Bureau of Meteorology and the United States Geological Survey. A variation of the percentile known as the "percent exceedance" is obtained by subtracting the percentile scale value from 100 percent (see help.waterdata.usgs.gov/faq/surface-water/what-is-a-percentile). However, for consistency with other Regional Water Strategy and related NSW government documents we retain the term percentile.

[14] These effects were tested for statistical significance using a Mann-Whitney U-test, and were all within 99 % confidence limits.

Table 22. Predicted ecological effects of combined option 1 under stochastic, NARCliM and east coast low modelling*

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
Number of years with greater or equal to 1 no-flow spell per 130 years	no effect	no effect	no effect	no effect	no effect	no effect
Average duration of no-flow spells (number of days)	no effect	moderate improvement to no effect	no effect	moderate improvement to no effect	no effect	moderate improvement to no effect
Number of no-flow events per 130 years	no effect	major improvement to moderate impact	no effect	moderate improvement to moderate impact	no effect	moderate improvement to moderate impact
Very low flow rate (ML/d), or the 95%ile.	no effect	major impact to minor improvement	no effect	major impact to moderate improvement	no effect	major impact to moderate improvement
Low-flow rate (ML/d), or 90%ile.	no effect	minor impact to no effect	no effect	moderate impact to no effect	no effect	moderate impact to no effect
Median number of days below the low-flow threshold	minor impact	no effect to extreme impact	minor impact	no effect to extreme impact	minor impact	no effect to extreme impact
Low flow standard deviation	no effect	no effect to minor improvement	no effect	no effect to minor improvement	no effect	no effect to minor improvement
Low-flow days below the 75%ile	no effect	no effect	no effect	no effect	no effect	no effect
Base-flow rate (ML/d), or 80%ile.	no effect	no effect	no effect	no effect	no effect	no effect
Mean annual discharge (ML/y)	no effect	no effect	no effect	no effect	no effect	no effect
Fresh flow rate (ML/d), or 20%ile	no effect	no effect	no effect	no effect	no effect	no effect
Average number of freshes per year	no effect	no effect	no effect	no effect	no effect	no effect
Average duration of freshes (number of days)	no effect	no effect	no effect	no effect	no effect	no effect

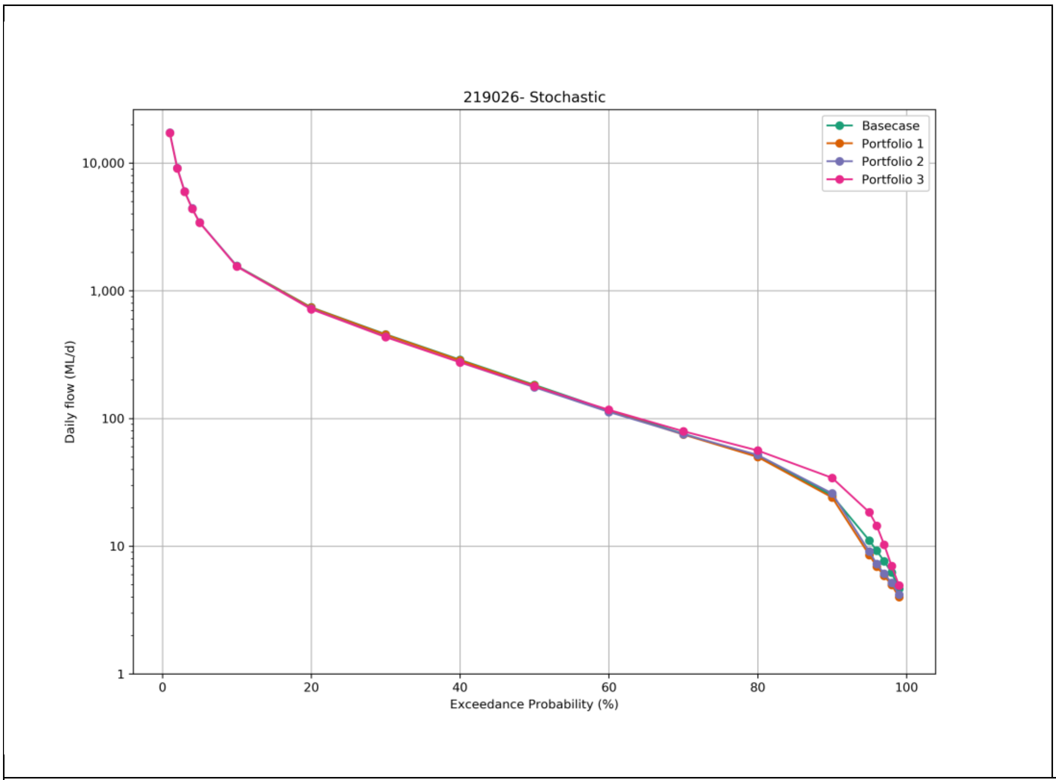
Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
High flows–2.5-year Average Recurrence Interval[15] flow rate (ML/d)	no effect	no effect	no effect	no effect	no effect	no effect
High flows–5-year Average Recurrence Interval flow rate (ML/d)	no effect	no effect	no effect	no effect	no effect	no effect
Very high flows–10-year Average Recurrence Interval flow rate (ML/d)	no effect	no effect	no effect	no effect	no effect	no effect
Monthly flow coefficient of variation	no effect	no effect	no effect	no effect	no effect	no effect
Daily flow coefficient of variation	no effect	no effect	no effect	no effect	no effect	no effect
Weekly flow coefficient of variation	no effect	no effect	no effect	no effect	no effect	no effect

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for stochastic, NARCliM and east coast low scenarios.

(ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level.

(iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

[15] The average recurrence interval is the average number of years that it is predicted will pass before an event of a given magnitude occurs



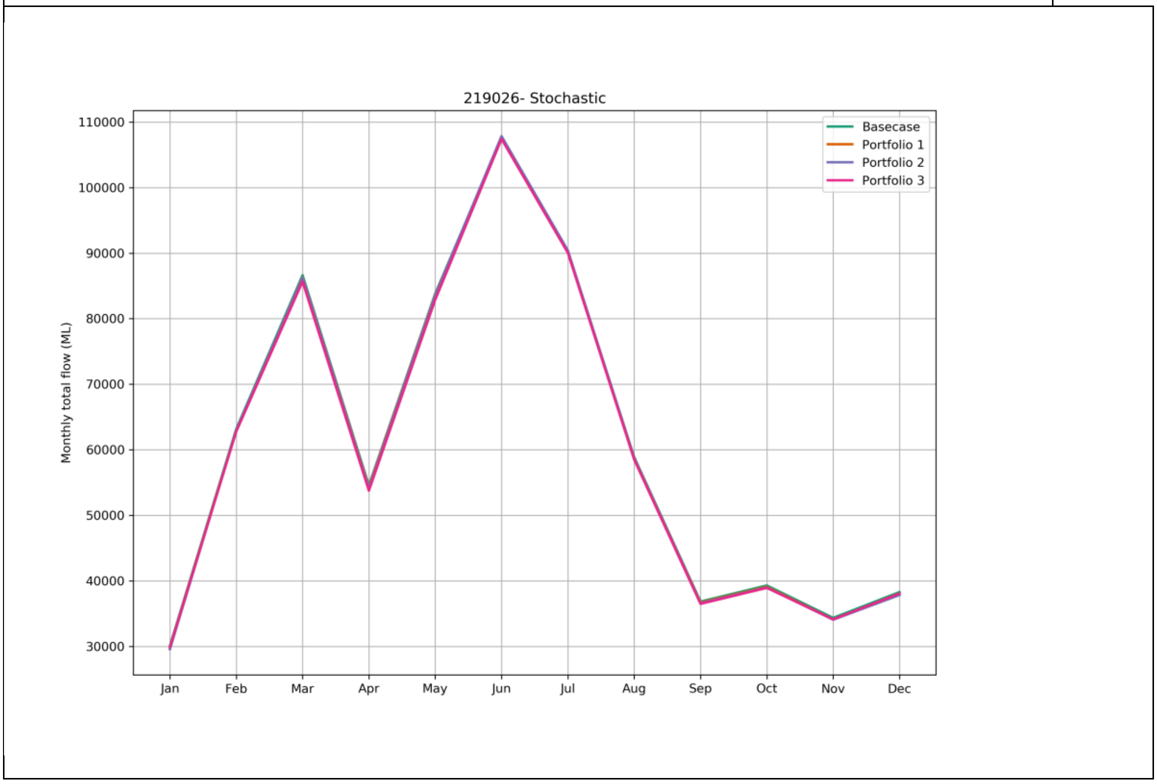
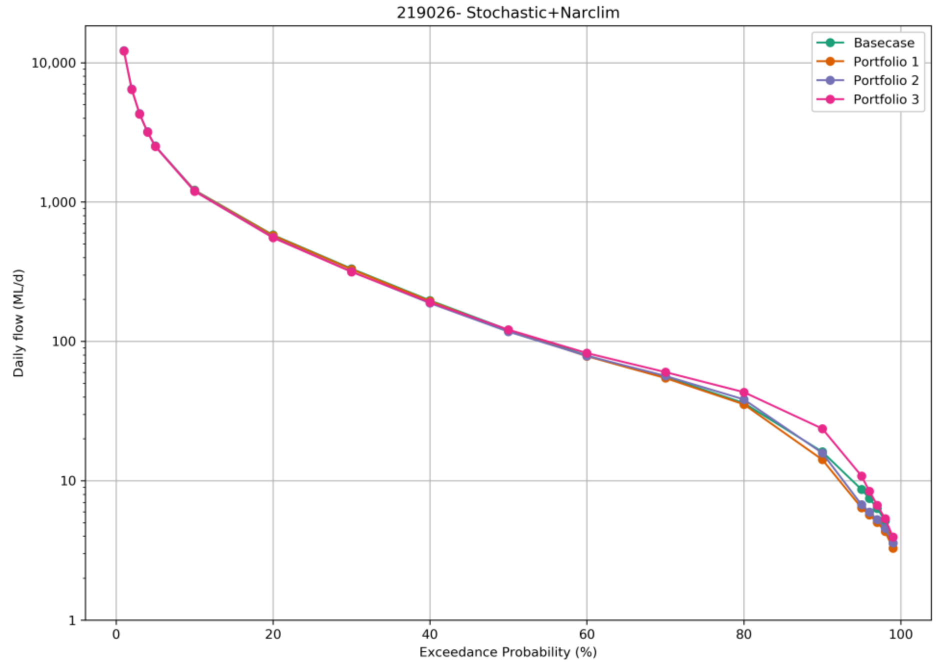


Figure **8**. Flow exceedance curve and monthly flow averages for Bega River at Warraguburra (gauge 219206) under stochastic modelling



