Department of Planning and Environment

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# North 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, practicing the oldest living culture on Earth and as the Traditional Owners and Custodians of the lands and waters.

We acknowledge that the people of the Anaiwan, Biripi, Bundjalung, Dunghutti, Githabul, Gumbaynggirr and Yaegl nations hold a significant connection to the lands upon which the North Coast Regional Water Strategy falls.

The North Coast region holds areas of great spiritual, cultural and economic importance to Aboriginal people and the NSW Government recognises the connection of water to the people of these nations.

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# Introduction

The NSW Government is developing 12 regional 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.

This report provides the detailed assessments, both economic and ecological, for the option outlined in the Draft Regional Water Strategy North Coast: Shortlisted Actions - Consultation Paper released in May 2022.[1] It outlines the results of the options assessment process for all relevant options in the North Coast. The only option subject to detailed assessment in the North Coast was:

- Option 1: Expand the Clarence-Coffs Harbour Regional Water Supply Scheme.

No rapid cost benefit analysis was undertaken in the North Coast. However, the rapid ecological assessment was applied to all options.

## Purpose of the detailed economic and ecological analysis

The purpose of undertaking detailed economic and ecological analysis of an option is to examine how the option will influence the use of water in the region, impact environmental watering requirements and assess the economic consequence of implementing the option.

The hydrologic modelling in the North Coast region covers the observed historical, long-term paleoclimate (stochastic) and climate change (NARCliM). We have 10,000 years of data in each data set. For both economic and environmental analyses proposed options subject to detailed analysis are evaluated according to these two climate datasets and compared with a base case of no change in policy or infrastructure.

For the economic analyses this long-term 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". In addition, a series of scenarios are conducted on each of the options as well as a breakeven analysis that determines at what value of water the cost of the proposed option equates to its benefits.

The detailed assessment will help us to understand the resilience of the options in more extreme climate scenarios. This stage of the assessment measures economic and ecological outcomes. 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

[1] Accessible here: https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies

- 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 flow across floodplains or fill wetlands
- to assess whether changes to a set of flow parameters at several points were positive or negative relative to environmental water targets.

The detailed economic and ecological analysis describes the results of the hydrologic modelling for the relevant options put forward in the Draft North 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.

At this stage of the regional water strategies process, we are identifying and recording the types of questions that Aboriginal communities are likely to have about each of the options. We are also working out what information communities will need to make informed decisions about how specific options will affect them.

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

# Detailed analysis overview

## Detailed economic analysis overview

For proposed options we undertook detailed analysis based on potential future climate conditions, using long-term paleoclimate (stochastic) and climate change (NARCliM) models.

The key information that informed the cost-benefit analysis of each option included:

- **understanding what happens if we do nothing**, which included hydrological modelling under the two different hydrologic models. These models are sampled to each provide 1,000 40-year forecasts of the future of the region and how much water is available to different licences under the base case and each option. More detail on the base case is available in the North Coast Economic Base Case.
- **high level cost estimates** prepared for each option including capital and operational expenditure for infrastructure options,[3] and operational costs for non-infrastructure options. These costs were very broad and high level. Further investigation of any option will require more detailed cost estimates.
- **benefit estimates**, focusing on the economic value of water for towns and industries, which was developed and used as the primary benefit to assess the costs against. This is referred to as the Regional Water Value Function.[4] A summary of the value of water for each major water user is below. The detail behind how these values were calculated are in the North Coast Economic Base Case.

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

The net present value is the summation of the present value economic outcomes of the option case minus the summation of the 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 the option creates more costs than it generates benefits, when the time value of money is incorporated. Net present value can be expressed as Equation 1.

### Equation 1 Net Present Value (NPV)

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

The benefit-cost ratio divides the incremental benefits of an option to the region by the discounted whole-of-life cost (capital and operational expenditure) of the option. A benefit-cost ratio of 1 or

[3] Reference the ARUP cost estimate assumptions.

[4] See the *Regional Water Value Functions* (MJA, 2021) for all regions.

greater indicates that the project is economically feasible, as 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 rapid cost-benefit analysis are a decision-supporting 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 preclude an option from being progressed to the detailed analysis stage.

In addition to these decision-making tools, the detailed analysis also conducts:

- **sensitivity analysis** — used 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%)
    - capital and operational expenditure (+30% / -30%)
    - the value of water assigned to each economic activity
    - reactive infrastructure solutions
- **distributional impacts** — looked at how the option impacts different water users and classes of licences
- **breakeven analysis** — determines at what price a megalitre of water would result in the costs being equivalent to the benefits. This analysis assumes the proposed option is viable on the balance of outcomes within the economic analysis framework presented and determines what price for a megalitre of water would make the benefits equal the cost of the option.

It is not always possible to determine a breakeven point, so some options may not have a breakeven analysis described.

The detailed assessment was completed by applying the regional water value function to the outputs of the hydrologic modelling to determine the incremental change between the base case and the option, while taking into account the cost of the option.

# Detailed ecological analysis overview

The detailed ecological 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 flow across floodplains or fill wetlands (Figure 1). Each part of the flow regime plays an important role in supporting the health of the river.

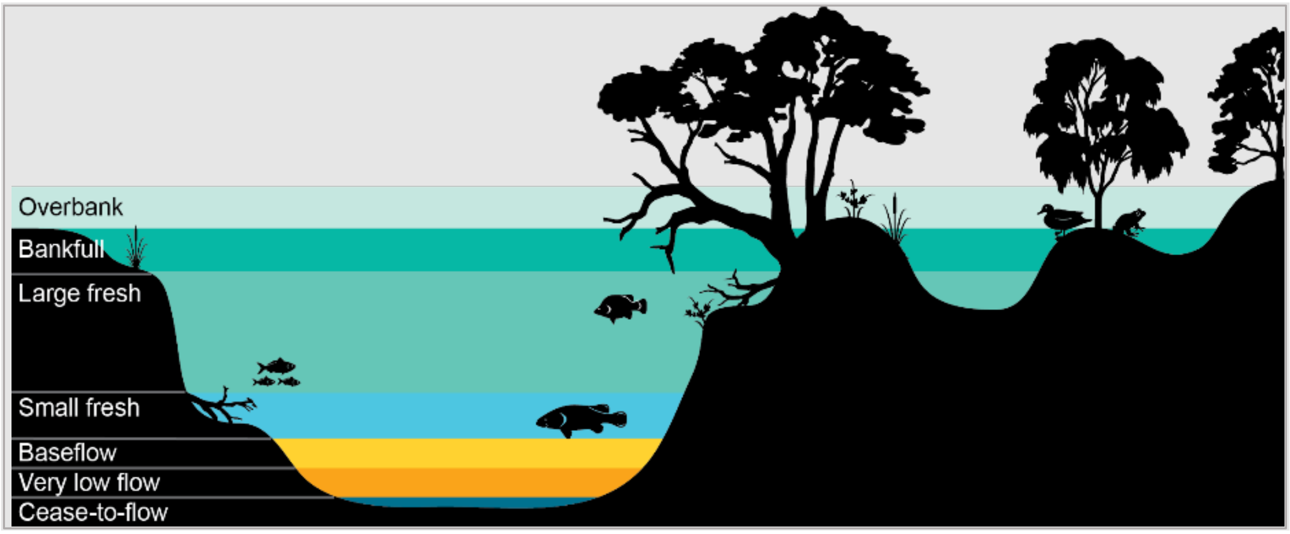



Figure 1. Conceptual model of the different components of roles of different flow regimes components

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 models. These integrated models were used to assess different options. That is, any 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. For this region, only one option was modelled.

