SURFACE WATER SCIENCE

Risk assessment for the Towamba River unregulated and alluvial water sources 2021

Evaluating risks to water dependent ecosystems and other uses

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NSW Environment, Energy and Science-Atlas of NSW Wildlife data

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NSW DPI Fisheries Fish Community Status and Threatened Species data

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NSW DPI Fisheries Fish Barrier database

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Acronyms and Definitions

Acronym	Meaning
ACT	Australian Capital Territory
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BF	Baseflow
BLR	Basic landholder right
BOM	Bureau of Meteorology
Class Licence	Licences that allow water extraction to occur when a defined flow class (A, B, C) is present (see flow classes definitions).
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.
CWP	Cold Water Pollution
DIPNR	Department of Infrastructure, Planning and Natural Resources
DLWC	Department of Land and Water Conservation
DO	Dissolved oxygen
DPE	Department Planning and Environment
DPI	Department of Primary Industries
DPIE	Department Planning, industry and Environment (DPE predecessor)
DWE	Department of Water and Energy
DWMS	Drinking Water Management System
EC	Electrical Conductivity
EEC	Endangered Ecological Community

Acronym	Meaning
EES	Environment, Energy and Science
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 rivers flow regime is characterised by its size and duration of various flows. How often a flow of a particular size occurs (percentile; volume of flow vs days of that flow) is used in unregulated river systems to determine CtP and daily extraction limits. Generally, three flow classes are defined above the CtP flow. 1 – very low flows 2 – ‘A’ class, low flows, generally CtP to 80^{th} percentile 3 – ‘B’ class, moderate flows, generally 50^{th} to 80^{th} percentile 4 – ‘C’ class, high flows, generally 0 to 50^{th} percentile
GDE	Groundwater Dependant Ecosystem
HEVAE	High Ecological Value Aquatic Ecosystem
IBRA	Interim Biogeographic Regionalisation for Australia
AS/NZS/ISO	Australian and New Zealand International Standard Organisation
MAXENT	Maximum entropy
MDBA	Murray Darling Basin Authority
ML	Megalitres
MZ	Management Zone
N/A	Not Applicable
NHMRC	National Health and Medical Research Council
NOx	Nitrite/nitrate
NRMMC	Natural Resource Management Ministerial Council
NSW	New South Wales
NTU	Nephelometric Turbidity Units

Acronym	Meaning
OB	Overbank
OEH	Office of Environment and Heritage
POELA	Protection of the Environment Legislation Amendment
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.
TSS	Total suspended solids
WA	Western Australia
WQ	Water Quality
WSP	Water Sharing Plan
WWTP	Wastewater Treatment Plant
YR	Year

Summary

Risk-based management assists water managers to prioritise and direct time and effort to monitor, mitigate, or respond to the factors that pose the highest overall risks. It ensures that management is targeted, efficient and effective, and when used adaptively, is an excellent tool for determining where future management and monitoring effort is required. NSW has been implementing a risk-based water planning process in unregulated rivers since 2004.

The risk assessment for the Towamba River unregulated and alluvial Water Sharing Plan Area follows the process illustrated in Figure 1.

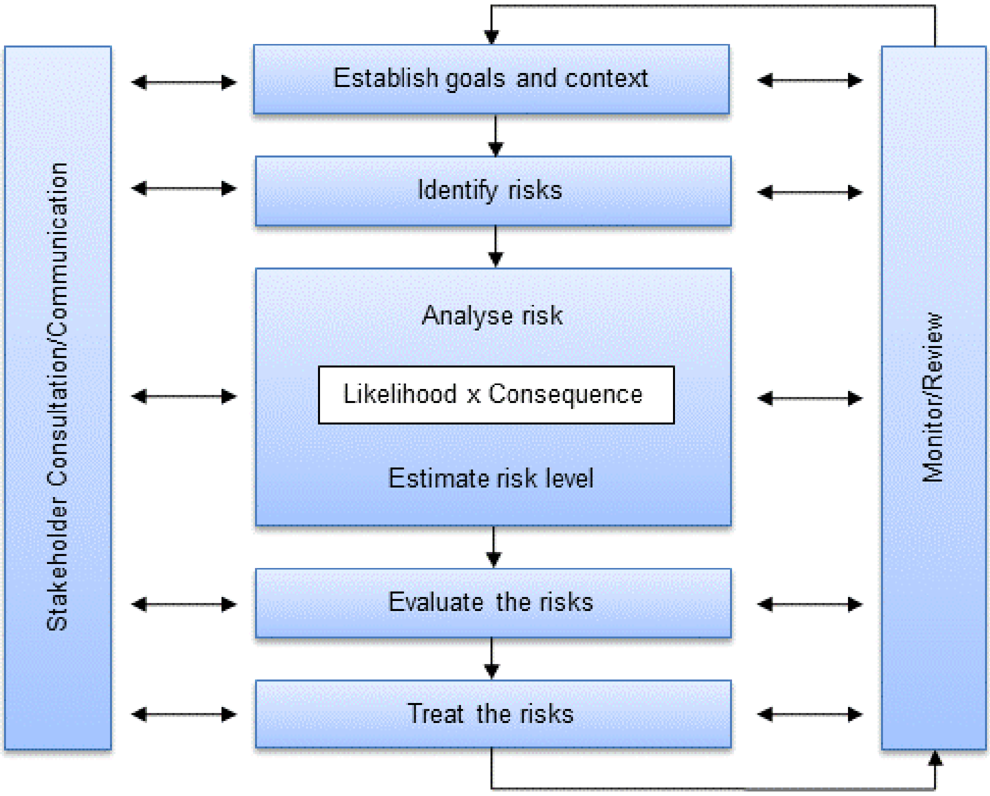

Figure 1: The risk management process. (Adopted from Standards Australia 2009; AS/NZS ISO 31000:2009)

A summary risk table has been developed for the Towamba River unregulated and alluvial WSP area to capture the key risk outcomes and potential management strategies. Key elements of the summary include identification of the risk causes, threats and impacts, consequence and likelihood metrics, existing water management actions and mechanisms, and risk outcomes. The consolidated 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 Towamba River Unregulated and Alluvial Water Sources 2010*.

Individual Water Source report cards that provide more detailed information are also available in Appendix A.

Summary Risk Table

The following summary tables have been extracted from their relevant sections to provide a brief overview. Refer to relevant sections for detailed information.

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY

		Previous Results				Current Results		
Unregulated water source	**Flow or Extraction Characteristic**	**Macro instream value**	**Macro hydrologic stress**	**Macro value classification**	**Current Water Sharing Plan Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Wallagoot Lake and Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher streams.	M	L^0	L^0
	Baseflow or Low Flows	H	L	a		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^0	L^0
Bondi Lake and Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher streams. • No water supply work approvals granted in water source.	N/A	L^0	N/A
	Baseflow or Low Flows	H	L	a		N/A	L^0	N/A
	Fresh Flows	N/A	N/A	N/A		N/A	L^0	N/A
	High and Infrequent Flows - combined	N/A	N/A	N/A		N/A	L^0	N/A
Sandy Beach Creek	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher.	M	H+	H+
	Baseflow or Low Flows	H	M	b		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^0	L^0
Tura Beach Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences. • The drawing down of pools is not permitted in the water source.	N/A	L^0	N/A
	Baseflow or Low Flows	N/A	N/A	N/A		N/A	L^0	N/A
	Fresh Flows	N/A	N/A	N/A		N/A	L^0	N/A

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY									
		Previous Results				Current Results			
Unregulated water source	Flow or Extraction Characteristic	Macro instream value	Macro hydrologic stress	Macro value classification	Current Water Sharing Plan Mechanisms	Consequence	Likelihood	Risk Rating
	High and Infrequent Flows - combined	N/A	N/A	N/A	• No water supply work approvals granted in water source.	N/A	L^0	N/A
Merimbula Creek	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher	H	L*	L*
	Baseflow or Low Flows	L	H	i		H	H-	H-
	Fresh Flows	N/A	N/A	N/A		H	L-	L-
	High and Infrequent Flows - combined	N/A	N/A	N/A		H	L-	L-
Merimbula Lake Tributaries	Zero Flow Periods	N/A	N/A	N/A	• • There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher.	M	H+	H+
	Baseflow or Low Flows	M	L	d		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^0	L^0
Pambula Lake Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher.	VH	H+	H+
	Baseflow or Low Flows	H	H	c		VH	H-	H-
	Fresh Flows	N/A	N/A	N/A		VH	L-	M-
	High and Infrequent Flows - combined	N/A	N/A	N/A		VH	L^0	M^0
Curalo Lake and Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	N/A	L^0	N/A
	Baseflow or Low Flows	M	L	d		N/A	L-	N/A
	Fresh Flows	N/A	N/A	N/A		N/A	L^0	N/A
	High and Infrequent Flows - combined	N/A	N/A	N/A		N/A	L^0	N/A

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY

		Previous Results				Current Results		
Unregulated water source	**Flow or Extraction Characteristic**	**Macro instream value**	**Macro hydrologic stress**	**Macro value classification**	**Current Water Sharing Plan Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Eden Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	M	L	d		M	L^0	L^0
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0
Nullica River	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	M	L	d		M	L-	L-
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0
Upper Towamba River	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at gauge number 220004 Towamba River in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class No take in A class on rising river. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No in-river dams on 3rd order or higher. No specific pool access rules, because there is CtP.	M	L+	L+
	Baseflow or Low Flows	H	M	b		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^0	L^0
Stockyard Creek	Zero Flow Periods	N/A	N/A	N/A	• • There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	H	L	a		M	L^0	L^0
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY

Unregulated water source	Flow or Extraction Characteristic	Previous Results: Macro instream value	Previous Results: Macro hydrologic stress	Previous Results: Macro value classification	Current Water Sharing Plan Mechanisms	Current Results: Consequence	Current Results: Likelihood	Current Results: Risk Rating
Mataganah Creek	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at gauge number 220004 Towamba River in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class No take in A class on rising river. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No specific pool access rules, because there is CtP. No water supply work approvals that take groundwater granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	M	M	e		M	M-	M-
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0
Myrtle Creek	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at gauge number 220004 Towamba River in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No take in A class on rising river. No specific pool access rules, because there is CtP. No water supply work approvals that take groundwater granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	M	M	e		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^0	L^0
Wog Wog River	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at gauge number 220004 Towamba River in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class.. No take in A class on rising river. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No in-river dams on 3rd order or higher. No specific pool access rules, because there is CtP.	M	L^0	L^0
	Baseflow or Low Flows	H	L	a		M	L-	L-
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0
Pericoe Creek	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	M	L	d		M	L^0	L^0
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY

		Previous Results				Current Results		
Unregulated water source	**Flow or Extraction Characteristic**	**Macro instream value**	**Macro hydrologic stress**	**Macro value classification**	**Current Water Sharing Plan Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Jingo Creek	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at a specific site in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class.. No take in A class on rising river. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is CtP.	M	L^0	L^0
	Baseflow or Low Flows	M	L	d		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^0	L^0
Lower Towamba River	Zero Flow Periods	N/A	N/A	N/A	• There is a cease to pump rule at gauge number 220004 Towamba River in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the C flow class.. No take in A class on rising river. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • No in-river dams on 3rd order or higher. No specific pool access rules, because there is CtP.	VH	L^0	M^0
	Baseflow or Low Flows	H	M	b		VH	M-	H-
	Fresh Flows	N/A	N/A	N/A		VH	L-	M-
	High and Infrequent Flows - combined	N/A	N/A	N/A		VH	L^0	M^0
Towamba Estuary Tributaries	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.	M	L^0	L^0
	Baseflow or Low Flows	H	M	b		M	L^0	L^0
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0
Green Cape	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher.	M	L^0	L^0
	Baseflow or Low Flows	H	L	a		M	L^0	L^0
	Fresh Flows	N/A	N/A	N/A		M	L^0	L^0
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^0	L^0

SECTION 3.1: RISKS TO FRESHWATER ECOSYSTEMS FROM WATER AVAILABILITY								
		Previous Results				Current Results		
Unregulated water source	**Flow or Extraction Characteristic**	**Macro instream value**	**Macro hydrologic stress**	**Macro value classification**	**Current Water Sharing Plan Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Wonboyn River	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No in-river dams on 3rd order or higher.	M	H+	H+
	Baseflow or Low Flows	H	L	a		M	L-	L-
	Fresh Flows	N/A	N/A	N/A		M	L^{0}	L^{0}
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^{0}	L^{0}
Far South Coast	Zero Flow Periods	N/A	N/A	N/A	• There are no flow classes established in the water source. • Pumping must cease when there is no visible flow at the pump site (or inflow and outflow from the pool from which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place if the dam is passing inflows as specified on the water supply work approval. • The drawing down of pools is not permitted in the water source. • No water supply work approvals granted in water source.	M	L^{0}	L^{0}
	Baseflow or Low Flows	H	L	a		M	L^{0}	L^{0}
	Fresh Flows	N/A	N/A	N/A		M	L^{0}	L^{0}
	High and Infrequent Flows - combined	N/A	N/A	N/A		M	L^{0}	L^{0}

Note: See Section 1.2 for description of ‘a’ to ‘i’ ratings assigned within Macro Assessment risk matrix. Colour coding for these ratings reflect the equivalent risk categories (red = high, orange = medium, green = low); N/A = no risk outcome or modelling available due to lack of data.

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased.

SECTION 3.2: RISKS TO FRESHWATER ECOSYSTEMS FROM POOR WATER QUALITY (turbidity, nutrients, pH, DO and electrical conductivity)					
Unregulated water source	**Water Quality Characteristic**	**Current Water Sharing Plan Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Towamba River at Towamba (Upper Towamba River Water Source)	Turbidity	• There is a cease to pump rule at a specific site in the water source, which is set at the 95th percentile flow. • There are flow classes established in the water source up to the B flow class, but are not used to limit water access. • There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source. • The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source. • Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place. • No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is CtP.	VH	L	M
	Total phosphorus		VH	L	M
	Filterable reactive phosphorus		VH	L	M
	Nitrate + Nitrite		VH	L	M
	Total nitrogen		VH	L	M
	pH		VH	L	M
	Dissolved oxygen		VH	L	M
	Electrical conductivity		VH	L	M

SECTION 3.3: Risk of insufficient groundwater for dependent ecosystems in the upstream alluviums				
Unregulated water source	**Current Control Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Wallagoot Lake and Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	VH	H	VH
Bondi Lake and Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	VH	L	M
Sandy Beach Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	H	H
Tura Beach Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	M	L	L
Merimbula Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	H	H
Merimbula Lake Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	H	H	H
Pambula Lake Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	VH	H	VH

SECTION 3.3: Risk of insufficient groundwater for dependent ecosystems in the upstream alluviums				
Unregulated water source	**Current Control Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Curalo Lake and Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	L	L
Eden Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	M	L	L
Nullica River	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	L	L
Upper Towamba River	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	M	H	H
Stockyard Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	L	L
Mataganah Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	VH	H	VH
Myrtle Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	VH	H	VH
Wog Wog River	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	VH	L	M
Pericoe Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	L	L
Jingo Creek	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	L	L
Lower Towamba River	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	VH	H	VH
Towamba Estuary Tributaries	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	M	H	H
Green Cape	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	M	L	L
Wonboyn River	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies.	H	L	L
Far South Coast	• Set back distances for high priority GDEs set in WSP for production bores and BLR. • Within 40m of river CtP applies	H	L	L

SECTION 3.5: RISKS TO FRESHWATER ECOSYSTEMS FROM POOR WATER QUALITY (temperature outside of natural ranges)			
Unregulated water source	**Water Quality Characteristic**	**Current Control Mechanisms**	**Risk Rating**
Yellow Pinch Dam	Cold water pollution	• Rare river releases	L^

^ Water temperature data not available. Risk based on Cold Water Pollution classification of 'negligible' in Preece (2004).

SECTION 4.1: Risk of insufficient water for estuarine ecosystems					
Estuary (Unregulated water source)	**Flow or Extraction Characteristics**	**Current Control Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
Wallagoot Lake (Wallagoot Lake and Tributaries Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	M	H
	Higher Inflows	• Nil	H	L	M
Bournda Lagoon (Sandy Beach Creek Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	H	H
	Higher Inflows	• Nil	L	L	L
Back Lagoon (Merimbula Creek Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	H	H
	Higher Inflows	• Nil	L	L	L
Merimbula Lake (Merimbula Lake Tributaries Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	M	L
	Higher Inflows	• Nil	H	L	M
Pambula River (Pambula Lake Tributaries Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	H	H
	Higher Inflows	• Nil	H	L	M
Curalo Lagoon (Curalo Lake and Tributaries Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	L	M
	Higher Inflows	• Nil	H	L	M
Shadrachs Creek (Eden Tributaries Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	L	L

SECTION 4.1: Risk of insufficient water for estuarine ecosystems					
Estuary (Unregulated water source)	**Flow or Extraction Characteristics**	**Current Control Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
	Higher Inflows	• Nil	L	L	L
Nullica River (Nullica River Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	H	L	M
	Higher Inflows	• Nil	L	L	L
Boydtown Creek (Towamba Estuary Tributaries Water Source)	Low Inflows	• Upstream access rules	L	L	L
	Higher Inflows	• Upstream access rules	L	L	L
Towamba River (Towamba Estuary Tributaries Water Source)	Low Inflows	• Upstream access rules	H	M	H
	Higher Inflows	• Upstream access rules	H	L	M
Fisheries Creek (Towamba Estuary Tributaries Water Source)	Low Inflows	• Upstream access rules	H	L	M
	Higher Inflows	• Upstream access rules	L	L	L
Twofold Bay (Green Cape Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	L	L
	Higher Inflows	• Nil	L	L	L
Saltwater Creek (Eden) (Green Cape Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	L	L
	Higher Inflows	• Nil	L	L	L
Woodburn Creek (Green Cape Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	L	L
	Higher Inflows	• Nil	L	L	L
Bittangabee Creek (Green Cape Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	L	L	L
	Higher Inflows	• Nil	L	L	L
Wonboyn River (Wonboyn River Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule	M	L	L
	Higher Inflows	• Nil	H	L	M
Merrica River (Far South Coast Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule • No licences in this water source	H	L	M

SECTION 4.1: Risk of insufficient water for estuarine ecosystems					
Estuary (Unregulated water source)	**Flow or Extraction Characteristics**	**Current Control Mechanisms**	**Consequence**	**Likelihood**	**Risk Rating**
	Higher Inflows	• Nil	L	L	L
Table Creek (Far South Coast Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule • No licences in this water source	L	L	L
	Higher Inflows	• Nil	L	L	L
Nadgee River (Far South Coast Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule • No licences in this water source	H	L	M
	Higher Inflows	• Nil	L	L	L
Nadgee Lake (Far South Coast Water Source)	Low Inflows	• Cease to pump when no visible flow at the pump site access rule • No licences in this water source	H	L	M
	Higher Inflows	• Nil	H	L	M

Key: VL = Very Low; L = Low; M = Medium; H = High; VH = Very High.

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1 Introduction

1.1 Risk assessment framework

To manage NSW water resources, it is important to identify risks to the volume and quality of the resource, and subsequent risks to the users and the environment that rely on the resource. Risk assessment is a well understood and accepted approach for managing natural resources. The consequences of impacts on natural resources are often hard to predict, therefore risk assessment relies on the probabilities of impacts occurring.