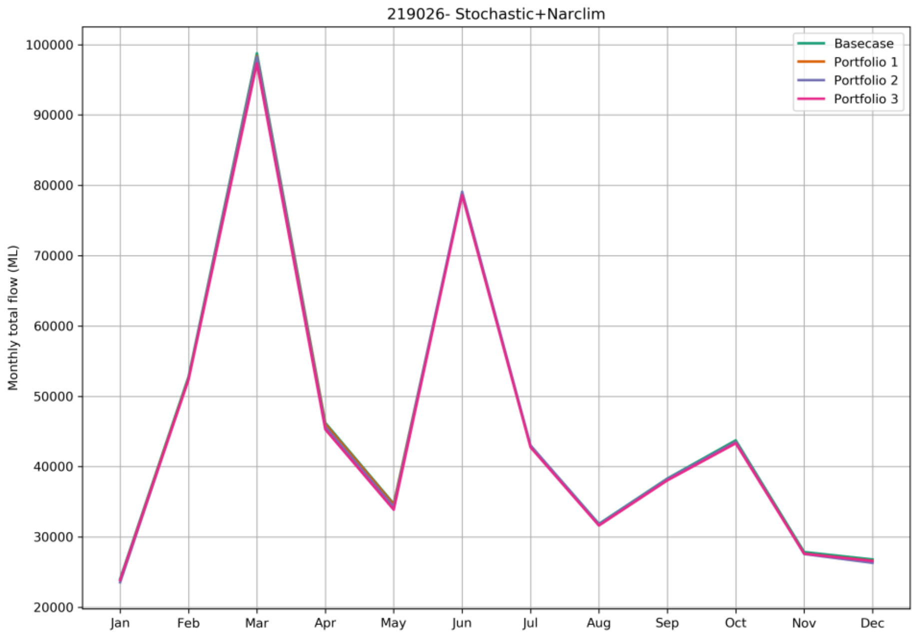
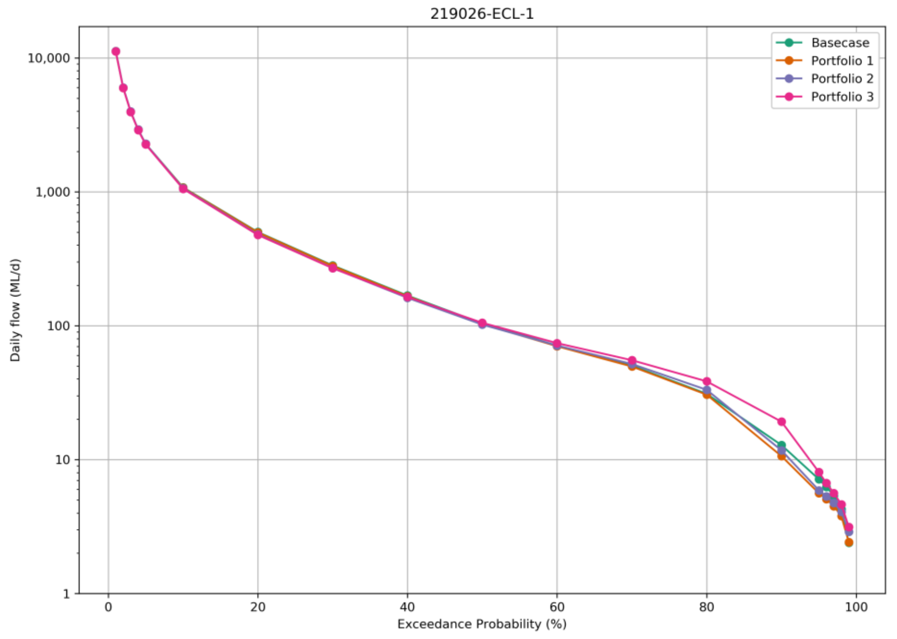


Figure 9. Flow exceedance curve and monthly flow averages for Bega River at Warraguburra (gauge 219206) under NARCliM modelling



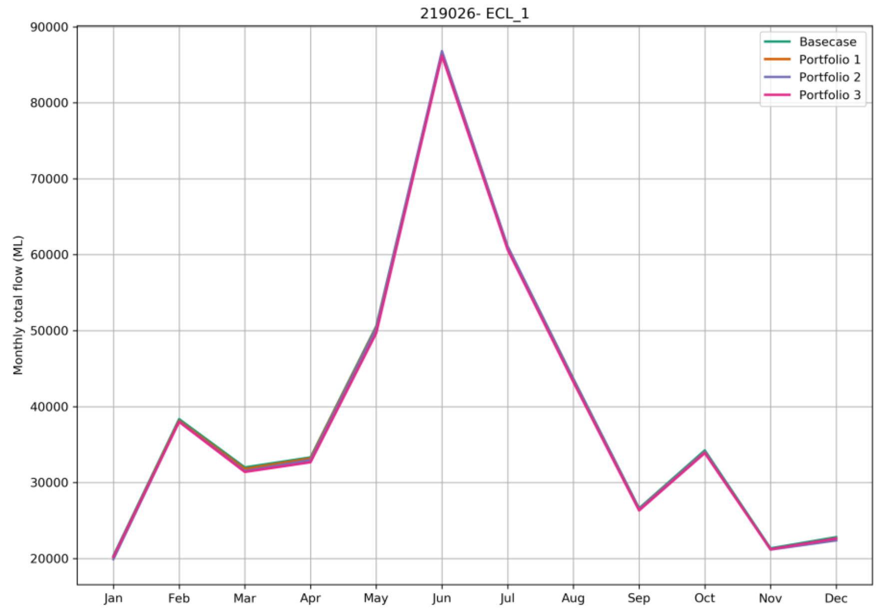


Figure 10. Flow exceedance curve and monthly flow averages for Bega River at Warraguburra (gauge 219206) under east coast low modelling

Combined option 2: Increase on-farm, centralised water storage; and activate water markets — variant 1

Combined option 2 showed similar but more extreme impacts than combined option 1. Again, the impact was on the number of days at or below low (90%ile) flows. The number of low flow days generally doubled across stochastic, NARCliM and east coast low scenarios. For Bega River at Warraguburra the annual median of days at low flows increased from 2 to 5, 7 to 15, and 6 to 13 days under the stochastic, east coast low and NARCliM scenarios respectively. Further upstream, and closer to Cochrane Dam, this option also increased low flows at Bemboka River at Bemboka. With low flows increasing from 1 to 7, 1 to 5 and 1 to 2 days under the stochastic, east coast low and NARCliM scenarios respectively. These are all proportionally large increases[16], but from relatively small numbers, so how they relate to real-world river operations and field ecology would require further investigation if this option was to progress.

The duration and frequency of freshes was also reduced, especially at Bemboka River at Bemboka (about 5 km west of Bemboka), Georges Creek at Steeple Flat (immediately downstream of Cochrane Dam) and Bega River at Kanoona which would receive about 73, 53 and 57 freshes/year under the base case under stochastic, east coast low and NARCliM scenarios respectively, but 24-25, 3-4 and 6-9% fewer freshes per year across the three climate scenarios[17]. For these streams, freshes would last about 9-11, 13-16 and 17-21 days under the base case but would have 25-29, 3-4 and 8-9% shorter fresh durations across all three climate scenarios under option 2. The frequency, timing, shape and duration are all important components of freshes, which are generally important for key ecological processes such as transferring river nutrients and stimulating movement and growth in native fish species. Gauge 219021 (Bemboka River at Bemboka) is the closest gauge to downstream Cochrane Dam, and so this river section is more subject to the effects of irrigation demands, which can cause more regular maintenance of low flows at the expense of larger flows like freshes.