Each of these model runs measured impacts at different gauges along the river. In the North Coast, the changes measured using standard ecological metrics have been assessed 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.

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[5]. 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).

[5] Based on categories used in Department of Planning, Industry and Environment (2019). Potential ecological outcomes from the implementation of IDELs in the Barwon – Darling River. Preliminary Assessment. September 2019.

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 economic detailed 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 a $/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.

Table 2. Key water users in the North Coast region

| Key water user | Water licence | Economic benefit of water use |
|---|---|---|
| **Towns (Clarence Valley, Coffs Harbour, Port Macquarie, Armidale)** | Local water utility | Reduction in economic cost of water supply shortfalls |
| **Annual crop producers (ie sorghum)** | • general security<br>• supplementary<br>• rainfall harvesting<br>• high security | Marginal increased yield of crop due to irrigation, compared to dryland production |

Table 3. Economic cost of town water supply shortages in North Coast

| Time in water shortage | Clarence Valley | Coffs Harbour | Port Macquarie | Armidale |
|---|---|---|---|---|
| **Population*** | 50,671 | 25,752 | 73,131 | 25,752 |
| **System type** | Unregulated | Unregulated | Unregulated | Unregulated |
| **0 - 6 months (restrictions)** | $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 |
| **Greater than 12 months** | $16,000/ML (Carting) | $16,000/ML (Carting) | $16,000/ML (Carting) | $16,000/ML (Carting) |

| Time in water shortage | Clarence Valley | Coffs Harbour | Port Macquarie | Armidale |
|---|---|---|---|---|
| **Continued shortages (greater than 24 months)** | $16,000/ML (Carting) | $16,000/ML (Carting) | $16,000/ML (Carting) | $16,000/ML (Carting) |

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

Table 4. North Coast agricultural water supply economic benefit[6]

| Crop | Cropping | Water licence | Marginal economic benefit (of water) ($/ML) |
|---|---|---|---|
| **Lucerne*** | Perennial pasture | • general security<br>• supplementary<br>• uncontrolled flow<br>• unregulated<br>• high security | $175/ML |

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

## Infrastructure costings

The capital and operational expenditure for infrastructure options are derived from cost models built to allow a consistent comparative assessment across regions.[7] 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 relationship of physical characteristics of infrastructure — such as dam size or pipeline length — and the expected cost to construct; with each category of infrastructure — dams, pipelines, desalination plants, etc. — having its own unique valuation method. These relationships are arrived at through analysis of past similar projects and professional assessment.

Capital and operational 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 no discounting is applied to the capital costs
- 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 through the addition of capital expenditure discounted at a linear rate until the end of the analysis period.

[6] Note that only values used in the analysis, which represent the highest value crop, were used. Further values on crop types group in the region can be seen in *Regional Water Value Functions* (MJA, 2020).

[7] Further details on these cost models are provided in Appendix A.

## Option 1: The expansion of the Clarence- Coffs Harbour Regional Water Supply Scheme to the Bellingen Shire Council

This option is for the expansion of the Clarence–Coffs Harbour Regional Water Supply Scheme to Bellingen Shire Council.[8] Towards the end of 2019, the levels in the Bellinger River continued to drop and Bellingen Shire Council had concerns regarding the volume of water in the aquifer and how long this would last if the Bellinger River stopped flowing. Bellingen Shire Council is considering alternate water supply options that could supplement the alluvial water source and secure water supply during a repeat of the dry conditions experienced in 2019, or worse.

To implement this option would involve constructing a pipeline between Coffs Harbour City Council's treated water supply network in the suburb of Boambee East and Bellingen Shire Council's main town water supply network that supplies water to Toormina Reservoir. The proposed option includes four different pipeline routes, all of which have been costed.

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

Table 5. Results for option 1

| Net Present Cost ($m) | Stochastic NPV ($m) | NARCliM NPV ($m) | Stochastic BCR | NARCliM BCR |
|---|---|---|---|---|
| 1 | -36.2 | -35.9 | 0.01 | 0.01 |

The results that this option has a negative net present value of approximately negative $36m under the stochastic and NARCliM dataset. The benefit-cost ratio remains fairly consistent at close to zero under both datasets, indicating that the costs of the extending the weirs capacity under this option outweigh the economic benefits. This outcome is not unexpected, given the earlier modelling of the economic base case for the North Coast region, which identified minimal shortfalls throughout the region.

The hydrologic record includes a great deal of variation, not fully represented in average values. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option, Table 6 presents the range of possible outcomes for the proposed option's performance over any 40-year period. The 1st percentile is effectively the worst outcome while the 99th is the best.

There is little change in the economic value of the option in any of the 1,000 realisations under the NARCliM or stochastic datasets. In both instances, the net present value varies from -$36m to -$35m. There are very few benefits identified in the hydrologic record.

Table 6. Decile and extreme percentile results for option 1

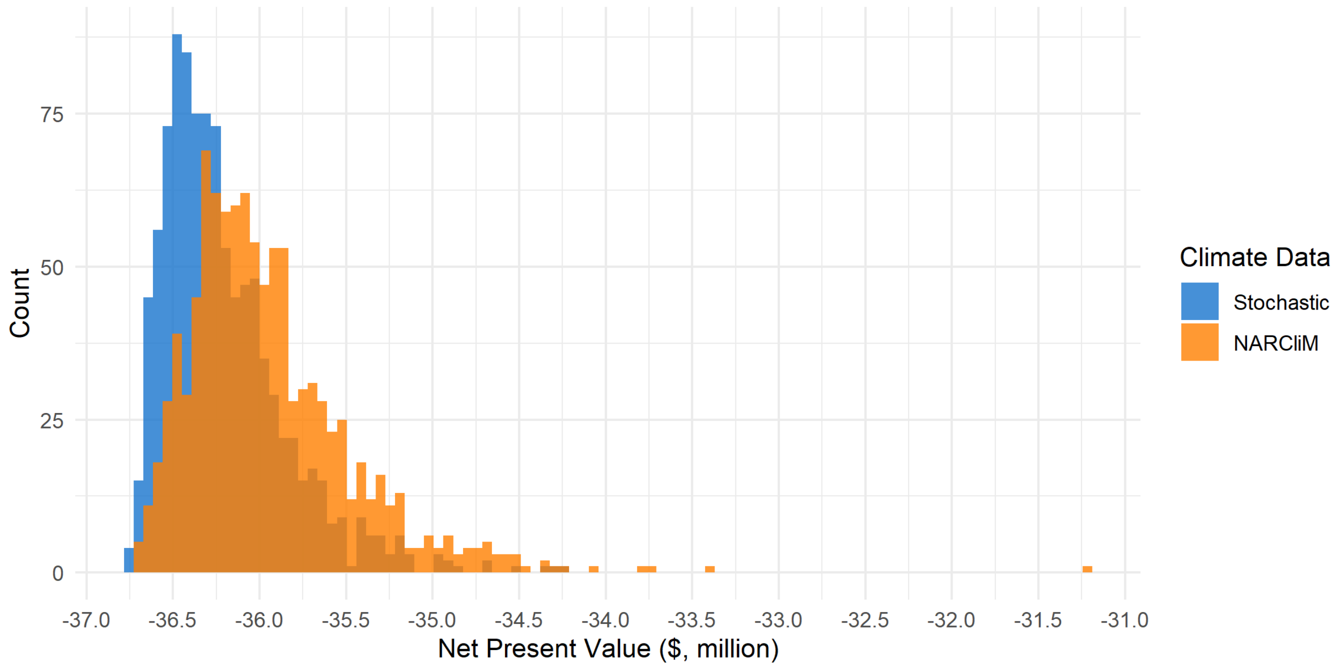
| Percentile | Stochastic NPV ($m) | Stochastic BCR | NARCliM NPV ($m) | NARCliM BCR |
|---|---|---|---|---|
| 1% | -36.7 | 0 | -36.6 | 0 |