NSW has been implementing risk-based water planning processes since the late 1990s including the Stressed Rivers Assessments in 1998 (DLWC, 1998a), the Aquifer Risk Assessment (DLWC, 1998b) and the macro water planning process developed in 2004, which was used in the development of Water Sharing Plans (WSPs) across the State (DIPNR, 2005; NSW Office of Water, 2011; Raine et al. 2012).

The risk assessment framework adopts a cause/threat/impact model that describes the pathway for potential impacts to a receptor such as an ecological asset, water user or any other value that may be affected. This approach provides a systematic way to identify a range of factors that may lead to an impact, while also being consistent with the internationally recognised risk standard which considers both likelihood and consequence.

Causes have the potential to induce a threat to various extents, depending upon the characteristics of the water resource. The causes, threats and impacts considered in this assessment are summarised in Table 1-1.

Table 1-1 Summary of causes, threats and impacts considered in this risk assessment

Cause	Threat	Impact
• Regulation of river flows by dams and weirs • Extraction by licensed water users • Extraction for basic landholder rights • Interception of water by farm dams, mining, and plantation forestry • Climate change altering rainfall, runoff and recharge to groundwater • Land management changes effecting landscape processes	• Altered parts of the flow regime (zero flow, baseflows, freshes, high flows) • Reduced connected alluvial groundwater levels • Poor water quality (temperature depression, suspended matter, nutrients, dissolved oxygen, pH, salinity) • Decline in groundwater levels	• Degradation of the riverine environment • Degradation of the connected groundwater-dependant environment • Degradation of the estuarine environment • Loss of water quality suitability for water use

The risk level of an impact is a function of the *likelihood* of a cause and threat occurring, and the *consequence* of the impact on the receptor. For this 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 rather conveys the probability that the threat will be significant.
- Consequence = the loss of value for an impacted receptor.

An example of how the cause/threat/impact model and likelihood/consequence standard have been combined is illustrated in Figure 1-1, for risks arising from river regulation and surface water extraction.

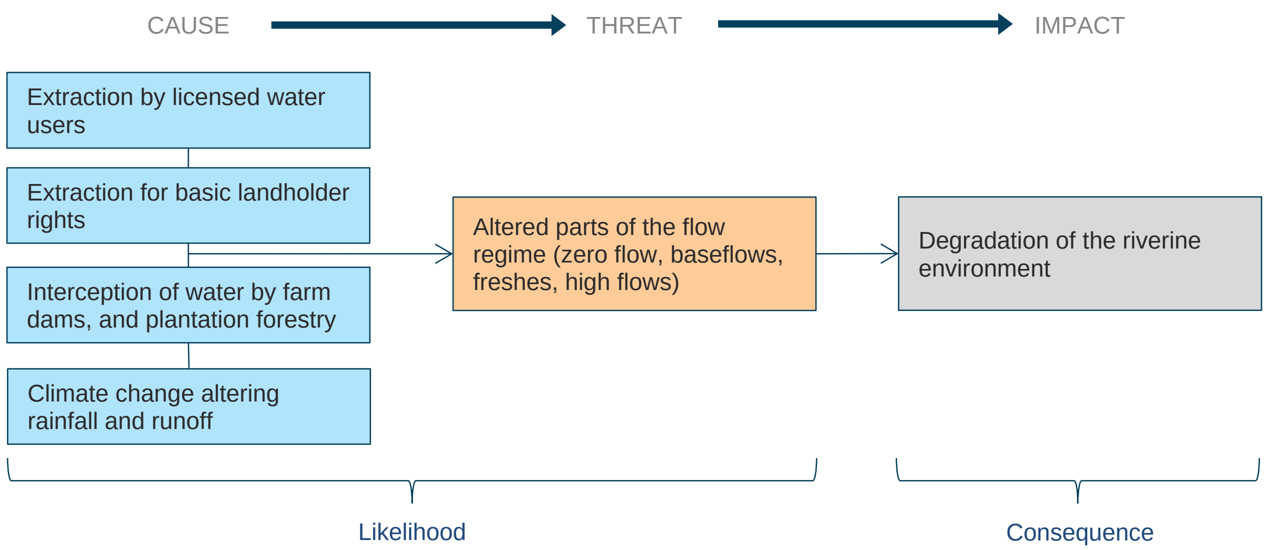

Figure 1-1 Example of an impact pathway for identifying risks to the environment associated with altering parts of the flow regime

A risk formula is developed from the impact pathway that elaborates on the response or causation model and the metrics that are used to quantify (or qualify) the consequences, and the likelihood of that consequence (Table 1-2).

Table 1-2 Formula used to derive risk to instream riverine environmental assets from the alteration of the flow regime

Risk	=	Consequence	and	Likelihood
There is a risk of insufficient water being available to maintain key ecosystem functions in unregulated rivers…		... that may lead to loss of instream riverine ecological values		… from an altered flow regime caused by water extraction, interception, and climate change

Risk levels are calculated using a standard risk assessment matrix that identifies different levels of consequence and likelihood (Figure 1-2).

		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

Figure 1-2 An example of a risk assessment matrix

1.2 How is this risk assessment related to the Macro Planning Approach?

The macro approach was developed to assist with water sharing planning in unregulated water sources across NSW from 2004 onwards (DIPNR, 2005; NSW Office of Water, 2011). A groundwater macro approach was also developed using similar principles (DPI, 2015). Macro water sharing plans applied a standardised approach to determining in-stream risk and community dependence on flows. They established community consultation guidelines and outlined potential rules for water access, trade and more.

The macro approach to risk assessment uses a standard 'Risk' = 'Consequence' x 'Likelihood' definition. The consequence for each water source was based on calculation of the instream value. The likelihood component was based on calculation of hydrological stress. A value classification matrix (Figure 1-3) was used to determine risk, providing a value classification code between *a* and *i* that guided the development of WSP access and trading rules (NSW Office of Water 2011).

The spatial information that was available for macro risk assessments only allowed for instream values (consequence) and hydrologic stress (likelihood) to be calculated at a water source scale. Additionally, macro likelihood calculations were only applied to baseflows (low flows that are typically met or exceeded around 80% of the time) as this was the flow class considered most likely to be affected by flow extraction.

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

Figure 1-3 Value classification matrix used in the macro approach to determine value classification codes between *a* and *i* (NSW Office of Water 2011). These values have been colour coded for the purpose of comparison with the risks assessed in this report.

This risk assessment continues to evaluate risks of insufficient water in low flows, but builds upon the previous macro approach by:

- Assessing likelihood and consequence at a river reach scale rather than a catchment or sub-catchment (water source) scale, thereby identifying whether consequence drivers are located above or below a likely source of extraction pressure.
- Assessing the risk of impact on different parts of the hydrograph (e.g. low flows, freshes and high flows).
- Considering additional causes of flow alteration.
- Assessing the risks from water quality.
- Continuing to consider risks of insufficient.
- Updating and sourcing newly available information for determining instream values.
- Applying a consistent approach to regulated and unregulated water sources (the macro approach was limited to unregulated water sources).

N.B. For this version, modelling results for the Towamba catchment, incorporating climate change are being developed, but not ready at time of preparation. This assessment considers low flows using existing hydrostress ratings for low flows only. Other flow stages will be updated when modelling is completed.

The new information, approaches and updates introduced in this risk assessment may lead to different risk outcomes for some water sources when compared to the earlier macro results. In order to clarify any comparative differences, the previous macro instream value, hydrologic stress and value classification code for a water source have been included in the Summary Risk Table at the front of this document. In cases where a water source risk outcome has changed between the macro and this current report, a detailed explanation has been included on the water source report card located in Appendix A.

1.3 Scope of this risk assessment

This risk assessment evaluates current or future risks, which can be managed through mechanisms within the WSP, that directly relate to the quantity or quality of water in the WSP area. Potential mitigation strategies that can be implemented through the WSP, such as improving flow for fish passage, are included for discussion in future options assessment workshops. Where mitigation strategies are available but can't be implemented through a WSP, 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 generally very few mechanisms within the scope of a WSP that can influence land use.

This risk assessment evaluates:

- risks of insufficient water for freshwater riverine ecosystems
- risks of poor water quality for freshwater riverine ecosystems
- risks of insufficient water for groundwater-dependant ecosystems connected to the rivers
- risks of insufficient water for estuarine ecosystems
- risks of unsuitable water quality for other water uses (irrigation and recreation).

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

- risks of change in water quality for groundwater-dependant ecosystems connected to the rivers
- risks of poor water quality for estuarine ecosystems
- 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.
- other risks raised by stakeholders during targeted consultation by DPE Water Planning team.

1.4 Limitations and uncertainties

This risk assessment uses the best data currently available. Quantitative state-wide data is used where possible to maintain consistency between WSP 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 hydrology models that can evaluate climate change, but not all of these will be available in time for use in the WSP risk assessments.

1.5 Ecological water needs of freshwater riverine ecosystems

1.5.1 Low flows and refuge pools maintain habitat prior to zero flows periods

When flows cease, the hydrologic connectivity between pools is broken. Isolated pools become critical refuges for wildlife, but if the period between flows is too long then conditions in the pools can deteriorate and become hazardous. Oxygen levels can drop while temperature, salinity and nutrient concentrations can increase. Isolated pools can also become stratified, producing layers of colder, deoxygenated water that produce toxic conditions if mixed with the surface layers.

Many Australian rivers have naturally occurring dry periods, but ecosystems can be at risk when the frequency and duration of these periods is lengthened by prolonged water extraction. Strategies are required to prevent or restrict water extraction when necessary. Broad strategies for reducing the risk of extended zero flow periods are listed in Table 1-3.

1.5.2 Low flows maintain habitat and hydrological connectivity

Baseflows typically occur between rainfall events and supply fresh water to habitats like riffle and pools, maintain connectivity between reaches and maintain healthy water quality. Resumption of baseflows after zero flow periods can improve the condition of refuge pools by diluting toxic build-ups and refreshing oxygen concentrations.

Research indicates that when flows fall below the 95th percentile (i.e. flow rates that are usually exceeded 95% of the time), significant amounts of habitat dry out. If these low flows persist and do not improve, there can be a potential loss in wildlife diversity (Reinfelds et al., 2004; Brooks et al., 2005; Haeusler & Reinfelds, 2016). Broad strategies for protecting a portion of baseflows are listed in Table 1-3.

1.5.3 Fresh flows maintain important ecological functions and water quality

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 play a critical role in transporting nutrients through river systems and stimulating reproduction and migration in aquatic wildlife.

After prolonged dry periods, fresh events play a critical role in connecting river reaches, mixing stagnant water in isolated pools and improving water quality. Freshes can also assist in the movement of sediment and ash slugs derived from bushfire events or other catchment disturbances. Broad strategies for protecting a portion of freshes are listed in Table 1-3.

1.5.4 High and infrequent flows maintain important ecological functions and water quality

High and very high flows are important for inundating high banks, and connecting the river with its floodplains, its wetlands, and its forests - allowing wildlife and nutrients to move back and forth until water levels subside. These movements are often a critical component in the life cycles of fish, vegetation, and frogs.

High velocity flows are also instrumental in maintaining river structures by scouring even the deepest pools and channels of silt and organic matter, maintaining pool depths, and moving sand bars and benches. Broad strategies for protecting a portion of large/infrequent flows are listed in Table 1-3.

1.6 Ecological water needs of groundwater dependant ecosystems upstream of tidal limit

1.6.1 Groundwater in highly connected surface and groundwater sources maintain water levels for GDEs and baseflows instream

Water levels in highly connected river alluvial aquifers vary with the height of the river as well as in response to rainfall and groundwater pumping. In the upland alluviums this may mean groundwater extraction reduces baseflow, or possibly induces recharge from the river into the aquifer. Where the alluvium is in contact with regional aquifers, with poorer water quality (e.g. saline), extraction could induce intrusion of this water reducing the quality of the water in the alluvium.

Limiting extraction in both surface and alluvial water can support the water level that the GDEs are dependent on, as well as support the water level in the rivers on which riverine ecology depends and protect the water quality. Broad strategies to maintain groundwater levels for GDEs are listed in Table 1-3.

1.7 Ecological water needs of estuarine ecosystems

1.7.1 Higher freshwater inflows (freshes and high flows) maintain connectivity and salinity levels below the tidal limit

Freshwater flows into estuaries create a zone where saline water and freshwater mix. This zone varies in its nature, from very persistent reaches of freshwater (a tidal pool) to very intermittent small areas of brackish water. Ecosystems in persistent tidal pools are more sensitive to change in freshwater inflows, while small intermittent tidal zone ecosystems are more tolerant of fluctuating saline conditions.

Freshes and higher inflows bring nutrients and can create large bodies of fresh and/or brackish waters. The nutrients from these flows often stimulate highly productive phases in the ecology of an estuary. The bodies of fresh and/or brackish waters provide vital habitat for important life cycle process in many species, such as spawning and nursery habitat. Broad strategies to maintain connectivity and salinity levels below the tidal limit are listed in Table 1-3.

1.7.2 Low inflows maintain limited connectivity and minimal salinity levels below the tidal limit in drier periods

The low inflows, while not generally associated with the same ecological process as the high flows, they can help maintain the habitat conditions created by the higher lows for a longer period. They also can persist through drier periods and allow some species to survive in an estuary where they may have been locally lost, or temporally lost, requiring time to recover. Broad strategies to maintain connectivity and salinity levels below the tidal limit are listed in Table 1-3.

1.8 Ecological water needs of groundwater dependant ecosystems downstream of tidal limit

1.8.1 Groundwater in highly connected surface and groundwater sources maintain water levels for GDEs and protecting for water quality

The alluvial areas downstream of the tidal limit are referred to as Coastal Floodplain Alluvial and often support dependant ecosystems in a similar way as the upriver alluviums. Additionally, there is a need to maintain the water levels to avoid oxidation of acid sulfate soils, which if in contact with air, can release acidic leachate into the aquifer and possibly the estuary. Like the upland alluviums the proximity of the saline water, in this case estuarine water, poses a risk if pumping was to induce intrusion into the alluvial aquifer. Broad strategies to maintain groundwater levels for GDEs are listed in Table 1-3.

Table 1-3 Example broad strategies to mitigate risks of insufficient water for the environment, above and below the tidal limit

Example broad strategy	Effect of such strategies	Relevant flow/water level component: Zero flow periods	Baseflows	Fresh flows	High/infrequent flows	Estuary flows	Groundwater Dependant Ecosystems	Relevant sections
Review low/very low flow class access rules	Reduce risk of longer zero flow periods with poorer water quality by protecting flows below 95th percentile	X	X			X	X	1.5.1 1.5.2 1.6 1.7.2
Review extraction rules during prolonged periods of drought (> 6 months)	Reduce risk of impacts to refugia and other low flows habitats by reducing pressure on them	X	X	X		X	X	1.5.1 1.5.2 1.5.3 1.6 1.7.1
Review joint surface/groundwater access rules in highly connected aquifers	Reduce risk of reduced surface flows by restricting drawdown from connected aquifers	X	X				X	1.5.1 1.5.2 1.6
Review medium to high flow class access rules	Reduce risk of impact to freshes and high flows by protecting a portion of these events			X		X		1.5.3 1.7.1
Review environmental water release rules from storage/dam	Reduce risks to all flow types by transmitting a portion of all flow types below the dam	X	X	X	X	X		1.5 1.7
Consider creation of an Environmental Water Allowance in storage/dam	Reduce risks by allocating water that can be used for planned small and medium flow releases	X	X	X		X		1.5.1 1.5.2 1.5.3 1.7
Review current trade rules in medium and high risk water sources	Reduce risk of over-extraction by limiting trade into medium or high risk water sources	X	X	X				1.5.1 1.5.2 1.5.3
Develop flow based water quality targets	Reduce risks of poor water quality by establishing flow targets based on water quality outcomes	X	X	X	X	X	X	all
Consider localised water level strategies where required	Reduce the risk of low water levels near important GDEs by restricting extraction, and drawdown in the vicinity						X	1.6 1.8

2 Overview of water use in the Towamba River unregulated and alluvial Water Sharing Plan area

The Towamba River unregulated and alluvial WSP covers an area of 2,345 km^2 and consists of three extraction management units consisting of 22 water sources. No water sources have been split into management zones in the Towamba Plan (Figure 2-1).

Significant primary industries in the Towamba area include beef cattle, lucerne and forestry production. The greatest demand for water comes from stock watering, small-scale irrigation of lucerne, as well as maintenance of fruit orchards and irrigation for fruit and vegetable production. Major population centres include Tathra, Merimbula, Pambula and Eden. The population of these centres is subject to seasonal population fluxes during summer holidays, creating a significant demand on town water supplies. Away from the coast there are several small rural towns such as Wyndham, Burragate, Rocky Hall and Towamba.

Access to water under basic landholder rights (BLR) is estimated at 3.87 ML/day (1,413 ML/year). Licensed water extraction in the Towamba plan totals approximately 320 ML/year for stock and domestic licences; 1400 ML/year for local water utilities (e.g. Bega Valley Shire Council); 2227 ML/year (unit shares) for unregulated licences; and 257 ML/year for Aquifer access licences.

Bega Valley Shire council is the largest extractor of water, owning and operating a number of dams and weirs. These include:

- Ben Boyd Dam
- Yellow Pinch Dam
- Tantawanglo Creek Weir (in the Bega River catchment and not in this WSP area)

The water used to fill Yellow Pinch Dam and supply the villages of Candelo and Wolumla comes from the Tantawangalo Creek. This part of the system in the north, is covered by the Bega-Brogo Water Sharing Plan, but forms part of the Tantawangalo-Kiah water supply system operated by the Bega Valley Shire Council. Tantawangalo Creek supplies about 1500 ML/year, whilst the Kiah borefield to the south of the water sharing plan area supplies about 1400 ML/year. Groundwater in this area comes from the Lachlan Fold Belt Coast Groundwater Source but the portion in this area is managed under this WSP.