Table 23. Predicted ecological effects of combined option 2 under stochastic, NARCliM and east coast low scenarios*

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
Number of years with greater or equal to 1 no-flow spell per 130 years	no effect	minor improvement to minor impact	no effect	minor improvement to no effect	no effect	minor improvement to no effect
Average duration of no-flow spells (number of days)	minor improvement	moderate improvement to no effect	no effect	moderate improvement to no effect	no effect	moderate improvement to no effect

[16] Statistically significant at greater than 99 % confidence, as assessed with a Mann-Whitney U-test

[17] Statistically significant at greater than 99 % confidence, as assessed with a Mann-Whitney U-test

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
Number of no-flow events per 130 years	minor improvement	extreme improvement to moderate impact	minor improvement	extreme improvement to moderate impact	minor improvement	extreme improvement to moderate impact
Very low flow rate (ML/d), or the 95%ile	no effect	moderate impact to moderate improvement	minor improvement	major impact to major improvement	minor improvement	major impact to major improvement
Low-flow rate (ML/d), or 90%ile.	minor improvement	no effect to major improvement	minor improvement	no effect to major improvement	minor improvement	no effect to major improvement
Median number of days below the low-flow threshold	extreme impact	no effect to extreme impact	moderate impact	no effect to extreme impact	moderate impact	no effect to extreme impact
Low flow standard deviation	minor impact	major impact to minor improvement	minor impact	major impact to minor improvement	minor impact	major impact to minor improvement
Low-flow days below 75%ile.	no effect	no effect	no effect	no effect	no effect	no effect
Base-flow rate (ML/d), or 80%ile.	no effect	no effect to moderate improvement	minor improvement	no effect to extreme improvement	minor improvement	no effect to extreme improvement
Mean annual discharge (ML/y)	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect
Fresh flow rate (ML/d), or 20%ile.	no effect	no effect	no effect	no effect	no effect	no effect
Average number of freshes per year	minor impact	major impact to no effect	minor impact	major impact to no effect	minor impact	major impact to no effect
Average duration of freshes (number of days)	minor impact	major impact to no effect	minor impact	major impact to no effect	minor impact	major impact to no effect

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
High flows–2.5-year Average Recurrence Interval flow rate (ML/d)	no effect	no effect to major improvement	no effect	no effect to moderate improvement	no effect	no effect to moderate improvement
High flows–5-year Average Recurrence Interval flow rate (ML/d)	no effect	no effect to minor improvement	no effect	no effect to moderate improvement	no effect	no effect to moderate improvement
Very high flows–10-year Average Recurrence Interval flow rate (ML/d)	no effect	no effect	no effect	no effect	no effect	no effect
Monthly flow coefficient of variation	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect
Daily flow coefficient of variation	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect
Weekly flow coefficient of variation	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for stochastic, NARCliM and east coast low scenarios.

(ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level.

(iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Combined option 3: Increase on-farm, centralised water storage water storage, and activate water markets — variant 2

The ecological effect assessment for combined option 3 followed the same approach as described for combined option 1. Note that the results for option 3 have been updated since these results were published in the south coast consultation paper[18], but also that Combined option 3 still shows generally more pronounced impacts than combined options 1 and 2.

There are several changes that indicate a more modified flow regime in the rivers under Option 3. The streams have 13-15% less frequent cease to flow events, but these are on average 63 % longer events under ECL and NARCliM, and 76% longer events under Stochastic scenarios. The reduction in cease to flow event frequency is most pronounced at Bemboka at Moran's Crossing with 99.9-100 % reduction. For example, from 1011 events/ 130 years to 1 event / 130 years under the NARCliM scenario. Bega River at Kanoona and Warraguburra similarly shows 85-90% and 68-71% reductions. The duration and frequency of freshes under option 3 is even more reduced than observed under option 2, again especially at Bemboka River at Bemboka, Georges Creek at Steeple Flat (Cochrane Dam) and Bega River at Kanoona. These streams receive about 32-37, 8-9 and 8-9% fewer freshes per year across the three climate scenarios[19]. For these streams, freshes would last about 9-11, 13-16 and 17-21 days under the base case, but would have 34-40, 7-8 and 9-10% shorter fresh durations across all three climate scenarios under option 3. There is a general 12-18% decrease in the number of low flow days in a year. For Bega River at Warraguburra this was a 100% decrease in low flow day frequency across the three climate scenarios (from baselines of 2, 7 and 6 days/per for Stochastic, ECL and NARCliM) [20]. On average, there are small percentage decreases in flow variation across daily, weekly and monthly flows, as well as about a 10% loss in variation in low flows. These results all suggest that while the stream flows are more protected from cease to flow and low flow events, they are also more actively managed.

[18] NSW Department of Planning and Environment (2022). South Coast Regional Water Strategy: Shortlisted actions -Consultation Paper. Shortlisted actions: Consultation Paper, May 2022.