[8] Option 1. Expand the Clarence-Coffs Harbour Regional Water Supply Scheme, described in NSW Department of Planning, Industry and Environment (2021). Draft Regional Water Strategy. North Coast: Long list of options. March 2021, PUB20/310, at: www.industry.nsw.gov.au/__data/assets/pdf_file/0006/354246/nc-options.pdf

| | | | | |
|---|---|---|---|---|
| 10% | -36.6 | 0 | -36.4 | 0.01 |
| 20% | -36.5 | 0.01 | -36.3 | 0.01 |
| 30% | -36.4 | 0.01 | -36.2 | 0.01 |
| 40% | -36.4 | 0.01 | -36.1 | 0.02 |
| 50% | -36.3 | 0.01 | -36 | 0.02 |
| 60% | -36.2 | 0.01 | -35.9 | 0.02 |
| 70% | -36.1 | 0.02 | -35.8 | 0.03 |
| 80% | -36 | 0.02 | -35.6 | 0.03 |
| 90% | -35.7 | 0.03 | -35.3 | 0.04 |
| 99% | -34.9 | 0.05 | -34.5 | 0.06 |

The information presented in Table 6 is given graphically in the histogram of net present values under both climate datasets in Figure 2. The net present value outcomes of the stochastic climate dataset are heavily right skewed indicating a higher probability of positive results for any 40-year period, with far fewer results producing a negative net present value. The results of the NARCliM realisations show far greater spread, demonstrating less certainty in a positive outcome for a given 40-year period. The number and magnitude of negative outcomes within the NARCliM dataset is much greater than those of the stochastic dataset.

Figure 2. Histogram of net present values for option 1




## Sensitivity analysis

Sensitivity analysis was undertaken for the option 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.

Table 7 provides the summary results data for for the central case and sensitivity analysis under the stochastic and NARCliM datasets. The full histograms of the sensitivity results can be seen in Figure 3 below. The table reveals a high level of sensitivity to both the discount rates and marginal economic values of water use in both climate datasets. These results are not sensitive to the adopted cost of the option.

Table 7. Sensitivity analysis of option 1 across the stochastic and NARCliM datasets

### Stochastic dataset

| Sensitivity case | PV Capital Cost ($m) | NPV ($m) | BCR Average | BCR Minimum | BCR Maximum | % of BCR with BCR > 1 |
|---|---|---|---|---|---|---|
| Central | 36.7 | -36.2 | 0.01 | 0 | 0.07 | 0 |
| Low discount rate (3%) | 32.6 | -31.6 | 0.03 | 0 | 0.11 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| High discount rate (10%) | 36.8 | -36.4 | 0.01 | 0 | 0.06 | 0 |
| Option cost (+30%) | 47.8 | -47.2 | 0.01 | 0 | 0.05 | 0 |
| Option cost (-30%) | 25.7 | -25.2 | 0.02 | 0 | 0.1 | 0 |
| Economic values (High) | 36.7 | -36.1 | 0.02 | 0 | 0.08 | 0 |
| Economic values (Low) | 36.7 | -36.3 | 0.01 | 0 | 0.06 | 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%) | 36.7 | -35.9 | 0.02 | 0 | 0.15 | 0 |
| High discount rate (10%) | 32.6 | -31.2 | 0.04 | 0 | 0.22 | 0 |
| Option cost (+30%) | 36.8 | -36.2 | 0.02 | 0 | 0.13 | 0 |
| Option cost (-30%) | 47.8 | -47 | 0.02 | 0 | 0.12 | 0 |
| Economic values (High) | 25.7 | -24.9 | 0.03 | 0 | 0.22 | 0 |
| Economic values (Low) | 36.7 | -35.8 | 0.03 | 0 | 0.19 | 0 |
| Low discount rate (3%) | 36.7 | -36.1 | 0.02 | 0 | 0.12 | 0 |