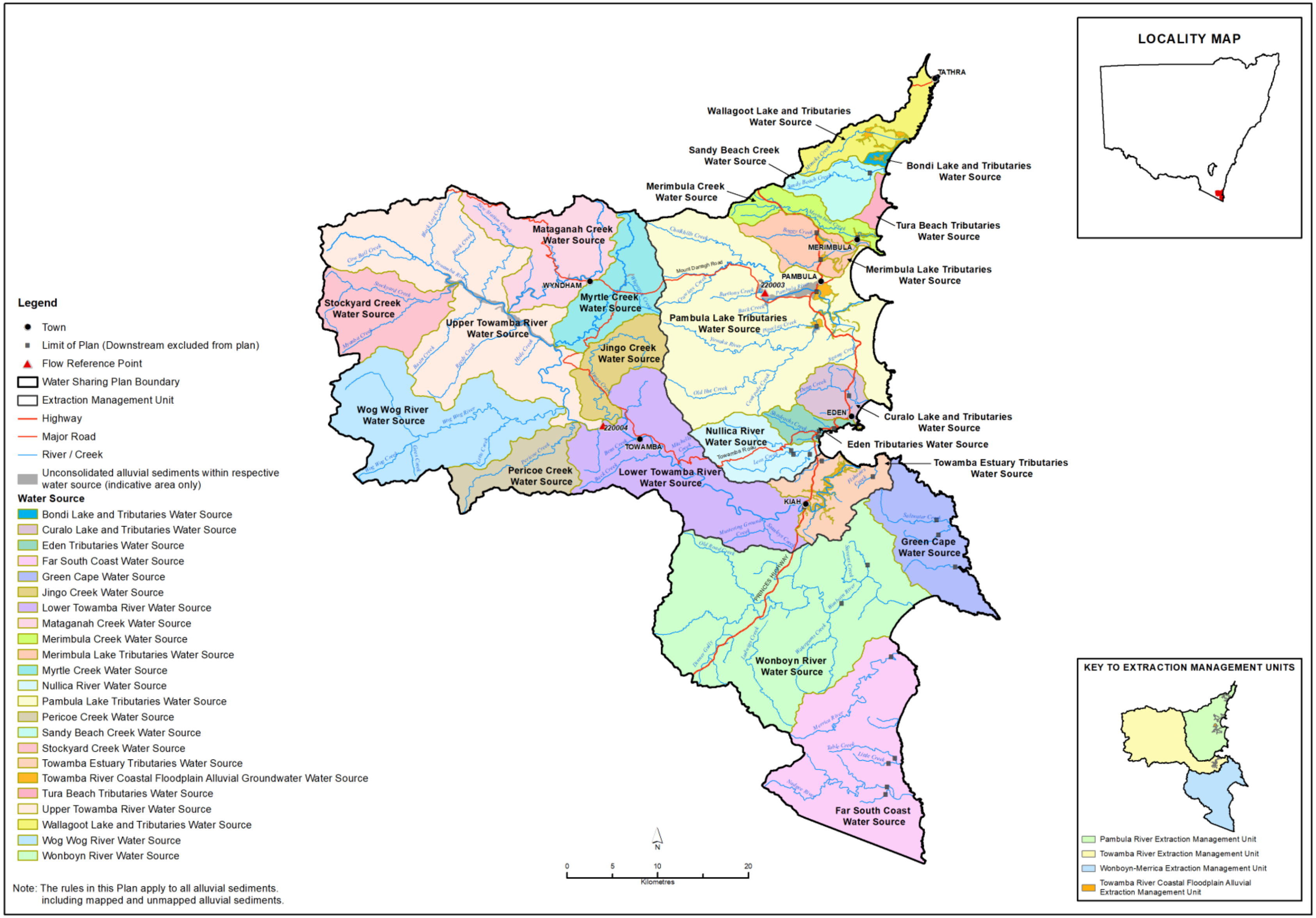

Figure 2-1 Map of Towamba River unregulated and alluvial WSP area including water sources

3 Risks to the environment upstream of the tidal limit

3.1 Risk of insufficient water for freshwater riverine 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 (e.g. climate change). Figure 3-1 shows the pathway from cause, to threat, to impact on the riverine ecosystem.

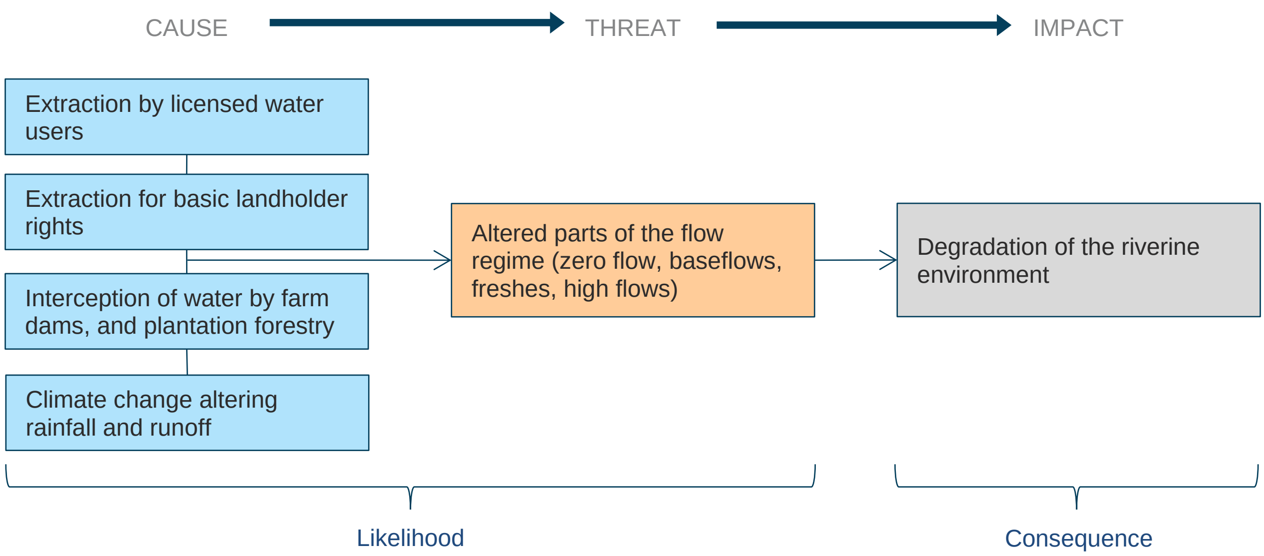

Figure 3-1 Impact pathway for identifying risks to the environment associated with altering parts of the flow regime in the rivers

The impact pathway can be used to develop a formula to evaluate the risk of degrading the ecology of the rivers. Table 3-1 describes the consequence and the likelihood of the impact occurring, to generate a formula to rate the level of risk.

Table 3-1 Formula used to derive risk to instream riverine environmental assets from the alteration of the flow regime in the rivers

Risk	=	Consequence	and	Likelihood
There is a risk of insufficient water being available to maintain key ecosystem functions in unregulated rivers…		... that may lead to loss of instream riverine ecological values		… from an altered flow regime caused by water extraction, interception, and climate change

3.1.1 Identifying freshwater riverine ecological values and consequence ratings

The consequences for each water source were derived using the High Ecological Value Aquatic Ecosystem (HEVAE) framework (Healey et al. 2018). This framework identifies values of diversity, distinctiveness, and naturalness at the river reach scale (Appendix B). For the Towamba River unregulated and alluvial WSP area, the HEVAE outcomes were derived from a relative assessment of value of the NSW coastal rivers south of the Shoalhaven Catchment (not inclusive).

The consequence rating is contributed to by the presence of flow dependent threatened plant and animal species, populations and endangered ecological communities (EECs) listed under State and Commonwealth legislation (Appendix C). These attributes feed into the HEVAE criteria. Current threatened species listings under State and Commonwealth legislation were also reviewed to ensure all water-related threatened factors were included in the coastal analysis.

A decision-making tool guided the final consequence rating by considering the location of the environmental values within a water source relative to the location of surface water extraction and interception licences. This allowed for prioritisation based on the probability of an impact occurring. The decision tree approach takes the range of river reach-based HEVAE outcomes to enable a logical consequence outcome to be derived for a whole water source. Each part of this process is documented and the rationale for each part of the tool is provided in Appendix B.

Final consequence ratings are provided in Table 3-2.

3.1.2 Calculating likelihood of insufficient water for freshwater riverine ecosystems

The likelihood of insufficient water for freshwater ecosystems was calculated by comparing a modelled flow sequence to equivalent flow sequences estimating the natural flow regime. The modelled flow sequence was either altered by current water use, where usage data was available, or full entitlement use where usage was unknown. The size of the difference between the modelled and estimated natural flow regime was determined by the likelihood of insufficient water being available to maintain the key ecosystem functions.

The hydrological models took account of interception by forestry plantations and licenced dams, basic landholder right (BLR) impacts (excluding harvestable rights), and licensed water extraction. Likelihood values were calculated for various components of the flow regime including low flows, baseflows, moderate/fresh flows and higher, potentially overbank flows (Appendix D).

The single reach hydrologic models have a simple configuration to simulate full development of the licensed entitlement under the current WSP access arrangements. Further configuration would be required for other purposes such as evaluating WSP rule changes. Climate change sequences were not sourced for these rivers.

Flows in the riverine environment are a continuum from periods with no flow at all through to large, rapid flow events. 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 heavy rain or flooding. In order to represent the variety of important flow types, likelihood calculations were made against the following set of hydrological flow components:

- Zero flow periods, during which surface flows have ceased.
- Baseflows, which are very low flows that maintain some connectivity and water quality;
- Freshes, which are larger flows that increase connectivity and inundate the sides of riverbanks.
- High flows 1.5 year ARI (average recurrence interval), large infrequent flows that completely fill a channel and wet both banks.
- High flows 2.5 year ARI (average recurrence interval), large and less frequent flows that break out onto floodplains.
- High flows 5.0 year ARI (average recurrence interval), very large and rare flows that can reach deep into forest, wetlands and floodplains.

Further details about the hydrologic flow components are provided in Appendix D. Final likelihood ratings are provided in Table 3-2.

3.1.3 Risk outcomes - insufficient water for freshwater riverine ecosystems

The matrix used to calculate risk of insufficient water for freshwater riverine ecosystems is provided in Figure 3-2.

		Likelihood (of hydrological alteration)		
		Low	Medium	High
Consequence (HEVAE consequence score)	Very Low	Low	Low	Low
	Low	Low	Low	Medium
	Medium	Low	Medium	High
	High	Low	Medium	High
	Very High	Medium	High	High

Figure 3-2 Risk matrix used for the risk of insufficient water for freshwater ecosystems

The resulting risk ratings of "insufficient water being available to maintain key ecosystem functions" are shown in Table 3-2 in the coloured columns.

Table 3-2 Risk of insufficient water for freshwater riverine ecosystems

Unregulated water source	Consequence	Likelihood						Overall risk rating					
		Zero flow periods	Baseflow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Baseflow or low flows	Fresh flows	High and infrequent flows		
					OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Wallagoot Lake and Tributaries	M	L^0	M-	L-	L^0	L^0	L^0	L	M	L	L	L	L
Bondi Lake and Tributaries	H	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Sandy Beach Creek	M	H+	H-	L-	L^0	L^0	L^0	H	H	L	L	L	L
Tura Beach Tributaries	L	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Merimbula Creek	H	L*	H-	L-	L-	L-	L-	L	H	L	L	L	L
Merimbula Lake Tributaries	M	H+	M-	L-	L^0	L^0	L^0	H	M	L	L	L	L
Pambula Lake Tributaries	VH	H+	H-	L-	L^0	L^0	L^0	H	H	M	M	M	M
Curalo Lake and Tributaries	M	L^0	L-	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Eden Tributaries	M	L^0	L0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Nullica River	M	L^0	L-	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Upper Towamba River	M	L+	L-	L-	L^0	L^0	L^0	L	L	L	L	L	L
Stockyard Creek	M	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Mataganah Creek	M	L^0	M-	L^0	L^0	L^0	L^0	L	M	L	L	L	L
Myrtle Creek	M	L^0	M-	L-	L^0	L^0	L^0	L	M	L	L	L	L
Wog River	M	L^0	L-	L^0	L^0	L^0	L^0	L	L	L	L	L	L

Unregulated water source	Consequence	Likelihood						Overall risk rating					
		Zero flow periods	Baseflow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Baseflow or low flows	Fresh flows	High and infrequent flows		
					OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Pericoe Creek	M	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Jingo Creek	M	L^0	L-	L-	L^0	L^0	L^0	L	L	L	L	L	L
Lower Towamba River	VH	L^0	M-	L-	L^0	L^0	L^0	M	H	M	M	M	M
Towamba Estuary Tributaries	M	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Green Cape	M	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L
Wonboyn River	M	H+	L-	L^0	L^0	L^0	L^0	H	L	L	L	L	L
Far South Coast	M	L^0	L^0	L^0	L^0	L^0	L^0	L	L	L	L	L	L

Key: OB = overbank flow, ARI = average recurrence interval.

+ = increase from near-natural condition; - = decrease from near-natural condition; 0 = no change from near-natural condition; * = not all aspects increased or decreased.

VL = Very Low; L = Low; M = Medium; H = High; VH = Very High; N/A = indicates no risk outcome or modelling available due to lack of data.

The cease to pump conditions in the water sources are intended to protect surface water during zero flow periods and low flows. The likelihood of impacting the ecological functions (e.g. survival in low flow periods) in this flow range was low in most water sources, but high for Sandy Beach, Merimbula and Pambula Lake Tributaries, and Wonboyn River water sources (Table 3-2), which resulted in high risk for these water sources. The risk was high for low flows, or baseflows, in most of these water sources as well as Wallagoot Lake and Tributaries and Merimbula Creek water sources. Where there was a very high consequence, based on the high ecological values that occur in these water sources, the risk in the higher flow ranges were rated medium although the likelihood of flow related impacts is low (Table 3-2).

3.2 Risk of poor water quality for freshwater riverine 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).

There are many causes and threats that can impact the health of water dependent ecosystems within the Towamba River unregulated and alluvial WSP area. The types of water quality degradation issues include:

- elevated levels of nutrients and suspended sediments
- dissolved oxygen and pH outside of natural ranges
- elevated levels of pathogens and toxicants.

These impacts could all lead to the alteration of instream ecological functions and reductions in the condition of ecological assets. Risks to the condition of water resources arising from water quality degradation have been assessed below. Figure 3-3 shows the pathway from cause, to threat, to impact of poor water quality on water dependent ecosystems.

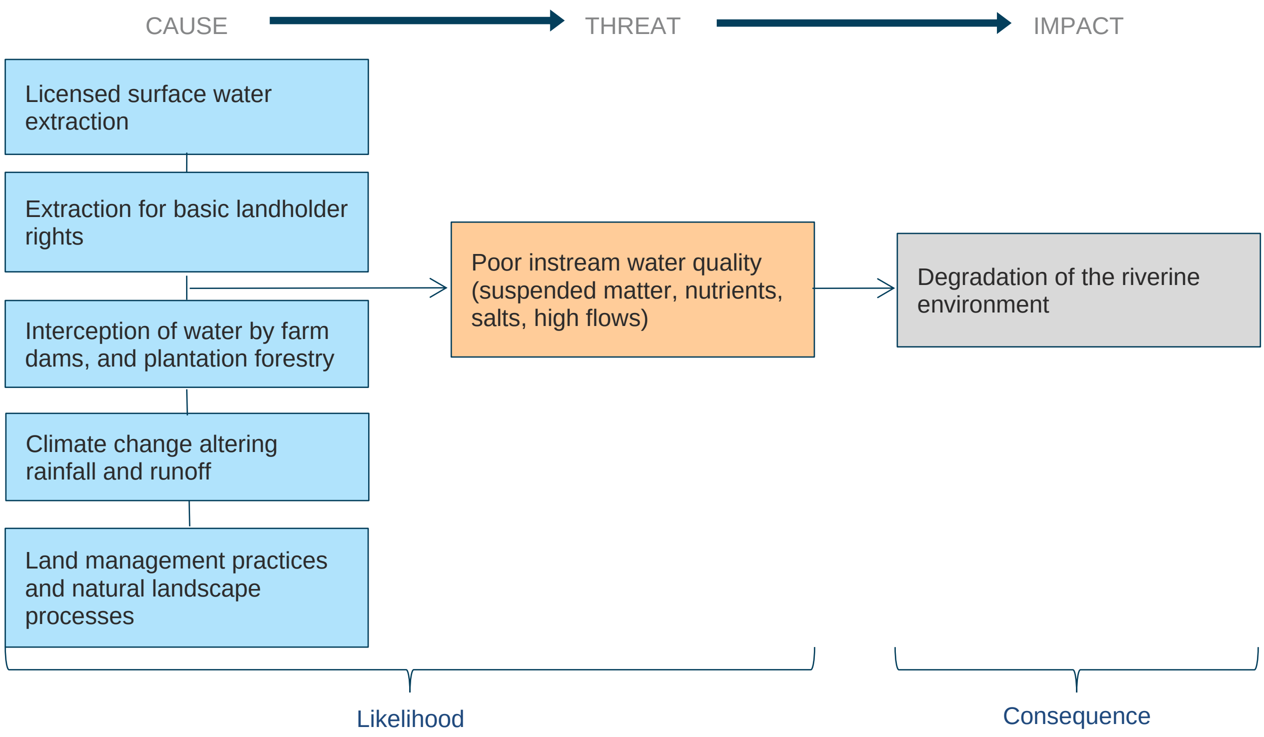

Figure 3-3 Impact pathway showing impact of water quality degradation (turbidity, nutrients, pH, DO EC) on the freshwater riverine environment

From the impact pathway, a risk formula is developed to evaluate the risk of degrading the ecology of the rivers. The risk formula identifies the metrics used to quantify (or qualify) the likelihood of flow regimes being altered significantly, and the consequence of that alteration occurring (Table 3-3).

Table 3-3 Formula used to derive risk to instream riverine environmental assets from the alteration of the flow regime in the rivers

Risk	=	Consequence	and	Likelihood
There is a risk of poor water quality (turbidity, nutrients, pH, DO and EC) water being available to maintain key ecosystem functions in unregulated rivers…		... that may lead to loss of instream riverine ecological values		… from an altered flow regime caused by water extraction, interception, climate change and land management

The headwaters of the Towamba River unregulated and alluvial WSP water sources are steep and extensively forested. There is no water quality data available to assess these upland areas. As they are largely undisturbed, it is expected that water quality risks would be minimal. In contrast, the flatter lowland areas associated with the major streams have been developed and modified from natural conditions. These areas support a range of land uses and developments that pose the highest risks to water quality.

Pathogens, pesticides, heavy metals and other toxicants are not monitored consistently across different monitoring programs. Risks arising from these types of water quality degradation are not addressed further in this assessment.

3.2.1 Identifying freshwater water quality values and rating consequence

Freshwater ecological consequence scores are based on the value and sensitivity of aquatic ecosystems to poor water quality. The risk consequence scores were determined using the HEVAE framework, which assesses the biota and other characteristics of the river (e.g. presence of threatened species or rare river styles) to rate the ecological value, including the distinctiveness of the area. A HEVAE rating ranging from very low to very high ecological value (5 ratings) was derived for each water source using the consequence decision support tree (Section 3.1.1, Appendix B). Consequence rating value for the Towamba River in the vicinity of the water quality monitoring site was rated very high.

3.2.2 Calculating likelihood of poor water quality due to turbidity, nutrients, pH, dissolved oxygen and electrical conductivity

The likelihood of water being of insufficient quality to maintain water-dependent ecosystems, recreational requirements, or productivity was assessed by comparing water quality data to accepted guidelines. Water quality data from one routine water quality monitoring station located within the Towamba River unregulated and alluvial WSP area was used for this assessment. The data was collected on a monthly basis for the State Water Quality Assessment and Monitoring Program (SWAMP).

Likelihood scores for total phosphorus, filterable reactive phosphorus, total nitrogen, nitrate and nitrite, pH, turbidity, dissolved oxygen and EC were calculated based on the frequency that the annual median for the measured parameter exceeded the water quality targets listed in Table 3-4 (combination of ANZECC (2000, 2006) and NSW Monitoring Evaluation and Reporting trigger values). Targets apply to zones approximating 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 3-4, a very low risk of environmental damage can be assumed. The data set used was the period 1 July 2015 to 30 June 2020.

Table 3-4 Water quality targets for water dependent ecosystem objectives for aquatic ecosystems

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)
Towamba (Montane zone, >700m)	10	20	15	250	25	90-110%	6.5-8.0	175
Towamba (Upland zone, 150 to 700m)	10	20	15	250	25	90-110%	6.5-8.0	175
Towamba (Lowland zone, <150m)	25	50	20	350	40	85-110%	6.5–8.0	350

Likelihood categories were defined by the frequency that the water quality target was exceeded over the five-year sampling period (Table 3-5).