[19] Statistically significant at greater than 99 % confidence, as assessed with a Mann-Whitney U-test

[20] Statistically significant at greater than 99 % confidence, as assessed with a Mann-Whitney U-test

Table 24. Predicted environment effects of combined option 3 under stochastic, NARCliM and east coast low scenarios*

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
Number of no-flow events per 130 years	moderate improvement	extreme improvement to no effect	moderate improvement	extreme improvement to no effect	moderate improvement	extreme improvement to no effect
Average duration of no-flow spells (number of days)	extreme impact	moderate improvement to extreme impact	extreme impact	moderate improvement to extreme impact	extreme impact	moderate improvement to extreme impact
Very low flow rate (ML/d), or 95%ile.	major Improvement	minor impact - extreme Improvement	major Improvement	minor impact - extreme Improvement	major Improvement	minor impact - extreme Improvement
Low-flow rate (ML/d), or 90%ile.	moderate Improvement	minor impact - extreme Improvement	moderate Improvement	minor impact - extreme Improvement	moderate Improvement	minor impact - extreme Improvement
Median number of days below the low-flow threshold	moderate improvement	extreme improvement to moderate impact	moderate improvement	extreme improvement to moderate impact	moderate improvement	extreme improvement to moderate impact
Low flow standard deviation	minor impact	extreme impact to minor improvement	minor impact	extreme impact to minor improvement	minor impact	extreme impact to minor improvement
Low-flow days below 75%ile.	no effect	no effect	no effect	no effect	no effect	no effect
Base-flow rate (ML/d), or 80%ile.	minor improvement	minor impact to extreme improvement	moderate improvement	minor impact to extreme improvement	moderate improvement	minor impact to extreme improvement
Mean annual discharge (ML/y)	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect
Fresh flow rate (ML/d), or 20%ile.	no effect	no effect	no effect	no effect	no effect	no effect
Average number of freshes per year	minor impact	extreme impact to no effect	minor impact	extreme impact to no effect	minor impact	extreme impact to no effect

Metric	Stochastic		NARCliM		East coast low	
	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges	Average effect	Range of effects across gauges
Average duration of freshes (number of days)	minor impact	extreme impact to no effect	minor impact	extreme impact to no effect	minor impact	extreme impact to no effect
High flows — 2.5-year Average Recurrence Interval flow rate (ML/d)	no effect	minor impact to no effect	no effect	minor impact to no effect	no effect	minor impact to no effect
High flows — 5-year Average Recurrence Interval flow rate (ML/d)	no effect	moderate impact to no effect	no effect	moderate impact to no effect	no effect	moderate impact to no effect
Very high flows — 10-year Average Recurrence Interval flow rate (ML/d)	no effect	moderate impact to no effect	no effect	moderate impact to no effect	no effect	moderate impact to no effect
Monthly flow coefficient of variation	minor impact	moderate impact to no effect	minor impact	major impact to no effect	minor impact	major impact to no effect
Daily flow coefficient of variation	minor impact	major impact to no effect	minor impact	major impact to no effect	minor impact	major impact to no effect
Weekly flow coefficient of variation	minor impact	moderate impact to no effect	minor impact	moderate impact to no effect	minor impact	moderate impact to no effect

*Notes: (i) The ecological effect is calculated as the percentage change against the base case for stochastic, NARCliM and east coast low scenarios.

(ii) All results are from averaged effects over time for each site, so the ranges represent the range of time-averaged values across sites, not the entire variability represented over time at the site or regional level.

(iii) The changes within little impact to little improvement correspond to changes at or less than 3% and are not considered significant. Changes greater than 3 up to 10, 10 to 20, 20 to 30, and greater than 30% are categorised as minor, moderate, major and extreme respectively.

Effects of all combined options

The main effects of the three combined options assessed were on the main stems of the rivers, not on the tributaries, except for those downstream of storages such as Cochrane Dam. The options also seem to have little effect on river flows larger than freshes. The significance of these results is still being explored. The metrics used for these coastal rivers are based on generic flow metrics rather than known ecological flow requirements for specific coastal river flow-dependent species or communities. Combined option 3 has the most effect on the flow regime, with moderate increases in low flow, reductions in cease to flow events, less variable flows and fewer and shorter freshes. The impacts on freshes under option 2, and especially 3 could be detrimental to fish species such as the Australian grayling. A key part of the grayling's life history is downstream migration following increased flows such as freshes, which then allow them to spawn in the lower freshwater or upper estuarine reaches of coastal streams[21]. Combined options 1 and 2 also had greater impacts on low flows, especially for the Bega River at Warraguburra. This might indicate even greater impacts during drier flow periods, which, in these analyses, have not been explored seasonally or during periods such as the Millennium Drought (about 1997 to 2010) or more recent droughts (especially during 2002-3 and 2017 to 2019). Hence, for any of the options that might progress, a more detailed assessment of the low flows and freshes effects that might impact the tributary, main river, estuarine and lagoon systems will be required.

Rapid analysis

Options that influence the supply and demand for water (hydrologic options) were initially put through a rapid assessment, based on what they are trying to achieve.

Options that seek to address the regional water strategy objectives for towns or economic activity were assessed through rapid cost-benefit analysis. Options that aim to improve ecological outcomes were assessed through a rapid ecological risk assessment.

These assessment criteria were used as a guide only for assessing whether there was merit in the option moving forward to the next stage of assessment. The rapid economic analysis and rapid ecological assessments are decision-support tools (as opposed to decision-making tools). This means an outcome that is not strictly positive (i.e. with a cost-benefit ratio less than 1) or a positive ecological assessment may still progress to a detailed assessment.

Rapid economic analysis

The rapid economic analysis involved assessing whether the benefits the option can generate are greater than the estimated costs. The key information that informed the rapid cost-benefit analysis of each option included understanding what happens if we do nothing, which included hydrologic modelling of the observed historical data (130 years). This looked at how much water would be available to different licences under the base case and each combined option. More detail on the base case is available in the economic base case.

As per NSW Government Treasury guidelines, a discount rate of 7% has been used in this analysis. All assessments took place over the length of the available historic climate record in the South Coast region, referred to as the instrumental record of 130 years (1890–2020). This allows an analysis of the performance of an option over a known climate period. Within this period, all infrastructure and policy settings are kept constant for the length of a hydrologic run.

[21] Koster, W. M., Dawson, D. R., & Crook, D. A. (2013). Downstream Spawning Migration by the Amphidromous Australian Grayling (Prototroctes maraena) in a Coastal River in South-Eastern Australia. Marine and Freshwater Research, 64, 31–41.

Table 25 gives an overview of the cost-benefit analysis outcomes for all options considered, including the net present value and benefit-cost ratio. **Error! Reference source not found.** shows the comparison of the predicted net benefits (or dis-benefits) of an option.

