Department of Planning and Environment

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Hydrologic analysis of options for the South Coast Regional Water Strategy -Tuross River

Regional Water Strategies Program

May 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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Executive Summary

The NSW Government made an election commitment to develop and progress regional water strategies across NSW. The South Coast Regional Water Strategy, which includes the Tuross River catchment, is one of 12 strategies being developed across NSW to meet this commitment. The strategies aim to determine how much water a region needs to meet future demand and identify challenges and choices involved in meeting those needs. The strategies set out actions to manage risks to water security, enable economic prosperity, and protect and enhance the environment.

The NSW Department of Planning and Environment has applied a risk-based approach to assessing hydrologic and economic implications and outcomes for a range of potential water supply and demand options. This approach was aimed at defining risks to essential water supplies and the regional economy from climate variability and drought.

Hydrological assessment was undertaken on a single infrastructure option within the Tuross River catchment, identified in the Draft South Coast Regional Water Strategy – Option 12: Eurobodalla Southern Storage. Modelling was undertaken to understand the impact of the option on existing water supply risks to water users in the Tuross River catchment, and to inform the detailed economic assessment of this option.

The assessment of water security and changes in the flows regime in Tuross River catchment was undertaken for three climatic regimes:

1. Instrumental climate – this data includes the period of available instrumental meteorological recordings for the catchment (1889–2020)
2. long-term historic climate projections (stochastic data) based on historic data — this approach applied stochastic modelling to our 130-year picture of past climate (step 1) to develop 13,000 years of possible climate sequences. This approach provided more information on climate variability and shows it's possible the region could experience more severe drought and wet sequences.
3. Applying climate-change projections to our new climate dataset: two climate change scenarios were developed based on work carried out through NARCliM, the Electricity Sector Climate Information project and research undertaken by University of Newcastle. The scenarios were applied to the 13,000 year dataset, including:
    a. A NARCliM-informed future climate scenario (based on a dry scenario for 2060 to 2079): this assumes that there is a dry, worst case climate change scenario in the future.
    b. Reduced number of east coast low (ECL): modelled one less east coast low event per year. A potential reduction in east coast lows as well as intensity of rainfall associated with east coast lows are associated with concerns for water security.

The eWater Source River System model was used to develop the Tuross River baseline model. This model was then used to undertake hydrologic and water supply assessment modelling to understand the key water security risks in the catchment and the impact the identified infrastructure option could have on this risk profile.

1. Introduction

The NSW Government made an election commitment to develop and progress regional water strategies across NSW. One of the key actions recommended in the State Infrastructure Strategy 2018–38 is to develop regional water strategies for all catchments in NSW. The South Coast Regional Water Strategy, which covers Bega-Brogo and Tuross River catchments, is one of 12 strategies being developed across NSW to meet this commitment. The strategies aim to determine how much water a region needs to meet future demand and identify challenges and choices involved in meeting those needs. The strategies set out actions to manage risks to water security, enable economic prosperity, and protect and enhance the environment.

The NSW Department of Planning and Environment has applied a risk-based approach to assessing hydrologic, economic and ecological implications and outcomes for a range of potential water supply and demand options. This approach was aimed at defining risks to essential water supplies and the regional economy from climate variability and drought in the South Coast region under existing water supply infrastructure, and potential for mitigating this risk by augmenting infrastructure or making operational changes.

For the Tuross River catchment, only a single infrastructure option from the *Draft South Coast Regional Water Strategy – Long list of options*[1] released in October 2020, met the criteria for hydrological modelling. The option modelled (as outlined in this report) is Option 12: Eurobodalla Southern Storage. A separate report presents the hydrological modelling of options for Bega River unregulated and Bega-Brogo regulated river catchments[2]Tuross River catchment, as well as to feed into the economic assessment of options for augmentation and development and for assessing ecological impacts.

The modelling was completed using the eWater Source River System Model. Hydrological modelling is a key input to the development of the final South Coast Regional Water Strategy. The modelling provides part of the evidence for the infrastructure option within the Tuross River catchment being included in the proposed shortlist of actions identified the *Draft South Coast Regional Water Strategy: Shortlisted Actions -Consultation Paper*[3].

[1] https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/south-coast-regional-water-strategy

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

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

2. Background

Tuross River catchment

The Tuross River catchment is located on the New South Wales south coast with an area of 2,180 km^2. More than 140 km in length, the Tuross River flows north, east and north-east generally. The Tuross River catchment is bounded to the north by the Deua River catchment, to the south by the Bega-Brogo regulated river system and to the west by the Kybeyan Range, which forms part of the Great Dividing Range. Rising in the eastern slopes of the Kybeyan Range as a part of the Great Dividing Range, the Tuross catchment has 13 tributaries. The major tributaries that enter the Tuross River include Wadbilliga River, Belimbla Creek, Wandella Creek, Gulph Creek, Reedy Creek and Bumbo Creek (shown in **Error! Reference source not f ound.**).

The Tuross River catchment consists mainly of steep, heavily forested land. The major towns of Tuross Head, Bodalla, Dalmeny, Kianga and Narooma are all located on the coastal plain.