Table 3-5 Likelihood metrics for risks of water quality impacting water-dependent ecosystems

Likelihood metric	Metric category	Metric category definition
Streams, rivers, lakes and wetlands	Low	the annual median water quality parameter for a site exceeds the water quality target no more than one year from 1 July 2015 to 30 June 2020
	Medium	the annual median water quality parameter for a site exceeds the water quality target at least two years but no more than three years from 1 July 2015 to 30 June 2020
	High	the annual median water quality parameter for a site exceeds the water quality target at least four years or every year from 1 July 2015 to 30 June 2020

Water quality sites were chosen based on availability of water quality data for the reporting period, reliability of data collected, and the location of the sampling site in combination with the HEVAE assessment, to provide representative coverage of consequence, likelihood and risk within each management zone.

Water quality data was obtained from one site located within the Towamba River unregulated and alluvial WSP area. The site is Towamba River at Towamba and is situated in the lowland zone. The data from this site has been used to determine the likelihood of water being unsuitable for water dependent ecosystems. The likelihood scores for each parameter are listed in Table 3-6.

3.2.3 Risk outcomes - turbidity, nutrients, pH, dissolved oxygen and electrical conductivity

Likelihood and consequence scores were assessed against a risk matrix to determine the overall risk outcomes for each water quality parameter. The risk matrix used to determine the risk to the health of water-dependent ecosystems due to water quality targets being exceeded is provided in Figure 3-4.

		Likelihood (of water quality targets being exceeded)		
		Low	Medium	High
Consequence (HEVAE consequence score)	Very Low	Low	Low	Low
	Low	Low	Low	Medium
	Medium	Low	Medium	High
	High	Low	Medium	High
	Very High	Medium	High	High

Figure 3-4 Risk matrix to determine risk outcomes of exceeding water quality targets on water-dependent ecosystems

Combining the consequence and likelihood ratings for the one monitoring site resulted in the overall risk levels shown in Table 3-6. Due to a very high consequence rating for the Towamba River at Towamba, the risk outcome for all parameters was medium. For all parameters, the likelihood of the current water quality adversely impacting aquatic ecosystems was low. However, as the consequence rating is very high, there is a 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 this site is listed in Appendix I Water Quality Data, Table I1.

Table 3-6 Risks of water quality exceeding targets impacting the heath of water-dependent ecosystems in the Towamba River unregulated and alluvial WSP area

Unregulated water source location	Consequence	Likelihood								Overall Risk Rating							
		Total phosphorus	Filterable reactive phosphorus	Total nitrogen	Nitrate + Nitrite	Turbidity	Dissolved oxygen	pH	Electrical conductivity	Total phosphorus	Filterable reactive phosphorus	Total nitrogen	Nitrate + Nitrite	Turbidity	Dissolved oxygen	pH	Electrical conductivity
Towamba River at Towamba (Upper Towamba River Water Source)	VH	L	L	L	L	L	L	L	L	M	M	M	M	M	M	M	M

Key: VL = Very Low; L = Low; M = Medium; H = High; VH = Very High.

3.3 Risk of insufficient groundwater for dependent ecosystems in the upstream alluviums

The causes for the alteration of groundwater levels in the connected alluvial aquifers includes direct groundwater extraction through licensed water use and BLR. Figure 3-5 shows the pathway from cause, to threat, to impact on the connected groundwater-dependant ecosystem (GDE).

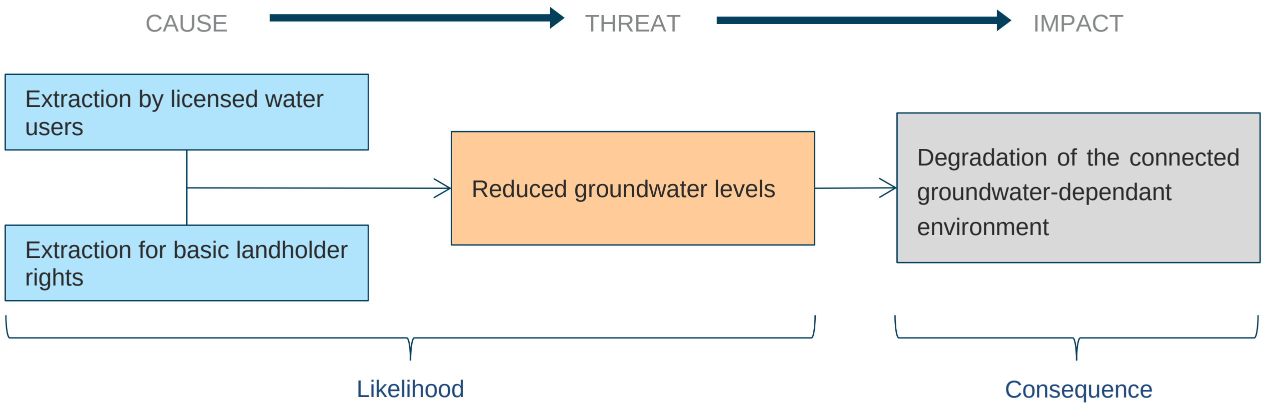

Figure 3-5 Impact pathway for identifying risks to the environment associated with reduced water levels in the connected alluvial aquifers

To evaluate the risk of degrading the GDEs within these water sources, the consequence of concern needs to be described. Table 3-7 describes the consequence, and the likelihood of it occurring, to provide a formula to rate the level of risk.

Table 3-7 Formula used to derive risk to alluvial groundwater-dependent environmental assets from reduced groundwater levels in the connected alluvial aquifers

Risk	=	Consequence	and	Likelihood
There is a risk of insufficient water being available to maintain water for vegetation dependant on connected alluvial aquifers…		... that may lead to loss of groundwater dependent ecological values		… from reduced groundwater levels caused by water extraction (as reflected by rate and magnitude of change in water levels at monitoring bores and the assumption that full entitlement is extracted)

3.3.1 Identifying groundwater dependent values and rating consequence

The ecological values and consequences for each GDE were derived using the HEVAE framework. This framework identifies values of diversity, distinctiveness, naturalness, and vital habitat to form an overall ecological value rating for the GDE (Dabovic et al. 2019) similar that used for the riverine HEVAE. The GDE HEVAE outcomes are derived from a relative assessment of value of the dependant ecosystems within the Interim Biogeographic Regionalisation of Australia (IBRA) subregions (Environment Australia, 2000).

Contributing to the consequence rating is the presence of threatened species and populations, and EECs listed under State and Commonwealth legislation that have linkages with GDEs. Current listings on agency threatened species websites were reviewed to ensure all related threatened factors were included in the analysis.

A decision-making tool guided the final consequence rating by considering the ecological values and the probability of those values being affected by groundwater extraction. The decision tree approach takes the range of GDE HEVAE outcomes into account to enable a logical consequence rating to be derived. Each part of this process is documented and the rationale for each part of the tool is provided in Appendix E (Figure E-1). The final consequence ratings are provided in Table 3-8.

3.3.2 Calculating likelihood of insufficient water for groundwater dependent ecosystems

The likelihood of insufficient water for GDEs is ideally rated by evaluating the historic water levels in the connected alluvial aquifers or through modelling (if available). Monitoring of water level has not been undertaken for any of the coastal alluvial aquifers in the Towamba Plan area. An alternative method, and more uncertain method, based on the presence or absence of licences (as described in Appendix G) has been used due to the lack of monitoring.

3.3.3 Risk outcomes - insufficient water for groundwater dependent ecosystems

Figure 3-6 shows the matrix used to calculate risk of insufficient water for GDEs.

		Likelihood (Change in recovered groundwater level category)			
		Low rate and magnitude of change in groundwater levels	Medium rate and magnitude of change in groundwater levels	High rate and magnitude of change in groundwater levels	Very High rate and magnitude of change in groundwater levels
Consequence (GDE HEVAE score)	Very Low	Low	Low	Low	Medium
	Low	Low	Low	Medium	High
	Medium	Low	Medium	High	High
	High	Low	Medium	High	Very High
	Very High	Medium	High	Very High	Very High

Figure 3-6 Risk matrix used for the risk of insufficient water for alluvial groundwater dependent ecosystems

This assessment includes the GDEs downstream of the tidal limit for the water sources listed in Table 3-8 as the lower floodplain groundwater source had not been defined at the time of the assessment.

The consequence rankings for the Towamba River unregulated and alluvial WSP water sources were high and very high due to DIWA and SEPP (Coastal Management) wetlands, threatened species, large and continuous patches of GDE vegetation, very high diversity, high naturalness, and vital habitat. The resulting consequence ratings for the groundwater dependant assets are shown in Table 3-8.

Table 3-8 Consequences of insufficient water for groundwater-dependant ecosystems

Unregulated water source	Consequence	Likelihood	Overall risk rating
Upper Towamba River	M	H	H
Jingo Creek	M	L	L
Pericoe Creek	M	L	L
Wog Wog River	VH	L	M
Lower Towamba River	VH	H	VH
Myrtle Creek	VH	H	VH
Mataganah Creek	VH	H	VH
Stockyard Creek	M	L	L
Far South Coast	H	L	L
Wonboyn River	H	L	L
Green Cape	M	L	L
Towamba Estuary Tributaries above mangrove limits	M	H	H
Nullica River above mangrove limits	M	L	L
Eden Tributaries	M	L	L
Curalo Lake and Tributaries	M	L	L
Pambula Lake Tributaries above mangrove limits	VH	H	VH
Merimbula lake Tributaries above mangrove limits	H	H	H
Merimbula Creek	M	H	H
Tura Beach Tributaries	M	L	L
Sandy Beach Creek	M	H	H
Bondi Lake and Tributaries	VH	L	M

Key: VL = Very Low; L = Low; M = Medium; H = High; VH = Very High; N/A = no risk outcome or modelling available due to lack of data.

3.4 Risk of groundwater quality change in the upstream alluviums

There is currently no water quality data available for groundwater in the upper connected alluviums. Therefore, this risk is unable to be assessed in the Towamba River unregulated and alluvial WSP area.

3.5 Risk of poor water temperature for freshwater riverine ecosystems

Water temperature outside natural ranges has been identified as a water quality degradation issue in many NSW catchments. The major cause of water temperature below natural ranges is the release of water from below the thermocline of large water storages in spring, summer and autumn. Release of stored water during winter may cause water temperature above natural ranges. The removal of shading riparian vegetation and reduced flows may also cause water temperature above natural ranges.

Water temperature influences many biological and ecosystem processes. The release of cold water can impact on ecosystem function and condition of ecological assets by causing temperature depression downstream. Warmer temperatures can increase growth rates and metabolism of in-stream plants, animals and algae. Temperature influences the spawning, breeding, and migration patterns of many aquatic animals. The impact pathway is shown in Figure 3-7.

Clearing of vegetation in the riparian zone and poor geomorphic condition can lead to increased sunlight reaching the water surface, resulting in increased water temperature. The extent and scale of this form of increased thermal pollution in the Towamba River unregulated and alluvial WSP area is unknown. Risks arising from increased thermal pollution are not addressed further in this assessment due to lack of data.

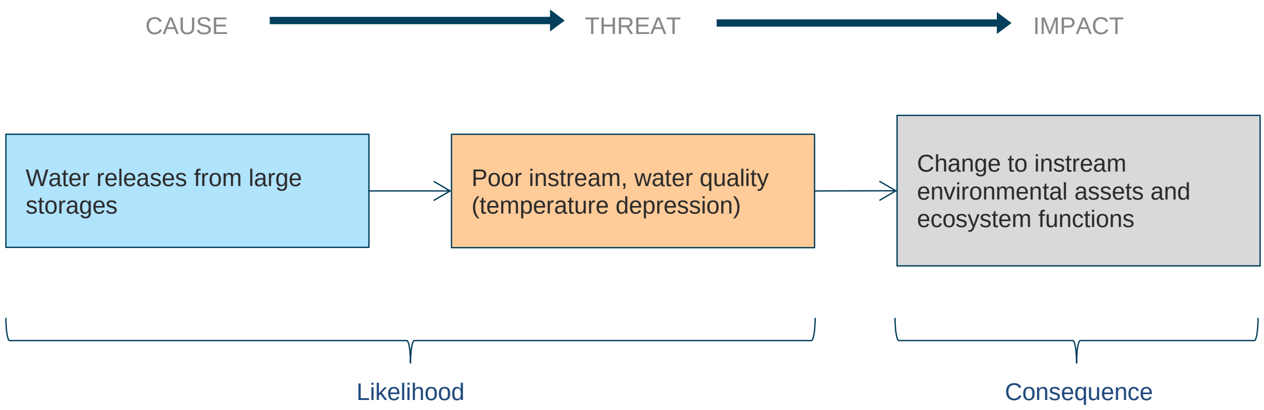

Figure 3-7 Impact pathway showing impact of cold water pollution on ecological functions and assets

3.5.1 Risk outcomes - water temperature outside natural ranges

This report indicates there are no on-river storages in the Towamba River unregulated and alluvial WSP area that could pose a cold water pollution risk (Preece, 2004).

While there are no large river storages, Bega Valley Shire Council has two water storages in the WSP area. Ben Boyd Dam is an off-stream water storage with water sourced from the Towamba River alluvial aquifer, known as the Kiah bore field. Yellow Pinch Dam has a small catchment with most water sourced from Tantawangalo Creek weir in the Bega catchment. It is understood that water is generally not released into the river system. For these reasons, it was determined that the risk of impacts from unseasonably cold (or warm) water releases on water dependent ecosystems in the Towamba River WSP area is low risk. (Note, should water be release from these dams, thermal pollution should be considered, as well as inter-valley transfer issues for Yellow Pinch Dam).

4 Risks to the environment downstream of the tidal limit

4.1 Risk of insufficient water for estuarine ecosystems

Alteration of freshwater inflows to an estuary through water extraction, interception of water moving through the landscape, or changes to rainfall and runoff caused by climate change, can impact on estuarine ecosystems. Figure 4-1 shows the pathway from cause, to threat, to impact on the estuarine ecosystem.

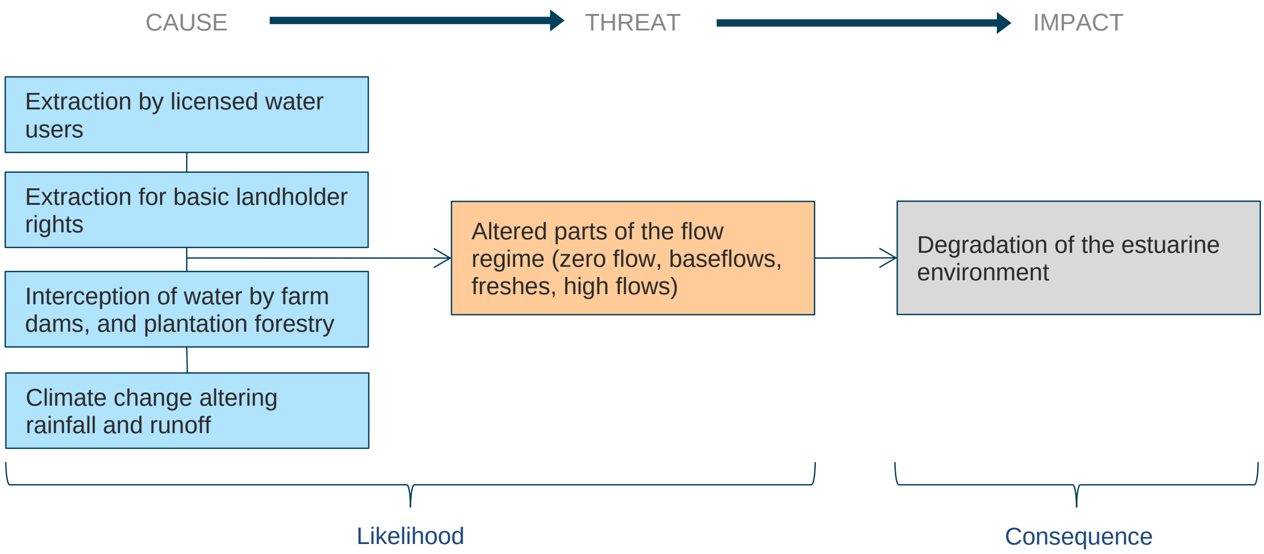

Figure 4-1 Impact pathway for identifying risks to the environment associated with alteration to the inflow regime in the estuarine reaches of the river system

The impact pathway can be used to develop a formula to evaluate the risk of degrading the ecology of the estuary. Table 4-1 describes a formula to derive risk based on the consequence and the likelihood of degradation occurring.

Table 4-1 Formula used to derive risk to estuarine environmental assets from the alteration of the inflow regime to the estuarine reaches of the river system

Risk	=	Consequence	and	Likelihood
There is a risk of insufficient water being available to provide for key ecosystem functions in upper reaches of the estuary…		... that may lead to loss of estuarine ecological values		… from an altered flow regime caused by water extraction, interception, and climate change

For most estuary types in NSW, freshwater inflows influence only the most upstream part of the estuary, sometimes referred to as the brackish reach or tidal pool. Tidal pools play a valuable role in the lifecycle of many species and can provide a reliable source of freshwater for extractive uses. The statutory definition of tidal limits for estuaries (as relevant to Water Sharing Plans) is the water area between the limit of mangrove extent (*Avicennia marina*), and the limit of tidal influence. However, tidal limits are constantly moving, influenced by sea level, rainfall, run-off inputs (including the effects of extraction or regulation), as well as specific estuary geomorphology.

Selecting mangroves as an indicator accounts for this inherent variability, as mangroves cannot survive in freshwater for extended periods of time.

Climate change in some regions will lead to reduced rainfall. In other regions, rainfall may increase, but is expected to be dominated by larger storm events, with longer dry periods between them. This will alter the hydrology of rivers draining to estuaries, with increased periods of low or no-flow, and consequently increased salinity intrusion. Additionally, climate-driven sea level rise in NSW is projected to be in the range 0.24 – 1.06 m by the year 2100, based on various greenhouse gas emission scenarios (Glamore et al. 2015). This will also lead to upstream migration of the salinity wedge. In some estuaries, these consequences are predicted to be more pronounced through a process known as tidal amplification. The extent of climate-based risk was not addressed in this risk assessment.

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 (NOW, 2009). This process includes assessment of some economic and cultural factors as well as ecological factors and is summarised below.

4.1.1 Identifying estuarine values and rating consequence

Estuarine consequence scores were based on a range of data sets, chosen to represent the attributes that best aligned with the HEVAE method for freshwater systems. These included ecological values (naturalness, diversity, rarity, representativeness and special features). Other attributes have also been used for non-extractive values (e.g. commercial and recreational fishing) and place values (National Parks, SEPP (Coastal Management) wetlands, Ramsar/JAMBA/CAMBA, declared locations), with individual scores combined to form an overall value score. A more detailed description is provided in Appendix F.

4.1.2 Calculating likelihood of insufficient water for estuarine ecosystems

Low flow hydrologic stress was used to determine the likelihood of extraction-related events occurring during low flows. This was defined as the ratio between 80th percentile flow derived from the full length of record available including pre and post development, and the 80th percentile same period but with extraction accounted. The 80th percentile was chosen for consistency with the key ecosystem metrics, but also to the previous macro assessments (DIPNR, 2005; NSW Office of Water, 2011) and is generally recognised as the upper limit of low flows. While it may not represent a specific threshold at which particular events may occur, it is a consistent indicator of the ability of extraction to significantly reduce flows during low flow periods.

