Department of Climate Change, Energy, the Environment and Water

Brunswick Unregulated and Alluvial Water Sharing Plan Risk Assessment 2024

Evaluating risks to water-dependent ecosystems and other uses

October 2024

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the traditional custodians of the land and pays respect to Elders past, present and future. We recognise Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to place and their rich contribution to society.

Artist and designer Nikita Ridgeway from Aboriginal design agency – Boss Lady Creative Designs, created the People and Community symbol.

Brunswick Unregulated and Alluvial Water Sharing Plan Risk Assessment 2024

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Glossary

Acronym/terminology	Meaning
Alluvial aquifer	A groundwater system whose geological matrix is composed of unconsolidated gravel, sand, silt or clay transported and deposited by rivers and streams.
Alluvium	In the groundwater context: Unconsolidated sediments deposited by rivers or streams consisting of gravel, sand, silt or clay, and found in terraces, valleys, alluvial fans and floodplains.
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average recurrence interval. ARI (measured in years) is a term used to describe flood size. It is the long-term average number of years between floods of a certain magnitude.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BF	Baseflow. Reliable background flow levels within a river channel that are generally maintained by seepage from groundwater storage, but also by surface inflows. They typically inundate geomorphic units such as pools and riffle areas.
BLR	Basic landholder rights. Where landholders can take water without a water licence or approval under section 52, 53 and 55 of the *Water Management Act 2000.*
Class Licence	Licences that allow water extraction to occur when a defined flow class (A, B, C) is present (see flow classes definitions).
CPHR	Conservation Programs, Heritage and Regulation branch
CtP	Cease to pump. Water sharing plans for the unregulated rivers require licence holders to stop pumping when the river flow falls below a certain level, referred to as cease to pump (CtP) rules.
DIWA	Directory of Important Wetlands in Australia
DO	Dissolved oxygen
DPE	Department Planning and Environment (superseded)
DPI	Department of Primary Industries
EC	Electrical conductivity
EEC	Endangered ecological community
EMU	Extraction Management Unit. A group of water sources for the purpose of managing average annual extraction units
EPA	Environment Protection Authority
Flow Classes	A river's flow regime is characterised by the size and duration of its flows. How often a flow of a particular size occurs (percentile; volume of

Acronym/terminology	Meaning
	flow vs days of that flow) is considered in unregulated river systems when setting the CtP and daily extraction limits. Generally, three flow classes are defined above the CtP flow. 1 – very low flows (the top of this flow class is the CtP) 2 – 'A' class, low flows, generally CtP to 80th percentile 3 – 'B' class, moderate flows, generally 50th to 80th percentile 4 – 'C' class, high flows, indicatively 50th to 0th percentile.
Fresh flows	Fresh flows (or freshes), are river flows that are largely caused by rainfall and can inundate the sides of river channels, in-channel bars and benches if they are present. Freshes assist in transporting nutrients through river systems and trigger reproduction and migration in aquatic wildlife.
GDE	Groundwater dependant ecosystem. Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
Groundwater	Water below the land surface. In the NSW groundwater management context, this means water that occurs beneath the ground surface in the saturated zone. In NSW we ONLY manage water in the saturated zone.
HEVAE	High Ecological Value Aquatic Ecosystem
LWU	Local water utilities
MDBA	Murray Darling Basin Authority
ML	Megalitres
ML/d	Megalitres per day
MZ	Management Zone. This is an area within a water source in which rules particular to that management zone will apply, for example, daily extraction limits and restrictions on dealings.
n.d	No date
NHMRC	National Health and Medical Research Council
NOx	Nitrite/nitrate
NSW	New South Wales
NTU	Nephelometric Turbidity Units
NVF	No visible flow
OB	Overbank flow. This is flow that spills over the riverbank or extends to floodplain surface flows.
pH	A measure of acidity or alkalinity

Acronym/terminology	Meaning
Salinity	The presence of soluble salts in water. Generally measured as electrical conductivity which is the ability of dissolved salts to transmit an electrical current. Also referred to as EC in this report.
SEPP	State Environmental Planning Policy
Surface water	Any freshwater that occurs above ground in rivers, creeks, streams, lakes, floodplains, wetlands, and reservoirs.
Water Source	Is the primary management unit used for defining where water sharing rules apply.
WSP	Water Sharing Plan. A plan made under the *Water Management Act 2000*.
YR	Year

Document overview

This risk assessment has been structured with a Summary risk table of the risks to water sources in the Brunswick Unregulated and Alluvial water sharing plan area at the start of this document. The summary includes:

- consequence and likelihood metrics
- existing water management actions and mechanisms
- risk outcomes.

The summary table also shows previous risk ratings, where available, assessed using the macro planning approach in the initial development of the Water Sharing Plan for the *Brunswick Unregulated and Alluvial Water Sources 2016* (the Brunswick 2016 plan).

In areas affected by tidal flows, freshwater can occur downstream of the tidal limit but upstream of the mangrove limit. This area is referred to as the tidal pool. Risks to the tidal pool and estuaries can occur from extraction and reduced inflows. For this reason, the risks to the environment in this report are divided into 2 parts:

- Section 3.1 Risks upstream of the tidal limit
- Section 3.2 Risks downstream of the tidal limit.

Figure 1 shows the tidal and mangrove limits in this water sharing plan area.

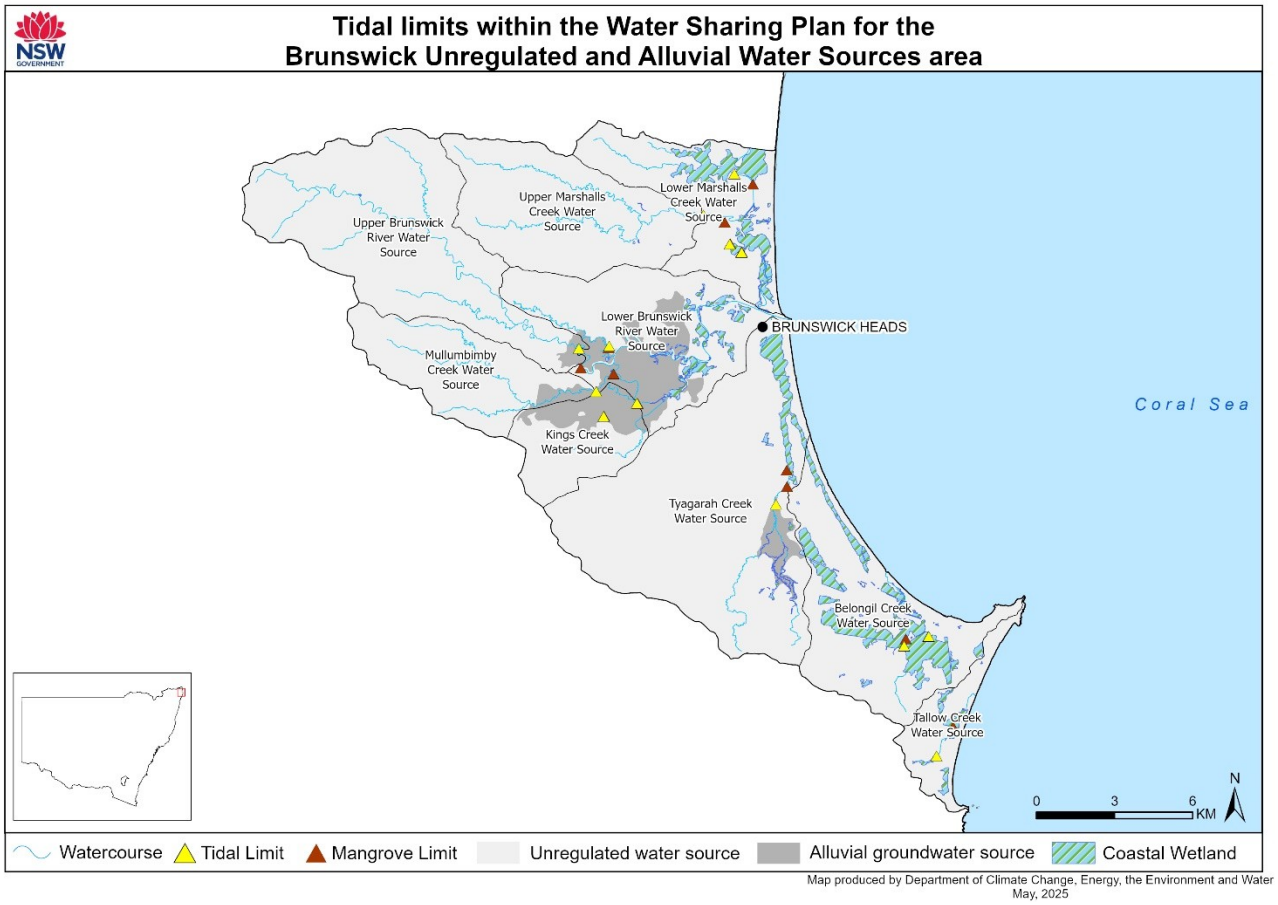

Figure 1: Tidal and mangrove limits in the water sharing plan area [zoom for additional detail]

Where water sources are identified with **medium** and **high** risk, more detailed information on risk drivers and ecological requirements for water are presented in sections 3 and 4. Water sources with low risk are not assessed any further.

Individual water source report cards are provided as appendices in alphabetical order. The report cards rate the risks associated with water quantity (zero, base, fresh and high flows), the water quality (where there is monitoring available) and describes the physical structures within the water source. The report card maps highlight recorded threatened species and predicted fish species with the highest flow sensitivity weighting of 4. These weightings range from one to 4, with 4 indicating the highest reliance on river flow. Current licence entitlements for each water source are also featured on the maps.

Summary tables of threatened species, flow requirements, gauge information and water quality data relating **directly** to the Brunswick plan area are also available in the appendices of this document.

An addition to the risk assessment report cards is a description of threatening geomorphic processes in water sources where ecological function may be affected. The location of these processes in the Brunswick plan area are included as maps in the appendices.

An addition to the risk assessment report cards is a description of threatening geomorphic processes in water sources where ecological function may be affected. The location of these processes in the plan area are included as maps in the appendices.

For background information on the methods used in defining risks, including the water sharing plan supplementary report process, refer to:

- Risk assessment methods document - Supporting method documents used in evaluating risks to water-dependent ecosystems 2023
- Background document – Water Sharing Plan Supplementary Report development process 2023.

For the method on assessing estuarine ecosystems in:

- Lower Marshalls Creek Water Source
- Lower Brunswick River Water Source
- Tyagarah Creek Water Source
- Belongil Creek Water Source
- Tallow Creek Water Source,

please see Estuary Inflow Integrated Assessment Methodology (NSW Office of Water, 2009).

Summary risk table

The following summary tables have been extracted from their relevant sections (s3.1.1, 3.1.2, 3.1.4 and 3.2.1) to provide a brief overview. Refer to relevant sections for detailed information.

Colours in the table represent the level of risk.

Legend	low risk	medium risk	high risk

In the previous macro planning approach, the macro value classification was used to determine risk, providing a value classification code between *a* and *i*. These codes in Table 1 have been colour coded to reflect the equivalent risk categories used in this report (green = low, orange = medium, red = high).

Table 1: Value classification matrix used in the macro approach to determine value classification codes between *a* and *i* (Source: NSW Office of Water 2011).

These values have been colour coded for the purpose of comparison with the risks assessed in this report.

-	Low hydrologic stress	Medium hydrologic stress	High hydrologic stress
Low instream values	g	h	i
Medium instream values	d	e	f
High instream values	a	b	c

Section 3.1.1: Risk of insufficient water for freshwater riverine ecosystems

For current water sharing plan mechanisms, see water source report cards s6.1 Appendix A.

Unregulated water sources

Belongil Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	L	L
Baseflow or low flows	H	L	a	M	L	L
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Kings Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	L	L
Baseflow or low flows	M	M	e	M	L	L
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Lower Brunswick River — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	H	H
Baseflow or low flows	H	L	a	M	L	L
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Lower Marshalls Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	H	H
Baseflow or low flows	H	L	a	M	H	H
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Mullumbimby Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	L	L
Baseflow or low flows	M	M	e	M	L	L
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Tallow Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	L	L
Baseflow or low flows	H	L	a	M	L	L
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Tyagarah Creek — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	H	H
Baseflow or low flows	H	H	c	M	H	H
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Upper Brunswick River — Previous results — Current results

Flow or extraction characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	H	H
Baseflow or low flows	M	H	f	M	M	M
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Upper Marshalls Creek — Previous results — Current results

Flow or Extraction Characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Consequence	Likelihood	Risk Rating
Zero flow periods	N/A	N/A	N/A	M	H	H
Baseflow or low flows	M	H	f	M	H	H
Fresh flows	N/A	N/A	N/A	M	L	L
High and infrequent flows - combined	N/A	N/A	N/A	M	L	L

Section 3.1.2: Risk of poor water quality for freshwater ecosystems (turbidity, nutrients, pH, DO and electrical conductivity)

For current water sharing plan mechanisms, see water source report cards s6.1 Appendix A

Simpsons Creek at Tyagarah (Tyagarah Creek Water Source - unregulated)

Water quality characteristic	Consequence	Likelihood	Risk Rating
Total phosphorus	M	H	H
Filterable reactive phosphorus	M	L	L
Total nitrogen	M	M	M
Turbidity	M	L	L
pH	M	M	M
Electrical conductivity	M	L	L

Section 3.1.4: Risk of insufficient water for near-river groundwater dependent ecosystems in upriver alluvials

For current water sharing plan mechanisms, see water source report cards s6.1 Appendix A

Belongil Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	VH	L	M
Zero flow periods where a decline in groundwater levels is occurring	VH	L	M
Baseflow or low flows where a decline in groundwater could occur	VH	L	M

Kings Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	M	H	H
Zero flow periods where a decline in groundwater levels is occurring	M	L	L
Baseflow or low flows where a decline in groundwater could occur	M	L	L

Lower Brunswick River

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	H	L	L
Zero flow periods where a decline in groundwater levels is occurring	H	H	H
Baseflow or low flows where a decline in groundwater could occur	H	L	L

Lower Marshalls Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	VH	L	M
Zero flow periods where a decline in groundwater levels is occurring	VH	H	VH
Baseflow or low flows where a decline in groundwater could occur	VH	H	VH

Mullumbimby Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	H	H	H
Zero flow periods where a decline in groundwater levels is occurring	H	L	L
Baseflow or low flows where a decline in groundwater could occur	H	L	L

Tallow Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	M	L	L
Zero flow periods where a decline in groundwater levels is occurring	M	L	L
Baseflow or low flows where a decline in groundwater could occur	M	L	L

Tyagarah Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	VH	H	VH
Zero flow periods where a decline in groundwater levels is occurring	VH	H	VH
Baseflow or low flows where a decline in groundwater could occur	VH	H	VH

Upper Brunswick River

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	VH	H	VH
Zero flow periods where a decline in groundwater levels is occurring	VH	H	VH
Baseflow or low flows where a decline in groundwater could occur	VH	M	H

Upper Marshalls Creek

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	H	H	H
Zero flow periods where a decline in groundwater levels is occurring	H	H	H
Baseflow or low flows where a decline in groundwater could occur	H	H	H

Brunswick River Coastal Floodplain Alluvial Groundwater Source

Flow or extraction characteristic	Consequence	Likelihood	Risk Rating
Precautionary principle based upon licensed extraction lowering groundwater levels	H	H	H

Section 3.2.1: Risk of insufficient water for estuarine ecosystems

For current water sharing plan mechanisms, see water source report cards s6.1 Appendix A

Unregulated water source	Inflow level	Consequence	Likelihood	Risk Rating
Marshalls Creek (Lower Marshalls Creek Water Source)	Low Inflows	L	H	M
	Higher Inflows	M	L	L
Brunswick River (Lower Brunswick River Water Source)	Low Inflows	L	L	L
	Higher Inflows	L	L	L
Tyagarah Creek (Tyagarah Creek Water Source)	Low Inflows	L	H	M
	Higher Inflows	M	L	L
Belongil Creek (Belongil Creek Water Source)	Low Inflows	H	L	M
	Higher Inflows	L	L	L
Tallow Creek (Tallow Creek Water Source)	Low Inflows	H	L	M
	Higher Inflows	L	L	L

Consolidated risk map

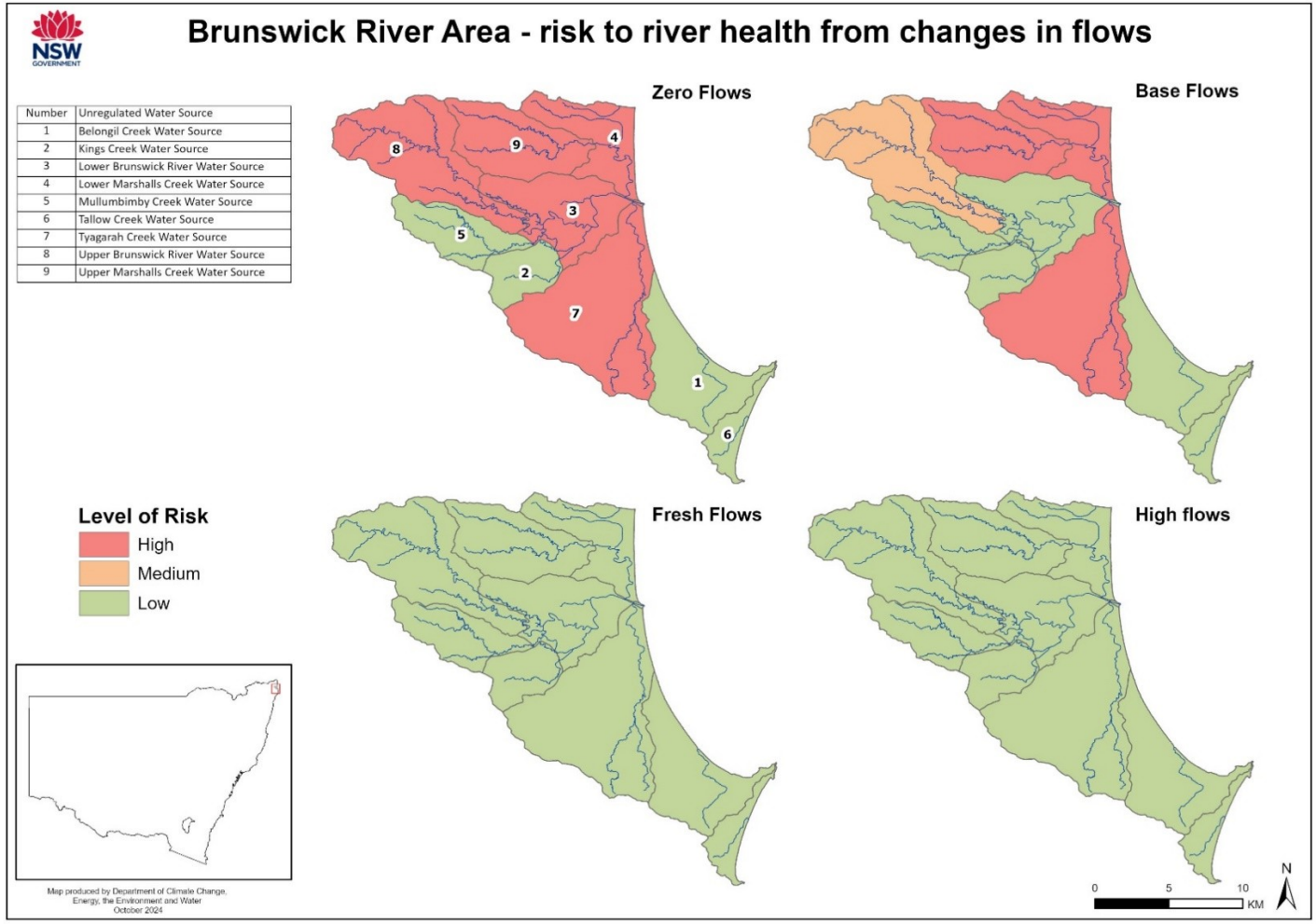

Figure 2: Map of the Brunswick River area showing risk to river health due to changes in flow [zoom for additional detail]

1 Introduction

1.1 Aim of this risk assessment

The Brunswick Unregulated and Alluvial Water Sources Risk Assessment 2024 aims to determine the level of ecological risk for each water source in the Brunswick Unregulated and Alluvial Water Sharing Plan (Brunswick plan) area using current data available at the time of assessment. This information will help identify and prioritise water sources with medium or high risks and inform the development of rules to mitigate these risks in the area's water sharing plan re-make.

Water sharing plan strategies for managing water are designed to maintain ecosystem health by protecting the flows needed to sustain both surface water and groundwater dependent ecosystems. Water sharing plan rules are designed to manage identified risks and aim to maintain flows to near natural conditions, protect in-river or off-river pools, and enable hydrologic connectivity within and between water sources where possible. The rules are designed to balance the needs of the environment, the community, and the economy under the principles of the *Water Management Act 2000* (the WM Act). Mitigation of identified environmental risks may also be identified in subsequent monitoring of the effectiveness of the water sharing rules. Additionally, these plans are reviewed and updated periodically to adapt to changes in water availability, water demand and the ecosystem.

1.2 Scope of this risk assessment

This risk assessment evaluates ecological risks, which can be managed through mechanisms within the water sharing plan, that directly relate to the quantity or quality of water in the water sharing plan area. Potential mitigation strategies that can be implemented through the water sharing plan, such as improving flow for fish passage, are included for discussion in future options assessment and may guide discussion at the interagency level to help finalise draft water sharing plan rules prior to public exhibition of a water sharing plan.

This risk assessment evaluates:

- risks of insufficient water for freshwater riverine ecosystems
- risks of poor water quality for freshwater riverine ecosystems
- risks of insufficient surface water recharge for connected alluvial and aquifer resources, leading to reduced availability for groundwater-dependant ecosystems
- risks of insufficient inflow for estuarine ecosystems
- risks of poor water quality for estuarine ecosystems
- risks of unsuitable water quality for other water uses (irrigation and recreation).

Some risks to water sharing plan outcomes will not be addressed in this assessment. This assessment **does not** evaluate:

- risks of altered water quality for groundwater-dependant ecosystems connected to the rivers
- risks to groundwater-dependant ecosystems or acid sulfate soil exposure from groundwater extraction
- risks to water quality associated with acid drainage from sediments via constructed drains
- risks of insufficient water in the tidal pools for estuarine ecosystems due to tidal pool extraction
- risks of insufficient water or poor water quality for Aboriginal values and uses
- risks of insufficient water for stock and domestic uses
- risks of insufficient water for consumptive uses
- risks of insufficient water and poor water quality for other social and economic outcomes
- risks from climate change
- other risks raised by stakeholders during targeted consultation by the Department of Climate Change, Energy, the Environment and Water (the department or Water Group), led by the Water Group's Planning team.

Where mitigation strategies are available, but cannot be implemented through a water sharing plan, they are identified in the risk assessment but not considered further. For example, management of land use practices can contribute to mitigating in-stream water quality and ecological risks, but there are no mechanisms within the scope of a water sharing plan that can influence land use.