Water resource planning and management

The area covered by the Water Sharing Plan for the Tuross River Unregulated and Alluvial Water Sources 2016 (water sharing plan) (see **Error! Reference source not found.**) comprises the Tuross River c atchment and adjoining coastal catchments of Brou Lake, Coila Lake, Corunna Lake, Lake Mummuga, Tilba Tilba Lake and Wagonga Inlet. It contains a total of 22 water sources covering an area of around 6,900 km^2.

All of the rivers and creeks in the water sharing plan area are unregulated, having no major storages to capture and control flows for water supply. Therefore, most water users rely on natural flows or small structures, such as weirs, for their supply. As in most unregulated rivers, flows are mostly affected during relatively dry times, when water is low and demand is high. The management of lands along river and creek banks is an important issue that can affect water flow and quality. For example, cattle grazing can damage sensitive riverbank vegetation resulting in erosion. Development along the coastal fringe can alter natural waterways and increase water pollution.

The Tuross River terminates in a complex estuarine lake and wetland system, which opens to the sea at Tuross Head. The Tuross River estuary covers 15.5 km^2 and is classified as a barrier estuary, which is wave-dominated with an open entrance. The tidal limit in the Tuross River is located at Comerang, 19 km from the ocean entrance (9 km upstream of the Princes Highway Bridge).

A number of small coastal streams that do not flow directly into the Tuross River are included in the water sharing plan: Coila Lake to the north; and Brou Lake, Corunna Lake, Lake Mummuga, Wagonga Inlet and Tilba Tilba Lake, which are south of the Tuross River. With the exception of Wagonga Inlet, these catchments comprise small coastal streams that terminate in shallow estuarine lakes that are intermittently open to the sea.

Wagonga Inlet is a wave-dominated estuary that covers an area of 6.9 km^2 with an identified catchment area of around 110 km^2. The entrance of the inlet has been open to the sea permanently since the construction of two entrance training walls in the 1970s.

The main agricultural land use in the water sharing plan area is livestock grazing, which occupies 10.5% of the catchment. Irrigation (predominantly for dairy pasture) covers just 1.3% of the catchment. Irrigated

dairy farms are found along the Tuross River (near Eurobodalla and Bodalla) at Corunna Lake and Tilba Tilba Lake.