Three of the 13 options produce a positive economic outcome for the region within the limits of the framework applied for the cost-benefit analysis. Note that these outcomes do not reflect the potential ecological impact of an option. If an option results in a negative benefit-cost ratio, it indicates that the option does not produce an aggregate benefit for the region before considering the cost.

Table 25. Rapid cost-benefit analysis outcomes overview

Option	Description	NPV ($m)	BCR (–)
1a	Pipe Brogo to Bega	-74.2	0.00
12a	Eurobodalla Southern Storage (extracting from flows > 20 ML/d and from low flows)	-81.4	0.00
12b	Eurobodalla Southern Storage (extracting from flows > 20 ML/d only)	-81.4	0.00
16a	Increased on-farm storage (in-stream harvesting dams) (dams with low-flow bypass)	1.3	2.35
16b	Increased on-farm storage (in-stream harvesting dams) (dams without low-flow bypass)	1.5	2.65
19a	Augment Brogo (pipe to Tuross town water supplies)	-105.4	0.00
19b	Augment Brogo (pipe to Bega town water supplies)	-105.3	0.00
19c	Augment Brogo (pipe to Tuross town water supplies and Bega town water supplies)	-105.1	0.00
21a	Pumped hydro (increased size of Cochrane Dam) (5.3 GL Steeple Chase storage, existing demand)	-166.0	0.00
21b	Pumped hydro (increased size of Cochrane Dam) (5.3 GL extra storage, increased demand)	-152.6	0.08
21c	Pumped hydro (increased size of Cochrane Dam) (20 GL extra storage, existing demand)	-187.3	0.01
21d	Pumped hydro (increased size of Cochrane Dam) (20 GL extra storage, increased demand)	-173.2	0.08

Option	Description	NPV ($m)	BCR (–)
34	Increased utilisation of Bega regulated system (activation of sleeper licences)	9.1	-

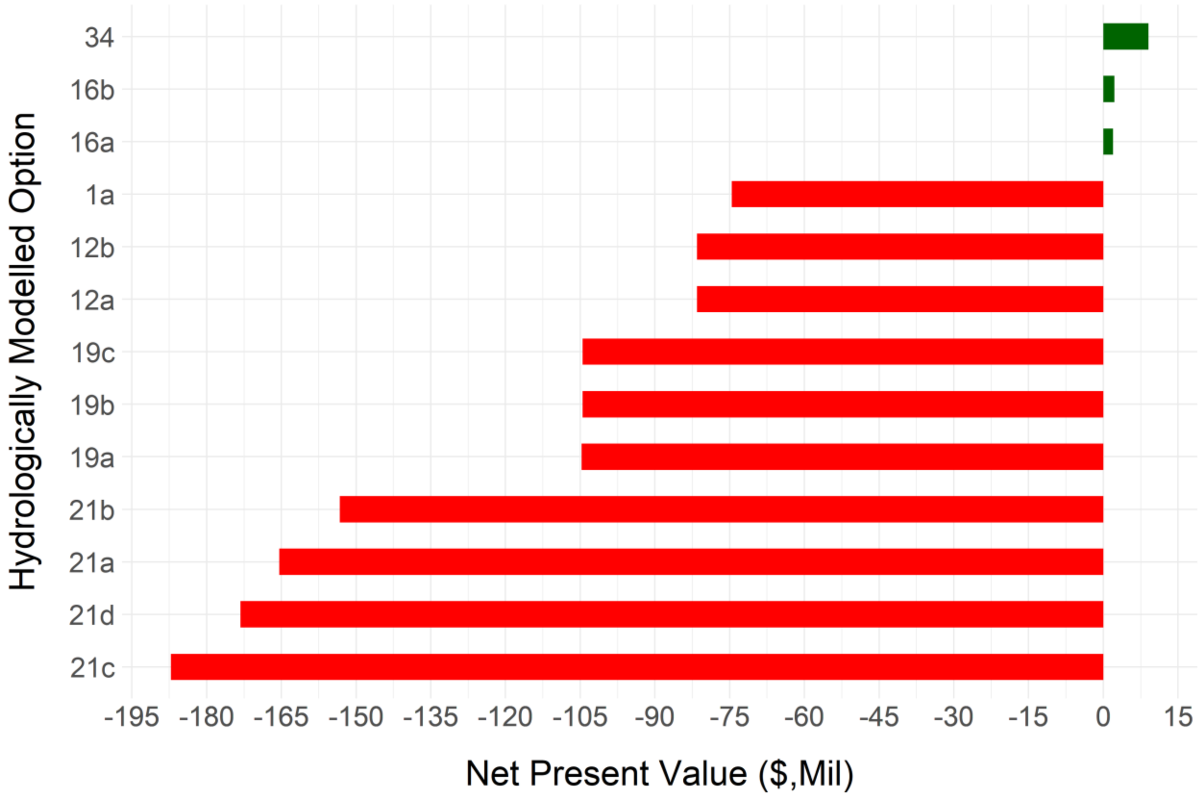


Figure 11. Rapid cost-benefit analysis outcomes overview

Rapid ecological analysis

As described in the generic options assessment process the rapid ecological assessment involved a high-level assessment of the ecological impact (or improvement) resulting from each of the options in the long list of the Draft South Coast Regional Water Strategy and new options identified during the public consultation process. The rapid ecological assessment was based on the expert opinion of scientists from the Department of Planning and Environment — Water and — Environment, Energy and Science; and the Department of Primary Industries — Fishing. Ecological assessment was undertaken separately by each agency and then the assessments were combined for an overall result for each option. In developing their rankings, the scientists were asked to consider how the option might impact:

- geomorphology (bed and bank erosion, and sediment transport)
- floodplain and riparian vegetation
- wetland ecology

- fish breeding, recruitment and movement
- water quality (temperature, dissolved oxygen, nutrients, refuge pool conditions) and river hydraulics (availability of flowing water and other diverse habitats)
- food-web impacts (e.g. inputs of nutrients from overland and tributary flows, quality of water release from dams and weirs)
- availability of held ecological water, and potential impacts on planned ecological water.