1.3 Limitations and uncertainties

This risk assessment uses the best data currently available. Quantitative state-wide data is used where possible to maintain consistency between water sharing plan areas. If state-wide data is not available, qualitative, or local data sets may be used. Data that is not currently available for all areas but is part of an ongoing program and provides significant benefit to the risk assessment may be used. For example, NSW Government is currently developing coastal climate change risk assessments, but not all of these will be available in time for use in this water sharing plan risk assessment. Its future inclusion may highlight risks in certain water sources that were previously unaccounted for or reveal increased risks that extend beyond the 10-year lifespan of these plans. This highlights the need for ongoing monitoring and adaptation strategies to ensure the health of our water resources in a changing climate.

2 Overview of water use in the Brunswick Unregulated and Alluvial Water Sharing Plan area

Figure 3 is a map of the Brunswick plan area, showing the boundaries of the water sources, extraction management units and management zones. Table 2Error! Reference source not found. provides a summary of the characteristics of the plan area.

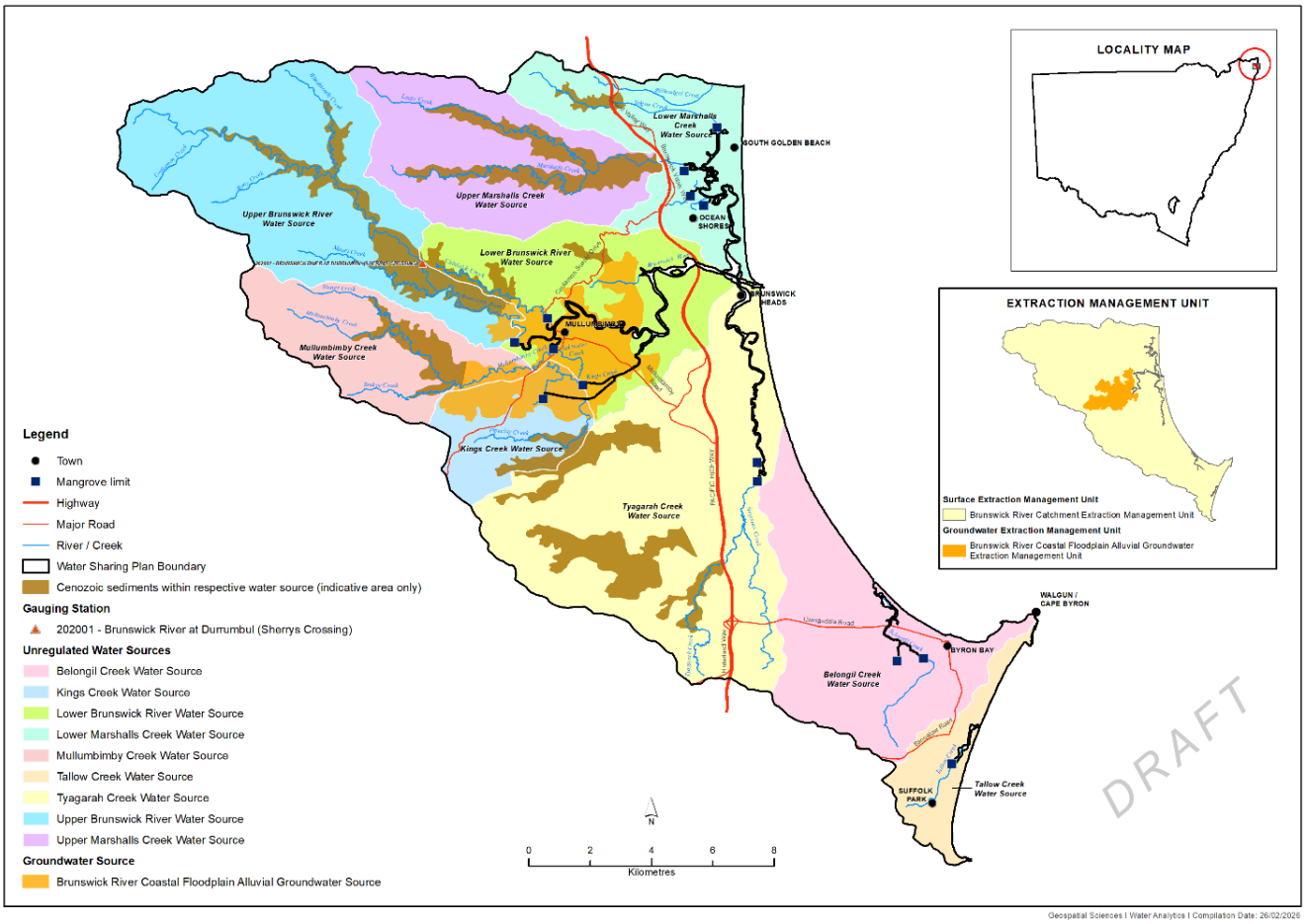

Figure 3: Map of Brunswick Unregulated and Alluvial water sharing plan area including water sources [zoom for additional detail]

Table 2: Brunswick Unregulated and Alluvial water sharing plan area snapshot

(Source: NSW DPI Brunswick water sharing plan Background document 2016)

Water Sharing Plan	Brunswick Unregulated and Alluvial Water Sources 2024 Water Sharing Plan
Catchment area	Total water sharing plan area is approximately 273.3 km^2
Description	The area covered by the Brunswick water sharing plan is located on the far north coast of NSW. It includes the Brunswick catchment and the adjoining smaller coastal catchments of Belongil and Tallow creeks to the south, extending along the coastline from Broken Head north to Wooyung. The catchment is bounded to the north and west by the Tweed River catchment and to the south and west by the Richmond River catchment. Elevations rise steeply across the catchment from sea level on the coast to around 700 metres in the Burringbar and Koonyum ranges, which form the western and southern boundaries of the catchment. The catchment consists of various landforms, with 48% being relatively flat, 19% undulating to hilly, 12% hilly to steep, 16% rugged mountainous, and 4% with slopes greater than 27 degrees. The Brunswick catchment is drained by the Brunswick River, which begins in the Burringbar Ranges. After reaching Mullumbimby, it traverses the catchments flatter coastal areas until it is joined by its two large tributaries Marshall and Simpson's creeks, at Brunswick Heads and then discharges to the Pacific Ocean. Downstream from Mullumbimby the river comes under the tidal influence of the estuary. Near Byron Bay are the catchments of Belongil Creek and Tallows Creek. Both are small intermittently closed and open lagoons (ICOLL) with small local catchments.
Major tributaries	The major tributary to the Brunswick River is Mullumbimby Creek. Other major tributaries include Marshall and Simpson's creeks.

Water Sharing Plan	Brunswick Unregulated and Alluvial Water Sources 2024 Water Sharing Plan
Areas of ecological significance	Areas of significance within the Brunswick catchment include the Tyagarah Nature Reserve, Billinudgel Nature Reserve, Brunswick Heads Nature Reserve, Mooball National Park, and significant coastal wetlands and estuaries protected within national parks and nature reserves along the coastal strip. The catchment includes multiple environmentally significant wetlands. The largest of these are Cumbebin Swamp at Byron Bay, Billinudgel Creek, swamp forest at Mooball Creek, and extensive wetlands associated with Cudgen Lake and Cudgen Creek. Billinudgel Creek and Cudgen Lake are listed as nationally significant in the Directory of Important Wetlands in Australia. The Brunswick catchment provides habitat for a number of significant species and ecological communities that are protected under the *Threatened Species Conservation Act 1995.* Threatened fish, frog, bird and wet flora species occur in all the water sources within the plan area, as do the endangered ecological communities. Threatened species and their flow sensitivity ratings in the Brunswick water sharing plan area are listed in Appendix B Threatened species populations and endangered ecological communities.
Number of EMU's	1
Number of management zones	Nil
Number of water sources	The plan covers 9 surface water sources (including upriver alluvial aquifers) and one groundwater source (that covers an area of floodplain alluvial aquifer). These are grouped together in the Brunswick River Catchment EMU.
Largest water entitlements in the plan area	There is approximately 2,556 ML of entitlement across 75 current access licences in the Brunswick 2016 plan. The largest entitlements are: • 1,060 ML (unregulated river access in the Tyagarah Creek water source) • 659 ML (unregulated river access in the Upper Brunswick River water source). Entitlements for each water source is located in their respective report cards (Appendix A Water source report cards) and also listed in the summary table in Appendix F Water source entitlements (Share Component) 2023/2024.

Water Sharing Plan	Brunswick Unregulated and Alluvial Water Sources 2024 Water Sharing Plan
Adjacent water sources independent of this water sharing plan	Groundwater contained in the Brunswick River Coastal Floodplain Alluvial Groundwater Source is managed by the *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016.*
Major towns/cities	Byron Bay, Mullumbimby, and Brunswick Heads, along with smaller settlements like Ocean Shores and Suffolk Park.
Major water storages	There are no major dams for water supply or instream structures. Most water users rely on natural flows for their water supply, although small dams and weirs may be present. Town water supplies for the major urban centres are sourced from storages in the adjacent Richmond catchment.
Major industries	• Horticulture and dryland cropping • Beef cattle grazing • Fruit and nut growing • Tourism and retirement industries.
Key water users	• Local water utilities (LWUs) such as local councils • Licensed stock and domestic users • Commercial users including irrigation for nurseries and turf growing.

3 Risks to the environment

Risk levels were calculated using a standard risk assessment matrix that identified different levels of consequence and likelihood (Table 3).

Table 3: An example of a risk assessment matrix

		Likelihood		
		Low	Medium	High
Consequence	Very Low	Low	Low	Low
	Low	Low	Low	Medium
	Medium	Low	Medium	High
	High	Low	Medium	High
	Very High	Medium	High	High

For the risk assessment, the following definitions have been adopted:

- Likelihood = the probability that a cause will result in a threat. It is not an indication of the size of the threat but conveys the probability that the threat will be significant.
- Consequence = the loss of value for an impacted receptor such as an ecological asset, water user or any other value that may be affected.

Where a risk is highlighted as medium or high, it does not necessarily imply that the water plan's existing rules are inadequate, but that further detailed investigation may be required.

Detailed methodologies on risk calculations upstream and downstream of the tidal limit can be found in these documents:

- Risk assessment methods document - Supporting method documents used in evaluating risks to water-dependent ecosystems 2023
- Background document – Water Sharing Plan option development process 2023

3.1 Risks upstream of the tidal limit

3.1.1 Water quantity for freshwater ecosystems

Changes to river flow are not only caused directly through water extraction but also by the interception of water moving through the landscape, and changes to rainfall and runoff processes (for example, climate change).

Water dependent ecosystems are adapted to the variability of this environment and many organisms require different flow types during different life stages. For example, breeding behaviour in many native fish is triggered by large flow events in spring or summer, and some native vegetation will only flower after flooding.

The likelihood of impacting the ecological functions in the zero and low flows is high or medium in the water sources that contain most of the water licences: Upper Brunswick River, Upper Marshalls Creek, Lower Marshalls Creek and Tyagarah Creek Water Sources. The exception being the Lower Brunswick River Water Source where basic landholder rights is likely to be contributing the high likelihood of impact in the zero-flow range.

The low flow likelihood and risk rating for the Upper Brunswick Water Source is medium unlike the other water sources containing larger numbers of license due to the cease to pump. This cease to pump also applies to the Kings Creek and Mullumbimby Creek water sources, which were rated as low risk in all flow ranges.

While likelihood of flow alteration is high in the zero and low flow ranges, the likelihood was rated low in all the higher flow ranges, from freshes to overbank flow, for all the water sources. This is due to the demand for water to irrigate crops in dry periods driving the pattern of extraction effecting the lower flow ranges, but not in the higher.

The resulting risk ratings of insufficient water being available to maintain key ecosystem functions are shown in Table 7.

3.1.2 Water quality for freshwater ecosystems

Water quality is an important driver of ecological processes and is a key factor in determining the overall condition of a waterway. Physical and chemical parameters such as temperature, pH, electrical conductivity (EC), nutrients, turbidity and dissolved oxygen (DO) can affect the biology and ecology of aquatic organisms, especially when outside tolerable levels (Watson et al., 2009).

Water quality targets apply to zones defined as lowland, upland and montane areas. Lowland areas have an altitude of less than 150 m, upland areas fall between 150 and 700 m and montane areas have an altitude greater than 700 m. If water quality parameters remain below or between the ranges listed in Table 4, a very low risk of environmental damage can be assumed.

Table 4: Water quality targets for freshwater ecosystems (based on ANZECC 2000 water quality guidelines)

Water Quality Zone (altitude)	Turbidity (NTU)	Total Phosphorus (µg/L)	Filterable Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Nitrate + Nitrite (NOx) (µg/L)	Dissolved oxygen (% sat)	pH	Electrical conductivity (µS/cm)
Montane zone, >700m	10	20	15	250	25	90-110%	6.5-8.0	175
Upland zone, 150 to 700m	10	20	15	250	25	90-110%	6.5-8.0	175
Lowland zone, <150m	25	50	20	350	40	85-110%	6.5-8.0	350

Water quality data from a single monitoring site in Byron Shire Council's water quality program was used for this assessment. This site was chosen based on its location, which is away from the influences of sewage treatment plant (STP) discharge.

The data set used was for 1 July 2018 to 30 June 2023.

The location of the water quality sites used in this assessment is shown in Figure 4.

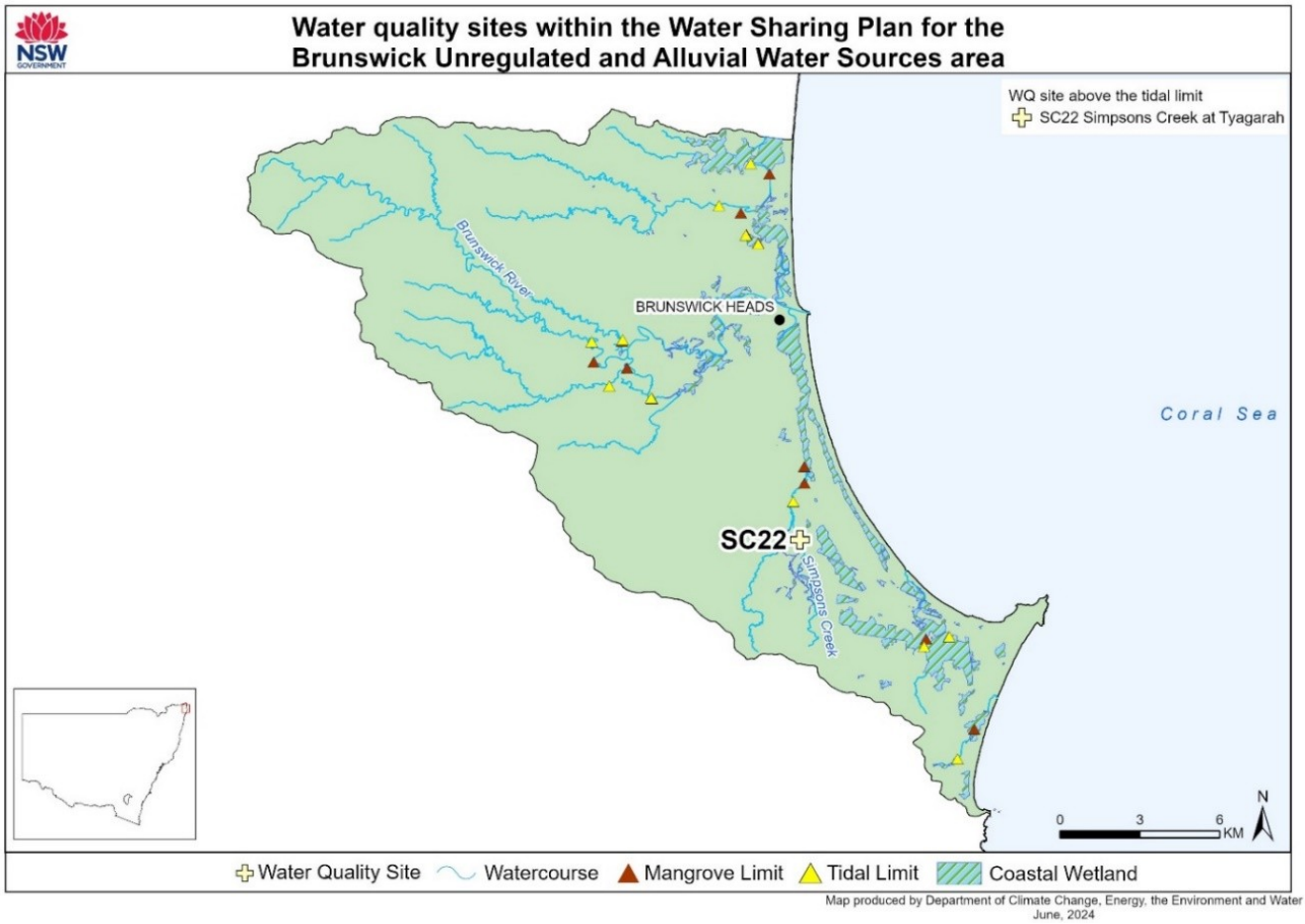

Figure 4: Water quality sites in the Brunswick catchment, upstream of the tidal limit

The site is:

- Simpsons Creek at Tyagarah (site reference number SC22) (Tyagarah Creek water source) (L)

Key: L = Lowland; U = Upland; M = Montane.

Only medium or high overall risk levels are shown in Table 8. Due to a medium consequence rating for Simpsons Creek at Tyagarah, the risk rating for calculated parameters was mostly low or medium. For most parameters, the likelihood of the current water quality adversely impacting aquatic ecosystems was low. However, as the likelihood rating for total phosphorus was high, there is a high risk that any decline from the existing water quality conditions could adversely impact sensitive water-dependent ecosystems.

The calculated median water quality data values for site SC22 are listed in 6.4 Appendix D Water Quality Data.

Although 5 year water quality data was not available for this risk assessment, the Environment Protection Authority (EPA) recently conducted a water quality monitoring program for the NSW east coast. Flooding and sewer overflows have affected the Brunswick River in the last couple of years. The EPA partnered with the department's Conservation Programs, Heritage and Regulation branch (CPHR) and established a flood recovery program for water quality monitoring East Coast project 2022. Water quality data was collected monthly during events and in real time. The data was collected during baseline flood and post flood conditions. The primary goal of this project was to provide information about how floods affect water quality and contribute to the recovery of waterways. This information aided waterway users and managers to make informed decisions after flood events.

Water quality data from the Flood recovery program is available on the East Coast project dashboard and includes water quality results for 8 sites in the Brunswick River (Figure 5). Only the 2 sites upstream of the tidal limit, (above Mullumbimby), are referred to in this section.

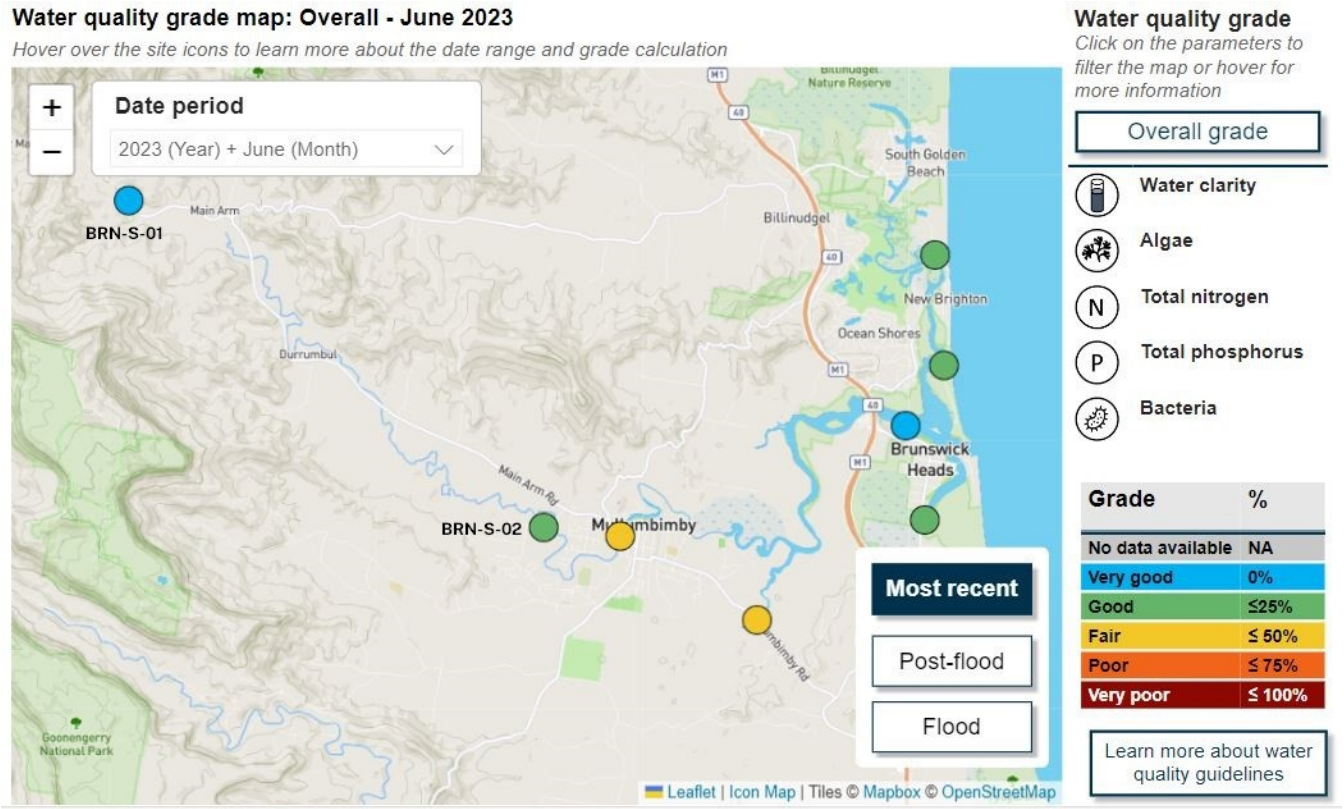

Figure 5: Brunswick River sampling site water quality grades for June 2023. Source: NSW EPA/CPHR

Based on ANZECC 2000 water quality guidelines and the percentage the guidelines were exceeded, the water quality parameters measured 5 factors: water clarity, algae, total nitrogen, total phosphorus, and bacteria. The results for each factor were given a grade (very good, good, fair, poor, or very poor). The overall health of a water site was determined by averaging the grades of these 5 factors. The colours blue, green, yellow, orange, and red represent the overall grade, with blue being very good and red being very poor.

In June 2023, the 2 water quality sites upstream of the tidal limit above Mullumbimby received good to very good ratings (Figure 5). The furthest upstream site BRN-S-01 on the Brunswick River received a “very good grade” as all 5 parameters did not exceed their water quality guideline values.

Site BRN-S-02, closest to Mullumbimby, received a “good” overall grade due to bacteria being the only parameter to exceed the guideline value.

A new citizen science project launched by Positive Change for Marine Life is currently underway to monitor water quality at five sites along the Brunswick River. The first round of sampling was conducted in November 2023. Results were not available at the time of this risk assessment however as sampling continues, the data will be made publicly available to provide information about the river’s health.

3.1.3 Cold water pollution

There are no major dams for water supply or instream structures in the Brunswick area that could pose a risk of cold water pollution as identified by Preece (2004). Most water users rely on natural flows for their water supply, although small dams and weirs may be present. Town water supplies for the major urban centres are sourced from storages in the adjacent Richmond catchment. For these reasons, the risk of impacts from unseasonably cold (or warm) water releases on water dependent ecosystems has not been assessed further.