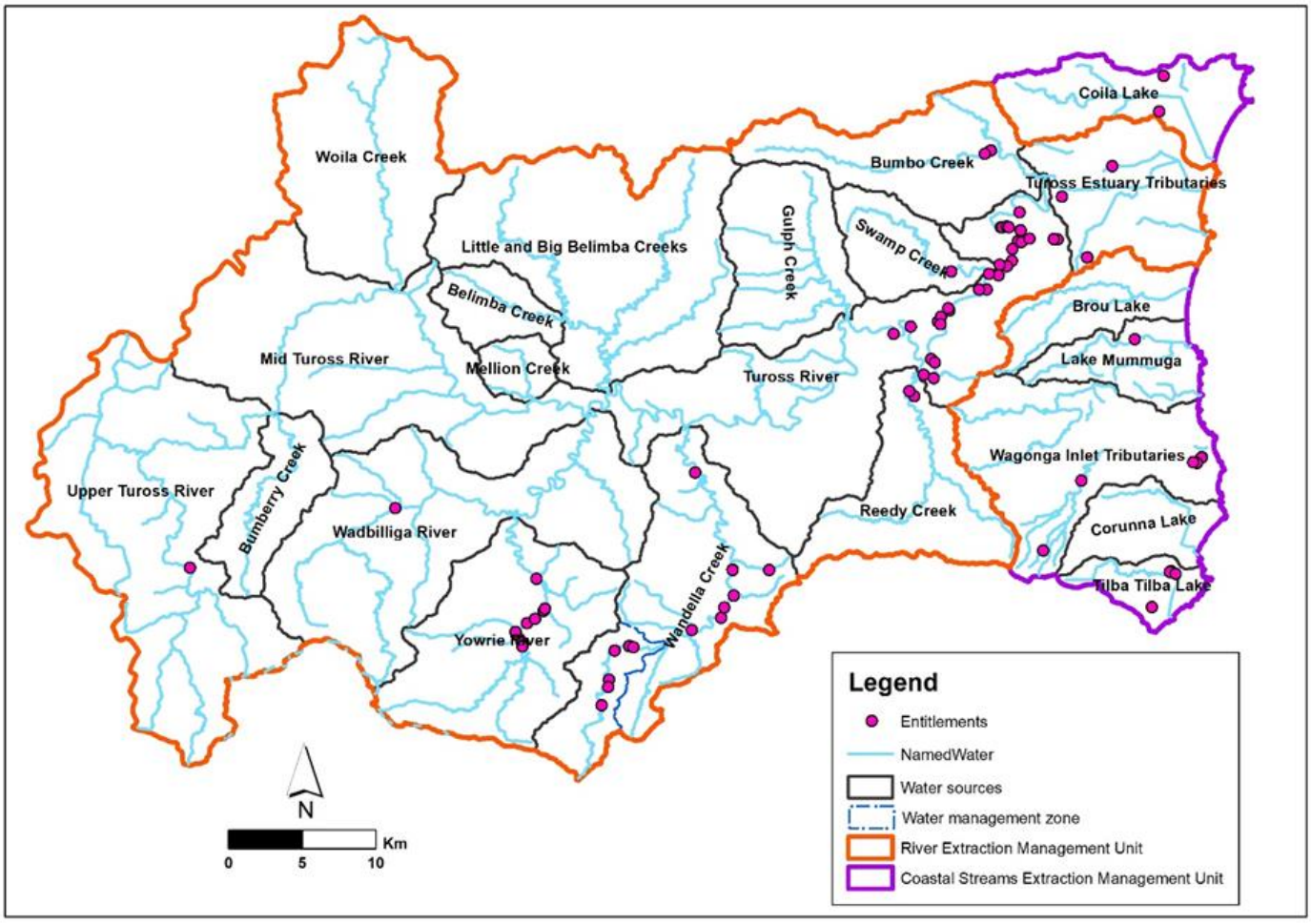

Figure 1: Tuross River catchment

Entitlement and water use

Water sharing plans set the limits on the amount of water that can be extracted from surface water and groundwater sources in the South Coast region. The annual sharing of water is managed through long-term average annual extraction limits (LTAAELs), while daily sharing is managed through cease-to-take rules,4 which can vary for different categories of licence.

At the commencement of the water sharing plan, there were approximately 136 water licences in the water sharing plan area, totalling 8,522 ML/yr of entitlement. This entitlement is divided between unregulated surface water (8,379 ML/yr) and alluvial groundwater (143 ML/yr). The total entitlement represents approximately 1.5% of the average annual discharge of the Tuross River. Since 2007, there has been an embargo on granting new surface water licences on the south coast. Alluvial aquifers were embargoed in 2008.

[4] Water sharing plans for unregulated rivers require licence holders to stop pumping when the river flow falls below a certain volume or salinity levels in tidal pool or estuary water sources increase above certain thresholds. These rules are referred to as cease-to-take rules. Cease-to-take rules apply to surface water licences in all unregulated water sources, excluding licences held by local water utilities, licensed stock and domestic users, and licences used for food safety and essential dairy care.

The majority of the unregulated surface water licences are located along the Tuross River between Gulph Creek and Bumbo Creek, and on Yowrie River between New England Creek and Cobblers Gully. The western part of the Tuross River catchment contains very few licences as much of the area is national park, with eight of the 22 water sources in the water sharing plan area have zero entitlements (Belimbla Creek, Bumberry Creek, Gulph Creek, Little and Big Belimbla, Mellion Creek, Mid Tuross River, Woila Creek, and Brou Lake). Of the total surface water entitlement, 96% is for irrigation, less than 1% for town water supply, 1% for industrial purposes, and the rest for stock, domestic and farming purposes.

Local water utility requirements

Town water within most of the plan area is provided by Eurobodalla Shire Council, while Bega Valley Shire Council supplies a small number of households in the Wandella Creek catchment. Entitlement is held in three water sources: Tuross River (902 ML/yr); Wagonga Inlet tributaries (40 ML/yr); and Wandella Creek (79 ML/yr).

During the summer and high demand periods, the Tuross River is the principal source of water through the Southern Water Treatment Plant for Eurobodalla Council's southern water scheme covering Bodalla to Mystery Bay.

During the winter and low demand periods, the entire Eurobodalla Shire is supplied from Deep Creek Dam through the Northern Water Treatment Plant. Deep Creek Dam is supplied from the Deua and Buckenbowra rivers.

3. Assessment framework

Modelled options

Hydrological assessment was completed for the options from the South Coast Regional Water Strategy long list of options. The modelling has been done to further understand the impact of an option on supply risks to water users in the Tuross River catchments, as well as to feed into the economic assessment. The Bega unregulated and Bega-Brogo regulated river catchments options modelling are is presented in a separate report (DPE, 2022).

Only one option described in the long list of options for the Draft South Coast Regional Water Strategy within the Tuross River catchment passed the rapid cost-benefit analysis. This was Option 12: Eurobodalla Southern Storage.

Options that passed the rapid cost-benefit analysis underwent additional hydrologic assessment. The hydrological assessment was completed using three sources of data.

Climate datasets

Instrumental climate

The instrumental climate refers to the period of available instrumental meteorological recordings (1889–2020) that are used as input into the rainfall–runoff models, required to generate runoff for river system models and as direct climate input to river system model simulations. River system modelling was initially undertaken using an historical dataset, which covered a 130-year period of data representing climatic and hydrological conditions (i.e. rainfall, lake evaporation, potential evapotranspiration and streamflow) over the period 1 July 1889 to 30 June 2020. All inflows are simulated.

For options assessment, fourteen replicates of 40-year periods were sampled from this data to provide a preliminary basis to evaluate options for shortlisting for portfolios. Further, it provided a faster way of testing the mechanics of the options.