Key ecosystem metrics for freshes were used to determine the likelihood of extraction-related impacts on higher flows events. Freshes are defined as flows events above the 20th percentile and include both instream and overbank flow events which are associated with rainfall. The metrics look at the frequency and duration of freshes and how they are altered by extraction. Similar to low flows, the metrics are the ratio between duration and frequency of freshes derived from the full length of record, and the duration and frequency for freshes for same period but with extraction accounted.

4.1.3 Risk outcomes - insufficient water for estuarine ecosystems

Five estuaries were assessed as having a high risk to estuarine values due to insufficient low flow inflows (Table 4-2).

Table 4-2 Risk to estuarine values due to insufficient inflows

Estuary	Consequence (Estuary value adjusted by sensitivity)		Likelihood		Overall risk rating	
	Low inflow	High inflow	Low inflow	High inflow	Low inflow	High inflow
Wallagoot Lake (Wallagoot Lake and Tributaries Water Source)	H	H	M	L	H	M
Bournda Lagoon (Sandy Beach Creek Water Source)	H	L	H	L	H	L
Back Lagoon (Merimbula Creek Water Source)	H	L	H	L	H	L
Merimbula Lake (Merimbula Lake Tributaries Water Source)	L	H	M	L	L	M
Pambula River (Pambula Lake Tributaries Water Source)	H	H	H	L	H	M
Curalo Lagoon (Curalo Lake and Tributaries Water Source)	H	H	L	L	M	M
Shadrachs Creek (Eden Tributaries Water Source)	L	L	L	L	L	L
Nullica River (Nullica River Water Source)	H	L	L	L	M	L
Boydtown Creek (Towamba Estuary Tributaries Water Source)	L	L	L	L	L	L
Towamba River (Towamba Estuary Tributaries Water Source)	H	H	M	L	H	M
Fisheries Creek (Towamba Estuary Tributaries Water Source)	H	L	L	L	M	L
Twofold Bay (Green Cape Water Source)	L	L	L	L	L	L
Saltwater Creek (Eden) (Green Cape Water Source)	L	L	L	L	L	L
Woodburn Creek (Green Cape Water Source)	L	L	L	L	L	L
Bittangabee Creek (Green Cape Water Source)	L	L	L	L	L	L
Wonboyn River (Wonboyn River Water Source)	M	H	L	L	L	M
Merrica River (Far South Coast Water Source)	H	L	L	L	M	L
Table Creek (Far South Coast Water Source)	L	L	L	L	L	L
Nadgee River (Far South Coast Water Source)	H	L	L	L	M	L
Nadgee Lake (Far South Coast Water Source)	H	H	L	L	M	M

4.2 Risk of poor 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 aquatic species and extractive uses. Water extraction, land use change, interception of water moving through the landscape and variability in rainfall and runoff can impact estuarine water quality. Similar threats and impacts were presented previously in the risk of insufficient flow in Figure 4-1. Decreased freshwater inflows can result in increased salinity as the tides push further upstream in the tidal pool. This risk can be evaluated by monitoring the salinity of the water in the brackish tidal pool zone. Figure 4-2 shows the pathway from cause, to threat, to impact on estuarine ecosystems.

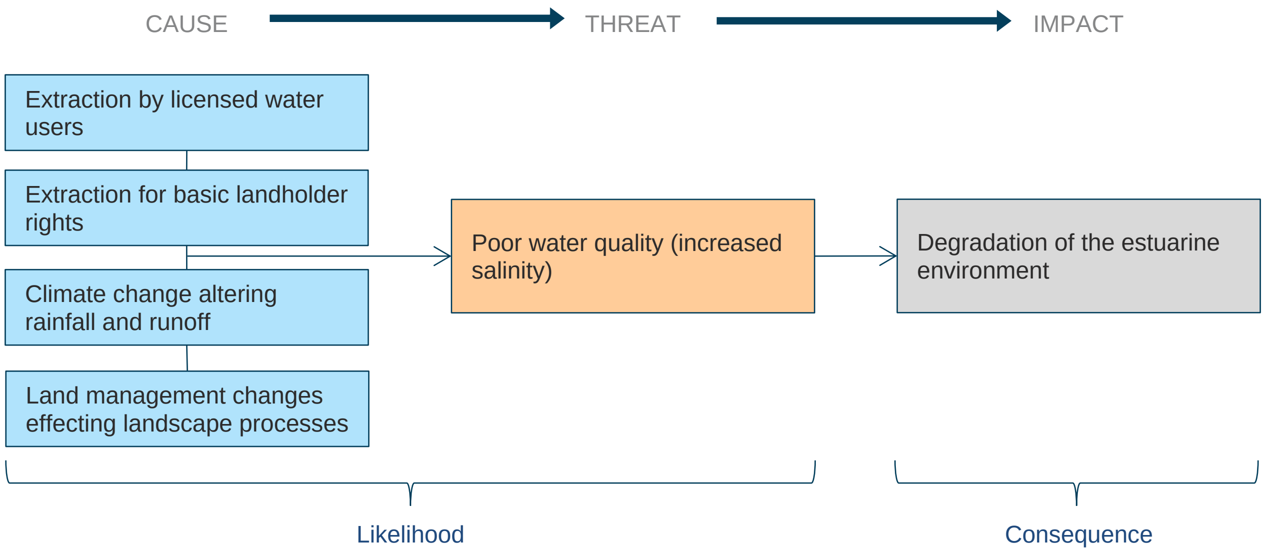

Figure 4-2 Impact pathway for identifying risks to the environment associated with poor water quality in the estuarine reaches of the river system

The impact pathway can be rewritten to generate a formula for evaluating risk based on the monitoring of electrical conductivity (EC), which is an indicator of salinity (Table 4-3).

Table 4-3 Formula used to derive risk to estuarine environmental assets from poor water quality in the estuarine reaches of the river system

Risk	=	Consequence	and	Likelihood
There is a risk of poor water quality not providing for key ecosystem functions in upper reaches of the estuary…		... that may lead to loss of estuarine ecological values		… from high salinity water during dry periods caused by water extraction, and climate change

There is currently no salinity monitoring data in the tidal reaches of the rivers in the Towamba River unregulated and alluvial WSP area. Therefore, this risk is not able to be assessed further in this report.

4.3 Risk of insufficient groundwater for dependent ecosystems in lower floodplain alluviums

A new water source, the Towamba River Area Coastal Floodplain Alluvium, will include the alluvial groundwater aquifers below the tidal limits of the current Towamba River unregulated and alluvial WSP. This water source is aligned to capture Coastal Floodplain Alluvial area not previously incorporated into a WSP. An assessment of the groundwater in the lower floodplain alluviums is provided in Appendix J.

This assessment considered a range of factors to establish a Long Term Annual Average Extraction Limit, which is designed to maintain the average water level in the aquifer at sustainable levels over the long term.

4.4 Risk of groundwater quality change in lower floodplain alluviums

Acid sulfate soils are naturally occurring sediments found in every coastal estuary in NSW. Modification of the natural surface drainage system, through the construction of drains to remove surface water from surrounding farmland or to drain low lying swamps to assist with flood mitigation, can expose acid sulfate soils to the atmosphere. These soils contain iron sulfides, which react with oxygen to create sulfuric acid. The areas of highest acid sulfate soils risk are in the low-lying areas at the bottom of each catchment, which in the Towamba River unregulated and alluvial WSP area, are within the Towamba WSP Coastal Floodplain Alluvium groundwater source.

Due to their low permeability and unsuitable groundwater quality for water supplies, these sediments are not typically considered a water supply target. Nevertheless, the aquifer assessment for the Towamba Floodplain Alluvium has identified a medium water quality risk due to potential disturbance of high probability acid sulfate soils near the coastline and brackish to saline groundwater. Further discussion of the risks of groundwater quality change in these lower floodplain alluviums is provided in Appendix J.

Risks associated with acid drainage from these sediments via constructed drains are not managed under the WSP rules. These aquifer interference activities are assessed and approved under the *Environmental Planning and Assessment Act 1979*.

5 Risk of unsuitable water for other uses

5.1 Risk of unsuitable water quality for other water uses upstream of tidal limit

In the freshwater river reaches, flow has a role in maintaining the quality of the water, including by; diluting and flushing saline water, maintaining dissolved oxygen levels, transporting nutrients, moderating temperature, and regulating growth of algae. These processes can reduce the suitability of the water in the rivers for human water uses.

While these processes occur naturally, reducing streamflow can exacerbate the risk by increasing the likelihood of unsuitable water quality. The causes of flow alteration are the same as those for section 3.2 (risk of poor water quality for freshwater ecosystems), therefore, the impact pathway for the risk of unsuitable water quality for other water uses is similar, but with the risk being 'unsuitable water quality for other water uses' (see Section 3.2 and Table 3-3).

5.1.1 Risks to water used for irrigation

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. EC less than 1,000 µS/cm is generally considered safe for agriculture and irrigation on all soil types with all methods of application (ANZECC, 2000). There are no continuous EC monitoring sites in the Towamba River unregulated and alluvial WSP area to assess this target. For this reason, monthly data from the routine water quality samples for the SWAMP monitoring site located upstream of the tidal limit have been used to assess this target. The median EC results were calculated from 2015 to 2020 and are listed in Appendix I Water Quality Data.

Electrical conductivity at this site had annual medians below 260 µS/cm, and pose no risk to crop health or soil structure from licensed water users using water for irrigation.

5.1.2 Risks to water used for recreational uses

Most algae are harmless and are a natural part of aquatic ecosystems. However, some types of blue-green algae (cyanobacteria) can produce hepatotoxins, neurotoxins and other toxins. Blue-green algae can increase to excessive levels if conditions are suitable, forming visible 'blooms' that can adversely affect water quality. The blooms can disrupt drinking water supplies, recreational activities, and water-dependent industries, and pose a risk to livestock, wildlife and human health.

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 5-1.

Table 5-1 Blue-green algae targets for recreational water

Water Quality Zone	Ecosystem Type	Guidelines
All	Recreational water bodies suitable for primary contact.	• ≤ 10 µg/L total microcystins; or ≤ 50 000 cells/mL toxic *Microcystis aeruginosa;* or 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; or • ≤ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present; or • Cyanobacterial scums not consistently present

Potentially toxic blue-green algal blooms have not been identified as a major issue in Towamba River unregulated and alluvial WSP area rivers.

5.1.3 Risks to water used for human consumption

Water utilities in NSW implement a risk-based approach to drinking water management to ensure a secure and safe drinking water supply. The *Public Health Act 2010* and the *Public Health Regulation 2012* require drinking water suppliers to develop and adhere to a Drinking Water Management System (DWMS) that takes a multiple barrier approach from catchment to tap. The DWMS addresses the elements of the Framework for Management of Drinking Water Quality (Australian Drinking Water Guidelines) and is a requirement of a water suppliers operating licence (NSW Ministry of Health 2013).

Bega Valley Shire Council manages risks to raw water according to the Australian Drinking Water Guidelines. Risks to raw water and their management strategies will not be addressed further in this assessment.

5.2 Risk of unsuitable groundwater quality for other water uses upstream of tidal limit

Groundwater quality is a function of recharge rates, residence time and the geological matrix through which the groundwater flows. Within a groundwater system, productive aquifers can be in close proximity to, and have some degree of hydraulic connection with, groundwater of lesser quality (e.g. that which is more saline). Pumping between zones of varying groundwater quality can induce a change in relative groundwater hydraulic heads, which can alter the groundwater quality in a locality.

5.2.1 Risks to irrigation from elevated salinity in groundwater

There is no data currently available to assess the risk of groundwater quality changes in this WSP area. Qualitatively the risk would appear to be low as there is very little licensed groundwater extraction for the purposes of irrigation in most water sources. Total groundwater entitlement, except for Lower Towamba River Water Source where there is a bore field used to town water supply, is less than 350ML, suggesting the likelihood of groundwater pumping inducing a change is low, with possibility of issues in the Lower Towamba River Water Source.

There are several aquifers that because of their proximity to the upstream alluvial aquifers could connect with the upland alluvial aquifers, and potentially lead to lesser quality entering the alluvial aquifers. The groundwater sources and WSPs that these aquifers are associated with are subsequently described here. The *Water Sharing Plan for the South Coast Groundwater Sources*

2016 provides management rules in relation to fractured and porous rock and coastal sands aquifers in the Towamba River area.

In the Lachlan Fold Belt Coast groundwater source water recharges from rainfall and river flows and filters through the rock system at varying speeds depending on its location in the landscape. Bores in this aquifer usually yield smaller amounts of groundwater. The groundwater in these systems support base flows to rivers, wetlands, caves, terrestrial vegetation and hypogean ecosystems, however, travel time of aquifer water to and from streams is relatively slow, being in the order of several years or decades. Therefore, this aquifer is not considered to be highly connected to river systems.

The South East Coastal Sands groundwater source is a group of geographically non-contiguous coastal sand aquifers located along the southern NSW coastline. These aquifers are mostly unconfined with a high porosity and shallow depth to the water table, although some localised layers of 'coffee-rock' (iron-indurated sand) and clays typically create semi-confined aquifers at depth.

5.3 Risk of unsuitable water quality for other water uses downstream of tidal limit

The freshwater inflow to an estuary creates a brackish water zone. In some estuaries this zone is large and permanent (the tidal pool), and in others it is small and temporary. As the causes of flow alteration are the same, the impact pathway for insufficient water for estuarine ecosystems (Figure 4-1 can be used.

5.3.1 Risks to irrigation from elevated tidal pool salinity

Where tidal pools exist, the water in them is regularly fresh, despite being affected by daily tidal movements. Irrigation from tidal pools in the Towamba River unregulated and alluvial WSP area has not been identified and is unlikely to occur as the salinity below the upper tidal limit is high relatively often, especially during low flow periods. It is possible that the mapped location of a bore near the Towamba River tidal limit, with 70ML linked to it, may be impacted by saltwater intrusion moving up the estuary.

While there is provision for the management of extractions from tidal pools, at this stage no licensed water extractions in this reach of the streams have been identified. Therefore, risk to irrigation from elevated tidal pool salinity will not be assessed further in this report.

There is currently no salinity monitoring data in the tidal reaches of the rivers in the Towamba River unregulated and alluvial WSP area.

5.4 Risk of unsuitable groundwater quality for other water uses downstream of tidal limit

5.4.1 Risks to irrigation from elevated salinity in groundwater

As noted previously in section 4.3, the Towamba Floodplain Alluvium water source covers the alluvial aquifers below the tidal limits associated with the estuarine reaches of river and the coast. The risk to irrigation from elevated salinity and/or the possible acidity of groundwater in these lower floodplain alluviums has been identified as a risk. Further discussion is provided in Appendix J.

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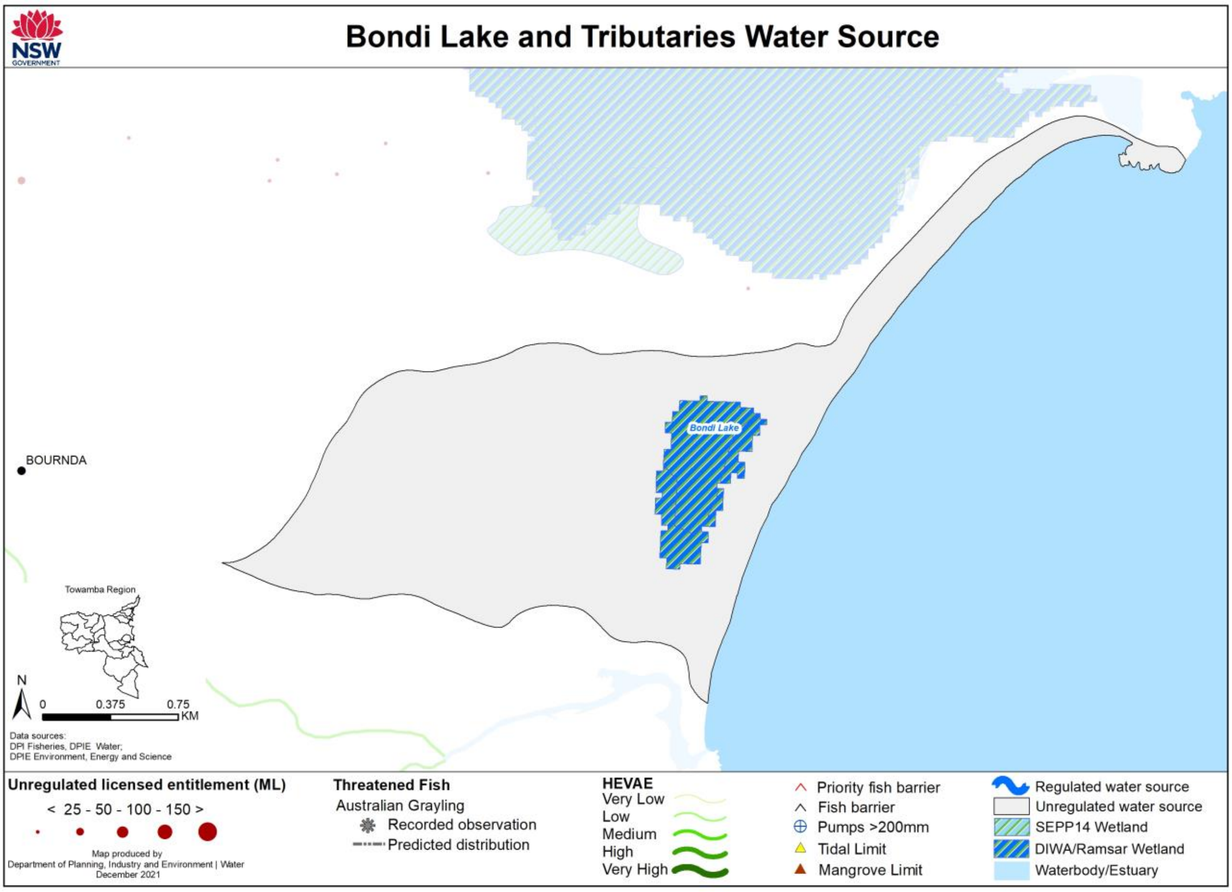
Appendix A Water source report cards

Bondi Lake and Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)					
Rating	High				
Drivers (ecological value)	Assess through estuary process. No HEVAE river reaches in this water source. See Appendix H1 for further details.				
Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L0	L0	L0	L0	L0	L0
Drivers (hydrologic alteration)	There is no entitlement in the water source.				
Level of Risk					
L0	L0	L0	L0	L0	L0

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Medium distinctiveness, very high diversity, high naturalness, medium vital habitat and DIWA wetlands.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
M	

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 Bondi Lake and Tributaries Water Source flows directly into Bondi Lake lagoon.

Riverbed and riverbanks

Bondi Lake and Tributaries Water Source contains Bondi Lake and its tributaries. Bondi Lake is a freshwater lagoon situated in a broad coastal valley. Freshwater coastal lagoons are fed by freshwater inflows from one or more small streams. They are typically shallow with sandy bottoms and are separated from the sea by a low-lying sand barrier which limits exchange between the sea and the lagoon. Geomorphic features, or river features, that provide habitat for the tributary streams in this water source typically include sediment bars, vegetated islands and flood channels. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. 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.