3.1.4 Water for near-river groundwater dependent ecosystems in upriver alluvials

Groundwater-dependent ecosystems (GDEs) are ecosystems that rely on groundwater for their water supply, such as wetlands and vegetation communities. In water sources where surface water and groundwater are highly connected, surface water often seeps into the ground, recharging the underlying aquifers. Changes in surface water flows (for example, zero and low flow periods) can reduce the recharge process and impact water available for near-river groundwater dependent ecosystems in the narrow alluvium.

Figure 6 is a conceptual model showing different surface water flows and the pathway to recharging groundwater.

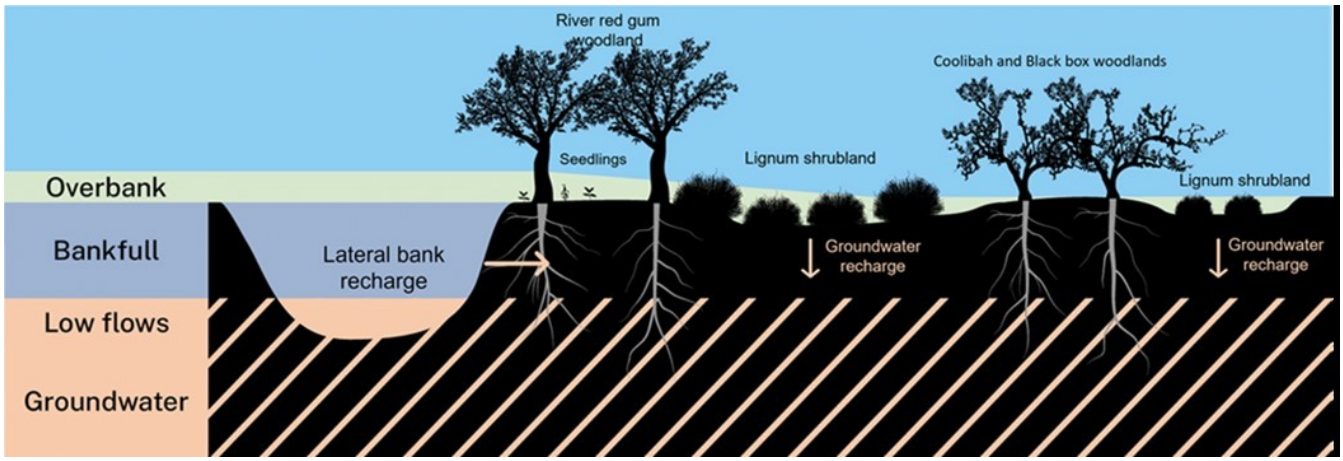

Figure 6: A conceptual model of groundwater recharge from different surface water flows

The risk rating of insufficient water for near-river groundwater dependent ecosystems was mostly high or very high for 6 water sources due to drivers of consequence ratings such as DIWA (Directory of Important Wetlands), SEPP (Coastal Management) wetlands, threatened species or communities, and large and continuous patches of GDE vegetation.

Risk ratings of reduced recharge from surface water flows for groundwater dependant assets in upstream alluviums are shown in the Summary Risk Table and Section 4.2, Table 10.

3.1.5 Impacts on irrigation from saline surface water

Water used for irrigation with elevated levels of salts can lead to potential crop damage. The aim of the salinity irrigation target is that the quality of surface water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.

Conductivity less than 1,000 µS/cm is considered safe for agriculture and irrigation on all soil types with all methods of application (ANZECC & ARMCANZ, 2000).

There are no continuous electrical conductivity monitoring sites in the Brunswick plan area to assess this target upstream of the tidal limit. For this reason, monthly electrical conductivity data from Byron Shire Council's monitoring site SC22 was used.

Electrical conductivity at this site had annual medians below 200 µS/cm and pose no risk to crop health or soil structure from licensed water users using water for irrigation. Irrigation downstream of the tidal limit, from the tidal pool is addressed in section 3.2.3.

The calculated median electrical conductivity values for the water quality site SC22 are listed in Appendix D Water Quality Data.

3.1.6 Recreation

Blue-green algae recreational water targets have been developed with the primary aim of protecting the health of humans from threats posed by the recreational use of water. This includes a low level of risk to human health from water quality threats from exposure to blue-green algae (cyanobacteria) through ingestion, inhalation or contact during recreational use of water resources. The targets are based on Chapter 6 of the National Health and Medical Research Council Guidelines for Managing Risk in Recreational Water (NHMRC, 2008). In addition, it is also a general target that cyanobacterial scums should not be consistently present. The recreational water targets are listed in Table 5.

Table 5: Blue-green algae targets for recreational water
(Source: NHMRC 2008)

Water Quality Zone	Ecosystem Type	Guidelines
All	Recreational water bodies suitable for primary contact.	• ≤10 µg/L total microcystins • ≤50,000 cells/mL toxic *Microcystis aeruginosa* • biovolume equivalent of ≤4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume • ≤10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present • Cyanobacterial scums not consistently present.

Above the tidal limit, there is no routine monitoring for blue-green algae in the water sharing plan area. From the median water quality results in Appendix D Water Quality Data, the total phosphorus levels exceeded the water quality guideline value of 0.05 mg/L for most years. Although there was insufficient 5 year data, total nitrogen had a minimum likelihood of medium. This suggests potential concerns for eutrophication and algal blooms.

Potentially toxic blue-green algal blooms have been more of a recurring issue below the tidal limit in the estuary of the Brunswick River where it posed potential risks to recreational activities, fishing, and the overall health of the estuary ecosystem. Effluent releases from the sewage treatment plant were identified as causing poor water quality in the upper estuary, favouring algal growth (BSC, 2018). Report cards from water quality monitoring in 2021-2022 by the department graded algae abundance as fair. More information on the Brunswick River Estuary and historical grades can be found on the department's Environment and Heritage webpage.

3.2 Risks downstream of the tidal limit

3.2.1 Water for estuarine systems

The statutory definition of tidal limits for estuaries (as relevant to water sharing plans) is the water area between the limit of mangrove (*Avicennia marina*) extent, and the limit of tidal influence, as mapped by Manly Hydraulics Laboratory (Manly Hydraulics Lab, 2006). This information is available on the SEED portal (https://www.seed.nsw.gov.au/). Tidal limits are influenced by sea level, as well as the specific shape and structure of an estuary.

Tidal pools are the interface between fresh water and saline estuaries. These pools often hold a significant volume of freshwater that is extracted for a range of uses. The management of flow classes in tidal pools typically relies on the flow reference point in the immediate upstream water source. Nonetheless, risks persist due to reduced inflows into estuaries, considering tidal pools are integral parts of estuaries.

Freshwater inflows and groundwater discharge influence the ecology of estuaries, crucial for their overall health. Alterations to freshwater inflows, such as water extraction, interception of water within the landscape, or changes in rainfall and runoff due to climate change, can disrupt estuarine ecosystems. Increased periods of low or no-flow increases salinity intrusion and lead to upstream migration of the salinity wedge.

In NSW, freshwater inflows primarily affect the most upstream part of estuaries, often referred to as the brackish reach or tidal pool. Tidal pools play essential roles in the lifecycle of many species and can provide a reliable source of freshwater for extractive uses.

The assessment of risk to estuary systems is calculated in a slightly different way to freshwater systems assessments. An existing process for assessing risk to estuaries has been used and is detailed in a separate report (NSW Office of Water, 2009).

The Marshalls Creek, Tyagarah Creek, Belongil Creek and Tallow Creek water source(s) were identified as having medium risk for low inflows. This is attributable to a high likelihood of reduced low inflows have an impact on ecological functioning of the Marshalls Creek and Tyagarah Creek estuaries, and the high ecological values identified in the Belongil and Tallow Creek estuaries. These values include saltmarsh, mangrove, national park estate and low hydro stress.

Identified values in the Upper Brunswick, Belongil, Mullumbimby, Tyagarah and Tallows Creek water sources include:

- Bilinudgel, Jinagong, and Brunswick Heads nature reserves
- Bilinudgel Creek and Cudgen Creek, which are connected to DIWA listed wetlands.
- Tallows and Belongil Creek intermittently closed and open lagoon (ICOL)
- SEPP14 wetlands on the Belongil, Brunswick, Tallows and Tyagarah creeks
- high habitat diversity including abundant mangrove and saltmarsh areas.

Most of the extraction in these water sources is upstream of or close to these values.

Loss of inflows is of concern primarily due to the mangroves, wetland areas and any associated impacts on aboriginal values, water licences and use that these inflows currently support.

3.2.2 Water quality for estuarine ecosystems

Changes to the quality of the water below the tidal limit can be a risk for estuarine ecosystems, potentially impacting estuarine and estuary dependent riverine aquatic species and extractive uses.

When freshwater inflows decrease, salinity (measured as electrical conductivity or EC) can increase as the tides push saltwater further upstream in the tidal pool. As the salinity increases, it can reduce the available habitat for certain species and can also cause an increase in the presence of certain species that are more tolerant of higher salinity levels. This risk can be evaluated by monitoring the salinity of the water in the brackish tidal pool zone.

There is currently no regular salinity monitoring data in the tidal reaches of the rivers in the Brunswick plan area. Therefore, this risk is not able to be assessed further in this report.

The department's Conservation Programs, Heritage and Regulation (CPHR) branch) samples a subset of estuaries every 3 years. The most recent sampling in the Brunswick River was completed over the 2021–22 summer, when 2 sites were sampled on a monthly basis. The parameters collected were algae and water clarity. The report card shows the condition of the estuary was fair with algae abundance graded fair (C), water clarity graded poor (D), and overall estuary health graded fair (C).

Grades for algae, water clarity and overall are represented as:

A – excellent

B – good

C – fair

D – poor

E – very poor.

Further historical information on Brunswick estuary grades and water quality monitoring can be found at: Environment and Heritage: Brunswick River.

Positive Change for Marine Life (PCFML) have undertaken research and mapped a number of threats across the Brunswick River estuary such as erosion and pollutants, as well as collecting dissolved oxygen readings (Marx & Goodsell, 2022).

Their data shows dissolved oxygen is lower in the upper tidal area with the lowest readings at approximately 28% (Figure 7). As a general guide, native fish and other large aquatic organisms

require at least 2 mg/L (or approximately 25%) of dissolved oxygen to survive but may begin to suffer if levels are below 4 to 5 mg/L (45 to 60%) for prolonged periods.

Figure 7: A map of dissolved oxygen readings shows the shift from more oxygenated water from the ocean on a given tide, slowly decreasing upstream. Source: Marx and Goodsell (2022)

3.2.3 Irrigation from tidal pools

Where tidal pools exist, the water in them is regularly fresh, despite being affected by daily tidal movements.

Irrigation from tidal pools in the Brunswick plan area has not been identified and is unlikely to occur. This is because salinity levels below the upper tidal limit are likely to be high, especially during low flow periods. There is currently no continuous salinity monitoring data available for the tidal reaches within this water sharing plan area. For these reasons, the risk of irrigation being affected by elevated salinity in tidal pools will not be further assessed in this report.

3.3 Groundwater

3.3.1 Upriver Alluvial

The upriver alluvials are narrow areas surrounding the rivers upstream of the tidal limit and comprising of alluvium. Groundwater and surface water are considered highly connected in these unregulated and upriver alluvial water sources. There is no groundwater extraction, the risk to the

environment is mainly associated with reduced recharge of the shallow alluvium from streamflow changes. Those risks are addressed above and shown in Appendix A.

3.3.2 Floodplain Alluvium groundwater source

The department undertook the groundwater risk assessment of the alluvial aquifer. The assessment evaluates the integrity of the groundwater system and socio-economic risks, identifies mitigation actions, and determines a Sustainability Index for the groundwater source.

The aquifer ecological risk assessment for the Brunswick Coastal Floodplain Alluvium identified a moderate water quality risk due to potential disturbance of high probability acid sulfate soils. It rated the ecological risk from groundwater extraction as moderate. For the full report, refer to report Assessment of the floodplain alluvium areas for the Brunswick River Coastal Floodplain Alluvial Groundwater Source DOC24/311333 (NSW DCCEEW, 2024b).

It is important to note that the groundwater and surface water risk assessment examine different hydrological and ecological risk pathways. Although both pathways may lead to similar ecological outcomes, the risks from surface water and groundwater extraction may differ. This is exacerbated by the larger spatial extent of contribution from the groundwater sources, which can span across several surface water sources.

4 Ecological needs of freshwater ecosystems

4.1 The importance of low flows

Water sources supporting endangered and vulnerable species with a flow sensitivity rating of 3 or 4, such as the Booroolong frog, are highlighted in the water source report cards in the appendices of this document. A summary of known flow requirements for key environmental assets is outlined in section 6.3 Appendix C. Where risks are high, the greatest benefits for these species can be gained by protecting the low flow requirements in water sources.
Contemporary evidence indicates that protecting low flows is important as they provide and maintain aquatic refuges, support the life cycle of water dependent plants and animals, and enable their survival throughout the drier summer months.

4.1.1 Benefits of managing and protecting low flows from water extraction

Protecting low flows has many ecological benefits. It will:

- protect flows above the cease to flow threshold and maintain river connectivity, while maintaining connectivity for downstream users
- reduce the frequency and duration of cease to flow events
- improve water quality by increasing dissolved oxygen levels and disrupt thermal stratification thus creating unfavourable conditions for blue-green algal growth
- protect aquatic ecosystems, endangered ecological communities, threatened fish and frog species
- protect low flows to improve the availability of water for basic landholder rights, health, hygiene and emergencies
- align the management of this water source to meet community expectations for improved protection of aquatic ecosystems
- ensure that water is available for human needs and the environment in the longer term.

Table 6 summarises the basic consequences of low flows across a range of factors, the benefits of flow events and cease-to-pump rules, and the flow thresholds required to mitigate these consequences.

Table 6: Consequences of low flows on aquatic ecosystems and the flows required to mitigate them.

Consequence of Low Flows/Cease to flow	Benefits of flow events and cease-to-pump rules	Flow thresholds (if any)	Reference
Anoxia/Hypoxia	Mix water column, flush low DO water and introduce fresh water with higher DO content.	Dependent on stratification, algae and organic matter loads. Flow velocity of 0.03-0.05m/s or greater to mix water column and small freshes	Mosley (2015)
Cyanobacterial blooms	Suppress cyanobacterial growth by creating conditions (high turbulence and turbidity) unfavourable for cyanobacterial growth. Can suppress stratification.	Continual flow and/or freshes large enough to mix water column after >10 days of CtF conditions.	Mitrovic et al. (2011)
Decline in pool and riffle biota recruitment	Maintains pools and riffles for egg and tadpole development	Continual flow	Bond et al. (2008)
Decline in habitat quality and availability	Reduces sedimentation, inundates important habitats for breeding and feeding	Continual flow	Rolls et al. (2012)
Declines in fish health and survival	Improves water quality, food web productivity and recruitment	Continual flow and small freshes	Marshall et al. (2016)
High salinity	Dilute high salinity groundwater and dilute salt build-up from evaporation	Continual flow	Sheldon et al. (2010)
Nutrient limitation and point source eutrophication	Mobilises nutrients from riverbank and longitudinal connection to alleviate nutrient limitation, flushes and dilutes nutrients if point source present	Continual flow and small freshes to mobilise N, P and organic matter	Mosley (2015)

Poor turtle health and low survival	Protect habitat critical for feeding, maintain water quality	Continual flow	Schaffer et al. (2015)
Reduced fish migration	Increases movement opportunities for migration and access to food and habitat.	Flows >0.3m above CtF levels for small-medium bodied fish, >0.5m for large-bodied fish. >0.1-0.2m for Australian Bass migration	Reinfelds et al. (2013); Marshall et al. (2016) ; Fairfull and Witheridge (2003).
Reduced macroinvertebrate diversity and abundance	Maintains habitat, maintains species diversity and abundance	Continual/basal flows. Flows with high enough velocity to reduce sedimentation	Rolls et al. (2012)
Salt wedge intrusion	Keeps freshwater inflows above minimum levels to avoid tidal pool salinity reaching critical thresholds	Dependent on river/estuary bathymetry, continual freshwater inflows high enough to minimise tidal pool salinity.	Herold et al. (2021)
Thermal stratification	Small flows can mix water column and break down stratification	Flow velocity of 0.03-0.05m/s or greater to mix water column, particularly for areas of low riparian vegetation	Mitrovic et al. (2003); Facey et al. (2021)

4.2 Summary of water sources with medium/high risk

The following water sources have been identified as having medium or high risk to aquatic ecosystems. Drivers of risk, potential impacts and mitigation strategies are summarised in Table 7 to Table 10. More detail on potential impacts due to water extraction under different flow conditions are shown in the conceptual models (Figure 8 to Figure 12). Appendix E lists the active and historical gauges in the water sharing plan focused on water extraction. Additional comments are provided in Appendix E for consideration where there are no gauges located in the water source. For potential mitigation options, refer to the supplementary report (when available). Refer to the water sharing plan outcome evaluation report – Environment and water quality, for evaluation of the Brunswick 2016 plan.

Table 7: Water quantity for surface water ecosystems

Water source	Ref. Pt/gauge no.	Flow type	Max. Risk rating	Drivers of risk rating (see report cards for details)	Indicators of long-term sustainability (good health)	Potential impacts	Current rule	Proposed rule	Reason for change Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Lower Brunswick River	Individual natural pool	Zero flows	H	Duration and/or frequency of zero flow periods is increased	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (Figure 8 - pools in no flow periods).	• Visible flow CtPrule at a specific site in the water source. • Visible flow condition at the pump site • The CtP rule does not apply to the upland alluvial groundwater licences. • Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity. • Trading into water source is permitted from Kings Creek, Mullumbimby Creek and Upper Brunswick River Water Sources only,	Changes proposed for public exhibition: • No net gain trade • Groundwater extraction from waterfront land limited by surface water access rules. • Access rules revised in the Upper Brunswick Water Source are likely to reduce the risks in Lower Brunswick Water Source.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source	Ref. Pt/gauge no.	Flow type	Max. Risk rating	Drivers of risk rating (see report cards for details)	Indicators of long-term sustainability (good health)	Potential impacts	Current rule	Proposed rule	Reason for change Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Lower Marshalls Creek	Tweed Valley Way crossing of Yelgun Creek	Zero flows	H	Duration and/or frequency of zero flow periods is increased	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (**Figure 8** - pools in no flow periods).	• Pumping is not permitted when there is no visible flow at Tweed Valley Way crossing of Yelgun Creek. • Visible flow condition at the pump site • The CtP rule does not apply to the upland alluvial groundwater licences. • Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity. • Trading into water source is permitted from Upper Marshalls Creek Water Sources only,	Changes proposed for public exhibition: • Trade into water source prohibited • Groundwater extraction from waterfront land limited by surface water access rules.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Lower Marshalls Creek	Tweed Valley Way crossing of Yelgun Creek	Low flows	H	Size of the low flow is reduced	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (**Figure 9** - pools in low flow periods, and **Figure 10** - running waters in low flow periods).			Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source	Ref. Pt/gauge no.	Flow type	Max. Risk rating	Drivers of risk rating (see report cards for details)	Indicators of long-term sustainability (good health)	Potential impacts	Current rule	Proposed rule	Reason for change Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Tyagarah Creek	Pacific Highway crossing of Tyagarah Creek	Zero flows	H	Duration and/or frequency of zero flow periods is increased	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (Figure 8 - pools in no flow periods).	• Visible flow CtP rule at the reference point of Pacific Highway crossing of Tyagarah Creek. • Visible flow condition at the pump site • The CtP rule does not apply to the upland alluvial groundwater licences. • Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity. • Trading into water source is not permitted. Trading within water source is permitted, subject to assessment.	Changes proposed for public exhibition: • Groundwater extraction from waterfront land limited by surface water access rules.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Tyagarah Creek	Pacific Highway crossing of Tyagarah Creek	Low flows	H	Size of the low flow is reduced	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (Figure 9 - pools in low flow periods, and Figure 10 - running waters in low flow periods).		Changes proposed for public exhibition: • Groundwater extraction from waterfront land limited by surface water access rules.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Upper Brunswick River	Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001)	Zero flows	H	Duration and/or frequency of zero flow periods is increased	Presence and distribution of known threatened species in the water source, including: the Giant barred frog, the Giant Dragonfly and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (Figure 8 - pools in no flow periods).	• CtP rule at the reference point of Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001), which is set at the 80th percentile flow (2 ML/day). • Commence to pump trigger, higher than the CtP trigger, • Visible flow condition at the pump site • The CtP rule does not apply to the upland alluvial groundwater licences. • Water must not be taken for more than 6 hours per day when flows are less than or equal to 4 ML/day at Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001) • Water must not be taken for 24 hours after flows at the Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001) first exceed 4 ML/day following a low flow of 2 ML/day • Trading into water source permitted from Kings Creek and Mullumbimby Creek Water Sources only subject to no net gain above water source entitlement at the Plan's commencement. Trade within water source permitted subject to assessment	Changes proposed for public exhibition: • No high flow conversions • No new in-river dams on a third order or higher order stream • • No Aboriginal Community Development Licences • Groundwater extraction from waterfront land limited by surface water access rules. • CtP when flows @ GS202001 are: 2 ML/d for the months November to May (inclusive) and 8 ML/day for the months June to October (inclusive). • Pumping restrictions for November to May: - 6 hours/day when flows are between 2ML/day and less than 6 ML/d - 24-hour commence to take 6 ML/day following a low flow of 2 ML/day	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Upper Brunswick River	Brunswick River at Durrumbul (Sherrys Crossing)	Low flows	M	Size of the low flow is reduced	Presence and distribution of known threatened species in the water source, including: the Giant barred frog, the	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See		Changes proposed for public exhibition: • No new in-river dams on a third order or higher order stream	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source	Ref. Pt/gauge no.	Flow type	Max. Risk rating	Drivers of risk rating (see report cards for details)	Indicators of long-term sustainability (good health)	Potential impacts	Current rule	Proposed rule	Reason for change Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
	gauge (202001)				Giant Dragonfly and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	conceptual models for further impact pathways (**Figure 9** - pools in low flow periods, and **Figure 10** - running waters in low flow periods).		• Groundwater extraction from waterfront land limited by surface water access rules.	
Upper Marshalls Creek	Walkers Lane crossing of Upper Marshalls Creek	Zero flows	H	Duration and/or frequency of zero flow periods is increased	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (**Figure 8** - pools in no flow periods).	• Visible flow CtP rule at the reference point at Walkers Lane crossing of Upper Marshalls Creek. • Visible flow condition at the pump site • The CtP rule does not apply to the upland alluvial groundwater licences. • Trading permitted into water source subject to no net gain above total licensed entitlement in the water source at the Plan's commencement. Trading within water source permitted, subject to assessment.	Changes proposed for public exhibition: • Trade into the water source is prohibited. • No new in-river dams on a third order or higher order stream • Groundwater extraction from waterfront land limited by surface water access rules.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source	Ref. Pt/gauge no.	Flow type	Max. Risk rating	Drivers of risk rating (see report cards for details)	Indicators of long-term sustainability (good health)	Potential impacts	Current rule	Proposed rule	Reason for change Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Upper Marshalls Creek	Walkers Lane crossing of Upper Marshalls Creek	Low flows	H	Size of the low flow is reduced	Presence and distribution of known threatened species in the water source, including: the Giant barred frog and Wallum froglet. Refer to the report card (Appendix A) for threatened species with a flow sensitivity rating of 3 or 4.	Loss of sensitive aquatic species; Decreases metabolism, feeding, reproduction; Susceptibility to other stressors; Behaviour modification. See conceptual models for further impact pathways (**Figure 9** - pools in low flow periods, and **Figure 10** - running waters in low flow periods).		Changes proposed for public exhibition: • No new in-river dams on a third order or higher order stream • Groundwater extraction from waterfront land limited by surface water access rules.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