Long-term climate projections (stochastic data) based on historic data The 'long-term climate projections (stochastic data) based on historic data' refers to the 13,000 years of stochastically-generated climate data (Kiem et al., 2020) that was used to assess options and combined options, as well as to define the base case. The data was originally supplied as 100 replicates of 130-year periods, which was merged to two continuous timeseries to represent the 13,000 year model run. For options assessment, a thousand 40-year periods were sampled from this data to provide a comprehensive assessment of valley outcomes across many possible climate realisations.

This approach provided more information on climate variability and shows it's possible the region could experience more severe drought and wet sequences.

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

Dry climate change scenario (NARCliM modelling)

The 'dry climate change scenario (NARCliM modelling)' refers to the stochastic climate data generated by multiplying the stochastic time-series of 13,000 years with average monthly scaling factors derived from NSW and Australian Regional Climate Modelling (NARCliM) climate projections for 2060–2079 compared to

the baseline period of 1990–2009 for each climate timeseries for every climate station used in the modelling. The average monthly scaling factors represent the mean of three regional climate models of CSIRO-MK3 GCM used in NARCliM 1.0. This set of stochastic data with climate projections are used in conjunction with the stochastic data to evaluate the final viability of portfolios, as well as to define future base cases. For options assessment, 1,000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of outcomes across many possible climate realisations.

This is source of data is referred to as 'NARCliM' throughout the report.

Dry climate change scenario (east coast low: ECL-1)

Options were also assessed against an alternative climate pathway to the NARCliM scaling. The stochastic climate was processed to remove one East Coast Low (ECL) event every year. A potential reduction in East Coast Lows as well as intensity of rainfall associated with east coast lows are associated with concerns for water security for the South Coast region.

This is source of data is referred to as 'ECL-1' throughout the report and utilises research undertaken through the Electricity Sector Climate Information project and research undertaken by University of Newcastle. This led to the ECL-1 scenario of 13,000 years duration.

Note, there was only a change in the rainfall time series and no change to the evaporation time series.

Outputs for option assessment

The outputs for all model runs for economic assessment are shown in. These outputs are provided at a daily timestep. There is only one town water supply point in the model. The existing town water supply user provides additional water for the summer demand due to tourism for the Eurobodalla Shire Council.

Some model outputs were only available for Option 12 and are noted as option-specific in Table 1.

Table 1 Model outputs for Economic Options Assessment

Output name	Option specific
Town Water Supply Eurobodalla Shire Council - South supplied	
Unregulated extracted	
Stock and domestic extracted	
Unregulated rainfall volume Harvested	
Unregulated idealised requirement	
Tuross Storage_ Eurobodalla Shire Council _Option > Storage Volume	Option 12
Tuross_Storage_ Eurobodalla Shire Council_Option > Extractions for town water supply user	Option 12

4. Tuross River hydrological baseline model

The hydrological computer models used by the NSW Department of Planning and Environment to underpin water management in NSW are quantitative, simulation models. Simulation models are widely used in water resources management to improve understanding of how a system works and could behave under different conditions. The department, along with other Australian water agencies, uses or is migrating to use the eWater Source software platform, which has been adopted as Australia's National Hydrological Modelling Platform.

The Tuross River baseline hydrological model was developed in 2020 by the Department of Planning and Environment—Water to include the full range of runoff conditions, as well as the operational rules of the current water sharing plan and subsequent irrigator behaviour.

One of the key objectives of new model development is to build a high-quality, robust and fit-for-purpose model to run a range of scenarios to inform decisions related to policy, planning and strategies, including regional water strategies.

A systematic approach (as outline in **Error! Reference source not found.**) was used to develop the model, w hich included the following key steps:

1. conceptualisation
2. data collation and review for flow modelling
3. flow model calibration
4. collation and review of data for demand modelling and demand model calibration
5. implementing management rules and ordering calibration
6. full model calibration and validation.

Table 2 and Table 3 present the headwater catchments and residual reaches included in the model. The locations of the gauges used for headwater and river reach calibrations are shown in Figure 2. A simplified schematic of the model is presented in Figure 3.

Table 2 Tuross headwater catchments

Gauge number	Gauge name
218001	Tuross River at Tuross Valley
218003	Yowrie River at Yowrie
218006	Wandella Creek at Wandella
218007	Wadbilliga River at Wadbilliga

Table 3 Tuross residual catchments

Upstream gauge	Downstream gauge	Downstream gauge name
218001	218002	Tuross River at Belowra
218005	218008	Tuross River at Eurobodalla
218007	218005	Tuross River downstream of Wadbilliga River Junction