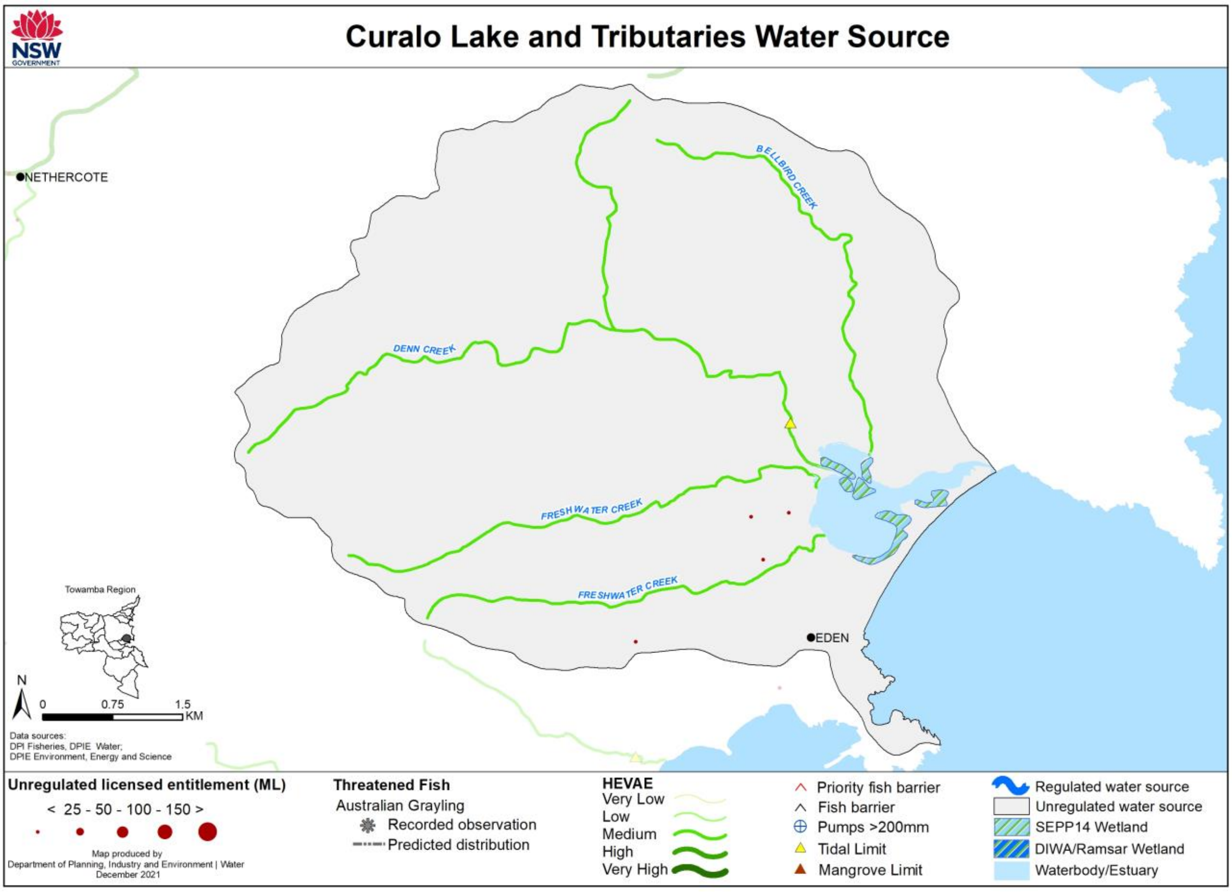
The current mapping of geomorphic river condition in the Bondi Lake and Tributaries Water Source indicates that condition in Bondi Lake and Tributaries has not been defined. Bondi Lake and Tributaries Water Source is a small coastal catchment wholly within National Park. Habitat values in adjacent water sources are threatened by 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Curalo Lake and Tributaries Water Source



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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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High, Diversity = Very Low to Low. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (known), Stuttering barred frog (known), Littlejohns tree frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^-	L^0	L^0	L^0	L^0
Drivers (hydrologic alteration)	No measurable changes to low or high flows under current development, due to very low entitlement in the water source.				

Level of Risk					
L^0	L^-	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Estuary inflow risk

Curalo Lagoon Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
High	High
Drivers (value)	Curalo Lagoon value rating is high (high representativeness, fish species richness, indigenous lands), low hydro stress.
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
M	M

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Medium distinctiveness, high diversity, medium naturalness and low vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Curalo Lake and Tributaries Water Source flows directly into Curalo Lagoon estuary and Twofold Bay.

Riverbed and riverbanks

Curalo Lake and Tributaries Water Source contains Bellbird Creek, Palestine Creek, Freshwater Creek and their tributaries. The main channel of the Curalo Lake and Tributaries is 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris and flood channels. 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 (e.g. 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.

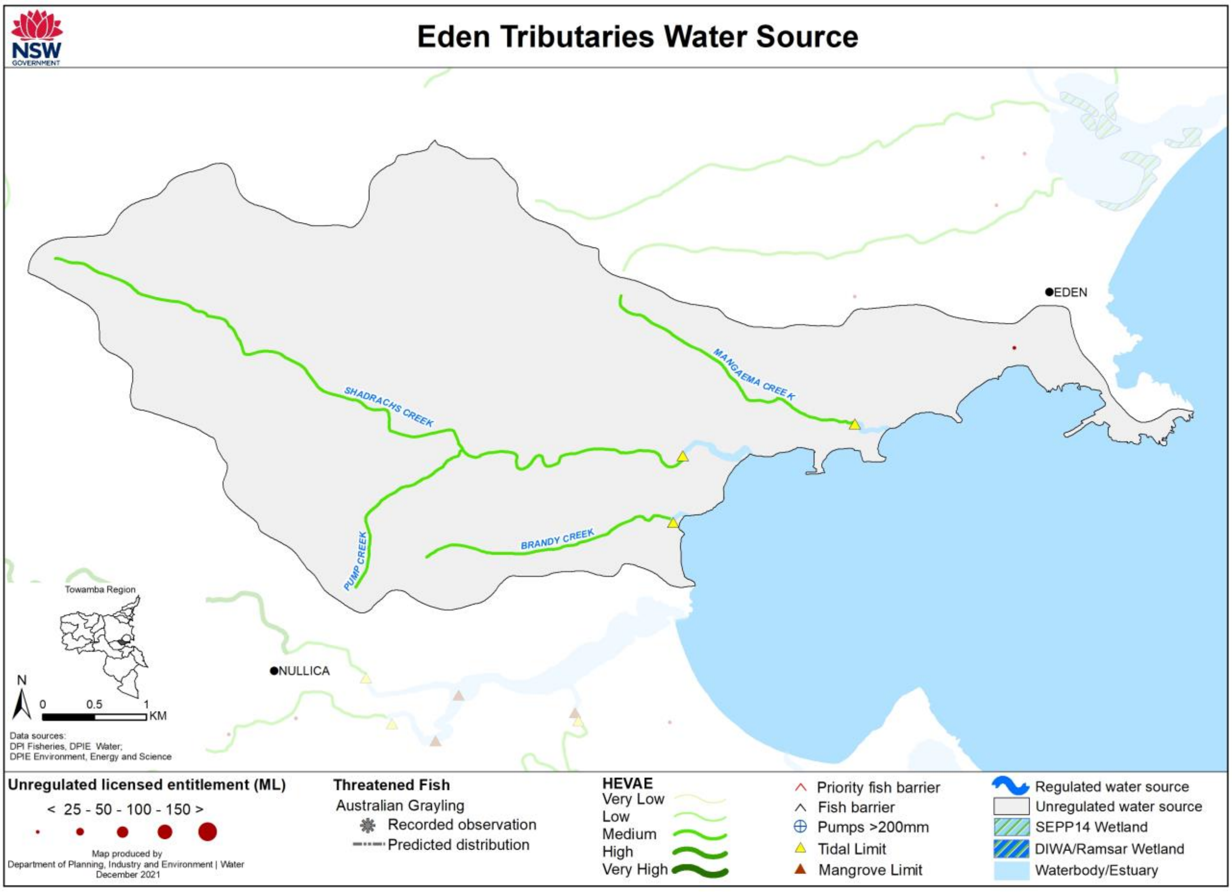
The current mapping of geomorphic river condition in the Curalo Lake and Tributaries Water Source indicates that condition is generally ‘good' in the upper water source and 'moderate' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover and 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Eden Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High, Diversity = Very low. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^0	L^0	L^0	L^0	L^0
Drivers (hydrologic alteration)	There is no entitlement in the water source.				
Level of Risk					
L^0	L^0	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Estuary inflow risk

Shadrachs Creek Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
Low	Low
Drivers (value)	No previous rating
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
L	L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Medium distinctiveness, high diversity, low naturalness and low vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Eden Tributaries Water Source flows directly into Twofold Bay.

Riverbed and riverbanks

Eden Tributaries Water Source contains Managaema Creek, Shadrachs Creek, Brandy Creek and their tributaries. The main channel of the rivers of the Eden Tributaries is 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris and flood channels. 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 (e.g. 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.

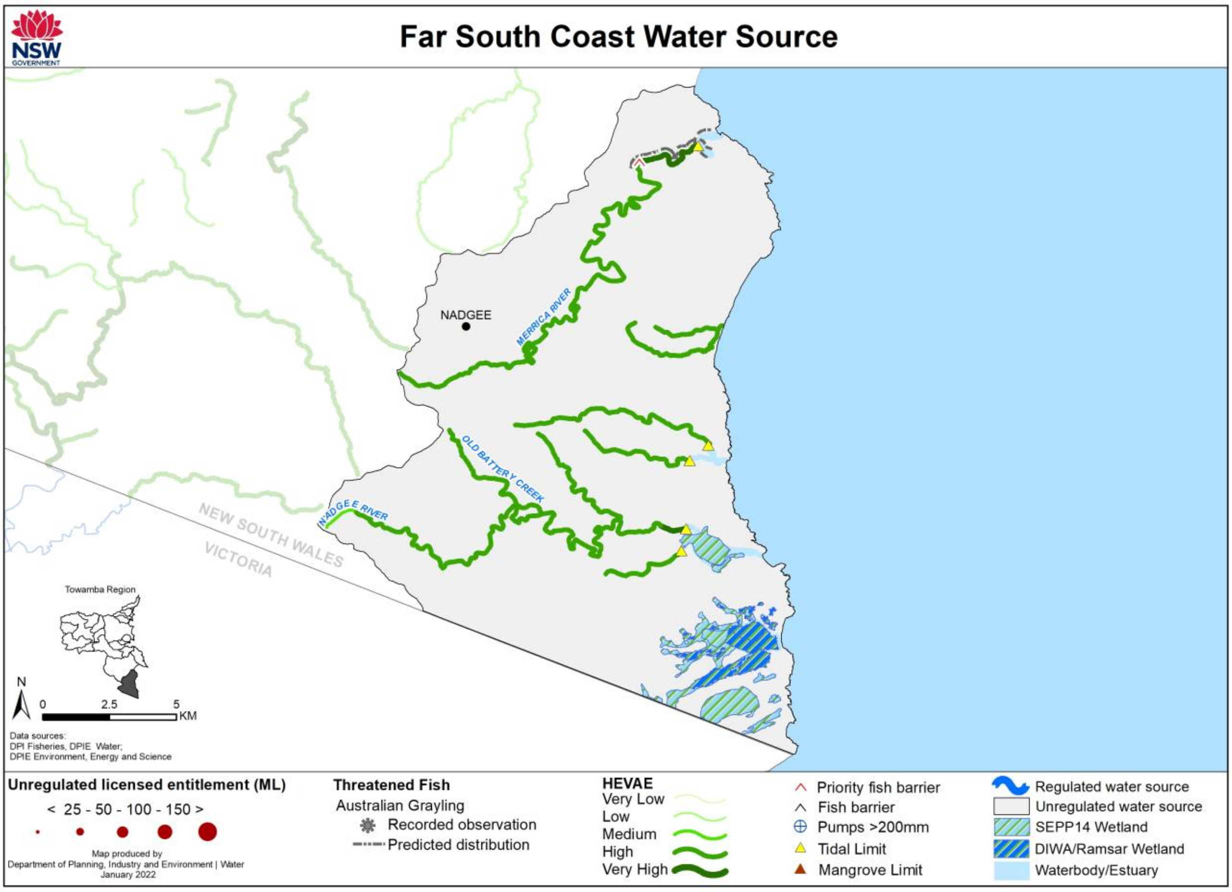
The current mapping of geomorphic river condition indicates that the Eden Tributaries are generally in ‘good' condition in the upper water source and 'moderate' condition in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover. Lack of appropriate 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Far South Coast 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium to Very High, Naturalness = Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (recorded), Giant burrowing frog (known), Stuttering barred frog (known), Australian grayling (predicted). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded), Giant dragonfly (recorded).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^0	L^0	L^0	L^0	L^0
Drivers (hydrologic alteration)	There is no entitlement in the water source.				
Level of Risk					
L^0	L^0	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Risk rating increased with HEVAE consequence rating higher. The balance of the HEVAE consequence rating is different, as no extraction in the water source, lots of National Park (Nadgee NP). This is the key reason why the consequence decision tree came out with a medium classification as opposed to the macro classification of high.

Estuary inflow risk

Merrica River Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
High	Low
Drivers (value)	Multiple estuaries - all medium value scores (high naturalness), low hydro stress.
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
M	L

Table Creek Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
Low		Low
Drivers (value)	Multiple estuaries - all medium value scores (high naturalness), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
L		L

Nadgee River Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
High		Low
Drivers (value)	Multiple estuaries - all medium value scores (high naturalness), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
M		L

Nadgee Lake Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
High		High
Drivers (value)	Multiple estuaries - all medium value scores (high naturalness), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		

Nadgee Lake Estuary	
M	M

Upland alluvium groundwater level risk

Consequence (GDE value)	High
Drivers (ecological value)	Medium distinctiveness, high diversity, medium naturalness and low vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Far South Coast Water Source flows directly into a number of coastal estuaries and into the Tasman Sea of the South Pacific Ocean.

Riverbed and riverbanks

Far South Coast Water Source contains Merrica River, Wirra Birra Creek, Little Creek, Nadgee River and their tributaries. The main channel of the Far South Coast tributaries is confined by bedrock in the upper and middle water source, opening up to a broad floodplain in the lower water source. The river bed is bedrock in the upper water source, gravelly and sandy in the tidal reaches. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris and flood channels. 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 (e.g. 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.

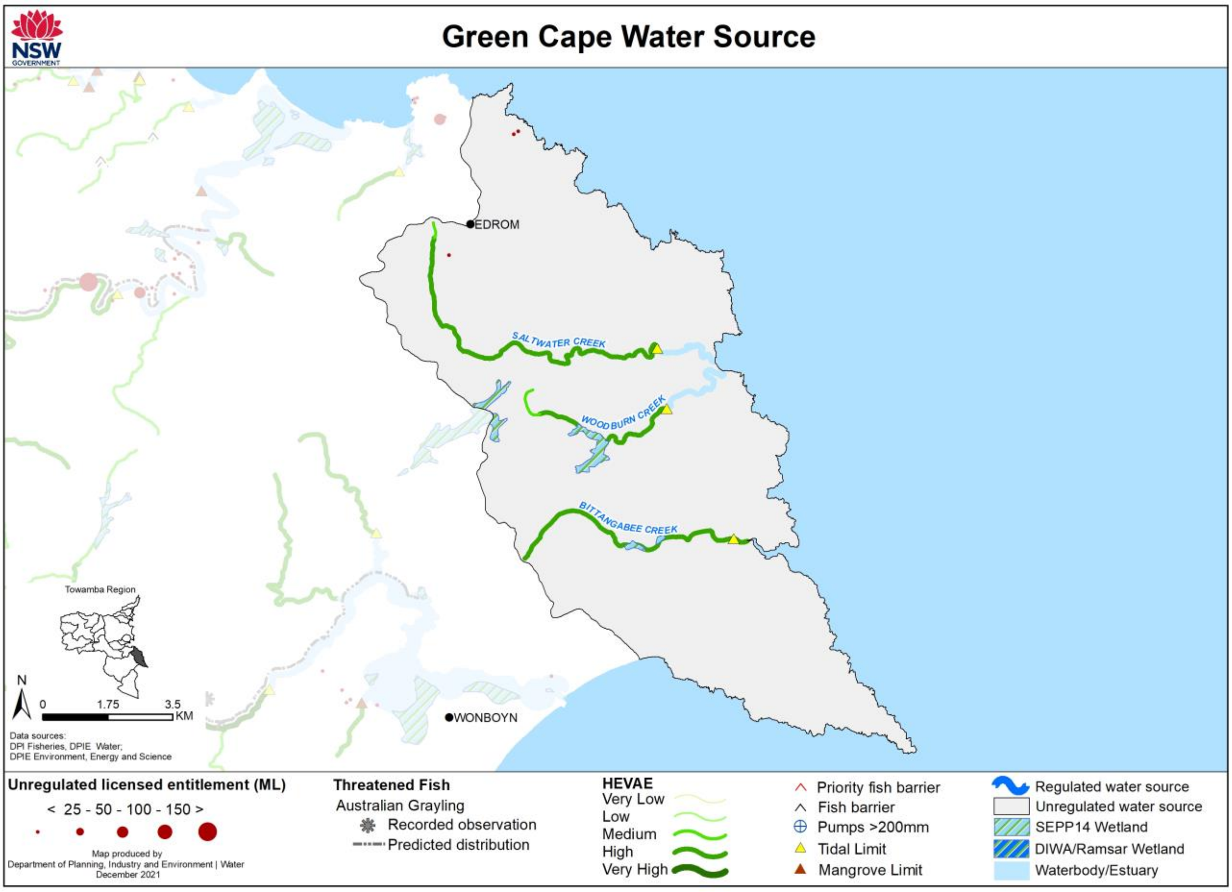
The current mapping of geomorphic river condition in the Far South Coast Water Source indicates that condition is generally ‘good' throughout. The Far South Coast Water Source is a small coastal catchment within a nature reserve. Habitat values in adjacent water sources are threatened by lack of appropriate 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Green Cape 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)						
Rating	Medium					
Drivers (ecological value)	Distinctiveness = High, Naturalness = Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (recorded), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).					
Likelihood (degree of hydrological alteration)						
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows			
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI	
L^0	L^0	L^0	L^0	L^0	L^0	
Drivers (hydrologic alteration)	There is very little entitlement in the water source and the location of entitlement on a small tributary presents a low risk of hydrological alteration.					
Level of Risk						
L^0	L^0	L^0	L^0	L^0	L^0	

Comparison of previous risk rating and this rating

Risk rating decreased with HEVAE consequence rated lower. The balance of the HEVAE consequence rating is different, as there is no extraction in the water source, and lots of National Parks (Nadgee NP), resulting in very high naturalness outcomes.

Estuary inflow risk

Twofold Bay Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
Low	Low
Drivers (value)	Multiple estuaries - all medium value scores (high representativeness, declared locations), low hydro stress.
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
L	L

Saltwater Creek (Eden) Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
Low		Low
Drivers (value)	Multiple estuaries - all medium value scores (high representativeness, declared locations), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
L		L

Woodburn Creek Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
Low		Low
Drivers (value)	Multiple estuaries - all medium value scores (high representativeness, declared locations), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
L		L

Bittangabee Creek Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
Low		Low
Drivers (value)	Multiple estuaries - all medium value scores (high representativeness, declared locations), low hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
L		L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Low distinctiveness, very high diversity, high naturalness and medium vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Green Cape Water Source flows directly into a number of small coastal estuaries.