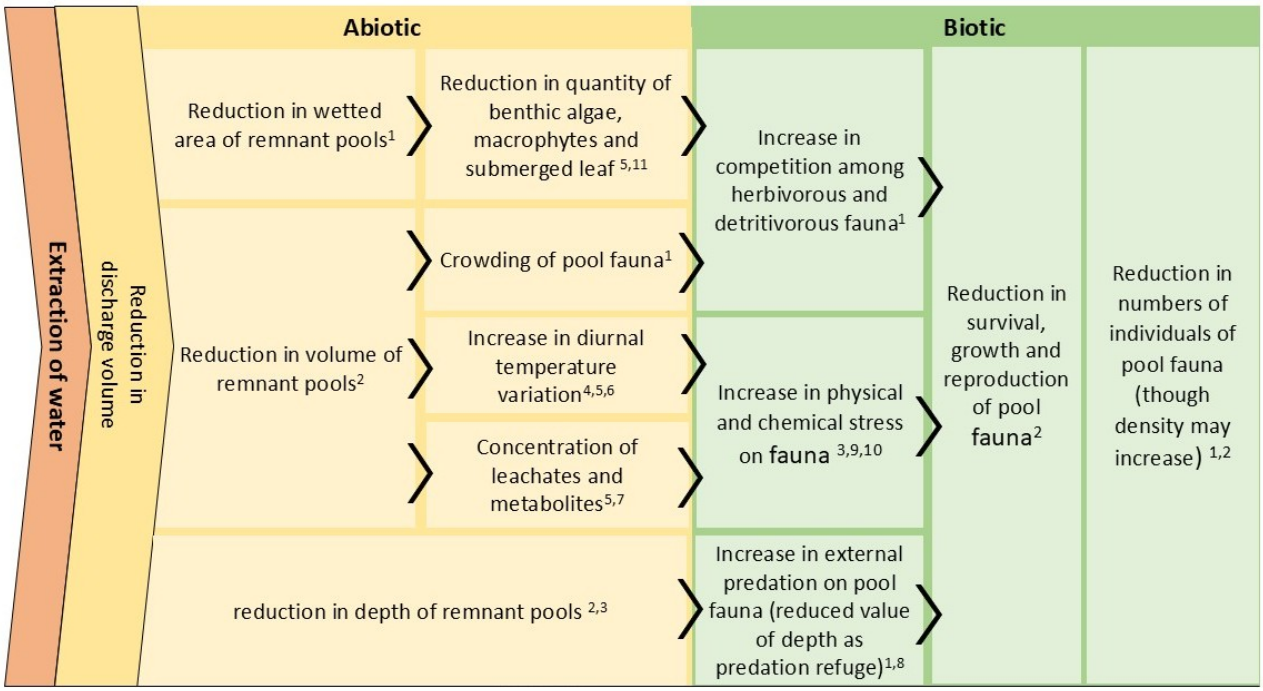

Figure 8: Conceptual model of ecosystem responses to water extraction in river pools under no-flow conditions.

Responses will vary with natural patterns of water loss and the timing, frequency and magnitude of extraction.

References: [1]Boulton and Lake (2008), [2]Boulton (2003), [3]Williams and Hynes (1977), [4]Larimore et al (1959), [5]Linklater (1994), [6]Boulton and Lake (1992a), [7]Towns (1985) [8]Extence (1981), [9]Boulton and Lake (1990), [10]Boulton and Lake (1992b), [11]Neif et al. (2017).

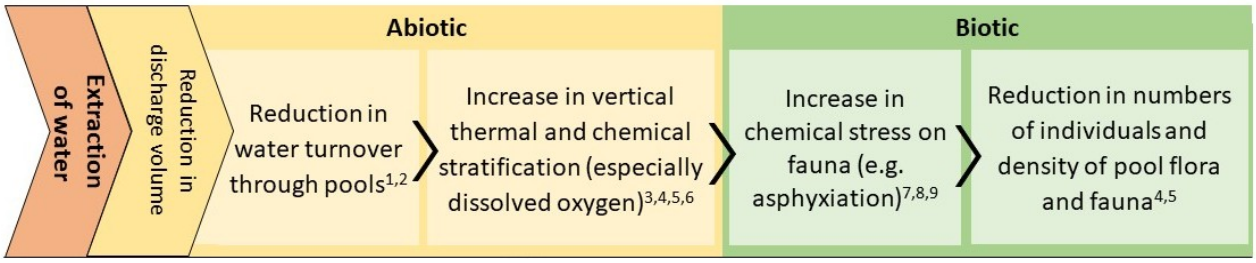

Figure 9: Conceptual model of ecosystem responses to upstream water extraction in river pools under low-flow conditions.

Responses will vary with natural discharge patterns and the timing, frequency and magnitude of extraction.

References: [1]Boulton (2003), [2]Williams and Hynes (1977), [3]Nielsen et al (1994), [4]Boulton and Lake (1990), [5]Boulton and Lake (1992a), [6]Linklater (1994), [7]Moog (1993), [8]Fox and Taylor (1955), [9]Madsen et al (2001).

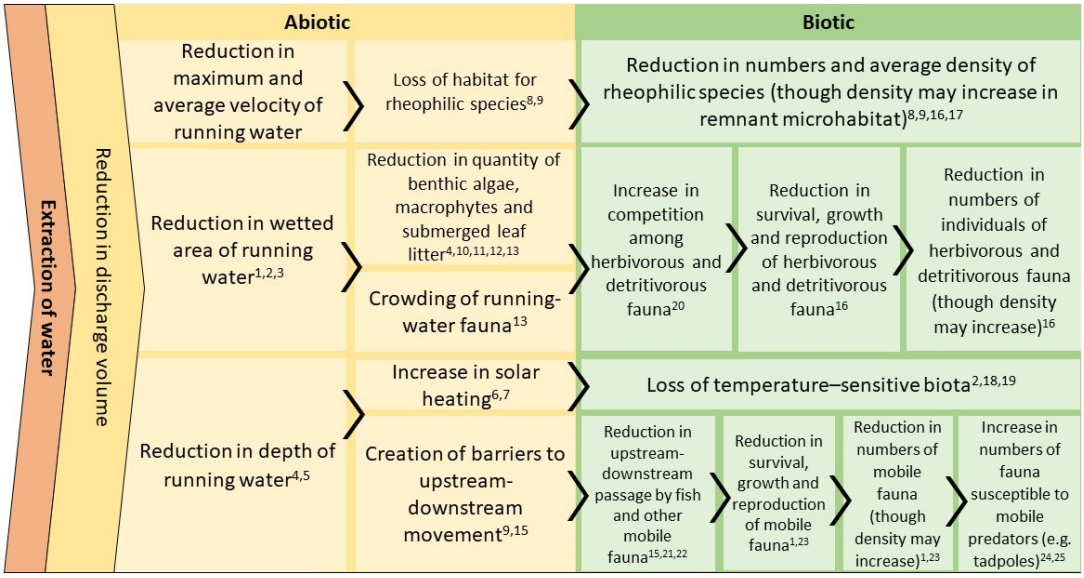

Figure 10: Conceptual model of ecosystem responses to upstream water extraction in river **running waters under low-flow conditions.**

Responses will vary with natural discharge patterns and the timing, frequency and magnitude of extraction.

References: [1]Kingsford (2000), [2]Cowx et al (1984), [3]Brasher (2003), [4]Ham, Wright and Berrie (1981), [5]McIntosh, Benbow and Burky (2002), [6]Constantz (1998), [7]Rader and Belish (1999), [8]Copp (1990), [9]Boulton and Lake (2008), [10]Neif et al (2017) [11]Madsen et al (2001), [12]O'Hare et al (2011), [13]Dewson et al (2007), [14]Linklater (1994), [15]Gallardo et al (2008), [16]Harris and Lawrence (1978), [17]Boulton (2003), [18]Connor et al (2003), [19]Gunn and Snucins (2010), [20]Hildrew and Townsend (1980), [21]Brooks et al (2017), [22]Brooks et al (2018), [23]Canton et al (1984), [24]Heyer et al (1975), [25]Wellnitz (2014).

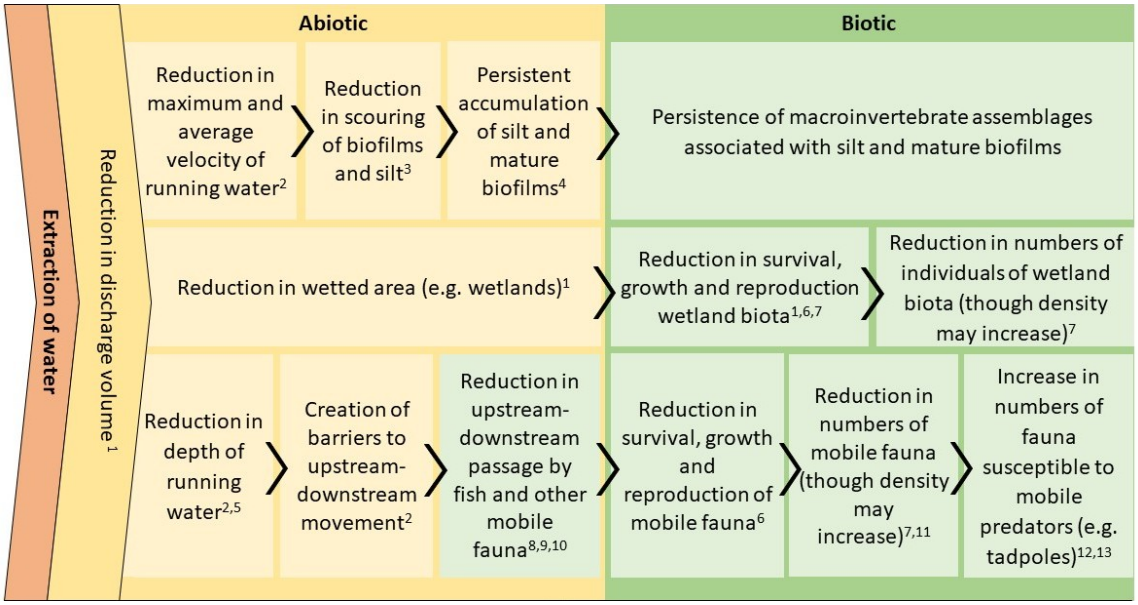

Figure 11: Conceptual model of ecosystem responses to upstream water extraction in **rivers under medium-flow and high-flow conditions (freshes and floods).**

Responses will vary with natural discharge patterns and the timing, frequency and magnitude of extraction.

References: [1]Kingsford (2000), [2]Boulton (2003), [3]Parker and Power (1997), [4]Battin et al (2008), [5]McIntosh et al (2002), [6]Kingsford and Johnson (1998), [7]Leslie (1995), [8]Brooks et al (2017), [9]Brooks et al (2018), [10]Gallardo et al (2008), [11]Kingsford and Thomas (1995), [12]Wellnitz (2014), [13]Heyer et al (1975).

Table 8: Water quality for surface water ecosystems

Water source	Ref. Pt/gauge number	Max. Risk rating	Water quality parameter and drivers of risk rating	Indicators of good health	Potential impacts	Current and proposed rules
Simpsons Creek At Tyagarah (Tyagarah Creek Water Source)	Pacific Highway crossing of Tyagarah Creek. No visible flow (NVF) at reference point.	H	Elevated total phosphorus	TP within local water quality guidelines for the flow condition at time of monitoring. Refer to ANZECC if local water quality guidelines are not available.	Increased risk of eutrophication leading to toxic algal blooms and hypoxic (low oxygen) or anoxic (no oxygen) conditions. This can cause fish kills and negatively impact other aquatic organisms. Table 6 summarises the basic consequences of low flows across a range of factors.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Simpsons Creek At Tyagarah (Tyagarah Creek Water Source)	Pacific Highway crossing of Tyagarah Creek. No visible flow (NVF) at reference point.	M	Elevated levels of total nitrogen	TN within local water quality guidelines for the flow condition at time of monitoring. Refer to ANZECC if local water quality guidelines are not available	Increased risk of eutrophication leading to toxic algal blooms and hypoxic (low oxygen) or anoxic (no oxygen) conditions. This can cause fish kills and negatively impact other aquatic organisms. Table 6 summarises the basic consequences of low flows across a range of factors.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Simpsons Creek At Tyagarah (Tyagarah Creek Water Source)	Pacific Highway crossing of Tyagarah Creek. No visible flow (NVF) at reference point.	M	pH outside of natural range	pH within local water quality guidelines for the flow condition at time of monitoring. Refer to ANZECC if local water quality guidelines are not available.	Water being of a quality unsuitable for irrigation, stock watering and/or farm water supply. Water being unsuitable for primary, secondary or visual recreation. Fish deaths. pH influences toxicity of other parameters (**for example,** heavy metals, ammonia). Table 6 summarises the basic consequences of low flows across a range of factors.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Table 9: Water for estuarine ecosystems

Water source	Ref. Pt/gauge no.	Flow or extraction type	Max. Risk rating	Drivers of risk rating	Indicators of good health	Potential impacts	Current and proposed rules
Marshalls Creek (Lower Marshalls Creek Water Source)	Tweed Valley Way crossing of Yelgun Creek	Low inflows	M	High habitat diversity and national park estate, and medium seagrass and saltmarsh values.	Tidal pool salinity range within historical/seasonal limits, and location of salt wedge. Extent of mangrove distribution in tidal pool reach. Presence of migratory/estuary dependent river flora and fauna. Examples include Bass, freshwater mullet and Oxleyan pygmy perch (Morris et al., 2001; Knight et al., 2012).	Elevated salinity, loss of hydrologic connectivity and estuary dependent riverine flora and fauna Refer to Figure 12 showing further ecosystem responses and potential impacts due to extraction and loss of inflows in estuaries. Table 6 also summarises the basic consequences of low flows across a range of factors and the benefits of flow events.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Tyagarah Creek (Tyagarah Creek Water Source)	Pacific Highway crossing of Tyagarah Creek	Low inflows	M	High entitlement, high ecological values including habitat diversity	Salinity range within historical/seasonal limits. Extent of mangrove distribution in tidal pool reach. Presence of migratory/estuary dependent river flora and fauna. Examples include Bass, freshwater mullet and Oxleyan pygmy perch (Morris et al., 2001; Knight et al., 2012).	Elevated salinity, loss of hydrologic connectivity and estuary dependent riverine flora and fauna Impacted by saline water intrusion via floodgates. Further assessment required to establish the extent and impacts of the issue. Refer to Figure 12 showing further ecosystem responses and potential impacts due to extraction and loss of inflows in estuaries.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source	Ref. Pt/gauge no.	Flow or extraction type	Max. Risk rating	Drivers of risk rating	Indicators of good health	Potential impacts	Current and proposed rules
Belongil Creek (Belongil Creek Water Source)	Pump site or natural pool	Low Inflows	M	High entitlement, high ecological values including habitat diversity	Salinity range within historical/seasonal limits. Extent of mangrove distribution in tidal pool reach. Presence of migratory/estuary dependent river flora and fauna. Examples include Bass, freshwater mullet and Oxleyan pygmy perch (Morris et al., 2001; Knight et al., 2012).	Elevated salinity, loss of hydrologic connectivity and estuary dependent riverine flora and fauna Impacted by saline water intrusion via floodgates. Further assessment required to establish the extent and impacts of the issue. Refer to Figure 12 showing further ecosystem responses and potential impacts due to extraction and loss of inflows in estuaries.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Tallow Creek (Tallow Creek Water Source)	Pump site or natural pool	Low Inflows	M	High entitlement, high ecological values including habitat diversity	Salinity range within historical/seasonal limits. Extent of mangrove distribution in tidal pool reach. Presence of migratory/estuary dependent river flora and fauna. Examples include Bass, freshwater mullet and Oxleyan pygmy perch (Morris et al., 2001; Knight et al., 2012).	Elevated salinity, loss of hydrologic connectivity and estuary dependent riverine flora and fauna Impacted by saline water intrusion via floodgates. Further assessment required to establish the extent and impacts of the issue. Refer to Figure 12 showing further ecosystem responses and potential impacts due to extraction and loss of inflows in estuaries.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

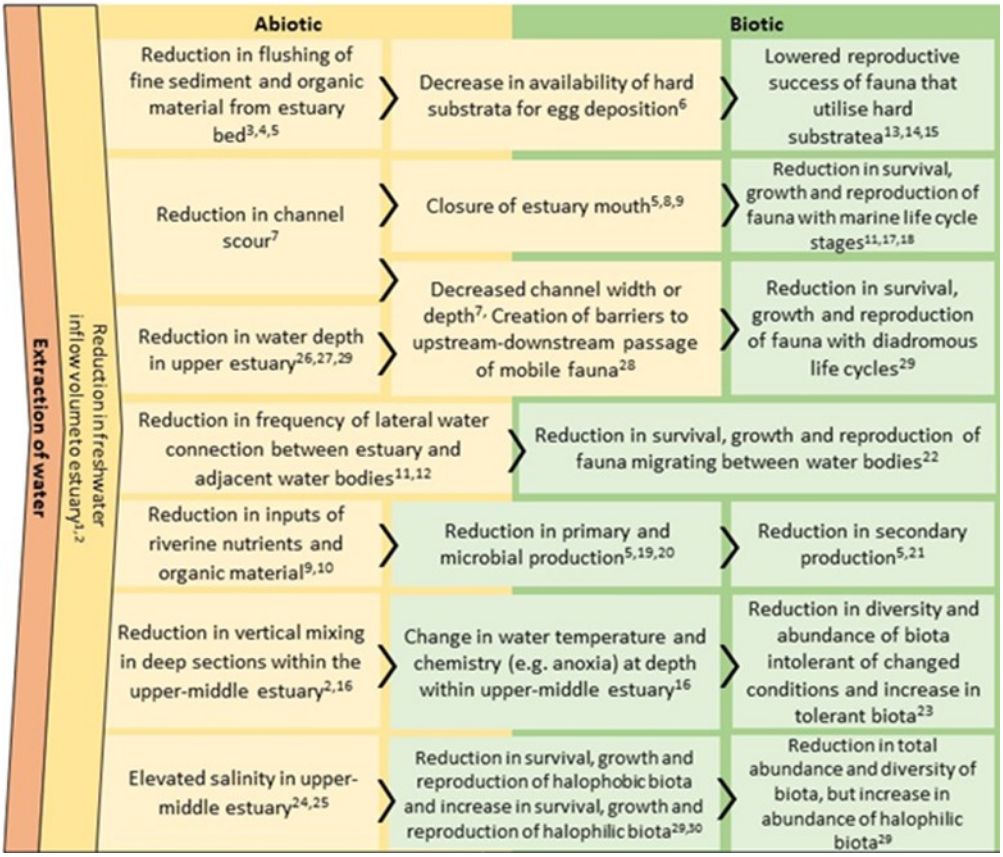

Figure 12: Conceptual model of ecosystem responses to upstream water extraction in estuaries under low inflow conditions.

Responses will vary according to natural discharge patterns and the timing, frequency and magnitude of extraction.

References: [1]Adams (2014), [2]Snow et al (2000), [3]Marais (1982), [4]Beamish et al (2011), [5]Alber (2002) , [6]Rolls et al (2012), [7]Moyle et al (2010), [8]Estevez (2002) , [9]Reddering (1988), [10]Plumsted (1990), [11]Gillson (2011), [12]Vinagre et al (2011), [13]Greenburg and Stiles (1993), [14]Piller et al (1999), [15]Helfman (2008), [16]Turner and Erskine (2010), [17]Harrison and Whitfield (1995), [18]Young and Potter (2002), [19]Hitchcock and Mitrovic (2015), [20]Howarth (1998), [21]Deegan et al (1986), [22]Dauble and Geist (2000), [23]Roy et al (2001), [24]Copeland (1966), [25]Guillien and Palanques (1992), [26]Boulton (2003), [27]Day et al (2012), [28]Choudhuri (1968), [29]Nielsen et al (2003), [30]Skinner et al (2001).

Table 10: Water quantity for groundwater dependent ecosystems

Water source (upstream alluviums)	Maximum risk rating	Drivers of risk rating	Indicators of good health	Potential impacts	Current and proposed rules
Belongil Creek	M	Very high distinctiveness, very high diversity, high naturalness and medium vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Kings Creek	H	High distinctiveness, medium diversity, very low naturalness and very low vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Lower Brunswick River	H	High distinctiveness, very high diversity, very low naturalness, medium vital habitat and the presence of coastal wetlands.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Lower Marshalls Creek	M	Very high distinctiveness, very high diversity, high naturalness and high vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Mullumbimby Creek	H	High distinctiveness, medium diversity, very low naturalness and low vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

Water source (upstream alluviums)	Maximum risk rating	Drivers of risk rating	Indicators of good health	Potential impacts	Current and proposed rules
Tyagarah Creek	VH	Very high distinctiveness, very high diversity, high naturalness and high vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Upper Brunswick River	VH	Very high distinctiveness, very high diversity, high naturalness and low vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Upper Marshalls Creek	H	Very high distinctiveness, very high diversity, low naturalness and low vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions.	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.
Brunswick River Coastal Floodplain Alluvial Groundwater Source	H	Very high distinctiveness, very high diversity, low naturalness and very low vital habitat.	Presence, distribution and diversity of GDE flora and fauna.	Less water available for GDEs from extraction, leading to biodiversity loss and local extinctions (350 recorded threatened fauna).	Refer to section 6.8 for full summary of proposed rules for this water sharing plan.