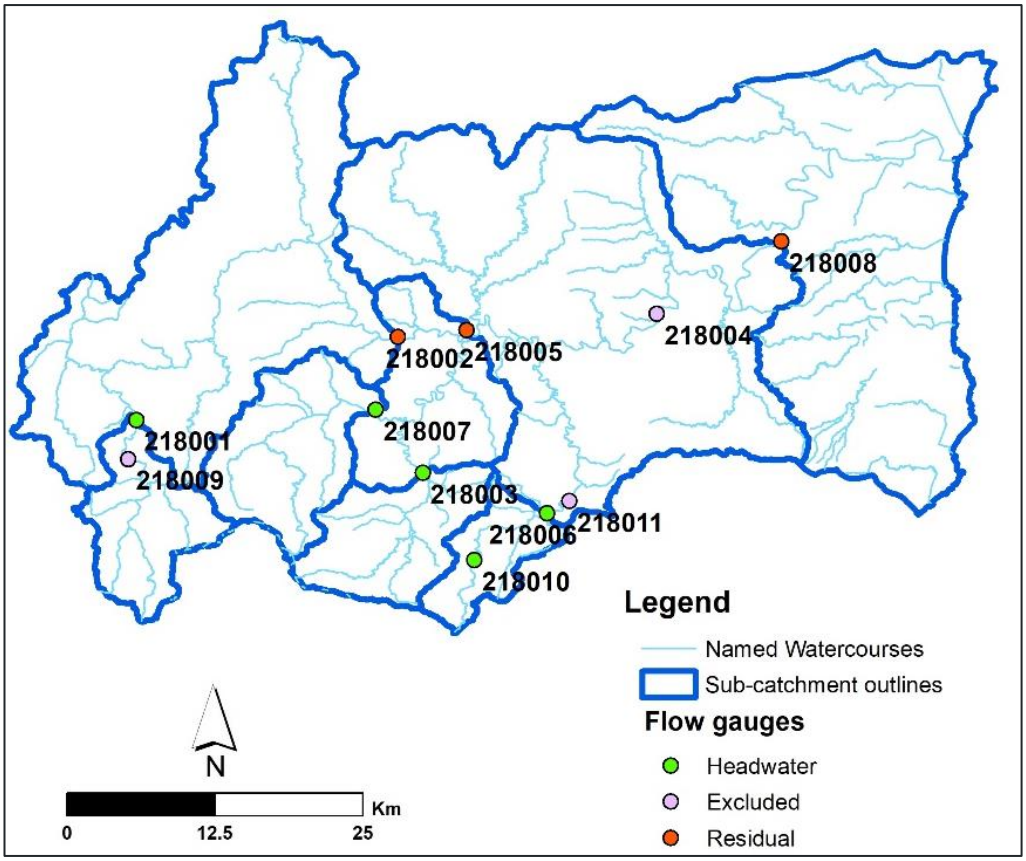

Figure 2 Tuross River Source model sub-catchments

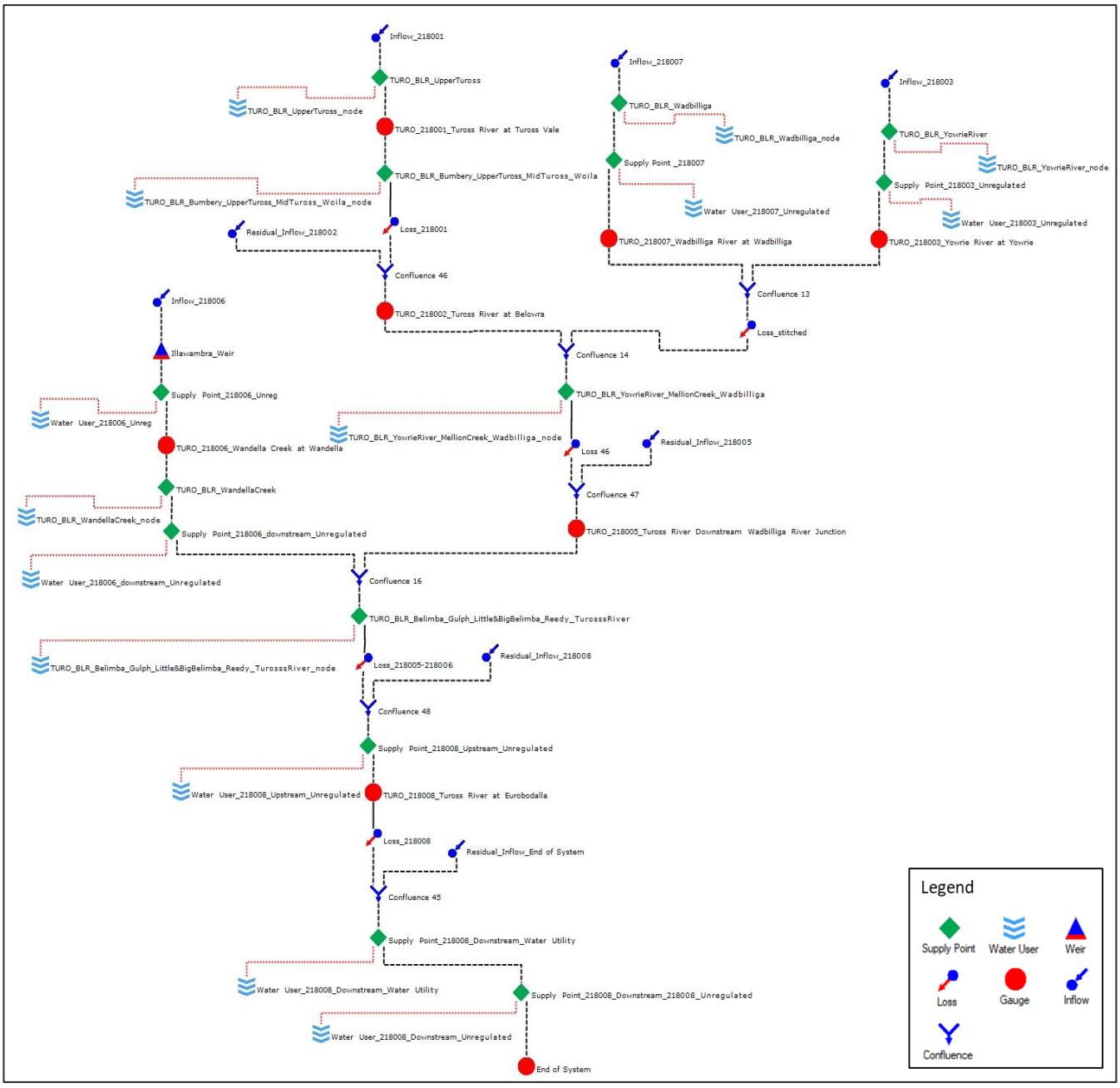

Figure 3 Schematic diagram of Tuross River System Source model

5. Option 12: Eurobodalla Southern Storage

Option description

Eurobodalla Shire Council has proposed the construction of an off-stream storage in the Tuross River catchment—the Eurobodalla Southern Storage—to meet its aspirations for future levels of service. The project involves constructing an off-river storage on an unnamed tributary of the Tuross River. The proposed works include:

- 3,000 ML of water storage capacity
- a new river intake pump station with a total river extraction capacity made up of a combination of flows from the river intake and the existing bore field.

Water will be stored in the proposed water storage facility to supplement the existing water supply network during periods of drought. The water storage facility will also supplement peak summer demands and provide sufficient water storage to allow the system to provide a secure yield in accordance with NSW Government g and comply with the requirements of the water sharing plan.

Option 12 is an existing NSW Government commitment.

The modelled sub-options were:

- 12a: Eurobodalla Shire Council's Eurobodalla Southern Storage and extracting from all flows (subject to water sharing plan rules)
- 12b: Eurobodalla Shire Council's Eurobodalla Southern Storage and extracting from high flows (> 20 ML/d and subject to water sharing plan rules).

Model configuration and assumptions

Model configuration

The following changes were made to model Option 12:

- A storage node was created for the Eurobodalla Shire Council's Eurobodalla Southern Storage :
  - implementing the LVA (level-volume-area) curves provided (via SMEC), spillway based on provided information