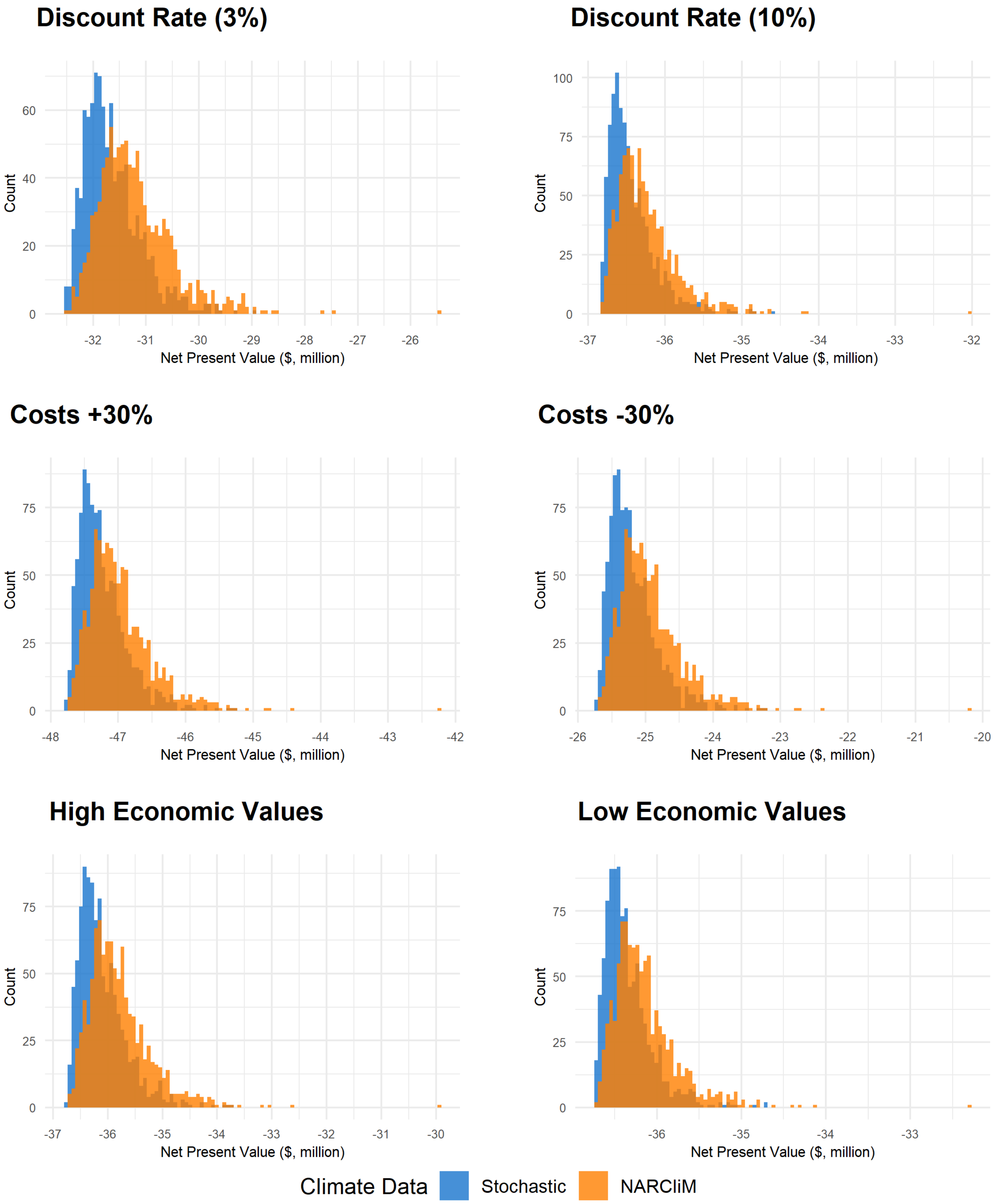



Figure 3. Sensitivity analysis of option 1 across the stochastic and NARCliM datasets

## Distributional impacts

Table 8 shows the distributional impacts that could be expected from the introduction of option 1 when compared to the Economic Base Case across both datasets.

Table 8. Distributional impacts from option 1 compared to the economic base case across both datasets

Stochastic dataset

| | Towns ($m) | Agriculture ($m) | Totals ($m) |
|---|---|---|---|
| Economic base case | -0.5 | 292.9 | 292.4 |
| Option 1 | 0 | 292.9 | 292.9 |
| Change ($m) | 0.5 | 0 | 0.5 |
| % Change | 98.9 | 0 | 0.2 |

NARCliM dataset

| | Towns ($m) | Agriculture ($m) | Totals ($m) |
|---|---|---|---|
| Economic base case | -0.8 | 285.1 | 284.3 |
| Option 1 | 0 | 285.1 | 285.1 |
| Change ($m) | 0.8 | 0 | 0.8 |
| % Change | 98.7 | 0 | 0.3 |

The table highlights that if option 1 was to go ahead there would be no significant changes in either the economic benefits or the underlying distribution of these benefits across the North Coast region under either the stochastic or NARCliM datasets.

## Breakeven analysis

This assessment looked at what the value of water security would need to be to justify the option. We used the breakeven price level and the calculated average benefit-cost ratio using a breakeven price level with both climate datasets (Table 9).

Table 9. Breakeven analysis for option 1

| Climate Dataset | BCR Average | Required economic value of high security entitlements ($/ML) |
|---|---|---|

| | | |
|---|---|---|
| **Stochastic** | 1.0 | $110,000 |
| **NARCliM** | 1.0 | $75,000 |

The results of the breakeven analysis show that a megalitre of improved water security would need to be worth $110,000 in the stochastic data set or $75,000 in the NARCliM dataset for the options costs to equate to its benefits.

# Detailed ecological analysis

## Key ecological values and assets

The diverse freshwater and estuarine habitats of the North Coast region support a range of high-conservation-value ecological communities, including several threatened and migratory species listed under state and Commonwealth legislation and international agreements.[9]

The Clarence River catchment includes nine wetlands listed in the Directory of Important Wetlands in Australia. These include Alumy Creek/Bunyip Swamp, The Broadwater, Bundjalung National Park, Cowans Pond Reserve, Everlasting Swamp, Lower Bungawalbin Catchment Wetland Complex, Tuckean Swamp, Wooloweyah Lagoon and the Clarence River Estuary. An unnamed swamp next to Kalang River in the Nambucca River catchment has also been identified as one of the most significant freshwater wetlands in the region.

The vulnerable comb-crested jacana and blue-billed duck, as well as the endangered black-necked stork have been recorded at the swamp. Blue Lake in the Yuraygir National Park provides habitat for the vulnerable brolga, the comb-crested jacana, the black-necked stork, little tern, and green and golden bell frog. The little tern is protected under both the Japanese (JAMBA) and Chinese (CAMBA) bilateral migratory bird agreements.

The Clarence River also provides vital habitat for the remaining viable populations of the endangered eastern freshwater cod, and the critically endangered Bellinger River snapping turtle[10] is only known from the Bellinger River catchment (Figure 4).

[9] Rassam D., Raiber M., McJannet D., Janardhanan S., Murray J., Gilfedder M., Cui T., Matveev V., Doody T., Hodgen M., & Ahmad M.E. (2014). Context statement for the Clarence-Moreton bioregion. Product 1.1 from the Clarence-Moreton Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia

[10] Cann, J., Spencer, R., Welsh, M., & Georges, A. (2015). Myuchelys georgesi (Cann 1997)–Bellinger river turtle. *Chelonian Research Monographs*, 1-9, and
McDowall, R. M. (Ed., 1996). Freshwater fishes of south-eastern Australia, Reed, for the endangered eastern freshwater cod (*Maccullochella ikei*).

(a) (b)

Figure 4. (a) Bellinger River snapping turtle (photo: Ricky Spencer), and (b) an eastern freshwater cod (photo: Brett Vercoe)

The North Coast region also supports high-conservation-value estuarine habitats. Cakora Lagoon and the Lake Innes and Lake Cathie estuarine system are saline, coastal lagoons with intermittently closed estuaries. These habitats support a diversity of wetland birds including the brolga, pied oystercatcher, black-necked stork and the Australasian bittern. Approximately 60 species listed on migratory bird agreements (JAMBA, CAMBA and Republic of Korea's ROKAMBA) have been observed in the Clarence Lowlands Wetland, with significant foraging and breeding habitat for migratory waders located in the Clarence River estuary. The tidal limit of the estuary extends 108 km inland, and provides important habitat for many fish, crustaceans, invertebrates and marine vegetation.

# Environmental Water Requirements

The focus of the North Coast assessment is on the Clarence River where we have assessed the impacts of one option on the flow regime. These impacts were described in an earlier consultation document[11] and are described in more detail here. The preservation of environmental flows is a critical, but not exclusive cause of the condition of aquatic ecosystems. The ecological condition of the North Coast region's water dependent ecosystems is largely driven by flows that connect in-stream benches, support organic carbon transfer and nutrient cycling, trigger movement and breeding of native fish and waterbirds, maintain vegetation condition, and maintain estuarine habitat quality.[12]

The timing (seasonality), frequency and duration of river flow pulses influence in-stream nutrient dynamics and provide cues for native fish to breed or migrate — including fish species such as Cox's gudgeon, Australian bass and the long-finned eel who move from upland to lowland streams over

[11] NSW Department of Planning and Environment (2022). Draft Regional Water Strategy. North Coast: Shortlisted Actions – Consultation Paper, May 2022, PUB22/340.