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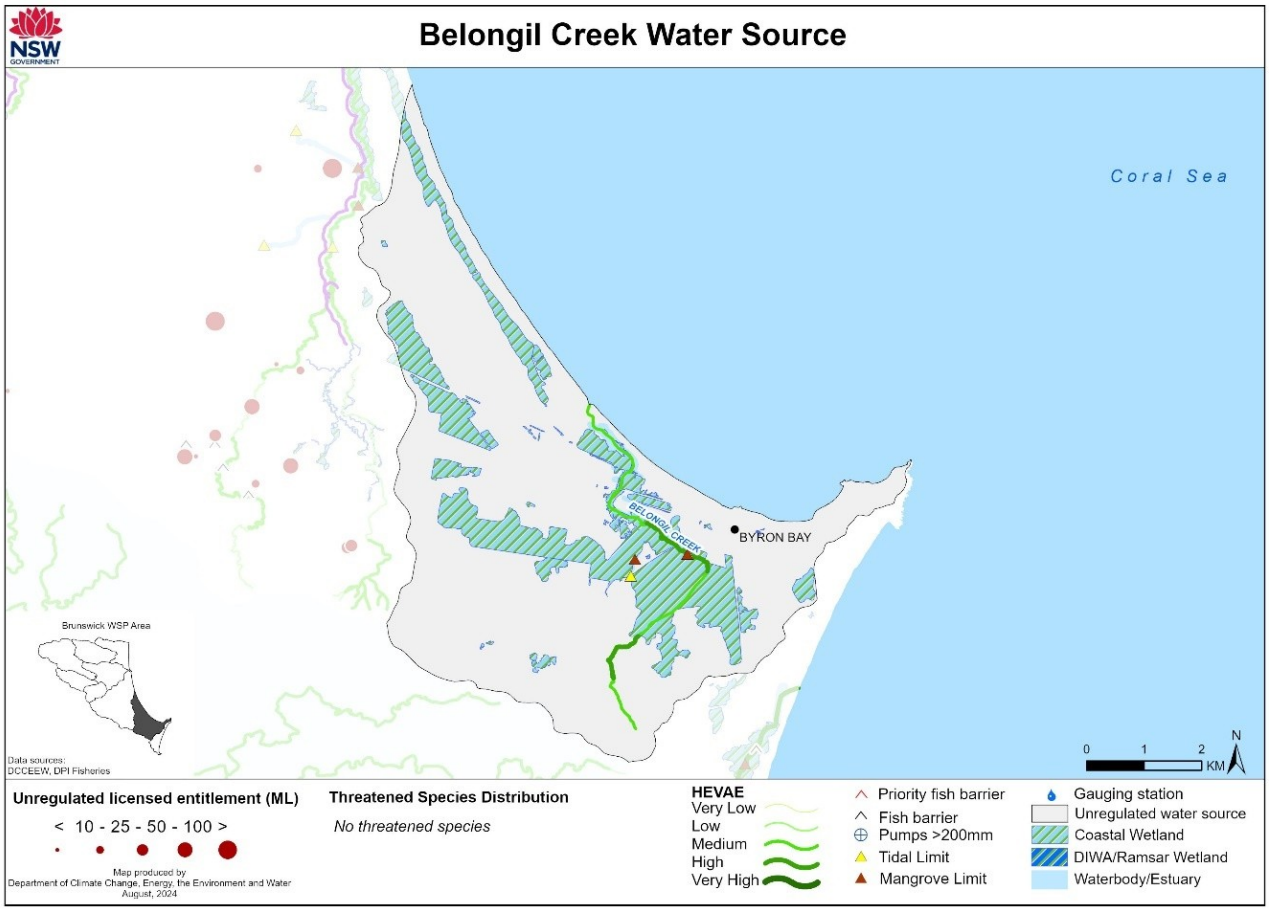
6 Appendices

6.1 Appendix A Water source report cards

Belongil Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Very High, Naturalness = Medium to High, Diversity = Very Low to Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Green and golden bell frog (recorded), Wallum froglet (recorded), Wallum Sedge frog (recorded)
Drivers (hydraulic alteration)	Currently there is no entitlement in the catchment that can impact streamflow.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	L^0	L^0	L^0	L^0	L^0	L^0
Level of Risk	L^0	L^0	L^0	L^0	L^0	L^0

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Same risk rating. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of Medium did not change and remains the same in this updated consequence assessment.

Estuary inflow risk

Belongil Creek Estuary

Drivers (ecological value)	Medium overall value with low hydrological stress, high mangrove and saltmarsh value and high sensitivity to loss of low inflows.

Estuary inflow risk	Low inflows (Base/Low Flows)	High inflows (Freshes)
Consequence (estuary value adjusted for sensitivity)	High	Low
Likelihood (degree of hydrological alteration)	Low	Low
Level of Risk	Medium	Low

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Very High
Drivers (ecological value)	Very high distinctiveness, very high diversity, high naturalness, medium vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	Low	Low	Low
Level of Risk	Medium	Medium	Medium

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Belongil Creek Water Source flows directly into Belongil estuary.

Riverbed and riverbanks

The main channel of Belongil Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad coastal floodplain in the lower water source. The river bed is sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include deep pools and shallow riffles, occasional disconnected pools, sediment bars, flood channels and chutes, swampy surfaces with discontinuous flow paths.

Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment accumulates in bars on the inside of river bends and deeper pools are formed on the outer bends. Pools provide refugia in low-flow conditions. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Belongil Creek is generally ‘moderate’ in the upper water source and tributaries and ‘good’ across the coastal plain. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation and urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Encroachment of human development can increase

pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

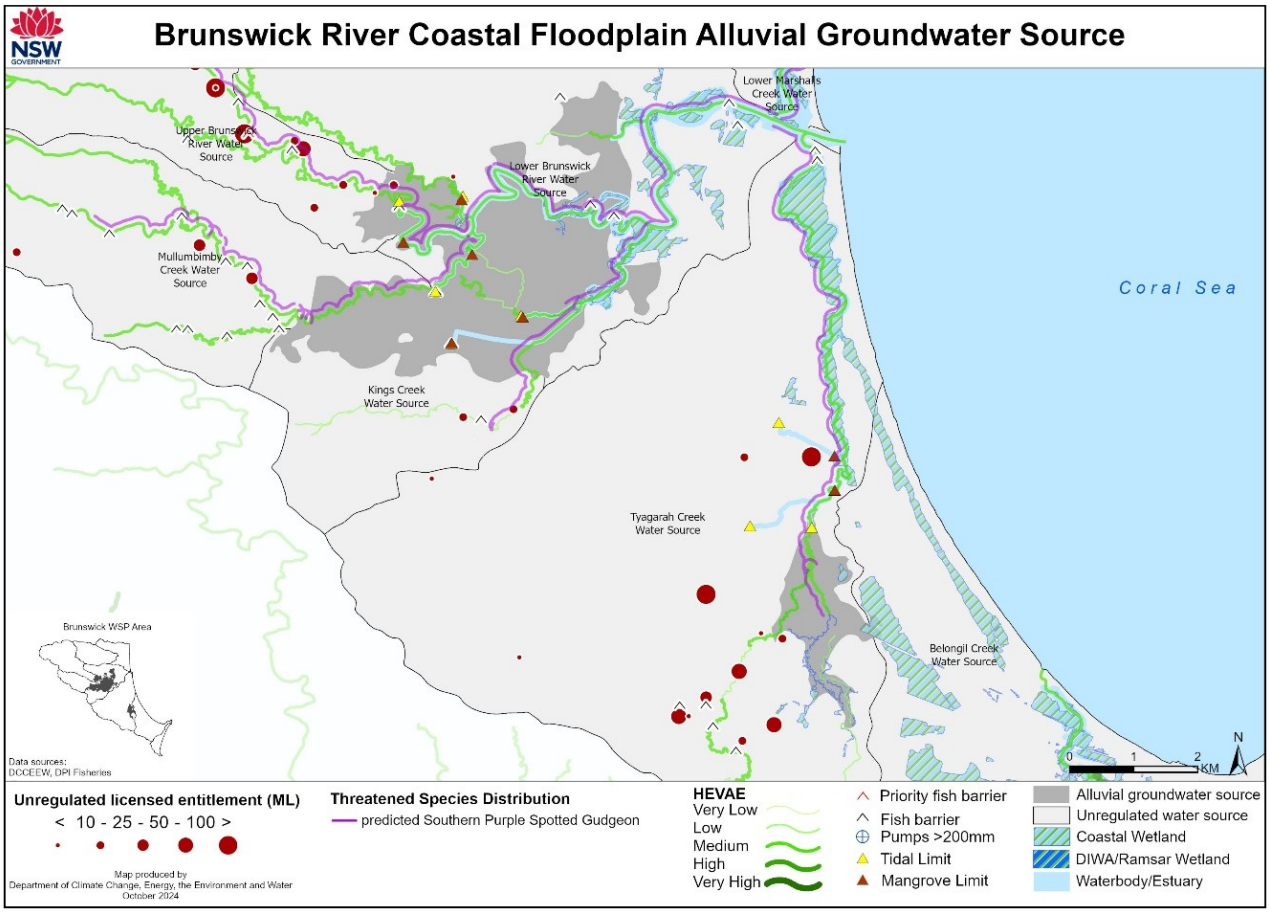
- 20th percentile (higher instream flow) 10 ML/day
- 50th percentile (typical flow) 3 ML/day
- 80th percentile (lower flow) 1 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at a specific site in the water source.
- No flow classes established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is inflow and outflow in the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Licence holders are not permitted to take water when there is no visible flow at the pump site, or where water is being taken from a pool, when the volume of water in that pool is less than the full capacity of the pool.
- Trade is not permitted into water source, but permitted, subject to assessment within water source.

Brunswick River Coastal Floodplain Alluvial Groundwater Source



Information presented in the report card

This report card rates the risks associated with water quantity of the Brunswick River Coastal Floodplain Alluvial groundwater source and lists drivers of the consequence rating. The last section summarises current water quantity management with regards to trading rules and managing local impacts.

Water Quantity

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	High
Drivers (ecological value)	Very high distinctiveness, very high diversity, low naturalness, very low vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	N/A	N/A
Level of Risk	High	N/A	N/A

Water Quality

Riverine and aquifer water quality

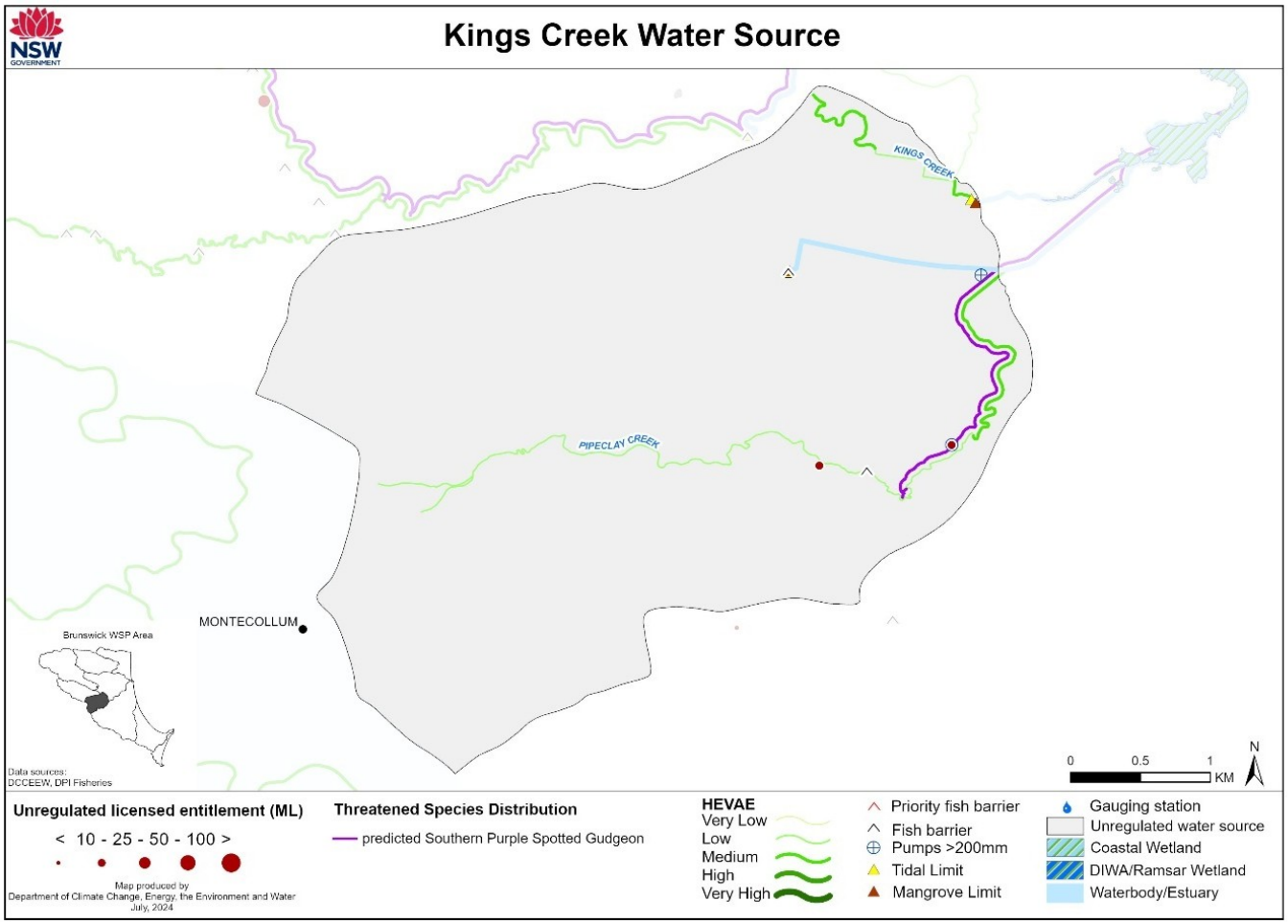
Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Water Quantity Management

Current water sharing plan mechanisms

- Trade is not permitted into groundwater source, but permitted, subject to assessment within groundwater source.
- Section 324 of the WM Act provides for the management of local impacts in groundwater sources. The Minister may prohibit or restrict the taking of water from a water source for a specified period to:
    - maintain or protect water levels in an aquifer
    - maintain, protect or improve the quality of water in an aquifer
    - prevent land subsidence or compaction in an aquifer
    - protect groundwater dependent ecosystems
    - maintain pressure, or to ensure pressure recovery, in an aquifer.
- Rules for available water determinations, access licences and water supply works approvals can be found at https://water.dpie.nsw.gov.au/__data/assets/pdf_file/0008/148976/Brunswick-Rules.pdf

Kings Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to Medium, Naturalness = Medium, Diversity = Very Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (recorded), Wallum Sedge frog (known), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 33 shares of water entitlement (see Appendix F Table F1 for licence category breakup) located on the southern arm of the Kings Creek system (Pipeclay Creek). The main control on extraction is a 2 ML/day cease to pump condition triggered by flow at a gauge in the neighbouring stream (the Brunswick River). Modelling indicates that water extraction in the Pipeclay Creek arm would have little impact at the end of the water source.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	L^0	L^-	L^-	L^0	L^0	L^0
Level of Risk	L^0	L^-	L^-	L^0	L^0	L^0

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Risk rating decreased with modelled likelihood rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of Medium did not change and remains the same in this updated consequence assessment.

The simulation of the 2 licences located in one half of Kings Creek, results in the likelihood of impacts on low flows at the end of the water source, which was previously rated medium, being decreased to a rating of low.

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Medium
Drivers (ecological value)	High distinctiveness, medium diversity, very low naturalness and very low vital habitat.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	Low	Low
Level of Risk	High	Low	Low

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Kings Creek Water Source flows into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Pipeclay Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad floodplain in the lower water source. The river bed is sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, meander cutoffs and paleochannels.

Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Pipeclay Creek is generally ‘poor’ throughout most of the water source. Habitat values in the main channel are threatened by channelisation and lack of appropriate riparian vegetation.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

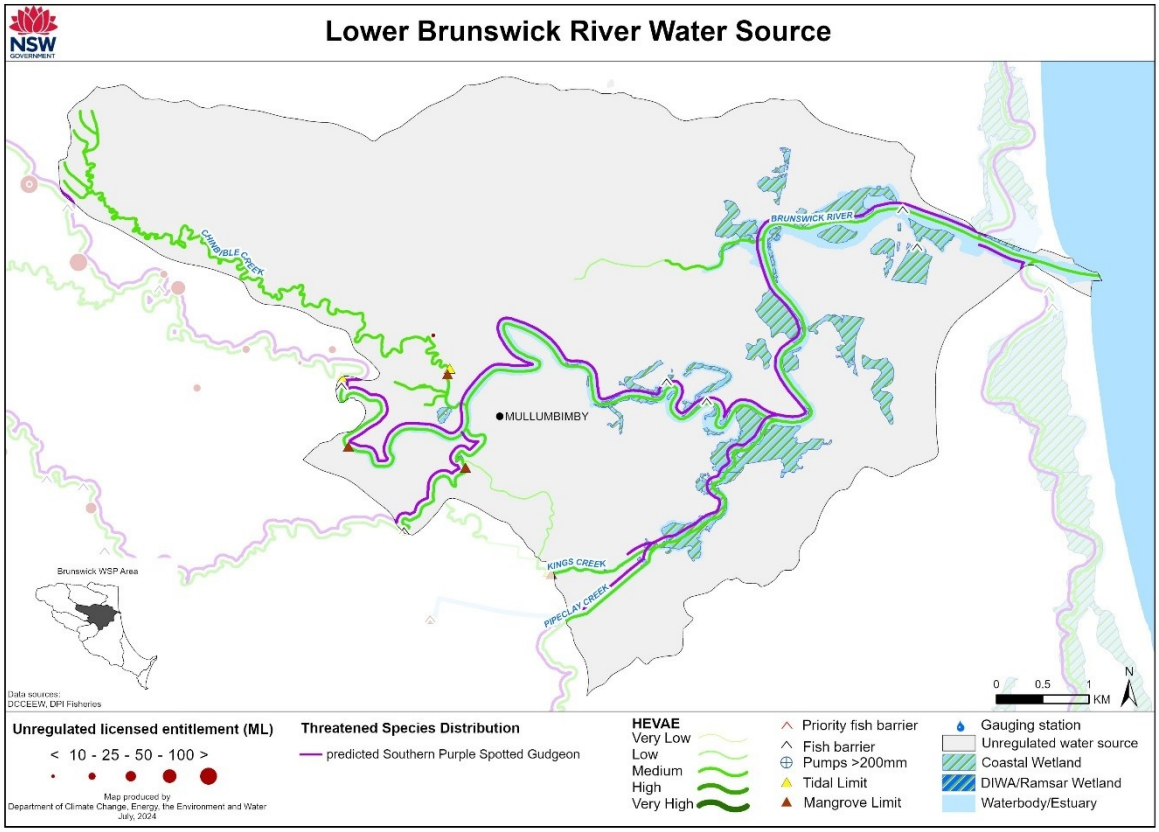
- 20th percentile (higher instream flow) 22 ML/day
- 50th percentile (typical flow) 6 ML/day
- 80th percentile (lower flow) 2 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Cease to pump rule at the reference point of Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001), which is set at the 80th percentile flow (2 ML/Day).
- Flow class established in the water source up to the C flow class, which currently are not used to limit water access.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is an inflow and outflow from the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) is permitted when cease to pump restrictions are in place.
- Water must not be taken for more than 6 hours per day when flows are less than or equal to 4 ML/day at Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001).
- Trading permitted into water source from Mullumbimby Creek, Tyagarah Creek and Upper Brunswick River water sources only, subject to a maximum water source entitlement of 50% of the 80th percentile (70 ML). Trade permitted within water source, subject to assessment.

Lower Brunswick River Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = Medium to High, Diversity = Very Low to Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (recorded), Wallum Sedge frog (known), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 5 shares of water entitlement (see Appendix F Table F1 for licence category breakup) located near the tidal limit of Chinbible Creek. The main control on extraction is a visible flow cease to pump condition, which is triggered by flow at each pump site. Modelling indicates zero flows may be impacted on the small Chinbible Creek, a tributary in this mainly estuarine water source.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	H^+	L^-	L^-	L^0	L^0	L^0
Level of Risk	H^+	L^-	L^-	L^0	L^0	L^0

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Risk rating decreased with HEVAE consequence rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of High decreased to Medium (consequence) value due primarily to no high value river reaches located within the water source (step 1 in Decision Tree).

Estuary inflow risk

Lower Brunswick River Estuary

Drivers (ecological value)	Low overall value, with only high marine estate rating and low hydrologic stress.

Estuary inflow risk	Low inflows (Base/Low Flows)	High inflows (Freshes)
Consequence (estuary value adjusted for sensitivity)	Low	Low
Likelihood (degree of hydrological alteration)	Low	Low
Level of Risk	Low	Low

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	High
Drivers (ecological value)	High distinctiveness, very high diversity, very low naturalness, medium vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	Low	High	Low
Level of Risk	Low	High	Low

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Lower Brunswick River Water Source flows directly into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Brunswick River and some of its tributaries (see Kings Creek, Mullumbimby and Upper Brunswick River water sources for additional tributaries) are confined by a bedrock valley in the upper water source, opening up to a broad coastal floodplain in the lower water source. The river bed is sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, meander cutoffs and paleochannels.

Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Brunswick River is generally ‘poor’ above the tidal limit. Habitat values in the main channel are threatened by channelisation and lack of appropriate riparian vegetation, urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. Encroachment of human development can increase pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

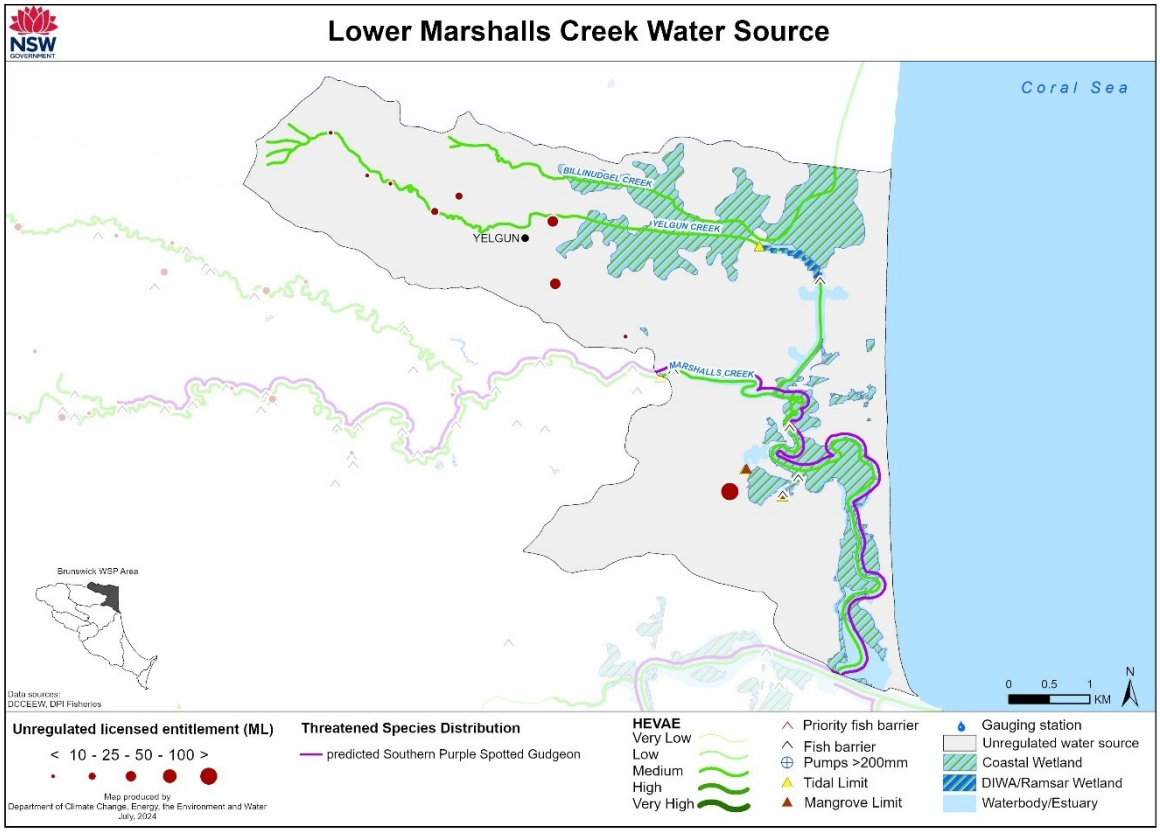
- 20^{th} percentile (higher instream flow) 10 ML/day
- 50^{th} percentile (typical flow) 3 ML/day
- 80^{th} percentile (lower flow) 1 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at a specific site in the water source.
- No flow classes established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is inflow and outflow in the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) have the same cease to pump restrictions as other licences.
- Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity.
- Trading into water source is permitted from Kings Creek, Mullumbimby Creek and Upper Brunswick River Water Sources only, subject to mandatory conditions regarding impact on freshwater wetlands mapped under State Environmental Planning Policy 14 – Coastal Wetlands (SEPP 14).Trading within water source is permitted subject to assessment, and subject to mandatory conditions regarding impact on freshwater wetlands mapped under SEPP 14.