  - valve was assumed to be optimised to meet all downstream orders.
- The rules for river extraction were set as:
  - assumed no losses in transferring water from the Tuross River to the storage
  - assumed that water will be pumped from the river to keep the storage above 75%. The 25% airspace allows the capture of large runoff events upstream.
- The update to the town water supply users is shown in Table 4:
  - assumed the storage can extract up to 500 ML per year from the main Tuross River, determined from an analysis of the requirements to supplement the harvested flows
  - assumed the updated demand pattern for users based on average behaviour (Figure 4)

— by calculating the population of the areas assumed NOT to be serviced by the scheme, it was determined approximately 60% of users would have direct access to the new storage. The total demand for the Option 12 was assumed to be 60% of the total demand (approximately 2,273 ML/yr). As the storage is 3,000 ML, this demand assumption seems reasonable because it would provide water security for approximately one year assuming no inflows or other access to connected users. This increases the town water supply demand in the model by almost 10 times—assumption is based on a lot of approximations but was determined to be acceptable in a strategic study, but not a detailed design.

it was assumed that servicing proximal users (who had access to streamflows and the storage) based on population, demand of approximately 870 ML/yr ("Tuross_RiverExtr_Pop (existing within the model)") could be supplied from the Tuross River and storage, and the remaining 1,406 ML/yr ("Tuross_Dam Extra population") could only be supplied from storage. This breakdown is shown in Table 4.