[12] Baker, J. (2013). Status report on rare and endemic species and other marine fauna of conservation concern in the northern river's CMA region, New South Wales. Report for the Northern Rivers Catchment Management Authority, New South Wales, June 2013, and Rassam et al. 2014 (previously cited).

their life cycle. Other species such as Australian bass and sea mullet are reliant on moving into and out of estuarine and marine environments in order to complete their life cycles[13].

Flow modification interacts with land management impacts on aquatic ecosystem health in the Clarence River catchment. This is partly ameliorated by a large proportion of the region comprising national park (20% of the Clarence River catchment) and state forest, where these protected areas help reduce human impacts on rivers.

However, riverbank erosion, gully erosion, invasive weeds, fire management practices, drainage and acid sulphate soils, introduced viruses, and fish kills from hypoxic (low oxygen) water all exacerbate any flow modification effects.[14] Clearing riparian vegetation and allowing stock access has caused accelerated erosion of stream banks in many reaches of North Coast rivers. Sediment eroded from streambanks has reduced in-stream habitat quality, leading to reduced populations and localised extinctions of native fish, platypus, and other plants and animals that depend on these rivers. An introduced virus decimated a population of Bellinger River snapping turtles in 2015, and low flows was one of the causal factors.[15]

For some of these issues, flows are also important because they can ameliorate the impact of the issue. For example, high-velocity river flows can flush accumulated sediment from streambeds and estuaries and this clearing of the channel improves these critical river habitats.

## Flow assessment

As described above, an ecohydrological assessment approach was developed to use generic ecological metrics and the two climate scenarios (stochastic and NARCliM) to assess the effects of any water management option across a representative suite of river sites in each NSW region.

Once the flow scenarios have been developed, the next step is to assess how the flow regime has changed. This is 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 that a shortlist of nine metrics collectively tended to show much the same 'story' as the full list of 20 metrics, many of which were interdependent. This list of nine was used for the South and Far North Coast regions, but the full list of 20 is shown here to better illustrate that there was a very weak response across all measures to the water management option tested.

In coastal regions, environmental water requirement metrics were not applied in the same way as they were for inland regions, because such metrics are not currently available. Environmental water requirements that are best suited to these regional water strategy assessments need to be developed collaboratively with agency experts. There will, however, always be limitations in the modelling, even with environmental water requirements. Environmental water requirements partly

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[13] McDowall, R. M. (Ed., 1996). Previously cited, for Cox's gudgeon (*Gobiomorphus coxii*), Australian bass long-finned eel (*Anguilla reinhardtii*), Australian bass (*Macquaria novemaculeata*) and sea mullet (*Mugil cephalus*).

[14] Rassam et al. 2014, as previously cited

[15] Spencer, R.J., Van Dyke, J., Petrov, K., Ferronato, B., McDougall, F., Austin, M., Keitel, C. and Georges, A. (2018). Profiling a possible rapid extinction event in a long-lived species. *Biological Conservation*, 221, 190-197.

address the challenge that the flow dependent species and communities have different and detailed environmental water requirements.

There also will always be external and long-term hydrologic and ecological effects associated with river management that neither the generic metrics or environmental water requirements cannot capture, which will affect the viability of aquatic species and populations.

The current generic metrics do attempt to capture the same processes as environmental water requirements for these events:

- **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, 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- to 10-year return interval.

As noted above, there is only one water management option for the North Coast Regional Water Strategy that was nominated for ecohydrological assessment (Table 10). This is the connection of Bellingen to the Clarence–Coffs Harbour regional water supply scheme via pipeline.

Table 10. Clarence River modelled option 1: Expand the Clarence-Coffs Harbour Regional Water Supply Scheme

| Option number | Scenario run number | Description |
|---|---|---|
| **Base case** | | Do-nothing: no intervention or options that would materially improve water reliability |
| **Option 1** | 1 | Connection of Bellingen to the Clarence-Coffs Harbour regional water supply scheme. This would include installation of a pipeline from Coffs Harbour to Bellingen to secure domestic water supplies for the town. |

As discussed earlier, the results are summarised using an 11-category system to rate the potential impacts or benefits to the environment (Table 11). This rating system is based upon that used by Department of Planning and Environment — Environment, Energy and Science to assess the potential ecological outcomes from the implementation of individual daily extraction limits in the Barwon–Darling system.[16]

[16] Department of Planning, Industry and Environment (2019), previously cited.

Table 11. 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%) |

# Impact of option on standard flow metrics

The impact of the option assessed on the standard metrics are shown in Table 12. Percentage changes rather than categories are reported in the table, as otherwise all results would be recorded as ‘no change’, because no significant (+3% or greater) impact or improvement on the Clarence River or its tributaries was identified from the 20 metrics assessed across 24 gauges.

The results indicate that if there is any impact of the pipeline, they are below the pre-determined 3% significance level. The five most significant results (all within a negative 1–2% effect) suggest a very small change in flow regime towards lower flows, including periodic drops to even lower flows within that low-flow range. For instance, that means an approximate 1% increase in low-flow standard deviation at Orara River at Karangi under both stochastic and NARCliM scenarios, as well as about a 1% and 2% decrease in the size of 95th percentile flows under stochastic and NARCliM scenarios respectively.

There was also a 1% increase in the number of years with a cease-to-flow event at Orara River at Glenreagh under the stochastic scenario. Similarly, a flow duration curve that compares the pipeline scenario against the base case, under current climatic conditions, indicates no or minimal low-flow impacts (Figure 5).

Table 12. Predicted effects of option 1 on environmental flow requirements under stochastic and NARCliM scenarios*

| Metric | Average % change under the stochastic base case | Average % change under the NARCliM base case |
|---|---|---|
| Number of years with more than or equal to one no-flow spell per 130 years (with the maximum impact, an increase for the stochastic scenario recorded on the Orara River at Glenreagh) | 0.0 (0.0 to 1.1) | 0.0 (0.0 to 0.2) |
| Average duration of no-flow spells (number of days) | 0.0 (–0.5 to 0.0) | 0.0 (–0.1 to 0.1) |
| Number of no-flow events per 130 years (with the maximum impact, an increase for the stochastic scenario recorded on the Orara River at Glenreagh) | 0.0 (0.0 to 0.6) | 0.0 (0.0 to 0.1) |
| Very low flow rate (ML/day), measured as the 95th percentile discharge of daily flows (with the maximum impact, a reduction for both climate scenarios recorded on the Orara River at Karangi) | 0.0 (–0.9 to 0.0) | –0.1 (–1.8 to 0.0) |
| Low-flow rate (ML/day), measured as the 90th percentile discharge of daily flows | 0.0 (–0.5 to 0.0) | 0.0 (–0.4 to 0.0) |
| Median annual low-flow days | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Median days below low flow | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Low-flow standard deviation (with the maximum impact, an increase for both climate scenarios recorded on the Orara River at Karangi) | 0.0 (0.0 to 0.7) | 0.1 (0.0 to 0.9) |
| Low-flow days below the 75th percentile | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | 0.0 (0.0 to 0.0) | 0.0 (–0.2 to 0.0) |

| | | |
|---|---|---|
| Mean annual discharge (ML/year) | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Fresh flow rate (ML/day), measured as the 20th percentile discharge of daily flows | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Average number of freshes per year | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Average duration of freshes (number of days) | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| High flows size (ML/day, of flow with an average 2.5-year recurrence interval) | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| High flows size (ML/day, of flow with an average 5-year recurrence interval) | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Very high flows size (ML/day, of flow with an average 10-year recurrence interval) | 0.0 (0.0 to 0.0) | 0.0 (0.0 to 0.0) |
| Monthly flow coefficient of variation | 0.0 (0.0 to 0.1) | 0.0 (0.0 to 0.1) |
| Daily flow coefficient of variation | 0.0 (0.0 to 0.1) | 0.0 (0.0 to 0.2) |
| Weekly flow coefficient of variation | 0.0 (0.0 to 0.1) | 0.0 (0.0 to 0.2) |

*Notes: (i) the numbers in the bracket represent the minimum and maximum

(ii) all results are from averaged effects over time for each site, and 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.