Lower Marshalls Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = Medium to Very High, Diversity = Very Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (recorded), Wallum Sedge frog (known), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 249 shares of water entitlement (see Appendix F Table F1 for licence category breakup) in the catchment that can impact streamflow. The main control on extraction is a cease to pump condition triggered by visible flow at the Tweed Valley Way road crossing of Yelgum Creek. Modelling indicates that in the Yelgum Creek tributary, where almost half the entitlement is located, that the zero flows and low flows could be impacted.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	H^{+}	H^{-}	L^{*}	L^{0}	L^{0}	L^{0}
Level of Risk	H^{+}	H^{-}	L^{*}	L^{0}	L^{0}	L^{0}

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Risk rating increased with HEVAE consequence rated lower and modelled likelihood rated higher. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of High decreased to a Medium (consequence) value due primarily to no high value river reaches located within the water source (step 1 in Decision Tree).

The simulation of the small tributaries that flow into the Marshall Creek estuary (including Yelgun Creek), which have relatively small flows, results in the likelihood of impacts on low flows at the end of the water source, which was previously rated low, being increased to a rating of high.

Estuary inflow risk

Lower Marshalls Creek Estuary

Drivers (ecological value)	Medium naturalness due to combination of high hydrological stress at on low inflows, with high national park estate, high habitat diversity and high sensitivity to loss of high inflows.

Estuary inflow risk	Low inflows (Base/Low Flows)	High inflows (Freshes)
Consequence (estuary value adjusted for sensitivity)	Low	Medium
Likelihood (degree of hydrological alteration)	High	Low
Level of Risk	Medium	Low

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Very High
Drivers (ecological value)	Very high distinctiveness, very high diversity, high naturalness, high vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	Low	High	High
Level of Risk	Medium	Very High	Very High

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Lower Marshalls Creek Water Source flows into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Marshalls Creek and some of its tributaries (see Upper Marshalls Creek water source for additional tributaries) are confined by a bedrock valley in the upper water source, opening up to a broad coastal floodplain in the lower water source. The river bed is bedrock and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, cutoffs or oxbow lakes, swampy surfaces with discontinuous flow paths.

High-energy bedrock features produce a variety of flow habitats for aquatic insects and fish. Pools provide refugia in low-flow conditions. Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (o for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation.

The current mapping of geomorphic river condition indicates that Marshalls Creek is generally ‘good’ in the un-cleared areas of the water source and ‘poor’ to ‘moderate; elsewhere. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation and urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Encroachment of human development can increase pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

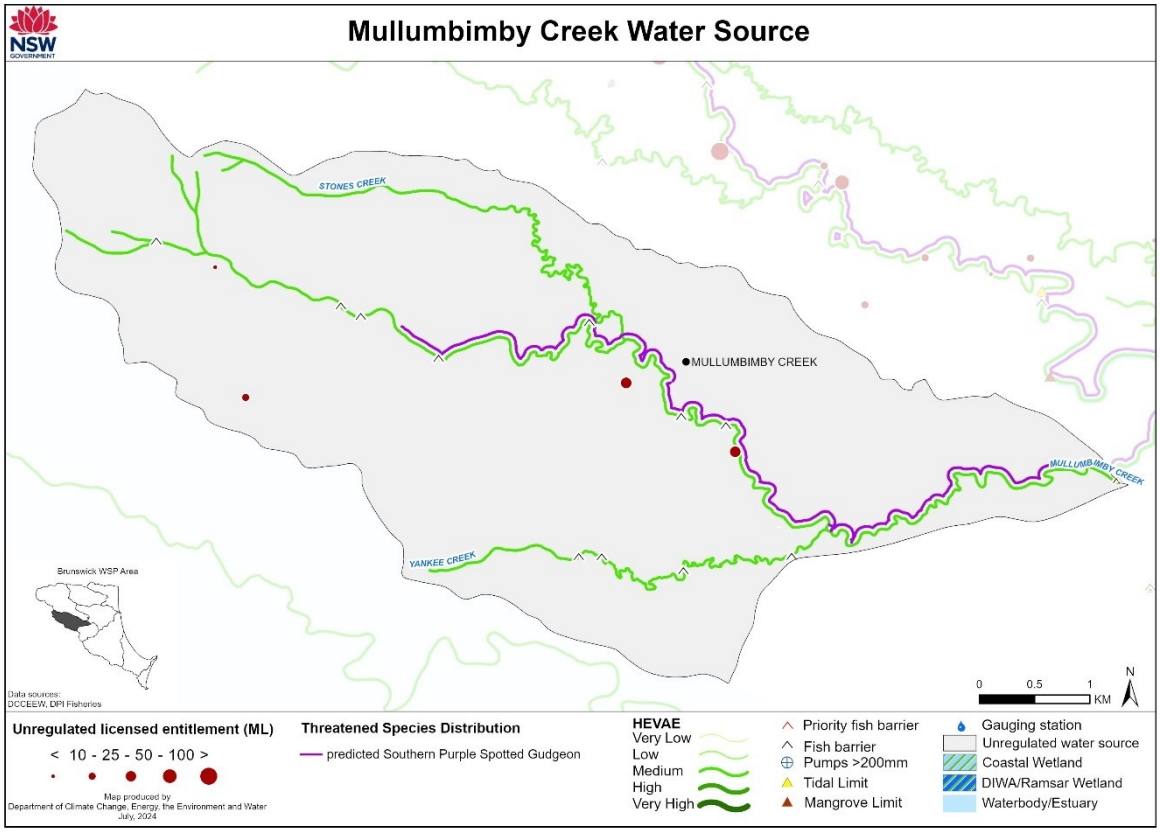
- 20th percentile (higher instream flow) 15 ML/day
- 50th percentile (typical flow) 4 ML/day
- 80th percentile (lower flow) 1 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at a specific site in the water source.
- An 'A' flow class established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is inflow and outflow in the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) have the same cease to pump restrictions as other licences.
- Pumping is not permitted when there is no visible flow at Tweed Valley Way crossing of Yelgun Creek.
- Trading into water source is permitted from Upper Marshalls Creek Water Sources only, subject to mandatory condition regarding impact on freshwater wetlands mapped under State Environmental Planning Policy 14 – Coastal Wetlands (SEPP 14). Trading within water source is permitted subject to assessment, and subject to mandatory conditions regarding impact on freshwater wetlands mapped under SEPP 14.

Mullumbimby Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to Medium, Naturalness = Medium to Very High, Diversity = Very Low to Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (known), Wallum Sedge frog (known), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 97 shares of water entitlement (see Appendix F Table F1 for licence category breakup) half of which is associated with a dam and the other half of licences is in the mid reaches of Mullumbimby Creek. The main control on extraction is a 2 ML/day cease to pump condition triggered by flow at a gauge in the neighbouring stream (the Brunswick River). Modelling indicates that water extraction would have little impact at the end of the water source.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	L^{+}	L^{-}	L^{-}	L^{0}	L^{0}	L^{0}
Level of Risk	L^{+}	L^{-}	L^{-}	L^{0}	L^{0}	L^{0}

+ = increase from near-natural condition; -= decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Risk rating decreased with modelled likelihood rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of Medium did not change and remains the same in this updated consequence assessment.

The simulation of the licences, some in the headwater dams, are all located in one half of Mullumbimby Creek, and results in the likelihood of impacts on low flows at the end of the water source, which was previously rated medium, being decreased to a rating of low.

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	High
Drivers (ecological value)	High distinctiveness, medium diversity, very low naturalness, low vital habitat and lower mobility of fauna species.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	Low	Low
Level of Risk	High	Low	Low

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Mullumbimby Creek Water Source flows into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Mullumbimby Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad floodplain in the lower water source. The river bed is bedrock, gravelly, sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, cutoffs or oxbow lakes.

High-energy bedrock features produce a variety of flow habitats for aquatic insects and fish. Pools provide refugia in low-flow conditions. Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation.

The current mapping of geomorphic river condition indicates that Mullumbimby Creek is generally ‘good’ in the upper water source and ‘moderate’ to ‘poor’ in the main channel of Mullumbimby Creek

and its lower tributaries. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation and urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Encroachment of human development can increase pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

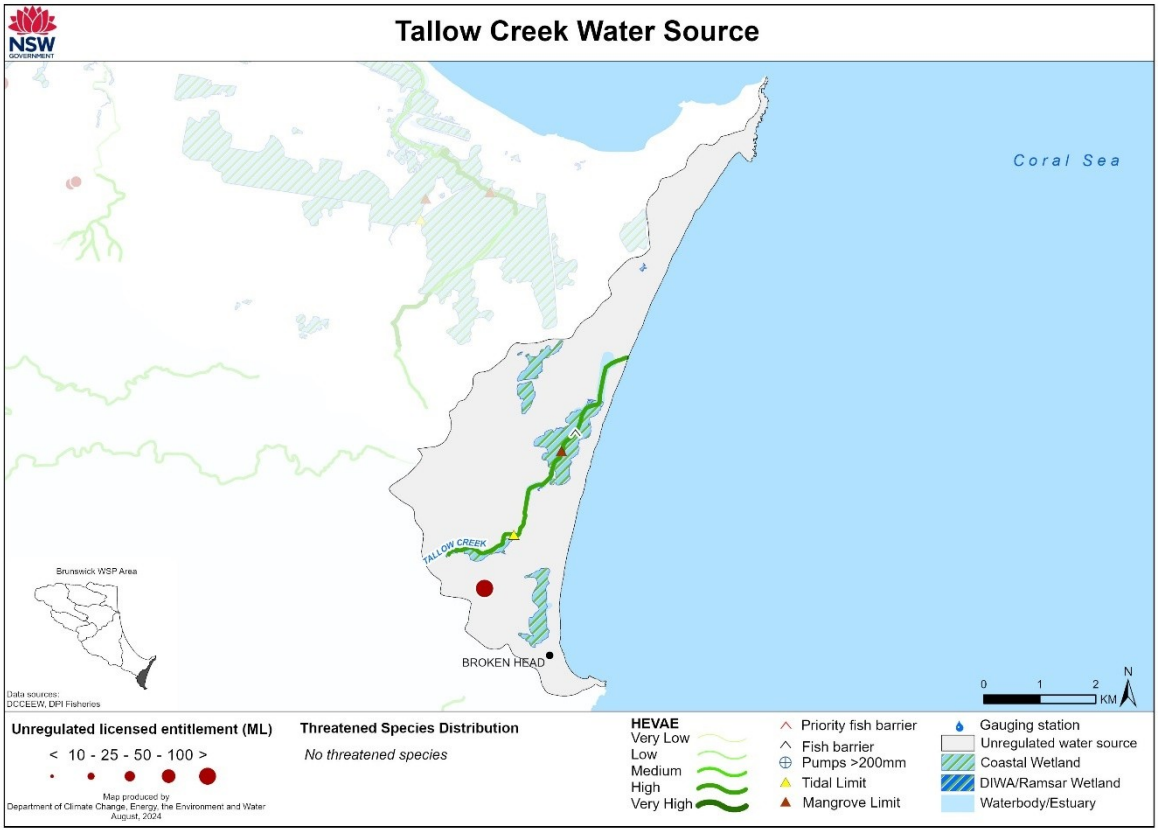
- 20th percentile (higher instream flow) 34 ML/day
- 50th percentile (typical flow) 9 ML/day
- 80th percentile (lower flow) 2 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Cease to pump rule at the reference point of Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001), which is set at the 80th percentile flow (2 ML/day).
- Flow class established in the water source up to the C flow class, which currently are not used to limit water access.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is an inflow and outflow from the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) is permitted when cease to pump restrictions are in place.
- Water must not be taken for more than 6 hours per day when flows are less than or equal to 4 ML/day at Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001)
- Trading into water source is permitted from Kings Creek and Upper Brunswick River Water Sources only, subject to no net gain above total licensed entitlement in the water source at the Plan's commencement. Trading within water source is permitted, subject to assessment.

Tallow Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = High, Naturalness = High, Diversity = Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Green and golden bell frog (recorded), Wallum froglet (recorded), Wallum Sedge frog (recorded), Green-thighed frog (known), Giant dragonfly (known)
Drivers (hydraulic alteration)	Currently there is 103 shares of water entitlement (see Appendix F Table F1 for licence category breakup) associated with a dam in a headwater of a small stream within this coastal water source. The main control on extraction is a visible flow cease to pump condition, which is triggered by flow at each pump site. Modelling indicates that at the end of the water source there is little impact on the streamflow.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	L^0	L^-	L^-	L^-	L^-	L^-
Level of Risk	L^0	L^-	L^-	L^-	L^-	L^-

+ = increase from near-natural condition; -= decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Same risk rating but HEVAE consequence rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of High decreased to a Medium (consequence) value due to a single isolated licence located within the water source.

Estuary inflow risk

Tallow Creek Estuary

Drivers (ecological value)	Medium overall value, due to low hydrological stress, high mangrove and saltmarsh value and high sensitivity to loss of low inflows.

Estuary inflow risk	Low inflows (Base/Low Flows)	High inflows (Freshes)
Consequence (estuary value adjusted for sensitivity)	High	Low
Likelihood (degree of hydrological alteration)	Low	Low
Level of Risk	Medium	Low

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Medium
Drivers (ecological value)	High distinctiveness, medium diversity, low naturalness, medium vital habitat and a high number of threatened species.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	Low	Low	Low
Level of Risk	Low	Low	Low

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Tallow Creek Water Source flows directly into Tallow Creek estuary.

Riverbed and riverbanks

The main channel of Tallow Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad coastal floodplain in the lower water source. The river bed is sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include occasional disconnected pools, swampy surfaces with discontinuous flow paths.

Ponds are irregularly spaced between swampy, grassy swales and are only connected during high flow. They often hold permanent water during dry periods and provide refugia. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Tallow Creek is generally ‘moderate’ to ‘poor’ above the tidal limit. Habitat values in the main channel are threatened by channelisation, lack of appropriate riparian vegetation and urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. Encroachment of human development can increase pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

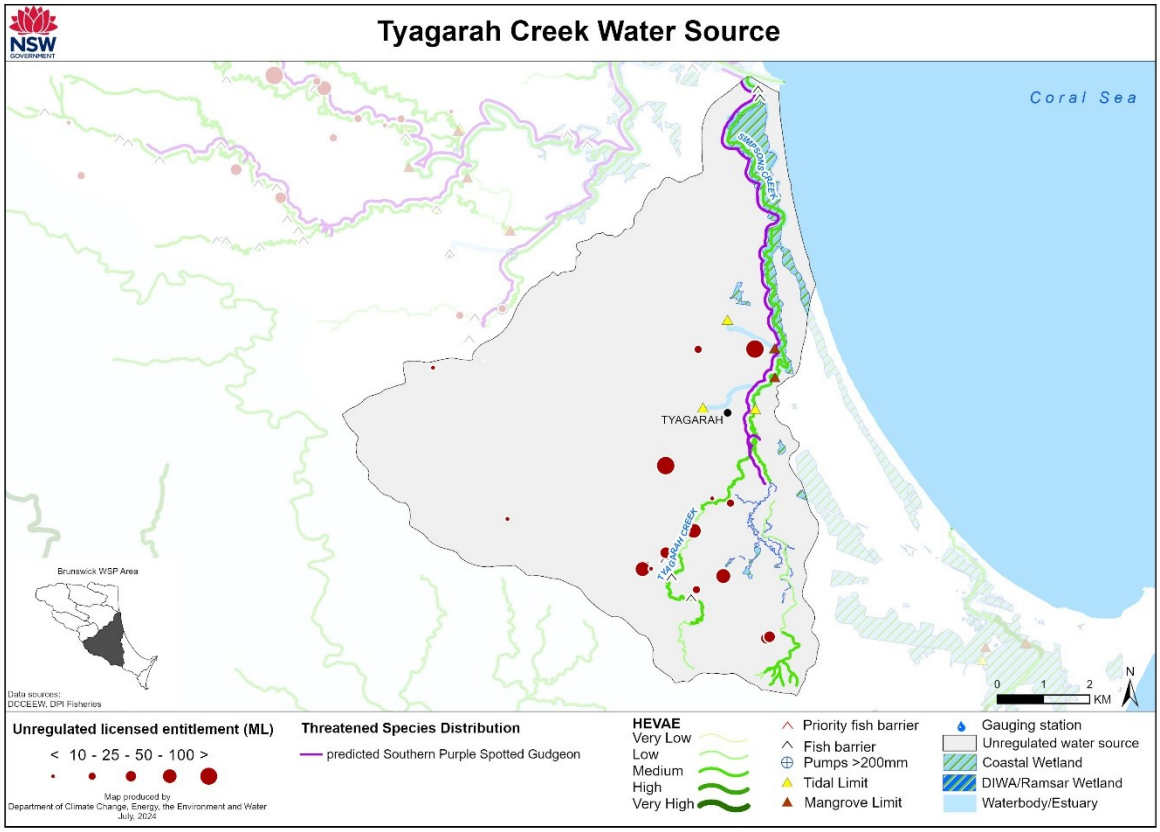
- 20^{th} percentile (higher instream flow) 2 ML/day
- 50^{th} percentile (typical flow) 1 ML/day
- 80^{th} percentile (lower flow) 0 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at a specific site in the water source.
- No flow classes established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is inflow and outflow in the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) have the same cease to pump restrictions as other licences.
- Trading into water source is not permitted. Trading within water source is permitted, subject to assessment.

Tyagarah Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to High, Naturalness = Medium to High, Diversity = Very Low to Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Green and golden bell frog (recorded), Wallum froglet (recorded), Wallum Sedge frog (recorded), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 1067 shares of water entitlement (see Appendix F Table F1 for licence category breakup) and a third of this (265 shares) is distributed in the mid and upper reaches of Tyagarah Creek tributary (the other two thirds of the entitlement sits in 2 large licences (400 and 280 shares) in other tributaries). The main control on extraction is a cease to pump condition triggered by visible flow at the Pacific Highway crossing of Tyagarah Creek. Modelling indicates zero and low flows could be impacted in dry periods.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	H^{+}	H^{-}	L^{-}	L^{0}	L^{0}	L^{0}
Level of Risk	H^{+}	H^{-}	L^{-}	L^{0}	L^{0}	L^{0}

+ = increase from near-natural condition; -= decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Same risk rating but HEVAE consequence rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of High decreased to a Medium (consequence) value due primarily to no high value river reaches located within the water source (step 1 in Decision Tree).

Estuary inflow risk

Tyagarah Creek Estuary

Drivers (ecological value)	Low naturalness due to high hydrological stress on low flows, high mangrove and saltmarsh value and high sensitivity to loss of high inflows.

Estuary inflow risk	Low inflows (Base/Low Flows)	High inflows (Freshes)
Consequence (estuary value adjusted for sensitivity)	Low	Medium
Likelihood (degree of hydrological alteration)	High	Low
Level of Risk	Medium	Low

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Very High
Drivers (ecological value)	Very high distinctiveness, very high diversity, high naturalness, high vital habitat and multiple EECs.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	High	High
Level of Risk	Very High	Very High	Very High

Water Quality

Riverine and aquifer water quality

Consequence Rating	Medium

Water Quality parameter and Risk	Turbidity (NTU)	Total Phosphorus (µg/L)	Filterable Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Nitrate + Nitrite (NOx) (µg/L)	Dissolved oxygen (% sat)	pH	Electrical conductivity (µS/cm)
Likelihood (frequency of exceeding targets)	L	H	L	M	N/A	N/A	M	L
Level of Risk	L	H	L	M	N/A	N/A	M	L

Aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the alluvial environments.

Physical Structure

The Tyagarah Creek Water Source flows directly into Tyagarah Creek estuary.

Riverbed and riverbanks

The main channel of Simpsons Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad floodplain in the lower water source. The river bed is sandy and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, cutoffs or oxbow lakes.

Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Simpsons Creek is generally ‘poor’ above the tidal limit. Habitat values in the main channel are threatened by channelisation, lack of appropriate riparian vegetation and urban encroachment.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. Encroachment of human development can increase pressure on river ecology due to increased flood velocity and erosion of instream habitat features. Water quality is also impacted by increasing development. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

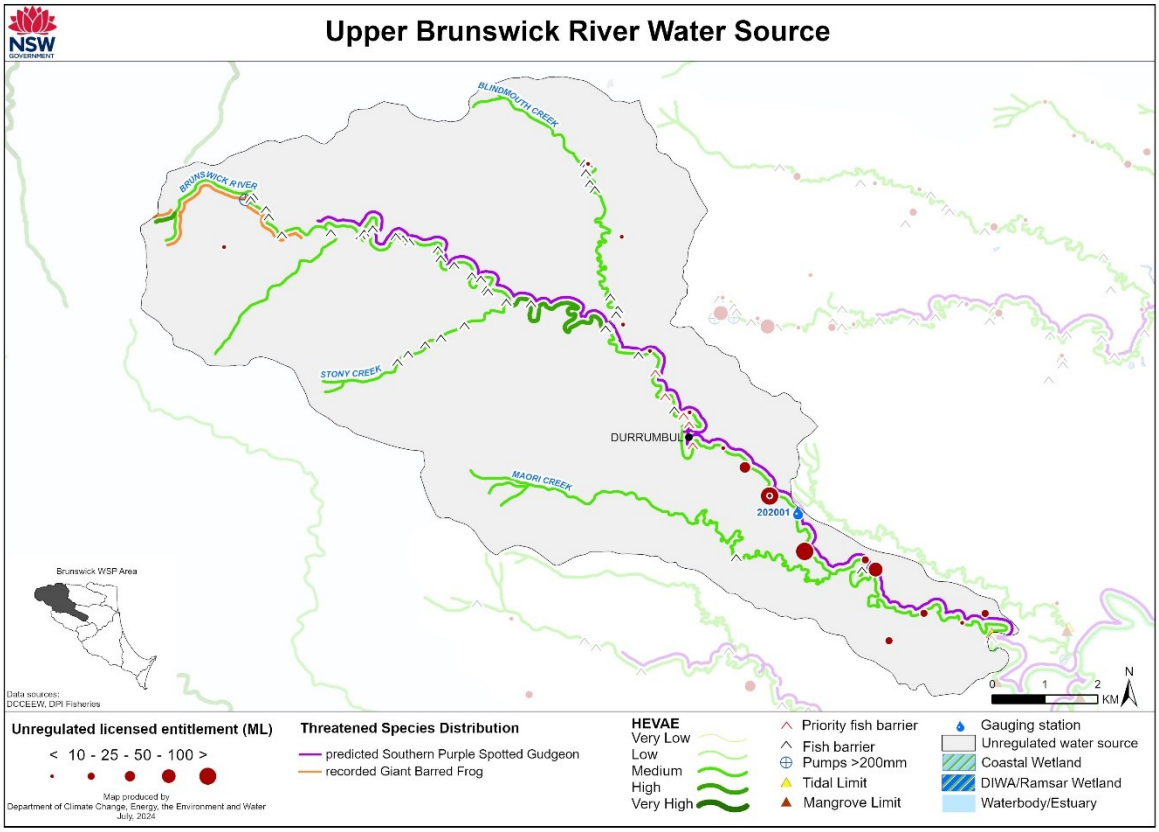
- 20th percentile (higher instream flow) 25 ML/day
- 50th percentile (typical flow) 6 ML/day
- 80th percentile (lower flow) 2 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at the reference point of Pacific Highway crossing of Tyagarah Creek.
- An 'A' flow class established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is inflow and outflow in the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) have the same cease to pump restrictions as other licences.
- Water must not be taken when flows passing through the culvert pipes, located approximately 100 metres downstream of the Pacific Highway near the south western corner of Lot 25 DP 85823, Parish of Brunswick, County of Rous, are less than 100 millimetres in depth.
- Trading into water source is not permitted. Trading within water source is permitted, subject to assessment.