Table 26. Rapid ecological professional assessment of each of the options in the Draft South Coast Regional Water Strategy – long list of options, and new options identified during the public consultation process

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
1. Pipeline from Brogo Dam to Bega–Tathra town water supply system	Minor/moderate impact	May have implications for water dependent cultural sites, and the recreational, amenity and social value of impacted systems. Additional extraction will place pressure on planned environmental water and any held environmental water or environmental contingency allowance made available in the system.
2. A reserve volume for the Brogo–Bermagui town water supply system	Minor/moderate impact	Potential impacts to environment if less water is released for ecological use.
3. Water treatment plant for Brogo–Bermagui town water supply system	No/little change	Potential ecological benefits due to improved water quality.
4. Water treatment plant for Yellow Pinch Dam	No/little change	Potential ecological benefits due to improved water quality.
5. Upgrade water main between Bewong and Milton	Minor/moderate impact	Potential consequences for the Shoalhaven River if more water is drawn from it due to increased pipe capacity.
6. Pipeline connecting Bega Valley Shire Council and Eurobodalla Shire Council town water supply systems	Major/extreme impact	Consequences dependant on if additional water is utilised, or if same amount of water is simply transferred.

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
7. Vulnerability of surface water and groundwater supplies to sea level rise	Minor/moderate improvement	May have impacts to surface water flows and groundwater dependent ecosystems in source catchments depending on levels of connectivity. Incorporated into: • Proposed action 1.6: Assess the vulnerability of surface water supplies to sea level rise and saltwater intrusion • proposed action 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources
8. Re-use of reclaimed water	Minor/moderate improvement	Has many positive benefits to the environment and hydrology, but also some ecological risks that would need to be carefully managed. This option will be supported through action 6.7 of the NSW Water Strategy – Proactive support for water utilities to diversify sources of water.
9. Managed aquifer recharge investigations and policy	Minor/moderate impact	Ecological risks potentially high so would need to be done carefully. Some potential ecological benefits.
10. Decentralised desalination	Minor/moderate impact	Risks may include overcharging that may cause flooding in unintended areas, aquifer collapse, aquifers breaking into other aquifers, contamination (salt, heavy metals etc). Brine disposal is also a major ecological concern.
11. In-stream dam at Reedy Creek	Major/extreme impact	In-stream dam is likely to result in ecological and hydrologic impacts.
12. Eurobodalla Southern Storage	Major/extreme impact	Eurobodalla Shire Council is implementing this project with NSW Government support through the Safe and Secure program and with Commonwealth Government support.

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
13. Increased harvestable rights[22]	Major/extreme impact	Reduced flow into streams due to capture within dams is likely to have some ecological and hydrologic impacts. Level of impacts will depend on capture rules and take-up. See proposed action 2.6: Address catchment-based impacts of increased harvestable rights limits
14. Improve releases from Cochrane Dam to better match the water demands of irrigators	Minor/moderate impact	Possible impacts of changed flow regimes on the natural stream function. Could also be benefits.
15. Increased industry access to high flows	Major/extreme impact	Potential impacts will be dependent on the rules put in place around this. May be minor if only during very large flow events. Incorporated into proposed actions 2.5: Reduce the take of low flows and 3.3: Investigate increased on-farm storage
16. Increased on-farm water storage	Major/extreme impact	Potential impacts dependant on if water extraction is during low or high stream flows. Risks reducing river and stream flow even lower creating ecological and hydrologic impacts. See proposed action 3.3: Investigate increased on-farm storage
17. A grid of off-stream storages in the Bega Valley	Minor/moderate impact	Potential impact due to capture of water that would otherwise be within streams. Increased on-stream and off-stream storages will enable extraction of the full licenced entitlement. This will result in reduced ecological water if the current level of extraction does not meet the 'full licenced entitlement'.

[22] The NSW Government has made recent amendments to coastal harvestable rights. As of May 2022, NSW's coastal-draining catchments can capture and store up to 30% of the average annual regional rainfall from their landholding as harvestable rights water, with restrictions on certain uses. For further information see: www.dpie.nsw.gov.au/water

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
18. Tuross River barrage	Major/extreme impact	Potential for barrage to reduce upstream and downstream dispersal of aquatic organisms moving from fresh-salt water habitats and vice-versa. Incorporated into proposed action 3.6: Improve water security for lower Tuross water users
19. Increase capacity of Brogo Dam	Major/extreme impact	Downstream ecological and hydrologic impacts likely. Impacts of flooding additional areas surrounding dam.
20. Increase capacity of Cochrane Dam	Major/extreme impact	Downstream ecological and hydrologic impacts likely. Impacts of flooding additional areas surrounding dam.
21. Brown Mountain Water Project (pumped hydro scheme)	Major/extreme impact	This option is highly likely to reduce ecological flows and impact aquatic ecosystems in the Bemboka and Bega Rivers.
22. In-stream dam at Crystalbrook	Major/extreme impact	In stream dam is likely to result in ecological and hydrological impacts.
23. Establish sustainable extraction limits for South Coast surface water and groundwater sources	Major/extreme improvement	Sustainable extraction would benefit the environment and hydrology. See proposed action 2.3: Establish sustainable extraction limits for surface water and groundwater sources
24. Convert low-flow water access licences to high-flow water access licences	Minor/moderate improvement	Likely to be a benefit in some systems but may differ depending on the system and if landholders can be encouraged to extract during high flow events. See proposed action 2.5: Reduce the take of low flows
25. Extend water and sewer services to southern villages (Shoalhaven Water)	Minor/moderate improvement	Unlikely to have major ecological benefits.