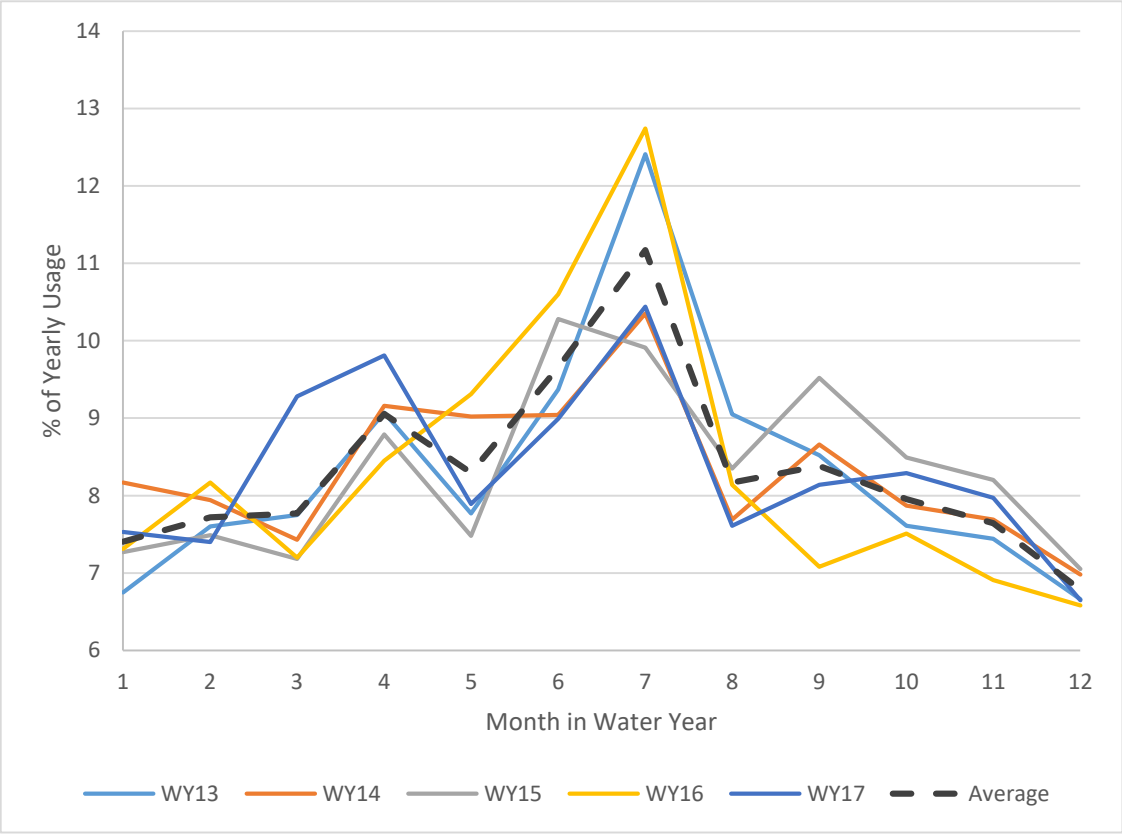

Figure 4 Updated demand curve for users (demand curve for all of the Eurobodalla Shire supplied network)

Table 4 Calculation of new population supplied by Eurobodalla Shire Council's Eurobodalla Southern Storage

Output name	Number of users	Demand (ML)
Current Eurobodalla Shire Council Population	37,966	3,860
Population serviced by Option 12 (estimate)	22,359	2,273
Tuross_RiverExtr_Pop (existing within the model)	8,527	867
Tuross_Dam Extra population	13,833	1,406

A schematic of the changes to the model for Option 12 is shown in Figure 5.