Upper Brunswick River Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to High, Naturalness = Medium to Very High, Diversity = Very Low to Medium For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (recorded), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (known), Wallum Sedge frog (known), Green-thighed frog (known), Giant dragonfly (known)
Drivers (hydraulic alteration)	Currently there is 691 shares of water entitlement (see Appendix F Table F1 for licence category breakup) located on the main river in the middle and lower reaches of the river. The main control on extraction is a 2 ML/day cease to pump condition triggered by flow at a gauge in the neighbouring stream (the Brunswick River). Modelling indicates licensed extractions and basic landholder rights extractions, could impact zero flows. While low flows could also be impacted, it would likely be to a lesser degree.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	H^{+}	M^{-}	L^{-}	L^{0}	L^{0}	L^{0}
Level of Risk	H^{+}	M^{-}	L^{-}	L^{0}	L^{0}	L^{0}

+ = increase from near-natural condition;-= decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Risk rating decreased with modelled likelihood rated lower. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of Medium did not change and remains the same in this updated consequence assessment.

The simulation of a cease to pump rule, which protects the low flows, results in the likelihood of impacts on low flows at the end of the water source, which was previously rated high, being decreased to a rating of medium.

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	Very High
Drivers (ecological value)	Very high distinctiveness, very high diversity, high naturalness, low vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	High	Medium
Level of Risk	Very High	Very High	High

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Upper Brunswick River Water Source flows into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Brunswick River and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad floodplain in the lower water source. The river bed is bedrock, gravelly and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, cutoffs or oxbow lakes.

High-energy bedrock features produce a variety of flow habitats for aquatic insects and fish. Pools provide refugia in low-flow conditions. Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation.

The current mapping of geomorphic river condition indicates that Brunswick River is generally ‘good’ in the upper water source and ‘moderate’ to ‘poor’ in the main channel of the Brunswick River and its lower tributaries. Habitat values in the main channel are threatened by channelisation, channel instability and lack of appropriate riparian vegetation.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form

continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. Active bed and bank erosion impacts river ecology by modifying physical habitat and reducing water quality. Altered channels are vulnerable to bank collapse, especially on outer bends. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located within the water source and was factored by area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

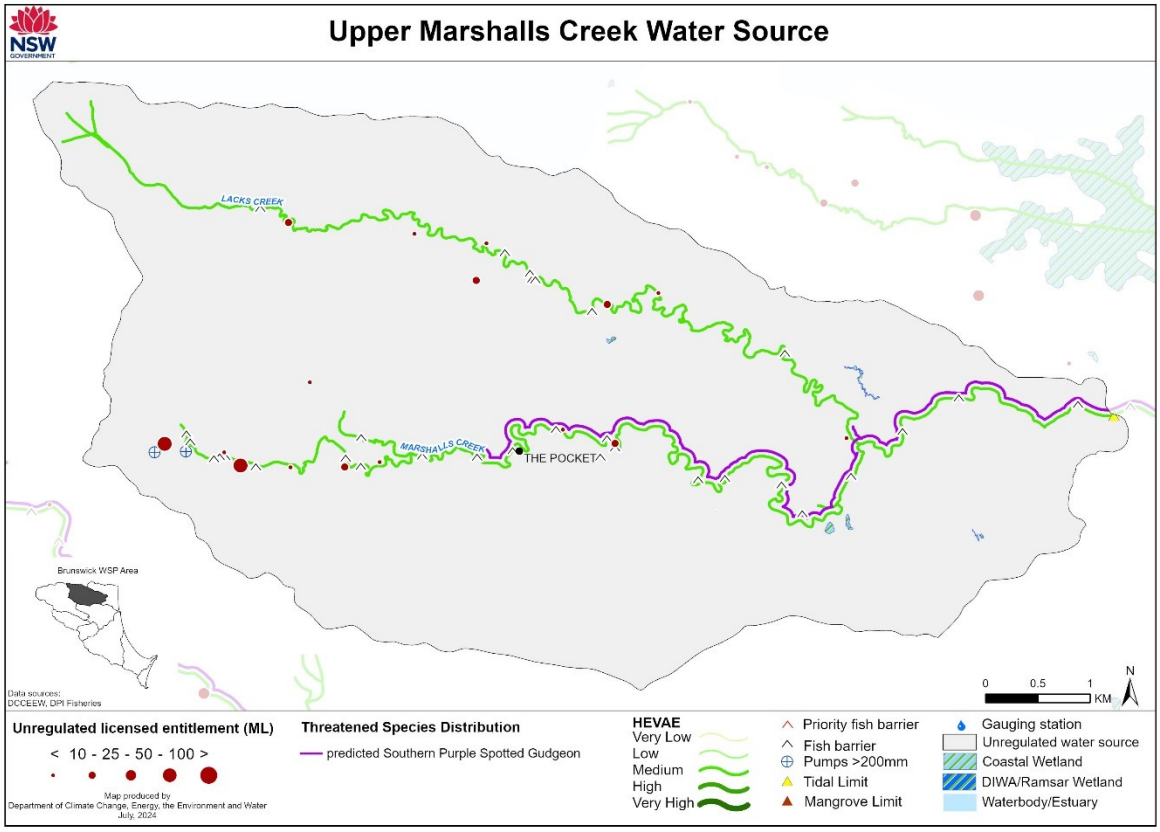
- 20th percentile (higher instream flow) 77 ML/day
- 50th percentile (typical flow) 20 ML/day
- 80th percentile (lower flow) 6 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Cease to pump rule at the reference point of Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001), which is set at the 80th percentile flow (2 ML/day). specific site in the water source, which is set at the 80th percentile flow. Commence to pump trigger, higher than the cease to pump trigger, is also established in this water source.
- Flow class established in the water source up to the C flow class, which currently are not used to limit water access.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is an inflow and outflow from the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) is permitted when cease to pump restrictions are in place.
- Water must not be taken for more than 6 hours per day when flows are less than or equal to 4 ML/day at Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001)
- Water must not be taken for 24 hours after flows at the Brunswick River at Durrumbul (Sherrys Crossing) gauge (202001) first exceed 4 ML/day following a low flow of 2 ML/day
- Certain licences are exempt from the cease to pump rules.
- Trading into water source permitted from Kings Creek and Mullumbimby Creek Water Sources only subject to no net gain above water source entitlement at the Plan's commencement. Trade within water source permitted subject to assessment.

Upper Marshalls Creek Water Source



Information presented in the report card

The quality of the habitat that aquatic species use in a water source is influenced by several factors. Three of the broad factors are:

- water quantity (either streamflow or groundwater level) and how it varies
- water quality and how it varies
- physical structure (either the riverbed and riverbanks, or the aquifer).

This report card rates the risks associated with water quantity, the water quality (where there is monitoring available) and describes the physical structures. The last section summarises current water quantity management.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Consequence Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to Medium, Naturalness = Medium to Very High, Diversity = Very Low For threatened species with the highest flow sensitivity weighting of 4 = Giant barred frog (known), Purple spotted gudgeon (predicted), Coastal petaltail (dragonfly) (predicted) Next highest flow sensitivity of 3 = Wallum froglet (known), Wallum Sedge frog (known), Green-thighed frog (predicted)
Drivers (hydraulic alteration)	Currently there is 290 shares of water entitlement (see Appendix F Table F1 for licence category breakup) distributed in the upper and middle reaches of Marshall Creek and its tributaries. The main control on extraction is a cease to pump condition triggered by visible flow at Walkers Lane crossing of Marshall Creek. Modelling indicates licensed extractions and basic landholder rights extractions, could impact zero flows and the low flows.

Water Quantity and stream flow risk	Zero Flows	Low Flows	Freshes	1.5 YR ARI^	2.5 YR ARI^	5.0 YR ARI^
Likelihood (degree of hydrological alteration)	H^{+}	H^{-}	L^{-}	L^{0}	L^{0}	L^{0}
Level of Risk	H^{+}	H^{-}	L^{-}	L^{0}	L^{0}	L^{0}

+ = increase from near-natural condition; -= decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased; ^ = high and infrequent flows; N/A = no risk outcome or modelling available due to lack of data.

Comparison of previous risk rating and this rating

Same risk rating. The new HEVAE process has reach based outcomes as opposed to the whole of water source outcomes the former macro water sharing plan classification process used. The final Macro value of Medium did not change and remains the same in this updated consequence assessment.

Upriver alluvium groundwater recharge risk from insufficient surface water

Consequence (GDE value)	High
Drivers (ecological value)	Very high distinctiveness, very high diversity, low naturalness, low vital habitat and the presence of coastal wetlands.

Groundwater recharge risk near rivers from insufficient surface water	Surface Water Entitlement Extraction	Zero Flow Periods	Low inflows (Base/Low Flows)
Likelihood (degree of hydrological alteration)	High	High	High
Level of Risk	High	High	High

Water Quality

Riverine and aquifer water quality

Monitoring of water quality was not available or not adequate to evaluate the risk of poor water quality to the riverine, or alluvial environments.

Physical Structure

The Upper Marshalls Creek Water Source contributes flow through several other water sources into Brunswick River estuary.

Riverbed and riverbanks

The main channel of Marshalls Creek and its tributaries are confined by a bedrock valley in the upper water source, opening up to a broad coastal floodplain in the lower water source. The river bed is bedrock, gravelly and fine-grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, bedrock pools, runs or glides, scour pools, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris, flood channels, backswamps and chute channels, cutoffs or oxbow lakes.

Fast-moving, shallow flow over riffles provides important habitat for many aquatic insects and fish. Deep pools with slower flow provide refugia in low-flow conditions. Large woody debris (for example, logs) provide shelter for fish and substrate for aquatic algae and plants to grow on. Debris also provides roughness to reduce erosion risk. Sediment bars provide instream habitat by modifying water depth and introducing different sized sediment to the river bed. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. Flood channels of various types only carry flow in high-flow conditions, but often hold water in pools or wetland-like conditions long after high flows have ceased. These features provide important habitat for aquatic and terrestrial fauna, including breeding sites for waterbirds.

The current mapping of geomorphic river condition indicates that Marshalls Creek is generally ‘good’ in the upper water source and ‘poor’ in the main channel of Marshalls Creek. Habitat values in the main channel are threatened by channelisation and lack of appropriate riparian vegetation.

Lack of appropriate vegetation within and surrounding the river channel increases vulnerability to damaging erosion and to invasive weed incursion and reduces key habitat for aquatic organisms. Loss of riparian vegetation is associated with higher water temperatures, greater rates of gross primary production and increased runoff rates. Modification of natural watercourses to form continuous channels in swampy areas reduces the ability of floodplains to hold water and provide habitat. See Appendix G Threatening geomorphic processes, Figure G1 for locations.

Hydrology

For this water source the 202001 gauge was used. This gauge is located in an adjacent stream (in another water source) and was factored for area.The flow records used cover the period(s) 02/11/1954 to 21/04/2020. Estimates of the factored flows for this water source are:

- 20th percentile (higher instream flow) 50 ML/day
- 50th percentile (typical flow) 13 ML/day
- 80th percentile (lower flow) 4 ML/day

Water Quantity Management

Current water sharing plan mechanisms

- Visible flow cease to pump rule at the reference point at Walkers Lane crossing of Upper Marshalls Creek.
- An 'A' flow class established in the water source.
- Visible flow condition at the pump site (if extraction is from an in-river pool, extraction can only occur when there is an inflow and outflow from the pool from which the pump extracts).
- The cease to pump rule does not apply to the upland alluvial groundwater licences.
- Pumping from in-river dams (for example, weirs) is permitted when cease to pump restrictions are in place.
- Water must not be taken when flows passing through the box culvert pipe, located at The Pocket road crossing near the southern boundary of Lot 1 DP 123296, Parish of Billinudgel, County of Rous, are less than 50 millimetres in depth.
- Trading permitted into water source subject to no net gain above total licensed entitlement in the water source at the Plan’s commencement. Trading within water source permitted, subject to assessment.

For more information on HEVAE and the decision tree process, refer to the Coastal Risk Assessment methods document 2023.

6.2 Appendix B Threatened species populations and endangered ecological communities

Table B 1: List of threatened species populations and endangered ecological communities used in the Distinctiveness Criteria for the Far North Coast area. Note that the Brunswick River Unregulated and Alluvial Water Sharing Plan is a subset of this list. Note that flow sensitivity weightings rank the reliance of a threatened species, population or endangered ecological community (EEC) to river or stream flow. The higher the reliance on stream flow the higher the weighting. Status weighting is a combined ranking of NSW and Commonwealth status based on Vulnerable, Endangered and Critically Endangered status categories

Common Name	Scientific Name	Abbreviation	Distinctiveness Parameter	NSW Status	Commonwealth listing	Flow Sensitivity Weighting	Status Weights
Lowland Rainforest on Floodplain in the New South Wales	Lowland Rainforest on Floodplain in the New South Wales	LRFNCeec	EEC	EEC	Critically Endangered	4	4
Montane Peatlands and Swamps of the New England Tableland	Montane Peatlands and Swamps of the New England Tableland	MPSeec	EEC	EEC	Endangered	4	3
Eastern freshwater cod	*Maccullochella ikei*	EFCfish	Fish	Endangered	Endangered	4	3
Oxleyan pygmy perch	*Nannoperca oxleyana*	OPPfish	Fish	Endangered	Endangered	4	3
Purple spotted gudgeon	*Mogurnda adspersa*	PSGfish	Fish	Endangered	Not listed	4	3
Booroolong frog	*Litoria booroolongensis*	BRfrog	Frog	Endangered	Endangered	4	3
Fleay's barred frog	*Mixophyes fleayi*	FBfrog	Frog	Endangered	Endangered	4	3
Giant barred frog	*Mixophyes iteratus*	GBAfrog	Frog	Endangered	Endangered	4	3
Mountain frog	*Philoria kundagungan*	MOFfrog	Frog	Endangered	Not Listed	4	3
Philoria richmondensis	*Philoria richmondensis*	PHRfrog	Frog	Endangered	Not Listed	4	3
Stuttering barred frog	*Mixophyes balbus*	STBfrog	Frog	Endangered	Vulnerable	4	3
Coastal Petaltail (dragonfly)	*Petalura litorea*	CPaqua	Other Aquatic	Endangered	Not Listed	4	3
Green and golden bell frog	*Litoria aurea*	GGBfrog	Frog	Endangered	Vulnerable	3	3
Green-thighed frog	*Nyctimystes brevipalmatus*	GRTfrog	Frog	Vulnerable	Not listed	3	2
Loveridge's frog	*Philoria loveridgei*	LVGfrog	Frog	Endangered	Not Listed	3	3
Wallum froglet	*Crinia tinnula*	WAfrog	Frog	Vulnerable	Not Listed	3	2
"Olongburra Frog	*Litoria olongburensis*	WSfrog	Frog	Vulnerable	Vulnerable	3	2

Common Name	Scientific Name	Abbreviation	Distinctiveness Parameter	NSW Status	Commonwealth listing	Flow Sensitivity Weighting	Status Weights
Wallum sedge frog"							
Giant Dragonfly	*Petalura gigantea*	GDaquatic	Other Aquatic	Vulnerable	Not listed	3	2
Maundia triglochinoides	*Maundia triglochinoides*	MTpl	Plant	Vulnerable	Not listed	3	2
Australasian Bittern	*Botaurus poiciloptilus*	ABITbird	Bird	Endangered	Endangered	2	3
Australian Painted snipe	*Rostratula australis*	APSbird	Bird	Endangered	Endangered	2	3
Blue-billed Duck	*Oxyura australis*	BBDbird	Bird	Vulnerable	Not Listed	2	2
Broad-billed Sandpiper	*Limicola falcinellus*	BBSbird	Bird	Vulnerable	Not Listed	2	2
Black bittern	*Ixobrychus flavicollis*	BBTbird	Bird	Vulnerable	Not Listed	2	2
Black-necked stork	*Ephippiorhynchus asiaticus*	BNSbird	Bird	Endangered	Not Listed	2	3
Brolga	*Grus rubicunda*	BRbird	Bird	Vulnerable	Not Listed	2	2
Black-tailed Godwit	Limosa limosa	BTbird	Bird	Vulnerable	Not Listed	2	2
Comb-crested Jacana	*Irediparra gallinacea*	CCJbird	Bird	Vulnerable	Not Listed	2	2
Cotton Pygmy-Goose	*Nettapus coromandelianus*	CPGbird	Bird	Endangered	Not Listed	2	3
Curlew Sandpiper	*Calidris ferruginea*	CUSRbird	Bird	Endangered	Critically Endangered	2	4
Eastern Curlew	*Numenius madagascariensis*	ECbird	Bird	Not listed	Critically Endangered	2	4
Freckled duck	*Stictonetta naevosa*	FDbird	Bird	Vulnerable	Not Listed	2	2
Great Knot	*Calidris tenuirostris*	GKbird	Bird	Vulnerable	Critically Endangered	2	4
Greater Sand-plover	*Charadrius leschenaultii*	GSPbird	Bird	Vulnerable	Not Listed	2	2
Lesser Sand-plover	*Charadrius mongolus*	LSPbird	Bird	Vulnerable	Not Listed	2	2
Magpie Goose	*Anseranas semipalmata*	MGbird	Bird	Vulnerable	Not Listed	2	2
Pale-vented Bush-hen	*Amaurornis moluccana*	PVBHbird	Bird	Vulnerable	Not Listed	2	2
Sanderling	*Calidris alba*	SDbird	Bird	Vulnerable	Not Listed	2	2
Terek Sandpiper	*Xenus cinereus*	TSbird	Bird	Vulnerable	Not Listed	2	2

Common Name	Scientific Name	Abbreviation	Distinctiveness Parameter	NSW Status	Commonwealth listing	Flow Sensitivity Weighting	Status Weights
Freshwater Wetlands on Coastal Floodplains of the NSW	Freshwater Wetlands on Coastal Floodplains of the NSW	FWCFeec	EEC	EEC	Not listed	2	3
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW	SSFCFeec	EEC	EEC	Not listed	2	3
Greater Broad-nosed Bat	*Scoteanax rueppellii*	GBBmam	Mammal	Vulnerable	Not listed	2	2
Southern Myotis (bat)	*Myotis aelleni*	SMmam	Mammal	Vulnerable	Not listed	2	2
Tall Knotweed	*Persicaria elatior*	TKpl	Plant	Vulnerable	Vulnerable	2	2
Eastern Osprey	*Pandion cristatus*	OSbird	Bird	Vulnerable	Not Listed	1	2
Lowland Rainforest in the NSW North Coast and Sydney Basin	Lowland Rainforest in the NSW North Coast and Sydney Basin	LRNCSBeec	EEC	EEC	Critically Endangered	1	4
Subtropical Coastal Floodplain Forest of the NSW	Subtropical Coastal Floodplain Forest of the NSW	SCFNCeec	EEC	EEC	Not listed	1	3
Pouched Frog	*Assa darlingtoni*	POFfrog	Frog	Endangered	Not Listed	1	3
Brush Saropus	*Phyllanthus microcladus*	BSpl	Plant	Endangered	Not Listed	1	3
Oldenlandia galoides	*Oldenlandia galioides*	OGpl	Plant	Endangered	Not Listed	1	3
Rotala tripartita	*Rotala tripartita*	RTpl	Plant	Endangered	Not listed	1	3
Swamp Foxglove	*Centranthera cochinchinensis*	SFpl	Plant	Endangered	Not listed	1	3
Slender Screw Fern	*Lindsaea incisa*	SSFpl	Plant	Endangered	Not listed	1	3
Southern Swamp Orchid	*Phaius australis*	SSOpl	Plant	Endangered	Endangered	1	3
Waterwheel Plant	*Aldrovanda vesiculosa*	WPpl	Plant	Endangered	Not Listed	1	3

6.3 Appendix C Summary of known flow requirements

The details provided here explain the river flow requirements for some environmental values/assets that may occur in a water sharing plan area. For each value, details are provided about the important times for ecological needs and links to specific types of river flows. These details are supported by key documents that describe these river flow needs. Flow needs may be different between each of the values shown here. Not all values or assets occur in every water source.

6.3.1 Native fish

Native fish are those who live primarily in the freshwater parts of rivers and may or may not move to and from the saltwater areas in estuaries to breed.

Australian Bass

Australian Bass, Macquaria novemaculeata. Source: Tarmo Raadik. License: All rights reserved

A popular recreational fish that moves between freshwater and salt water to breed when higher river flows occur.

Figure C 1: Australian Bass. (Source: Fishes of Australia)

Table C 1: Australian Bass - Summary of the known flow requirements, critical month(s), life-history, and related literature reference.

Importance (life history or other)	Critical month(s)	Flow requirement	References
Pre-breeding migration downstream to estuary	May – Jul Can differ slightly between northern NSW populations and southern NSW populations	Baseflow, medium to high flows, and optimal river height (0.2m>) and sub-optimal (0.15-0.2m)	DPIE Water (2021) Reinfelds et al. (2013) Harding et al. (2017) Bonetti et al. (2016)
Post-breeding migration upstream to freshwater	Aug-Oct	Bass migrate well into headwaters and probably move incrementally upstream. Baseflow, flow pulses (freshes), and optimal river height (>0.2m) and sub-optimal (0.15-0.2m).	As above

Importance (life history or other)	Critical month(s)	Flow requirement	References
Juvenile migration to freshwater reaches	Jan-May	Juveniles are weaker swimmers than adults, but maximum flow thresholds are unknown. At a minimum it would require multiple connecting flows during the migratory season	As above

Eel-Tailed catfish

Freshwater Catfish, Tandanus tandanus. Source: Gunther Schmida / http://www.guntherschmida.com.au. License: CC BY Attribution-Noncommercial-ShareAlike

Is a species native to the Murray-Darling River system. These fish prefer slow-moving streams, lakes, and ponds with plenty of fringing vegetation.