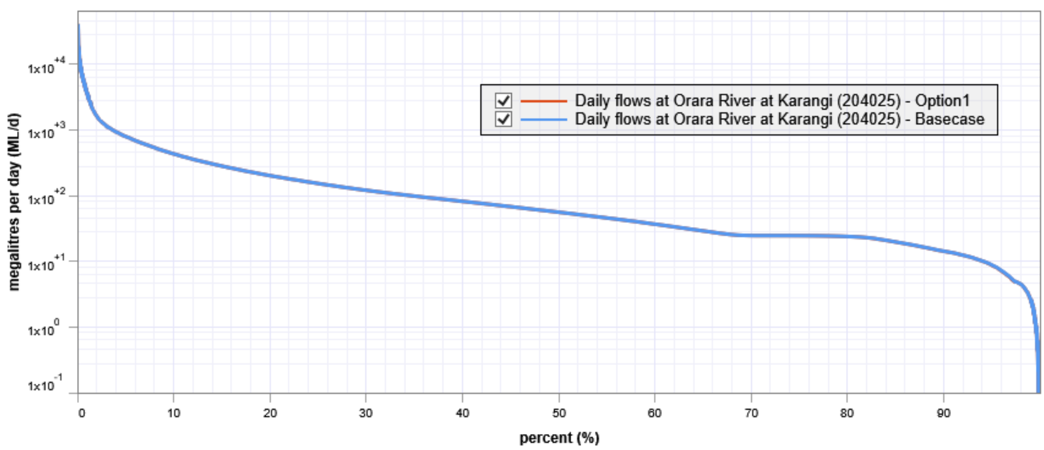


Figure 5. Flow duration curve comparing differences in flows between the option and the base case without climate scenarios included (note that the curve is on a logarithmic scale)

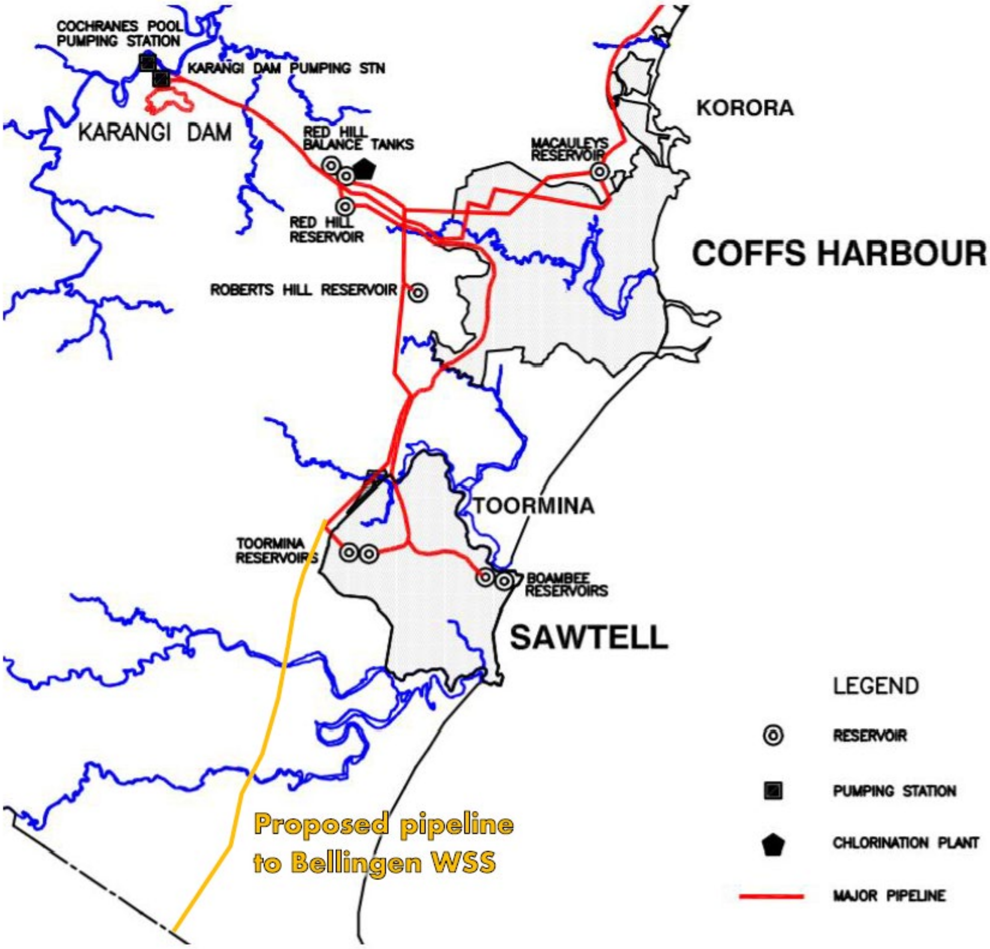


Figure 6. Schematic of proposed Coffs Harbour to Bellingen pipeline options showing the pumping stations that draw Orara River flows into Karangi Dam[17]

Although the Karangi Dam does draw from the Orara River via pumping stations (Figure 6), there was no expectation that the option would have a significant effect on Orara River flows. The lack of a significant (3% or greater) impact of this option can be attributed to four factors. First, the proposed pipeline from Coffs Harbour to Bellingen will be connected to the existing regional water supply scheme and its impact will be constrained by the capacity of the current infrastructure. Second, the current water sharing plan rules provides limits on extraction from the Orara River during low flow periods. Third, the regional water supply scheme draws water from a variety of sources, including the Clarence, Orara and Nymboida rivers, thereby distributing its impact and reducing the impact on any one source. Fourth, the proposed additional water delivered to Bellingen will represent a small demand as it is only required when Bellingen cannot access water locally.

At this stage, it is not presumed that the small changes in flow would have any significant ecological effects. The flow duration curve (Figure 5), which is derived from the entire time series suggests no or very little difference between the base case and this option at low (and any other) flows but does not consider long term flow variability and future climate change impacts. The

[17] From NSW Public Works (2020). Bellingen Shire Council Water Supply Options Report. Prepared for Bellingen Shire Council. Report Number: ISR20021. June 2020.

environmental metric results (including minimums and maximums, Table 12) are derived from site-based averages and do not provide information on time-specific events, but still suggest very weak effects.