Riverbed and riverbanks

Green Cape Water Source contains Saltwater Creek, Woodburn Creek, Bittangabee Creek. The main channel of the Green Cape tributaries is swampy in its upper reaches, becoming confined by gorges in the lower water source. The river bed is bedrock and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

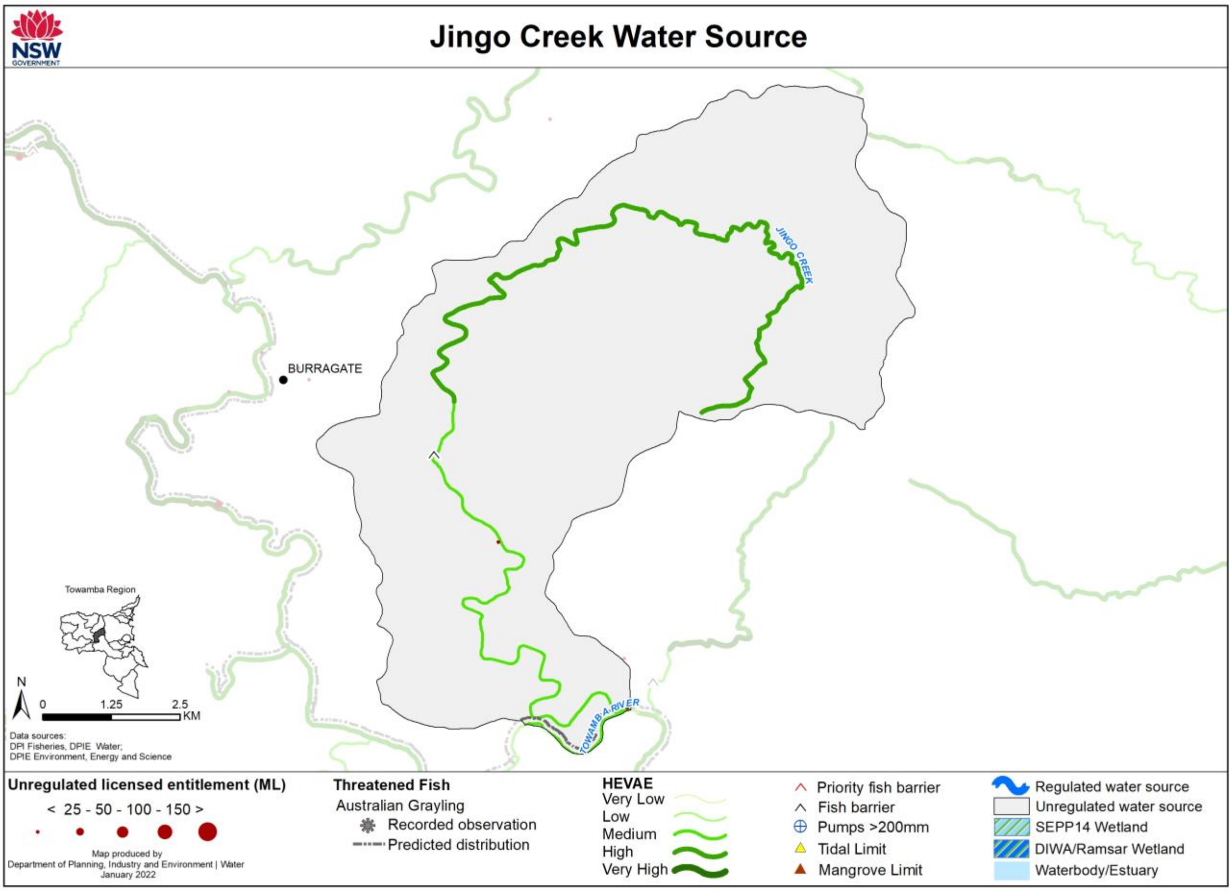
The current mapping of geomorphic river condition in the Green Cape Water Source indicates that condition in the Green Cape tributaries is generally ‘good' throughout the water source. Green Cape Water Source is a small coastal catchment of mostly forested areas within national park reserve. Habitat values in other parts of the water source are threatened by 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Jingo 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium to High, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^-	L^-	L^0	L^0	L^0
Drivers (hydrologic alteration)	Minor reduction in number of freshes per year in high flow season likely the result of extraction of higher flows by run of river irrigation.				
Level of Risk					
L^0	L^-	L^-	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	High distinctiveness, high diversity, medium naturalness and low vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Jingo Creek Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Jingo Creek Water Source contains the main channel of Jingo Creek and its tributaries. The main channel of the Jingo Creek is confined by bedrock in the upper water source, partly confined in the mid water source and confined in the lower water source. The river bed is bedrock and gravelly. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, chute channels. 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 (e.g. 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.

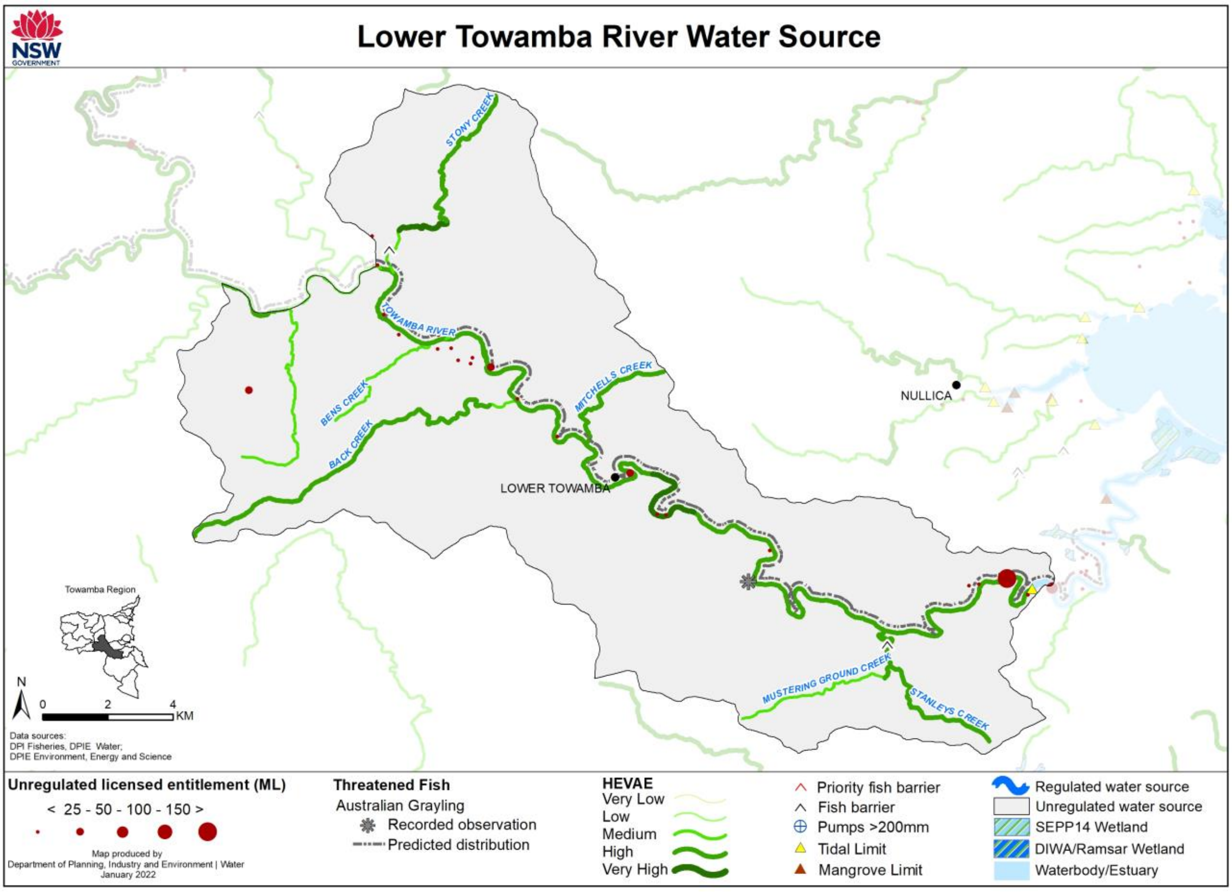
The current mapping of geomorphic river condition indicates that Jingo Creek is generally ‘good' in the upper water source, 'moderate' in the mid water source and 'good' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability and sediment slugs. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a cease to pump rule at a specific site in the water source, which is set at the 95th percentile flow.
- There are flow classes established in the water source up to the B flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is a cease to pump.

Lower Towamba 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Very High
Drivers (ecological value)	Distinctiveness = Medium to High, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Australian grayling (recorded), Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
L^{0}	M^{-}	L^{-}	L^{0}	L^{0}	L^{0}

Drivers (hydrologic alteration)	Decrease in 80th percentile flows in high and low flow seasons and slight decrease in average duration of freshes in low flow season results from river extraction during low flow conditions. No change in zero flow events may be the result of CtP protecting lowest flow class.

Level of Risk

M^{0}	H^{-}	M^{-}	M^{0}	M^{0}	M^{0}

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Medium distinctiveness, very high diversity, high naturalness, high vital habitat and an EEC.

Likelihood (presence of licenced entitlement)
H

Level of Risk
H

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 Towamba River Water Source flows into Towamba River estuary.

Riverbed and riverbanks

Lower Towamba River Water Source contains the main channel of the lower reaches of the Towamba River and its tributaries. The main channel of the lower reaches of the Towamba River is partly confined by a bedrock valley. The river bed is sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars, vegetated islands and large woody debris and flood channels, backswamps, chute channels. 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 (e.g. 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.

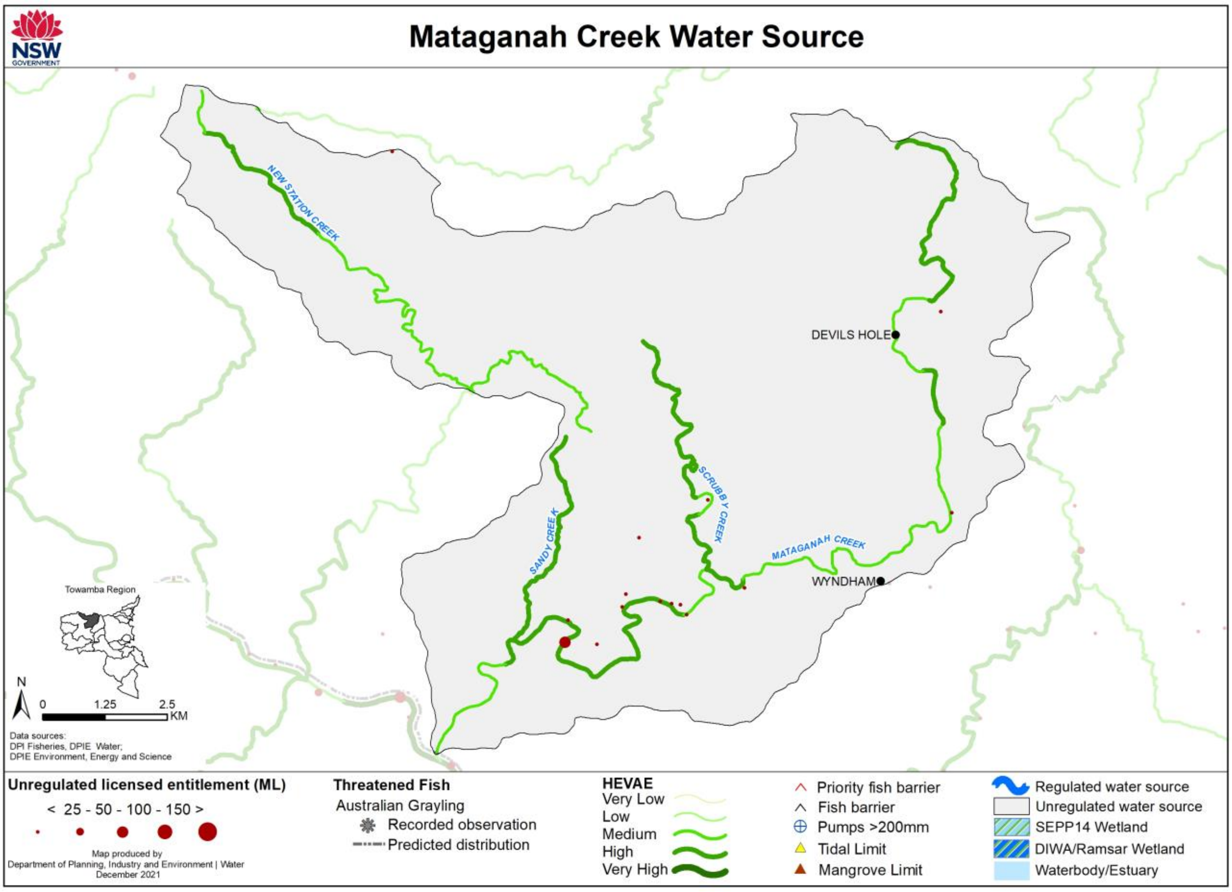
The current mapping of geomorphic river condition indicates that the lower reaches of the Towamba River is generally ‘poor' in the main channel and 'good' to 'moderate' in the tributaries. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability and sediment slugs. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are flow classes established in the water source up to the C flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is a cease to pump.

Mataganah 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = Very High, Diversity = Very Low to Low. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^-	L^0	L^0	L^0	L^0

Drivers (hydrologic alteration)	Alteration of the low flows evident with the majority of entitlement is associated with run of river irrigation.

Level of Risk

L^0	M^-	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Very high distinctiveness, high diversity, high naturalness, medium vital habitat and an EEC.

Likelihood (presence of licenced entitlement)

H

Level of Risk

H

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 Mataganah Creek Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Mataganah Creek Water Source contains the main channel of Mataganah Creek and its tributaries. The main channel of the Mataganah Creek is confined by a bedrock valley, opening up into a partly confined valley 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

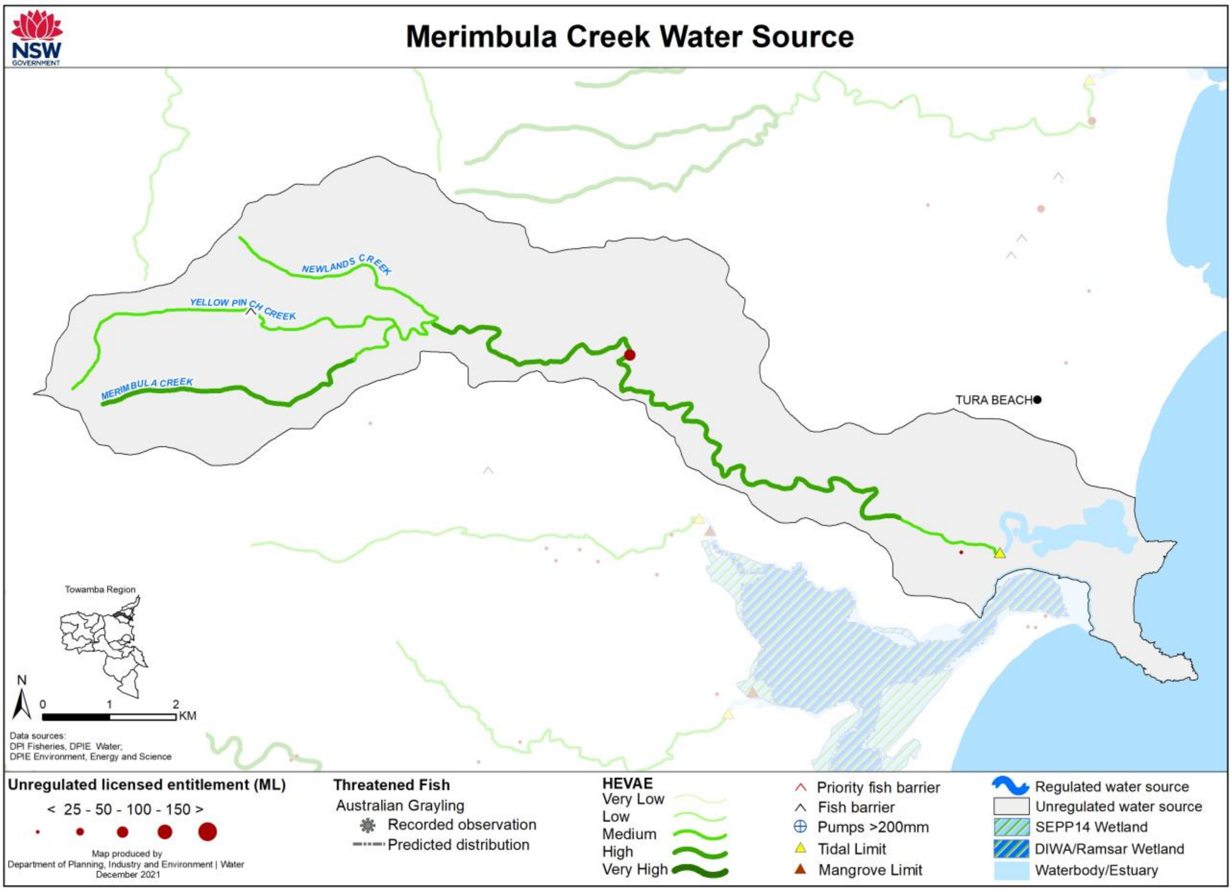
The current mapping of geomorphic river condition indicates that Mataganah Creek is generally ‘good' in the upper water source, 'moderate' to 'poor' in the mid reaches of the water source and 'moderate' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability and sediment slugs. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a cease to pump rule at a specific site in the water source, which is set at the 95th percentile flow.
- There are flow classes established in the water source up to the B flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No take in A class on rising river. No specific pool access rules, because there is a cease to pump.

Merimbula 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	High
Drivers (ecological value)	Distinctiveness = Medium to High, Naturalness = High to Very High, Diversity = Very Low to Low. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^*	H^-	L^-	L^-	L^-	L^-
Drivers (hydrologic alteration)	Low flows reduced by run of river pumping.				

Level of Risk

L^*	H^-	L^-	L^-	L^-	L^-

Comparison of previous risk rating and this rating

Risk rating increased with HEVAE consequence rating higher. The balance of the HEVAE consequence rating is different, due to an increase in fish diversity scores from low to moderate, low naturalness (macro) moving to high and very high (HEVAE), and the approach to assessing the location of extraction relative to high value HEVAE reaches.

Estuary inflow risk

Back Lagoon Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
High	Low
Drivers (value)	Back Lagoon value rating is medium (indigenous lands), hydro stress low.

Likelihood (degree of hydrological alteration)

Low inflows (Base/Low Flows)	High inflows (Freshes)
H	L

Level of Risk

H	L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Low distinctiveness, very high diversity, high naturalness and medium vital habitat.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Merimbula Creek Water Source flows directly into Black Lagoon estuary.