Figure C 2: Eel-Tailed catfish. (Source: Fishes of Australia)

Table C 2: Eel-Tailed catfish - Summary of the known flow requirements, critical month(s), life-history, and related literature reference.

Importance (life history or other)	Critical month(s)	Flow requirement	References
Reproduction and migration	Sep-Mar	Spawning enhanced by flow increase during spring.	DPI Fisheries (2019) Koehn et al. (2020)
Egg and larval drift	Sep-Mar	Water level (baseflows) needs to be maintained for at least 14 days during nesting to prevent nest abandonment	As above

Importance (life history or other)	Critical month(s)	Flow requirement	References
Juvenile dispersal	post-spawning	Facilitated by second small in-channel peak event. Larval drift over short to moderate scales for up to 10 days, with recruitment relying on flows for dispersal and conditioning.	As above

Purple spotted gudgeon

Southern Purplespotted Gudgeon, Mogurnda adspersa. Source: Gunther Schmida / http://www.guntherschmida.com.au. License: CC BY Attribution-Noncommercial-ShareAlike 3.0

Typically inhabits calm rivers, creeks, and wetlands with plenty of underwater vegetation, branches, and rocks for cover.

Figure C 3: Purple spotted gudgeon. (Source: Fishes of Australia)

Table C 3: Purple spotted gudgeon - Summary of the known flow requirements, critical month(s), life-history, and related literature reference.

Importance (life history or other)	Critical month(s)	Flow requirement	References
Reproduction and migration/General ecology	Spring	Low-flow, slow moving streams, instream pools and wetlands typically require aquatic vegetation or cover from overhanging edge vegetation. Fluctuations in water level as a result of regulation and/or extraction may have negative impacts on reproduction and recruitment. Appears sensitive to high flow and velocities and when oxygen concentration drop below 3 mg/L. This species tends not to disperse widely. Generally found in streams with a permanent baseflow therefore providing low flows that enable hydrologic connectivity is important to protect populations.	Stoffels et al. (2010) Hammer et al. (2012) NSW DPI (2015) NSW DPI (2017)
Egg and larval drift	Spring	Spawning may be maximised with increasing flow inundating spawning habitat. Eggs are laid on aquatic vegetation, rocks or logs and is ideal in very low flows. Larval drift unlikely.	As above
Juvenile dispersal	Spring to early Summer	Because of noted limited dispersal or movement in adults and larvae, juveniles are likely to have the same limited dispersal requirements. However, this may be influenced by an increase in stream flows.	As above

6.3.2 Flow dependent frogs

Giant barred frog

Giant Barred Frogs are very large (up to 115mm long) and powerfully built. They are found along freshwater streams with permanent or semi-permanent water, generally (but not always) at lower elevation.

Figure C 4: Giant barred frog. Image: Peter Richards. NSW DCCEEW (2024a).

Table C 4: Giant barred frog - Summary of the known flow requirements, critical month(s), life-history, and related literature reference.

Importance (life history or other)	Critical month(s)	Flow requirement	References
Breeding (oviposition or egg deposition) is in-stream, then eggs are 'kicked' onto riparian substrates and overhangs for hatching.	Oct – Feb	Requires shallow flowing water (very low flows and baseflows) through riffle zones for egg deposition	Anstis (2017) NSW DCCEEW (2024a).
Metamorphosis from tadpole to frog	Year round (up to 14 months from hatching)	Avoid cease-flow periods to ensure pool habitats are suitable for tadpole development	As above
Occurs in riparian zones along permanent or semi-permanent streams.	Year round	Avoid cease-flow periods to ensure pool habitats are suitable for egg-laying	As above

6.3.3 Macroinvertebrates

Flow-dependent macroinvertebrate communities

Flow-dependent macroinvertebrates such as caddisflies and beetles, are typically found in streams with lots of riffles. A riffle habitat is an area of fast moving, broken water over cobble or boulder substrate.

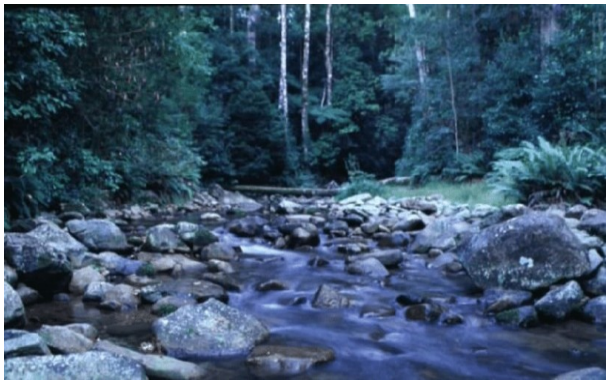


Figure C 5: Flow-dependent macroinvertebrates (From left to right: Top row – Hydropsychidae, Simulidae. Middle row – Dytiscidae, Elmidae, Psephenidae, Helicopsychidae. Bottom row - Corydalidae, Gyrinidae. Source: Macroinvertebrates.org).

Good riffle habitat at Cockerawombeeba Ck, Hastings River catchment on the mid-north coast of NSW (Source: Turak et al., 2004).

Table C 5: Flow-dependent macroinvertebrate communities - Summary of the known flow requirements, critical month(s), life-history, and related literature reference

Importance (life history or other)	Critical month(s)	Flow requirement	References
Protect macroinvertebrate diversity and abundance within flowing habitats (riffles, runs and rivulets)	All year	Maintaining a baseflow or low flow to protect flowing habitats (riffles, runs and rivulets) between pools	Brooks et al. (2011) Brooks et al. (2005) Brooks and Haeusler (2016) Clunie and Koehn (2001) Coleman and Brooks (2020) Cabot et al. (2021) Davis (1977) Kaminskas and Humphries (2009) Leigh and Datry (2017) Miller and Golladay (1996) Pusey et al. (2010) Reich and Downes (2003) Rolls et al. (2012) Sternberg et al. (2008) Warburton et al. (1998) Wedderburn et al. (2014) Wood et al. (2022)
Protect food resources (macroinvertebrates) for native fish and other predators	All year	Maintain a minimum flow to prevent cease to flow events	As above

6.3.4 Water dependant mammals

Platypus

Platypuses are carnivorous and primarily feed on aquatic invertebrates, such as insect larvae, worms, and freshwater shrimp. They use their sensitive bills to detect prey in the water.

Figure C 6: Platypus. (Image: M Bannerman/DPE, Platypus | Native Animals | Environment and Heritage, n.d.)

Table C 6: Platypus - Summary of the known flow requirements, critical month(s), life-history, and related literature reference

Importance (life history or other)	Critical month(s)	Flow requirement	References
Refugia and habitat	All Year	Reducing zero flows or cease to flow events to protect refugia habitat and provide connectivity of habitats.	Bino et al. (2015) Bino et al. (2021) Bino et al. (2019) Coleman et al. (2022) Hawke et al. (2019) Serena and Grant (2017) Klamt et al. (2016)
Foraging habitat	Autumn - Spring	Maintaining a baseflow to protect access to lotic (riffles, runs and rivulets) habitat for foraging, especially in the lead up to breeding season	As above
Dispersal during mating season	Later Winter-Spring	Maintaining river connectivity between pools for adult dispersal in critical periods	As above

6.4 Appendix D Water Quality Data

Table D 1: Median water quality data for sites upstream of the tidal limits of the Brunswick Unregulated and Alluvial Water Sharing Plan area

Water Quality Site: SC22 - Simpsons Creek at Tyagarah (Tyagarah Creek Water Source)

Year	Conductivity (µS/cm)	Dissolved Oxygen (%Sat)	Nitrogen Oxidised (mg/L)	Nitrogen Total (mg/L)	pH	Phosphorus Soluble Reactive (mg/L)	Phosphorus Total (mg/L)	Suspended Solids (mg/L)	Temperature (°C)	Turbidity Field (NTU)
2018-2019	167.5	N/A	0.02	0.40	6.50	0.02	0.105	16	N/A	24
2019-2020	140.5	N/A	0.02	0.42	6.40	0.025	0.115	3.75	N/A	12.75
2020-2021	129.0	N/A	N/A	N/A	6.50	0.02	0.12	8	N/A	8.8
2021-2022	135.5	N/A	N/A	N/A	6.35	0.02	0.115	14.5	N/A	16
2022-2023	143.0	N/A	N/A	N/A	6.30	0.02	0.05	2	N/A	6.5
Water Quality guidelines (Lowland zone, <150m)	350	85-110%	0.04	0.35	6.5–8.0	0.02	0.05	N/A	N/A	25

N/A = no available data. Values highlighted in red are outside the water quality target.

6.5 Appendix E Current and historical gauges in the Brunswick Unregulated and Alluvial water sharing plan

The following tables in Appendix E list the gauges in the Brunswick plan area. Gauges may be:

- active and listed in the water sharing plan as a reference point
- active but not listed in the water sharing plan
- historical or discontinued where the gauges have been closed or moved to another organisation to maintain. Refer to WaterNSW to obtain information regarding these gauges.

Additional comments are included to assist Surface Water Science and Planning with their current assessment and flow management options.

Table E 1: Details on Brunswick Unregulated water sharing plan gauges (reference points) in each water source. Focused only on surface water extraction. Based on Sect 44 & 45 in the Brunswick water sharing plan 2016 & Brunswick rule summary sheet. The additional comments section highlights the water source priority ranking where medium or greater effort was required during the evaluation of the water sharing plan.

Water source name	Reference point	Rule	Is it shown in the report card water source map	Additional comments
Belongil Creek Water Source	Pump site or natural pool	NVF@pump site = access rule Other CtP rule is: Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity.	N/A	nil
Kings Creek Water Source	Brunswick River at Durrumbul gauge (202001)	Pumping is not permitted when flow is less than 2 ML/day at the reference point.	No. See Mullumbimby Creek Water Source	Daily pumping restriction apply when flows are < 4ML/d
Lower Brunswick River Water Source	Pump site or natural pool	NVF@pump site = access rule Other CtP rule is: Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity	N/A	nil
Lower Marshalls Creek Water Source	Tweed Valley Way crossing of Yelgun Creek	No visible flow (NVF) at reference point.	N/A	nil

Water source name	Reference point	Rule	Is it shown in the report card water source map	Additional comments
Mullumbimby Creek Water Source	Brunswick River at Durrumbul gauge (202001)	Pumping is not permitted when flow is less than 2 ML/day at the reference point.	No. See Upper Brunswick River Water Source	Medium priority water source. **Included in WSP evaluation.**
Tallow Creek Water Source	Pump site or natural pool	NVF@pump site or; Other CtP rule is: Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity.	N/A	nil
Tyagarah Creek Water Source	Pacific Highway crossing of Tyagarah Creek	No visible flow (NVF) at reference point.	N/A	nil
Upper Brunswick River Water Source	Brunswick River at Durrumbul gauge (202001)	Pumping is not permitted when flow is less than 2 ML/day at the reference point.	Yes	Medium priority water source. **Included in WSP evaluation.**
Upper Marshalls Creek Water Source	Walkers Lane crossing of Upper Marshalls Creek	No visible flow (NVF) at reference point.	N/A	nil

Table E 2: Brunswick basin - Full list of current gauges

(Source: NSW River Styles and HEVAE (argis.com)). Current (active) gauges can be found on WaterNSW Real Time data.

Active gauges listed in water sharing plan	Gauge number	Site commence date
Brunswick River at Durrumbul gauge	202001	21-Oct-1954
Active gauges, NOT listed in water sharing plan	**Gauge Number**	**Site commence date**
Burringbar Creek at Burringbar	202002	21-Jun-2006

Table E 3: Brunswick basin - Full list of historical (discontinued) gauges (from Pinneena list 2011)

Water Source Name	Historical (discontinued) gauge name	Gauge number
Upper Marshalls Creek	Marshalls Creek at Billinudgel	202400

6.6 Appendix F Water source entitlements (Share Component) 2023/2024

Table F 1: Summary of water source entitlements in 2023/2024 for the Brunswick Unregulated and Alluvial Water Sharing Plan area. Units are in shares (In recent years water accounts have been allocated 1 ML per share each year). Source: NRAR Water Licencing System

Water source	Aquifer	Domestic and stock	Unregulated river	Grand total
Brunswick River Coastal Floodplain Alluvial Groundwater Source	23	N/A	N/A	23
Kings Creek Water Source	N/A	18	15	33
Lower Brunswick River Water Source	N/A	N/A	5	5
Lower Marshalls Creek Water Source	40	1	208	249
Mullumbimby Creek Water Source	N/A	1	96	97
Tallow Creek Water Source	N/A	N/A	103	103
Tyagarah Creek Water Source	5	1	1,060.5	1,066.5
Upper Brunswick River Water Source	29	3	659	691
Upper Marshalls Creek Water Source	13	5	271	289
Grand Total	**110**	**29**	**2,417.5**	**2,556.5**

6.7 Appendix G Threatening geomorphic processes

Maps showing the location of some of the larger threatening geomorphic processes in the Brunswick water sharing plan area. Descriptions of the processes are in each report card in Appendix A. These processes are a result of changes in landuse and stream flow that may affect the ecological function.

Examples of degrading processes are channel erosion and excess sediment supply that partly or wholly infill pools that provide refuge. These impacts also restrict longitudinal connectivity along with smothering instream habitats, reducing diversity. A reduction in pool depth along with loss of vegetation cover leads to an increase in water temperature and evaporative losses, requiring higher cease to flow levels to protect ecological refuges.

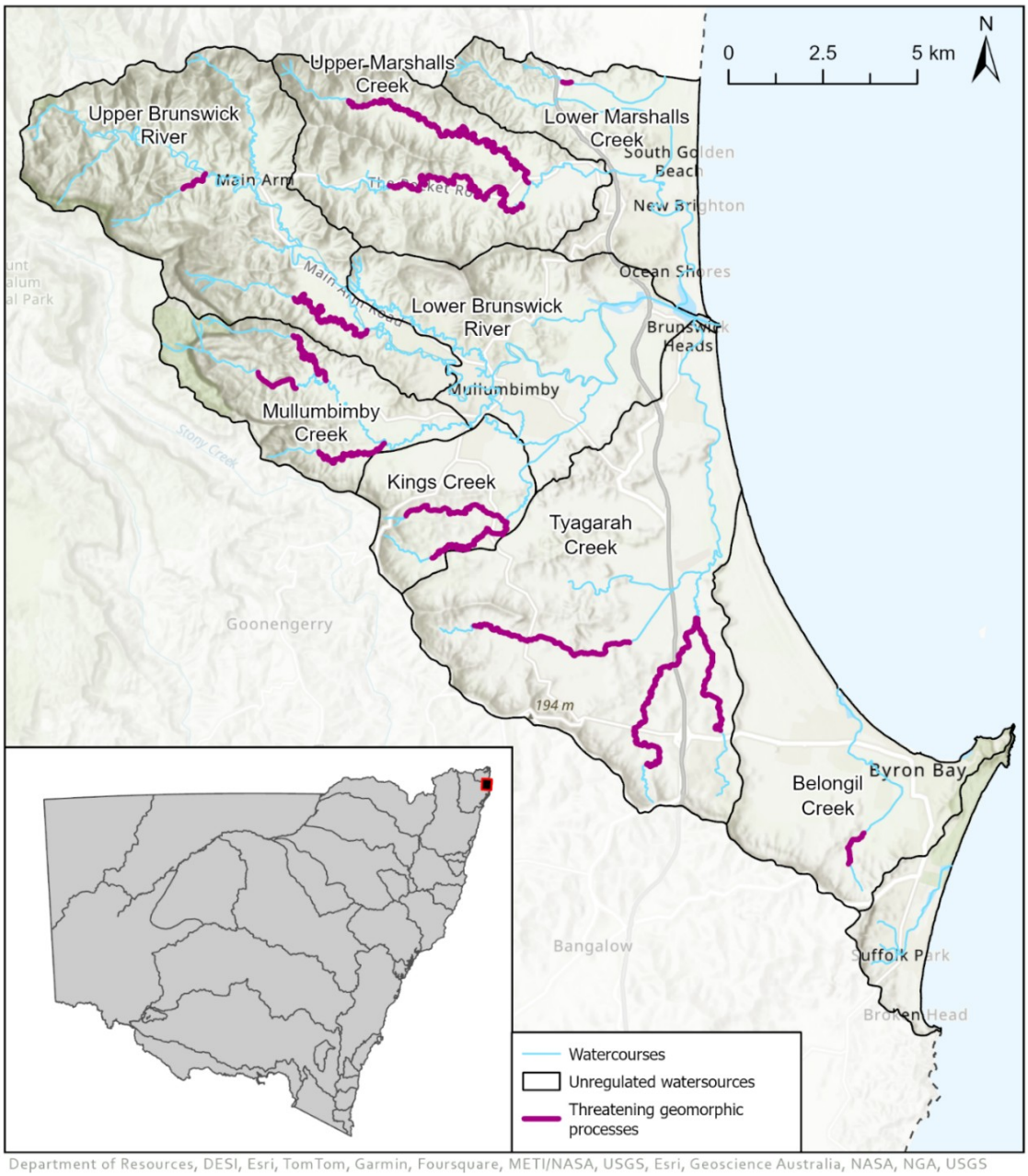


Figure G 1: Location of major geomorphic threatening process in the Brunswick catchment area. Refer to Appendix A Water source report cards for details.

6.8 Appendix H Summary of proposed rules for high or medium risk water sources in the Brunswick 2027 Water Sharing Plan (current May 2026)

The table below outlines the current rule, proposed rule, the reasons for the proposed rule and the date the proposed rule was endorsed for the water sources in the Brunswick water sharing plan area.

Table H 1: Summary of proposed rules for high or medium risk water sources the Brunswick 2027 Water Sharing Plan (current May 2026)

Water Source	Consequence	Likelihood	Risk	Rule	Proposed Rule	Reason	Date endorsed
Lower Brunswick River	MEDIUM	Zero flows: HIGH Low flows: LOW	Zero flows: HIGH Low flows: LOW	ACDLs	Prohibited	No suitable gauge	12/03/2025
				Trade	Trade permitted with no net gain from Kings Creek, Mullumbimby Creek, and Upper Brunswick River Water Sources only.	No net gain as high likelihood rating at zero flows.	24/03/26
				HFCs	Prohibited	No suitable gauge. Low entitlement (5ML <50ML). Tidal influence. High mangroves and saltmarsh value.	12/03/2025
				In-river dams	Prohibited	Adjacent to Cape Byron Marine Park.	12/03/2025
				Access	Visible flow at point of take. No drawdown of in-river pools or off-river pools. Groundwater extraction from waterfront land limited by surface water access rules.	No suitable gauge Low entitlement (5ML/year). Risk is driven by extraction from upstream water sources and access rules for Upper Brunswick water source have been reviewed and are proposed to be more restrictive which is expected to reduce the risks in this water source.	04/03/26

Water Source	Consequence	Likelihood	Risk	Rule	Proposed Rule	Reason	Date endorsed
Lower Marshalls Creek	MEDIUM	Zero flows: HIGH Low flows: HIGH	Zero flows: HIGH Low flows: HIGH	ACDLs	Prohibited	No suitable gauge	12/03/2025
				Trade	Trade in prohibited	No suitable gauge High likelihood rating at zero and low flows.	02/04/26
				HFCs	Prohibited	No suitable gauge	12/03/2025
				In-river dams	Prohibited	Adjacent to Cape Byron Marine Park.	12/03/2025
				Access	Visible flow at flow reference point. No drawdown of in-river pools or off-river pools. Groundwater extraction from waterfront land limited by surface water access rules.	No suitable gauge.	04/03/26
Tyagarah Creek	MEDIUM	Zero flows: HIGH Low flows: HIGH	Zero flows: HIGH Low flows: HIGH	ACDLs	Prohibited	No suitable gauge	12/03/2025
				Trade	Trade in prohibited	The water source is hydrologically disconnected until below the limit of the plan (mangrove limit).	04/03/26
				HFCs	Prohibited	No suitable gauge. Tidal influence. High mangroves and saltmarsh value.	12/03/2025
				In-river dams	Prohibited	Adjacent to Cape Byron Marine Park	12/03/2025
				Access	Visible flow at flow reference point No drawdown of in-river pools or off-river pools. Groundwater extraction from waterfront land limited by surface water access rules.	No suitable gauge.	04/03/26

Water Source	Consequence	Likelihood	Risk	Rule	Proposed Rule	Reason	Date endorsed
Upper Brunswick River	MEDIUM	Zero flows: HIGH Low flows: MEDIUM	Zero flows: HIGH Low flows: MEDIUM	ACDLs	Prohibited	Gauge highly variable. 50th percentile < 20 ML/day	12/03/2025
				Trade	Trade into water source permitted from Kings Creek, Mullumbimby and Lower Brunswick Water Source only subject to no net gain above water source entitlement at the Plan's commencement.	No net gain as high likelihood rating at zero flows.	04/03/26
				HFCs	Prohibited	Gauge highly variable. 50th percentile< 20 ML/day	12/03/2025
				In-river dams	Prohibited	Adjacent to a water source that influences the Cape Byron Marine Park.	12/03/2025
				Access	Cease to pump when flows @ GS202001 are: • 2 ML/d for the months November to May (inclusive) • 8 ML/day for the months June to October (inclusive). Pumping restrictions for November to May: - 6 hours/day when flows are between 2ML/day and less than 6 ML/d - 24-hour commence to take 6 ML/day following a low flow of 2 ML/day No drawdown of in-river pools or off-river pools. Groundwater extraction from waterfront land limited by surface water access rules.	Proposing environmental water requirements to protect a proportion of flows for fish (Australian Bass) and environment.	24/03/26

Water Source	Consequence	Likelihood	Risk	Rule	Proposed Rule	Reason	Date endorsed
Upper Marshalls Creek	MEDIUM	Zero flows: HIGH Low flows: HIGH	Zero flows: HIGH Low flows: HIGH	ACDLs	Prohibited	No suitable gauge	12/03/2025
				Trade	Trade in prohibited	No suitable gauge High likelihood rating at zero and low flows	02/04/26
				HFCs	Prohibited	No suitable gauge	12/03/2025
				In-river dams	Prohibited	Adjacent to a water source that influences the Cape Byron Marine Park.	12/03/2025
				Access	Visible flow at flow reference point No drawdown of in-river pools or off-river pools. Groundwater extraction from waterfront land limited by surface water access rules.	Retain existing rule as no suitable gauge and MEDIUM risk	04/03/26
Brunswick River Coastal Floodplain Alluvial Groundwater Source	HIGH	HIGH	HIGH	ACDLs	Up to 100 ML/year		19/02/2025
				Trade	No trade in	Prohibited under Access licence dealings Principles Order	04/03/26
				HFCs	N/A		
				In-river dams	N/A		
				Access	Nil	Not highly connected to surface water Low entitlement (23ML/yr) compared to recharge (2,602ML/yr) No monitoring bores. Local impacts (groundwater level drawdown) managed by S324 Orders for current extractions and by application assessments and distance rules in water sharing plans for new works.	19/02/2025