Any future uptake of this option will, however, still need to consider the climate change and low flow risks that already exist within the North Coast region[18]. For this option, ecological impacts on the base flows of upland streams were raised as a possibility by an expert panel (Table 13). This had weak support, with the strongest option effect showing 9.4 versus 9.5 no flow events/100 years for the base case and option respectively for the Orara River (at Glenreagh, under the Stochastic scenario). This is minor compared to climate change effects, with 14 events/100 years under NARCliM at the same site (with or without the pipeline). The last 130 years have also been less severe for stream flows, as the model using climate from this period indicates 7.6 no flow events/100 years, suggesting future NARCliM conditions could be 79% drier. Such rare periods of flow reduction can have major ecological impacts[19]. For example, they could impact fish migration, condition and survival of species such as Cox's gudgeon, Australian bass and the long-finned eel. These are all part of the diverse fish community within the Orara River[20]. As discussed, these species all require the full length of these coastal rivers, from upland streams such as the Orara River to the coast to complete their life cycles[21]. This includes Cox's gudgeon laying eggs on rock in upland streams and the male fanning the fertilised eggs for a couple of days, which would not be as effective under low, and consequently less oxygenated flows. The endangered eastern cod is also found in the Orara River and relies on such upstream habitat since its widespread range was substantially reduced by the 1930s. It requires clear flows, deep pools and instream cover[22]. Protection of such fish species from rare low flow effects requires ongoing implementation of current rules that protect the Orara and Nymboida Rivers from extraction during low flow periods[23]. Habitat improvement (e.g., ensuring in-stream habitat and an overstory along the riverbanks) also protects streams like the Orara river from low flow effects[24], as although it has a healthy fish community, it has poor ecological health by most other measures[25].

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[18] NSW Department of Planning and Environment (2022), previously cited.

[19] Reich, P., & Lake, P. S. (2015). Extreme hydrological events and the ecological restoration of flowing waters. *Freshwater Biology*, 60(12), 2639-2652.

[20] Cashner, R. C., Hawkes, G. P., Gartside, D. F., & Matthews, E. (1999). Fishes of the Nymboida, Mann and Orara Rivers of the Clarence River Drainage, New South Wales, Australia. *Proceedings of the Linnean Society of New South Wales* 121, 89-10, and Ryder, D., Mika, S., Richardson, M., Burns, A., Veal, R., Schmidt, J. and Osborne, M. (2014). Clarence Catchment Ecohealth Project: Assessment of River and Estuarine Condition 2014. Final Technical Report to the Clarence Valley Council. University of New England, Armidale. 225 pp.

[21] McDowall, R. M. (Ed., 1996), previously cited.

[22] Butler G.L., Rowland S.J., Baverstock P.R., Brooks L. (2014). Movement patterns and habitat selection of the endangered eastern freshwater cod *Maccullochella ikei* in the Mann River, Australia. *Endangered Species Research* 23:35-49. https://doi.org/10.3354/esr00557, and McDowall, R. M. (Ed., 1996), previously cited.

[23] Water Engineering Australia (2009). A crowning moment for a regional water strategy. *Water Engineering Australia* 3(4), 20-27. May 2009, and Clause 45 in NSW Government (2016). Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016. Current version for 6 January 2017 to date (accessed 20 June 2022).

[24] Reich, P., & Lake, P. S. (2015), previously cited.

[25]Ryder et al. (2014), previously cited

Table 13. Summary of the ecological assessments of the options in the North Coast region

| Proposed option number | Quantitative modelling results | Most relevant rapid ecological assessment (expert assessments across NSW agencies) |
|---|---|---|
| Option 1: Expand the Clarence-Coffs Harbour Regional Water Supply Scheme | No significant option effects, but 1–2% volume impacts on low-flow hydrology in Orara River under stochastic and NARCliM scenarios. A flow duration curve for the option versus the base case under current climatic conditions also indicates no significant effect on low flows. Potential rare, but significant ecological effects, especially under stochastic and NARCliM scenarios, require further assessment if this option is pursued. | Agencies were made aware of the proposed pipeline but did not have all the detail described in this report. Potential impacts were predicted across the range from minor to extreme, with a median prediction of minor/moderate (Table 15). Concerns were raised about possible reduction of base flows of upland streams from which the scheme extracts, especially during drought; and the associated ecological, geomorphological, water quality, cultural, recreational, amenity and other social implications. Detail of operations was required to assess further. |

# Rapid ecological analysis

The rapid ecological assessment involved a high-level assessment of the ecological impact or improvement of each of the long list of the Draft North Coast Regional Water Strategy. The assessment was based on the expert opinion of scientists from Department of Planning and Environment — Water — Water Science, Department of Planning and Environment — Environment, Energy and Science and Department of Regional NSW — Department of Primary Industries — Fisheries.

The assessment rating system is based on that used by DPE — Environment, Energy and Science to assess the potential ecological outcomes from the implementation of individual daily extraction limits in the Barwon–Darling system.[26] It uses a five-category ranking system to rate the potential impacts or benefits to the environment (Table 14).

Table 14. Categories to be used in ecological assessment

| Stage 1 category | Estimated percentage change in hydrology / ecology |
|---|---|
| Major/Extreme impact | More than 30% change in a negative direction (i.e. < -30%) |
| Minor/Moderate impact | More than 10% change in a negative direction (i.e. < -10%) |
| No/Little change | Between less than 3 % change in a negative direction (i.e.< 0%) and less than 3% change in a positive direction (>0% and <3%) |
| Minor/Moderate improvement | More than 10% change in a positive direction (i.e. >10%) |
| Major/Extreme improvement | More than 30% change in a positive direction (i.e. >30%) |

The 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

[26] Department of Planning, Industry and Environment (2019). Potential ecological outcomes from the implementation of individual daily extraction limits in the Barwon – Darling River. Preliminary Assessment. September 2019.

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

The purpose of this was to assess whether the options that aimed to improve outcomes for the environment should proceed to the next stage. This assessment did not rule out options that were aimed at improving outcomes for towns or industries.

Table 15. Rapid ecological assessment

| Draft strategy option | | Rapid ecological assessments | |
|---|---|---|---|
| 1 | Expand the Clarence-Coffs Harbour Regional Water Supply Scheme | Minor / moderate impact | Detailed cost–benefit analysis showed that costs outweighed benefits for this option. |
| 2 | Portable desalination | No / little change | Individual councils may consider portable desalination as part of their town integrated water cycle management planning supported through the Safe and Secure Town Water Program. |
| 3 | Emergency water supply provided by new pumped-hydro storage projects | Minor / moderate impact | There is insufficient information to progress this action at this stage. Kempsey Shire Council may consider this as part of their integrated water cycle management planning. |
| 4 | Augment Shannon Creek Dam | Major / extreme impact | Does not effectively address a key challenge for the region. The Clarence-Coffs Harbour Regional Water Supply Scheme does not require augmentation because the water security risk is currently low. |
| 5 | Upgrade major town water treatment facilities | No / little change | Individual councils may consider upgrades to town water treatment facilities as part of their town integrated water cycle management planning supported through the Safe and Secure Water Program. |
| 6 | Repurpose existing assets to provide emergency storage for local industries | Minor / moderate impact | Does not effectively address a key challenge for the region. A review of the existing works approvals owned by local councils across the region found limited opportunity for this option. |