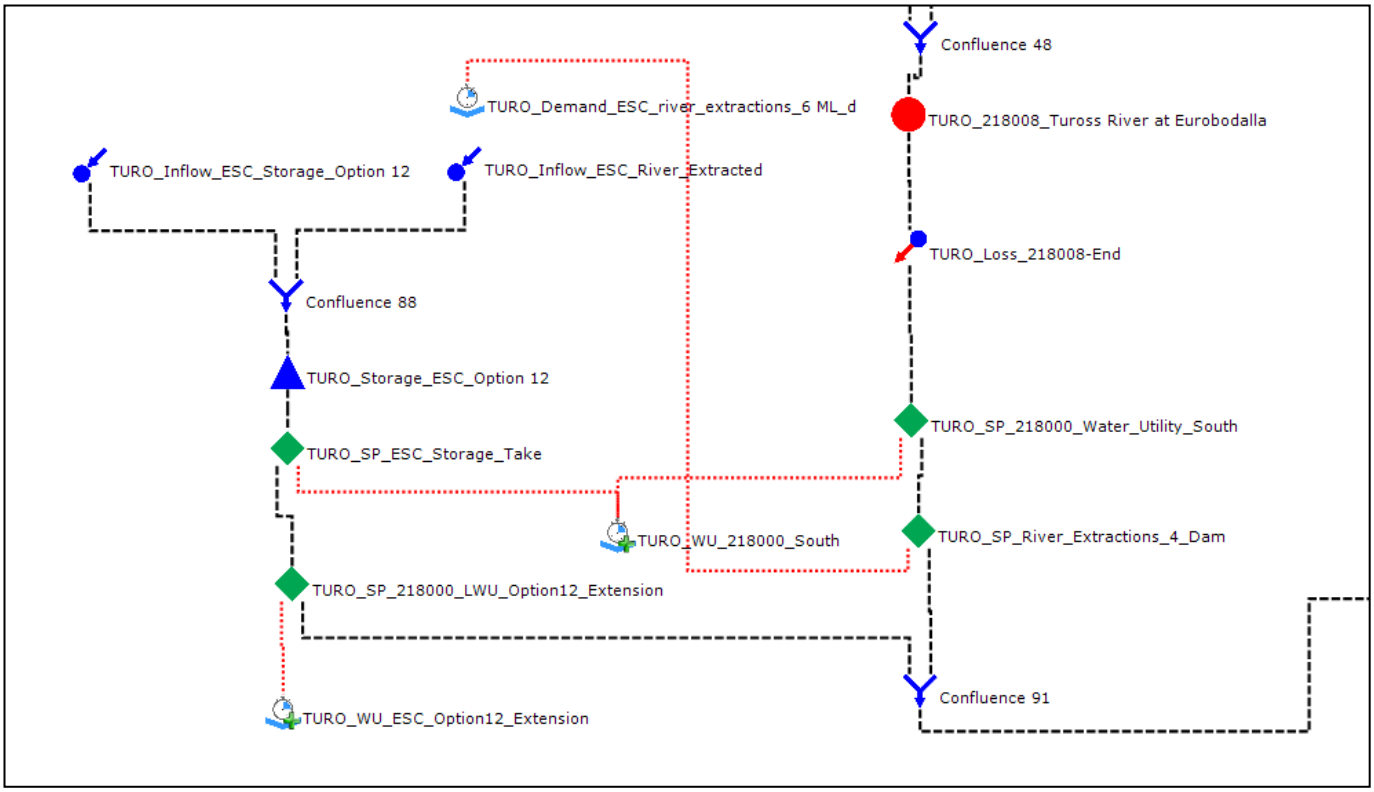

Figure 5 Option 12 conceptualisation (Eurobodalla Southern Storage node link diagram)

Model assumptions

The following assumptions were made, in absence of suitable data and information, to model Option 12:

- It was assumed all flows are harvested from the storage's upstream catchment (this was not an insignificant volume compared to the storage volume)

  — storage catchment area of 1.6 km^2 (correspondence with (consultants) SMEC).
- It was assumed that the storage will be kept relatively full; however, without detailed rules this will not be optimised behaviour.
- It was assumed that town water supply demands will be taken from the river as the main priority, only extracting from the storage if no flows are available.
- Storage spills will re-enter the stream.
- For extractions from the river to top up the storage, there will be a maximum pump rate of approximately 6 ML/d (correspondence with SMEC).

The following assumptions were made specifically to model Option 12a:

- extractions are subject to the water sharing plan rules.

The following assumptions were made specifically to model Option 12b:

- extractions subject to the water sharing plan rules and flows must be above 20 ML/d.

Modelling results

Overall, there is significant change to the town water supply system for Option 12, making it hard to directly compare to the base case. There is an increase in usage of 2 GL/yr in the catchment, increasing the total usage by approximately 60%. The full summary of results are in Table 5.

The following key results identified in the model were:

- There are no users downstream of the proposed storage in the model, so the impacts to the users downstream of the storage in the tidal section cannot be assessed.
- There is a significant reduction in flows at the Tuross River end of system at the 5th percentile.
- There is no significant change in usage between Option 12a and 12b. There is a reduction in water diverted from the river with the larger extraction threshold and an increase in time below volume thresholds. This indicates that the pumping rule allows the storage to become more stressed in a sustainable management rule.

The expected improvements in other adjacent systems that currently service the Eurobodalla Shire Council town water supply due to reduced demand has not been modelled nor assessed.

Table 5 Results summary for Eurobodalla Southern Storage - extracting from all flows (option 12a) and Eurobodalla Southern Storage - extracting from high flows > 20 ML/d (option 12b)

Output name	Baseline	Option 12a	Option 12b
Median annual diversion (ML/yr)			
Town Water Supply Eurobodalla Shire Council - South supplied	245	865	865
Town Water Supply Eurobodalla Shire Council - South Extension	-	1,403	1,403
Stock and domestic extracted	30	30	30
Unregulated extracted	3,032	3,032	3,032
Total	3,307	5,330	5,330
Water Diverted to Storage	-	1,262	1,227
Agricultural production			
Total Crop Area—Unreg (ha)	1,084	1,084	1,084
Unreg Rainfall Harvested (ML/yr)	4,235	4,235	4,235
Storage behaviour (Daily Analysis)— Eurobodalla Southern Storage			
At FSL (3120 ML)	-	0.1	0.1
Below 80% (2496 ML)	-	90.7	91.0
Below 60% (1872 ML)	-	4.6	7.9
Below 40% (1248 ML)	-	1.3	2.9
Below 10% (312 ML)	-	#N/A	#N/A
Streamflow (ML/yr)			
218005: Downstream Flow (daily mean)	179,496	179,496	179,496
218008: Downstream Flow (daily mean)	217,328	217,328	217,328
EOS: Downstream Flow (daily mean)	239,094	237,153	237,220
218005: Downstream Flow (5th%ile)	28,619	28,619	28,619
218008: Downstream Flow (5th%ile)	34,381	34,381	34,381
EOS: Downstream Flow (5th%ile)	36,802	34,677	34,883

6. Combined option assessment with instrumental, stochastic, NARCliM and east coast low climate data

Option 12 was not included as part of any combined option, so no results are presented in this section. For modelling results for the combined options, see the hydrological modelling report for the Bega unregulated and Bega-Brogo regulated river catchments DPE (2022).

7. References

DPIE (2020). Draft Regional Water Strategy, South Coast: Long list of options, October 2020.

DPE (2022). Hydrologic analysis of options for the South Coast Regional Water Strategy— regulated Bega-Brogo and unregulated Bega rivers.

Kiem et al., (2020). Stochastic climate data generation for South Coast New South Wales (Bega and Tuross River catchments). Australia, University of Newcastle.