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
26. Southern Reclaimed Water Management Scheme	Minor/moderate improvement	Using reclaimed sewage water should reduce reliance from storm water runoff and other clean water sources.
27. Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall Project	Minor/moderate improvement	
28. Fish-friendly water extraction	Minor/moderate improvement	Positive benefits all round. See proposed action 2.2: Implement fish-friendly water extraction
29. Improve fish passage in the South Coast region	Minor/moderate improvement	Positive benefits to ecology particularly fish. See proposed action 2.1: Improve fish passage
30. Improve stormwater management	Major/extreme improvement	Ecological outcomes will improve relative to the scale of investment and how long-term the investment is.
31. Bringing back riverine and estuarine habitats and threatened species	Minor/moderate improvement	Positive benefits to environment hydrology and water quality. Incorporated into proposed action 1.4: Deliver a river recovery program
32. Characterising coastal groundwater resources	Minor/moderate improvement	Provides good information to inform future decisions. See proposed action 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources
33. Protecting ecosystems that depend on coastal groundwater resources	Major/extreme improvement	Rivers should be included in the description of groundwater dependent ecosystems as a lot are baseflow fed i.e. groundwater dependent. See proposed action 1.9: Protect ecosystems that depend on coastal groundwater
34. Active and effective water markets	Minor/moderate impact	See proposed action 3.2: Review water markets

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
35. Improved data collection and information sharing	Minor/moderate improvement	Improved understanding will lead to both better future decisions and understanding of fish. See proposed actions 1.10: Improve monitoring of water extraction and 3.1: Provide better information about water access, availability and climate risks
36. Weir at Brogo–Bermagui town water supply off-take	Major/extreme impact	This option may have some ecological benefits compared to current situation. However, reduction of current high volumes of water being released could have negative ecological impacts. See proposed action 3.5: Identify the best option to improve water security for the Bermagui town water supply system
37. Shorten the Bega–Brogo regulated river system	Major/extreme impact	Reduced dam releases may have potential negative ecological impacts, however reduction of regulated area could also be positive.
38. Increase general security allocations in the Bega–Brogo regulated river system	Major/extreme impact	It is uncertain whether overall water use will increase or decrease under this option so it is difficult to assess the ecological impacts.
39. Regional network efficiency audit	Minor/moderate improvement	If the proposal does not change the overall volume of annual water use, then there may be little or no change. However, given the proposal may stimulate sleeper licences and is linked to increasing the capacity of the dam, it is expected that this will stimulate growth in use and demand and drive additional extraction.
40. River Recovery Program for the South Coast: a region-wide program of in-stream works, riparian vegetation and sediment control	Major/extreme improvement	Improved habitat ecology and hydrology. See proposed action 1.4: Deliver a river recovery program

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
New option — Apply the NSW Extreme Events Policy to the South Coast region	No/little change	Improved decision-making during drought and flood conditions. This option is being considered through action 4.3 of the NSW Water Strategy – Improve drought planning, preparation and resilience
New option — Quantify the resource potential of South Coast hard rock aquifers	Insufficient information to assess	Exploration will not directly affect ecosystems or hydrology. Potential future extraction would have impacts. Incorporated into proposed option 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources
New option — Plan for climate change impacts on coastal groundwater resources	Insufficient information to assess	Option will not have ecological consequences in itself. Incorporated into proposed action 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources
New option — Plan for land use pressures on coastal groundwater resources	Major/extreme improvement	Improved knowledge for future decision making may result in changed land practices that will benefit the environment and help protect groundwater resources.
New option — Identify ecological water needs to support healthy coastal waterways	Major / Extreme improvement	Environmental implications are based on supportive actions being implemented to protect or enhance environmental water needs, but does require further analysis. See proposed action 1.7: Identify ecological water needs to support healthy coastal waterways
New option — Support landholder adoption of best practice land management with advisory services and projects	Minor / Moderate improvement	See proposed action 1.5: Support landholder adoption of best practice land management

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
New option — Establish a research centre for agricultural water productivity, efficiency, and management	Not assessed	This option is about agricultural productivity and does not have environmental implications. Similar outcomes will be supported through proposed action 1.5: Support landholder adoption of best practice land management
New option — Identify water efficiency options that maximise agricultural water productivity, without reducing agriculture's share of water	Not assessed	It would be necessary to investigate the interaction of the option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect). This will be supported through proposed action 1.5: Support landholder adoption of best practice land management
New option — Upgrade council-owned sewage treatment plants to recycle water for allowable land use	Not assessed	Need further clarity about landuse approvals as it relates to the option. This option will be considered through action 6.7 of the NSW Water Strategy – Proactive support for water utilities to diversify sources of water
New option — Construction of storage facilities, such as dams and wetlands, for water to be used by agricultural enterprises, for firefighting and for recreation	Not assessed	Need further clarity about landuse approvals as it relates to the option. This will be supported through proposed action 3.3: Investigate increased on-farm storage
New option — Locate storages as high as practicable in the landscape, fill these storages by the interception of stormflow run-off with feeder drains, manage the flow in feeder drains using smart culverts, and utilise the water stored as soon as economically opportune using gravity-fed irrigation	Minor / Moderate impact	Would need to investigate the interaction of the option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect). This will be supported through proposed action 3.3: Investigate increased on-farm storage

Draft strategy option	Rapid ecological assessments (with median impact)	Key points made in commentary
New option — Construction of a barrage at Bottleneck Reach as an economical option	Major / Extreme impact	See proposed action 3.4: Investigate delivery efficiency improvements for the Bega–Brogo regulated river system
New option — Construct a much larger storage at the Crystalbrook site and use excess variable renewable energy to pump from this dam to the Cochrane dam, then generate power at the optimal price using existing infrastructure	Major / Extreme impact	Extreme impacts on the ecology of the catchment along with downstream catchments and communities.
New option — Educate and motivate the public to conserve water	Minor / Moderate improvement	See action 6.6 of the NSW Water Strategy – A new state-wide Water Efficiency Framework and Program
New option — Adopt adaptive management if an extreme event equivalent to a drought of record occurred, without carrying significant opportunity cost every single year	Insufficient information to assess	This option will be considered through action 4.3 of the NSW Water Strategy – Improve drought planning, preparation and resilience
New option — Conduct a review of water management practices and policies preceding and during the 2018–20 drought to identify lessons	Insufficient information to assess	Would need to investigate the interaction of the option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect). This option will be considered through action 4.3 of the NSW Water Strategy – Improve drought planning, preparation and resilience