| Draft strategy option | | Rapid ecological assessments | |
|---|---|---|---|
| 7 | Vulnerability of surface water supplies to sea level rise and saline intrusion | No / little change | Incorporated into:<br>• proposed action 1.6 Assess the vulnerability of surface water supplies to sea level rise and saltwater intrusion<br>• proposed action 1.8 Characterise and plan for climate change and land use impacts on coastal groundwater sources |
| 8 | New industry and rural licence category within major council storages | Minor / moderate impact | There was significant community opposition to this option. |
| 9 | Protecting coastal groundwater resources for town water supplies and rural water users | Minor / moderate improvement | Investigations are already being progressed by local council as part of their town integrated water cycle management planning. |
| 10 | Remove impediments to water reuse projects | No / little change | This option is being progressed through Action 6.7 of the NSW Water Strategy — Proactive support for water utilities to diversify sources of water. |
| 11 | Increase use of recycled wastewater for intensive horticulture | Minor / moderate impact | See proposed action 3.6: Increase use of recycled wastewater for intensive horticulture. |
| 12 | Indirect potable reuse of purified recycled water | Minor / moderate improvement | Individual councils may consider purified recycled water as part of their town integrated water cycle management planning supported through the Safe and Secure Water Program. |
| 13 | Direct potable reuse of purified recycled water | Minor / moderate improvement | Individual councils may consider purified recycled water as part of their town integrated water cycle management planning supported through the Safe and Secure Water Program. |
| 14 | Increase harvestable rights | Major / extreme impact | See proposed action 3.3: Implement proposed changes in harvestable rights for catchments in the North Coast region. |
| 15 | Increase on-farm water storage | Minor / moderate impact | See proposed action 3.5: Investigate increased on-farm water storage. |

| | Draft strategy option | Rapid ecological assessments | |
|---|---|---|---|
| 16 | Establish sustainable extraction limits for North Coast surface water and groundwater sources | Major / extreme improvement | See proposed action 2.3: Establish sustainable extraction limits for surface water and groundwater sources. |
| 17 | Convert low-flow water access licences to high-flow water access licences | Major / extreme improvement | See proposed action 2.5: Reduce the take on low flows. |
| 18 | Long-term water plans to support healthy coastal waterways | Major / extreme improvement | See proposed action 1.7: Identify environmental water needs to support healthy coastal waterways. |
| 19 | Characterising coastal groundwater resources | Minor / moderate improvement | See proposed action 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources. |
| 20 | Protecting ecosystems that depend on coastal groundwater resources | Major / extreme improvement | See proposed action 1.9: Protect ecosystems that depend on coastal groundwater resources. |
| 21 | Improve stormwater management | Minor / moderate improvement | This option will be considered as part Management Initiative 1 of the NSW Marine Estate Management Strategy. |
| 22 | Bringing back riverine habitat and threatened species | Major / extreme improvement | Incorporated with proposed action 1.3: Deliver a river recovery program. |
| 23 | Fish-friendly water extraction | Major / extreme improvement | See proposed action 2.2: Implement fish-friendly water extraction. |
| 24 | Improve fish passage in the North Coast region | Major / extreme improvement | See proposed action 2.1: Improve fish passage. |
| 25 | Addressing cold water pollution | Minor / moderate improvement | Does not address a key challenge for the region. |

| | Draft strategy option | Rapid ecological assessments | |
|---|---|---|---|
| 26 | Coastal, regional focused water reference groups | No / little change | The Department of Planning, Industry and Environment is currently consulting with water users on the North Coast of NSW to determine the best way to engage the community in regional water management. |
| 27 | Planning for climate change impacts on coastal groundwater resources | No / little change | Incorporated with proposed action 1.8: Characterise and plan for climate change and land use impacts on coastal groundwater sources. |
| 28 | River Recovery Program for the North Coast: a region-wide program of instream works, riparian vegetation and sediment control | Major / extreme improvement | See proposed action 1.4: Deliver a river recovery program. |
| 29 | Improved data collection on water use and patterns | Minor / moderate improvement | See proposed action 1.10: Improve monitoring of water extraction. |
| 30 | Active and effective water markets | Minor / moderate impact | See proposed action 3.4: Review water markets. |
| 31 | Apply the NSW Extreme Events Policy to the North Coast region | No / little change | This option will be considered through Action 4.3 of the NSW Water Strategy — Improve drought planning, preparation and resilience. |
| 32 | Regional demand management program | No / little change | Regional demand management will be considered through the NSW Water Strategy, specifically:<br>• Action 4.3 Improve drought planning, preparation and resilience<br>• Action 6.3 Deliver a new Town Water Risk Reduction Program<br>• Action 6.6 A new state-wide Water Efficiency Framework and Program. |
| 33 | Regional network efficiency audit | No / little change | This option will be considered through Action 6.6 of the NSW Water Strategy (a new State-wide Water Efficiency Framework and Program). |

| | Draft strategy option | Rapid ecological assessments | |
|---|---|---|---|
| 34 | Regional capacity building program and skills hub | No / little change | Incorporated with proposed action 1.5: Create additional advisory services and projects that support landholder adoption of best practice land management. |
| 35 | Support for local councils to lift performance standards | No / little change | This option will be supported through Action 6.3 of the NSW Water Strategy — Deliver a new Town Water Risk Reduction Program. |
| 36 | Regional framework to manage restrictions for non-urban water users of town water | Minor / moderate improvement | This option will be supported through Action 6.3 of the NSW Water Strategy — Deliver a new Town Water Risk Reduction Program. |
| 37 | Cancelling mining licences or leases within the Clarence River catchment | Insufficient information to assess | The regulation of mining exploration is managed under the Mining Act 1992, and any new mining leases require that a development consent under the Environmental Planning and Assessment Act 1979 be in place before any title is granted. Statutory requirements, which may include community consultation and an Environmental Impact Statement, would also apply during the development consent process. |
| 38 | A new dam above The Gorge on the Clarence River to provide an alternative water source and flood mitigation for the valley | Major / extreme impact | Local and system scale impacts anticipated on hydrology (surface and groundwater), connectivity (surface and groundwater), key fish habitat, ecology and possibly water quality with associated impacts on all native fish guilds and life histories. While increased operational control of the river will impact flow related ecology of native fish upstream and downstream, e.g. creation of lentic habitat upstream will disadvantage native fish while preferencing pest/invasive species. |
| 39 | New local storages in the Bellinger and Nambucca Valleys | Insufficient information to assess | Bellingen Shire Council and Nambucca Valley Councils may consider additional local storages as part of their town integrated water cycle management planning supported through the Safe and Secure Water Program.<br><br>To assess the implications would require investigating the interaction of option with existing water sharing arrangements to determine environmental implications from new practices (both direct and indirect). |
| 40 | Review BASIX requirements on existing urban dwellings | Insufficient information to assess | This option will be considered through Action 6.6 of the NSW Water Strategy — A new state-wide water efficiency framework and program. |

| Draft strategy option | | Rapid ecological assessments | |
|---|---|---|---|
| 41 | Support opportunities that retain water within the landscape | Insufficient information to assess | This option will be supported through proposed action 1.4: Deliver a river recovery program and 1.5: Create additional advisory services and projects that support landholder adoption of best practice land management.<br><br>This could be an improvement if this was only an environmental option that ensured existing wetland and groundwater systems have natural functioning water regimes to enable environmental outcomes. Monitoring before and after impacts would be required to determine ecological benefits/outcomes. |