Riverbed and riverbanks

Merimbula Creek Water Source contains Merimbula Creek and its tributaries. The main channel of the Merimbula Creek is 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

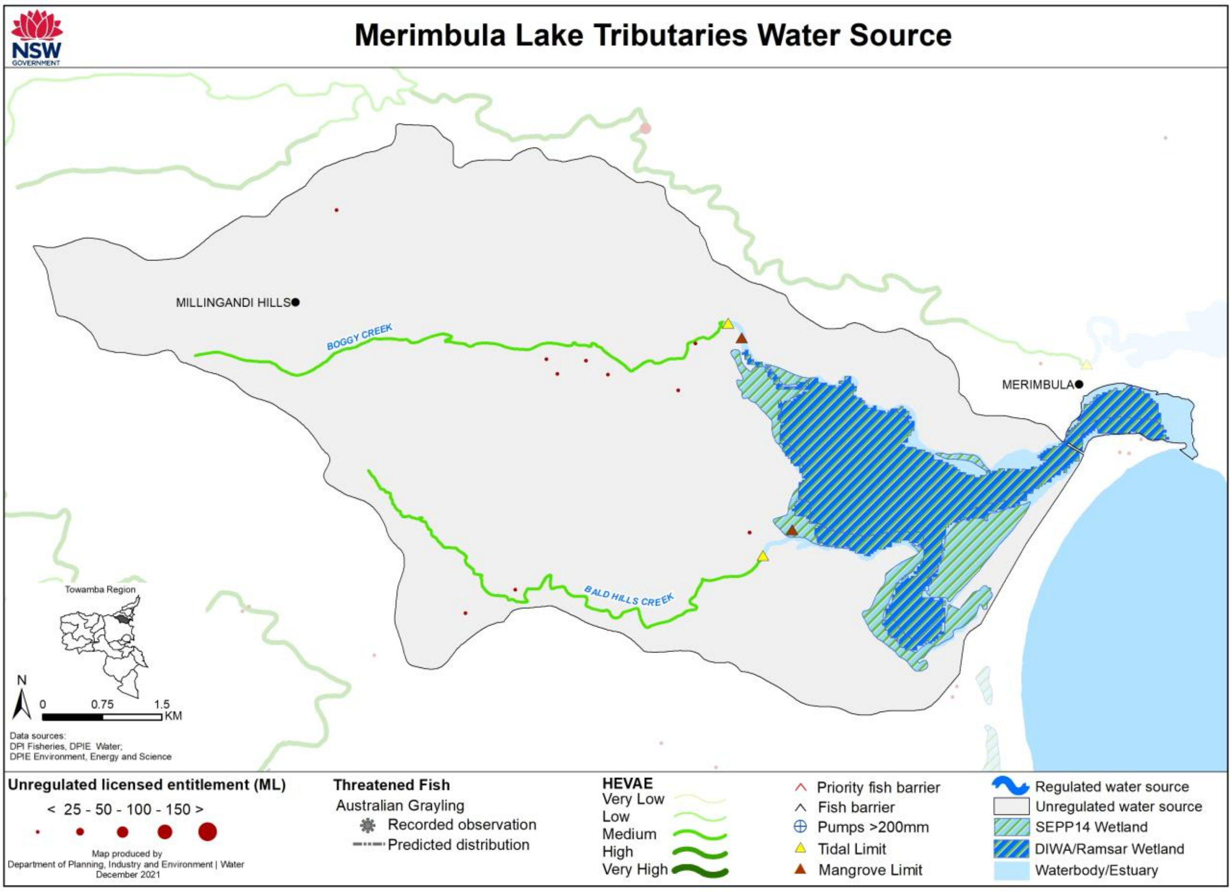
The current mapping of geomorphic river condition indicates that Merimbula Creek is generally ‘good' to 'moderate' throughout the water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover, altered flow regime and urban encroachment. Lack of appropriate vegetation 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. Dams and water storages alter rates of water and sediment transport, affecting the processes that maintain river channels and their associated habitats. Artificial rates of rise and fall in river levels may destabilise river banks and cause collapse. 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Merimbula Lake Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = High, Naturalness = High, Diversity = Very Low. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
H^+	M^-	L^-	L^0	L^0	L^0

Drivers (hydrologic alteration)	Significant increase in number of years with zero flow events, number of zero flow events per year and average duration of zero flow events in the low and high flow seasons. Slight decrease in number of freshes per year in the low and high flow seasons. Alteration is largely the result of extraction by river irrigation, harvesting low flows (no CtP set for this water source).

Level of Risk

H^+	M^-	L^-	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Risk rating increased due to modelled Likelihood rating higher. The modelled likelihood identified that irrigation, in combination with basic landholder rights, is quite high relative to the low flows in the small stream, which may have not been adequately considered in the previous hydro stress rating.

Estuary inflow risk

Merimbula Lake Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
Low	High

Drivers (value)	Merimbula Lake value rating is medium (high habitat diversity, fish species richness), hydro stress low.

Likelihood (degree of hydrological alteration)

Low inflows (Base/Low Flows)	High inflows (Freshes)
M	L

Level of Risk

Merimbula Lake Estuary	
L	M

Upland alluvium groundwater level risk

Consequence (GDE value)	High
Drivers (ecological value)	Very high distinctiveness, medium diversity, low naturalness, low vital habitat and an EEC.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Merimbula Lake Tributaries Water Source flows directly into Merimbula Lake estuary and Merimbula Bay.

Riverbed and riverbanks

Merimbula Lake Tributaries Water Source contains Boggy Creek, Bald hills Creek and their tributaries. The main channel of the Merimbula Lake Tributaries is 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, sandy and fine grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

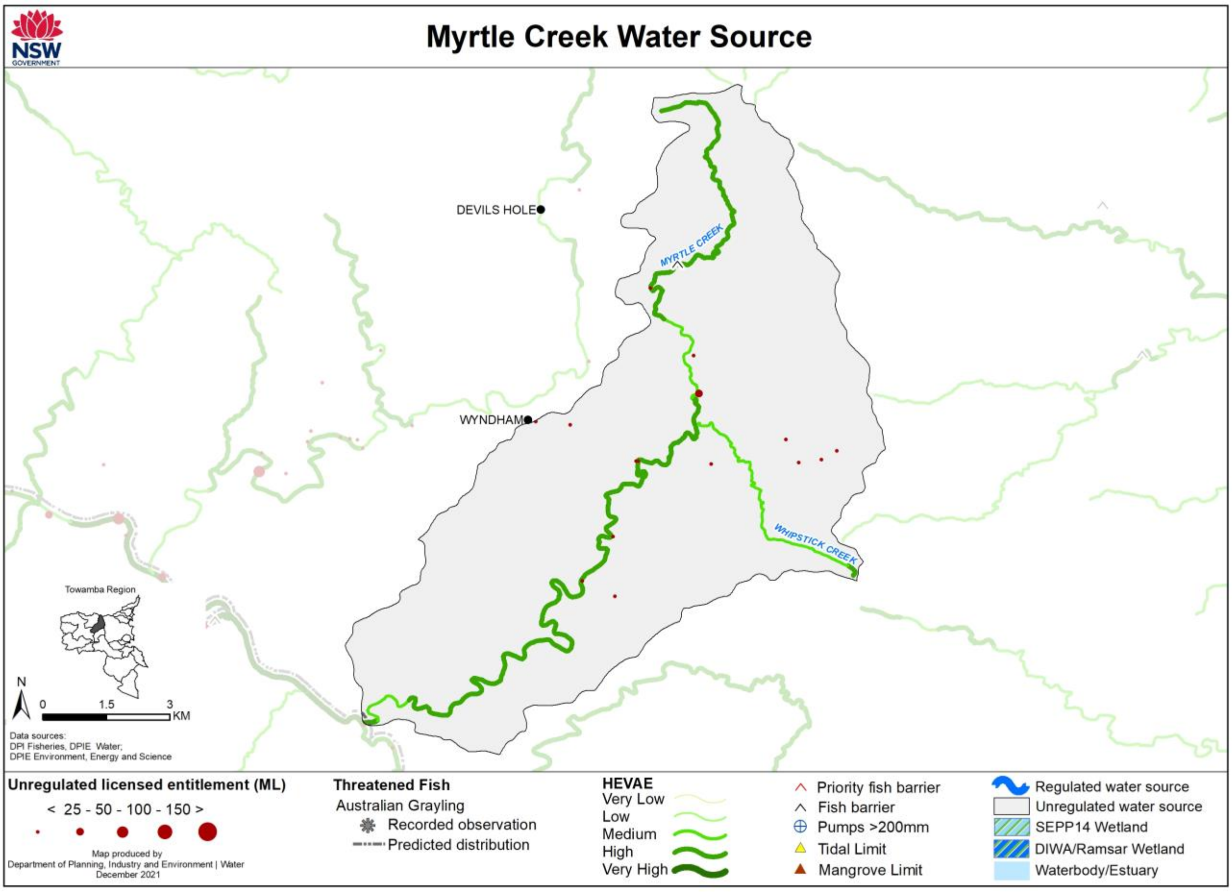
The current mapping of geomorphic river condition in the Merimbula Lake Tributaries Water Source indicates that condition is generally ‘good' in the upper water source and 'moderate' in the mid to lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Myrtle 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)					
Rating	Medium				
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Montane Peatlands and Swamps EEC (known), Littlejohns tree frog (known), Giant burrowing frog (recorded), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).				
Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	M^-	L^-	L^0	L^0	L^0
Drivers (hydrologic alteration)	Reduction in the size of the low flows is a result of run of river irrigation and alluvial extraction. CtP appears to be protecting low flows, with no increase to zero flows under development scenario.				
Level of Risk					
L^0	M^-	L^-	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Medium distinctiveness, very high diversity, high naturalness, medium vital habitat and an EEC.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Myrtle Creek Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Myrtle Creek Water Source contains the main channel of Myrtle Creek and its tributaries. The main channel of the Myrtle Creek is confined by a bedrock valley in the upper water source, opens up into a partly confined valley in the mid water source and transitions back to a gorge in the lower water source. The river bed is bedrock and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

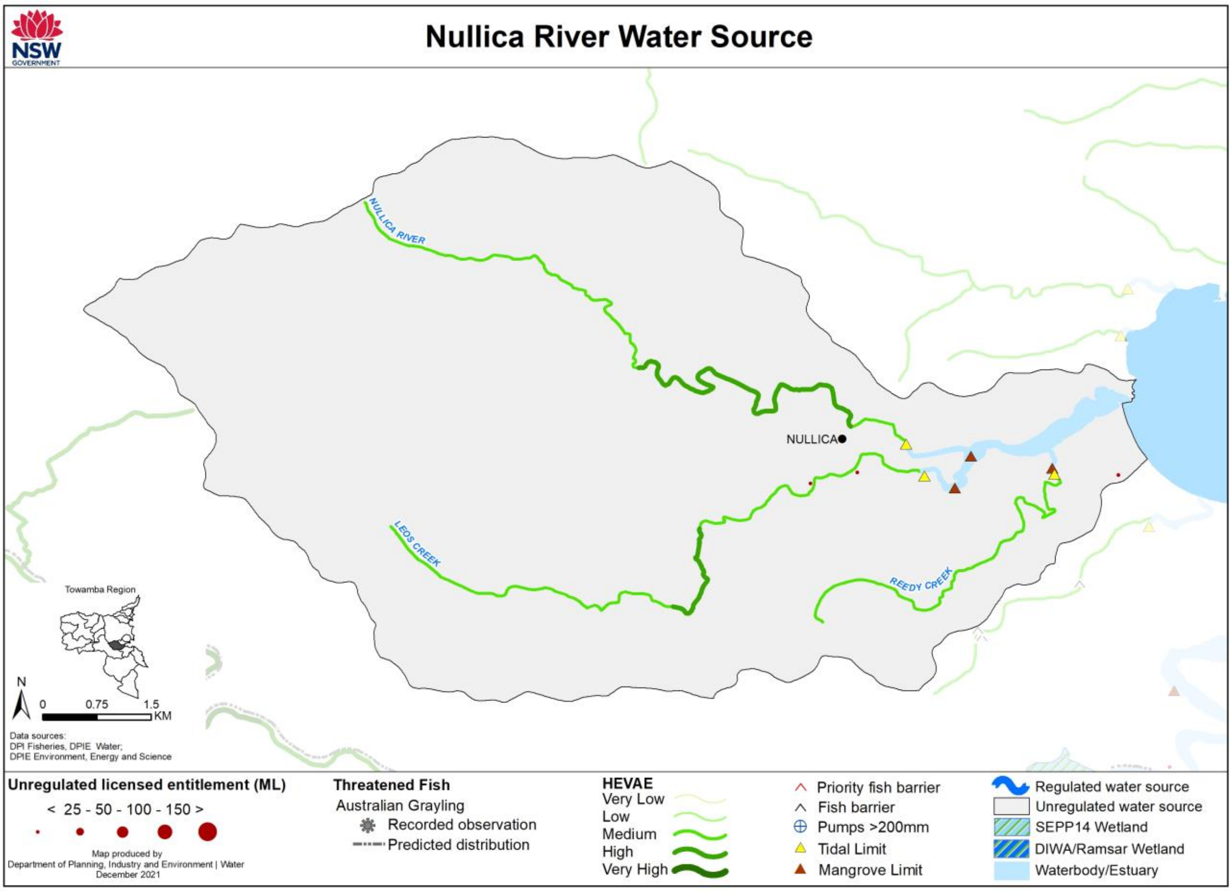
The current mapping of geomorphic river condition indicates that Myrtle Creek is generally ‘good' in the upper and lower water source, 'moderate' to 'poor' in the mid reaches of the water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability and sediment slugs. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a cease to pump rule at a specific site in the water source, which is set at the 95th percentile flow.
- There are flow classes established in the water source up to the B flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No take in A class on rising river. No specific pool access rules, because there is a cease to pump. No water supply work approvals granted in water source.

Nullica 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Littlejohns tree frog (known), Giant burrowing frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^-	L^0	L^0	L^0	L^0

Drivers (hydrologic alteration)	Little alteration of hydrology due to low levels of extraction by run of river irrigation and location of entitlement in the catchment.

Level of Risk

L^0	L^-	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating.

Estuary inflow risk

Nullica River Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
High	Low

Drivers (value)	Nullica River value rating is medium (high habitat diversity), low hydro stress.

Likelihood (degree of hydrological alteration)

Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L

Level of Risk

M	L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Medium distinctiveness, high diversity, high naturalness, medium vital habitat and many fauna species with low mobility.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Nullica River Water Source flows directly into Nullica River estuary and Twofold Bay.

Riverbed and riverbanks

Nullica River Water Source contains the main channel of the Nullica River and its tributaries. The main channel of the Nullica River is 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, sandy and fine grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include runs or glides, occasional steps, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

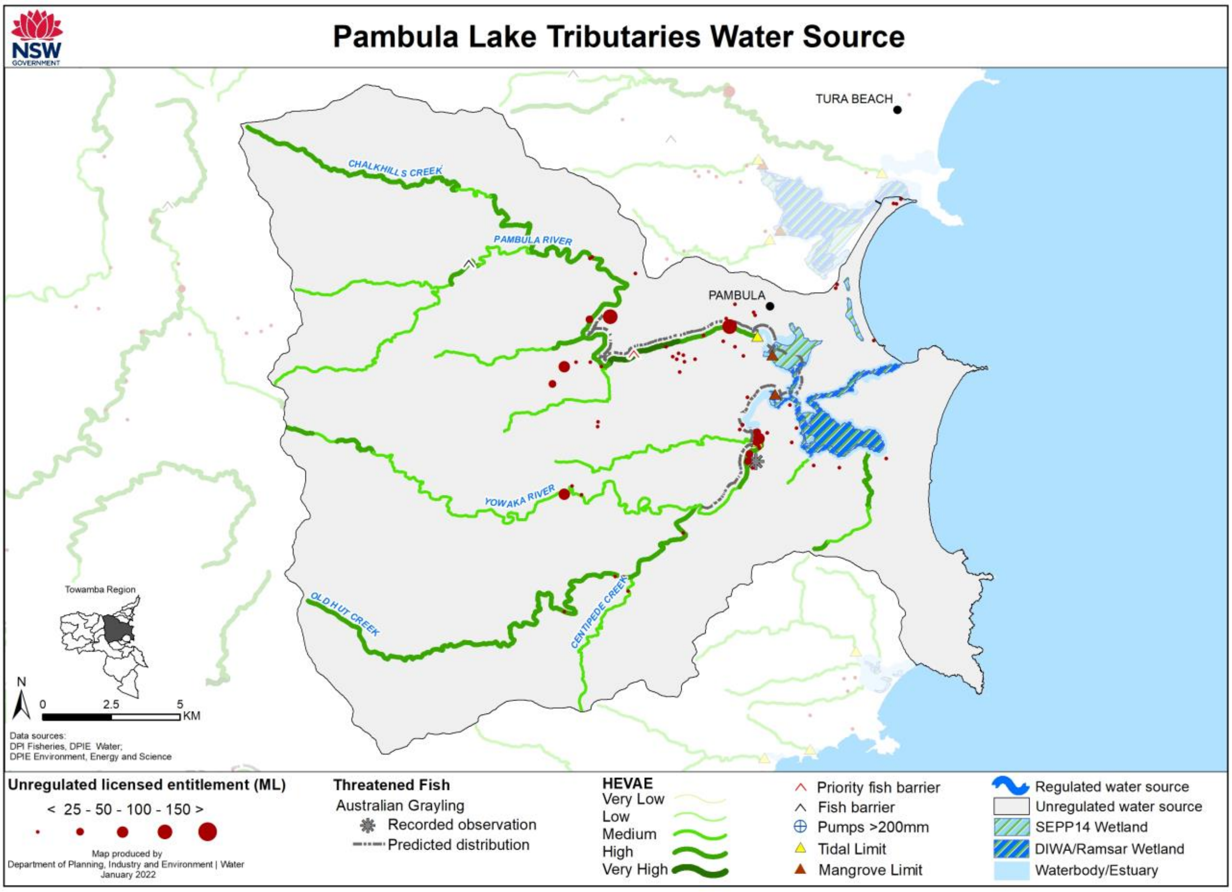
The current mapping of geomorphic river condition indicates that Nullica River is generally ‘good' in the upper water source and 'moderate' in the mid to lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover and sediment slugs. Lack of appropriate 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Pambula Lake Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Very High
Drivers (ecological value)	Distinctiveness = Medium to Very High, Naturalness = Medium to Very High, Diversity = Very Low to High. For threatened species with the highest flow sensitivity weighting of 4 = Australian grayling (recorded), Littlejohns tree frog (known), Giant burrowing frog (recorded), Stuttering barred frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
H^{+}	H^{-}	L^{-}	L^{0}	L^{0}	L^{0}

Drivers (hydrologic alteration)	Little alteration of hydrology due to low levels of extraction by run of river irrigation and location of entitlement in the catchment.

Level of Risk

Zero Flows	Base/Low Flows	Freshes	1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
H^{+}	H^{-}	M^{-}	M^{0}	M^{0}	M^{0}

Comparison of previous risk rating and this rating

Same risk rating.

Estuary inflow risk

Pambula River Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
High	High

Drivers (value)	Pambula River value rating is high (high representativeness, fish species richness, indigenous lands, habitat diversity), high hydro stress.

Likelihood (degree of hydrological alteration)

Low inflows (Base/Low Flows)	High inflows (Freshes)
H	L

Level of Risk

Low inflows (Base/Low Flows)	High inflows (Freshes)
H	M

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Medium distinctiveness, very high diversity, high naturalness, medium vital habitat and an EEC.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Pambula Lake Tributaries Water Source flows directly into Pambula River estuary.

Riverbed and riverbanks

Pambula Lake Tributaries Water Source contains Jigamy Creek, Yokawa River, Pambula River and their tributaries. The main channel of the Pambula Lake Tributaries is 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

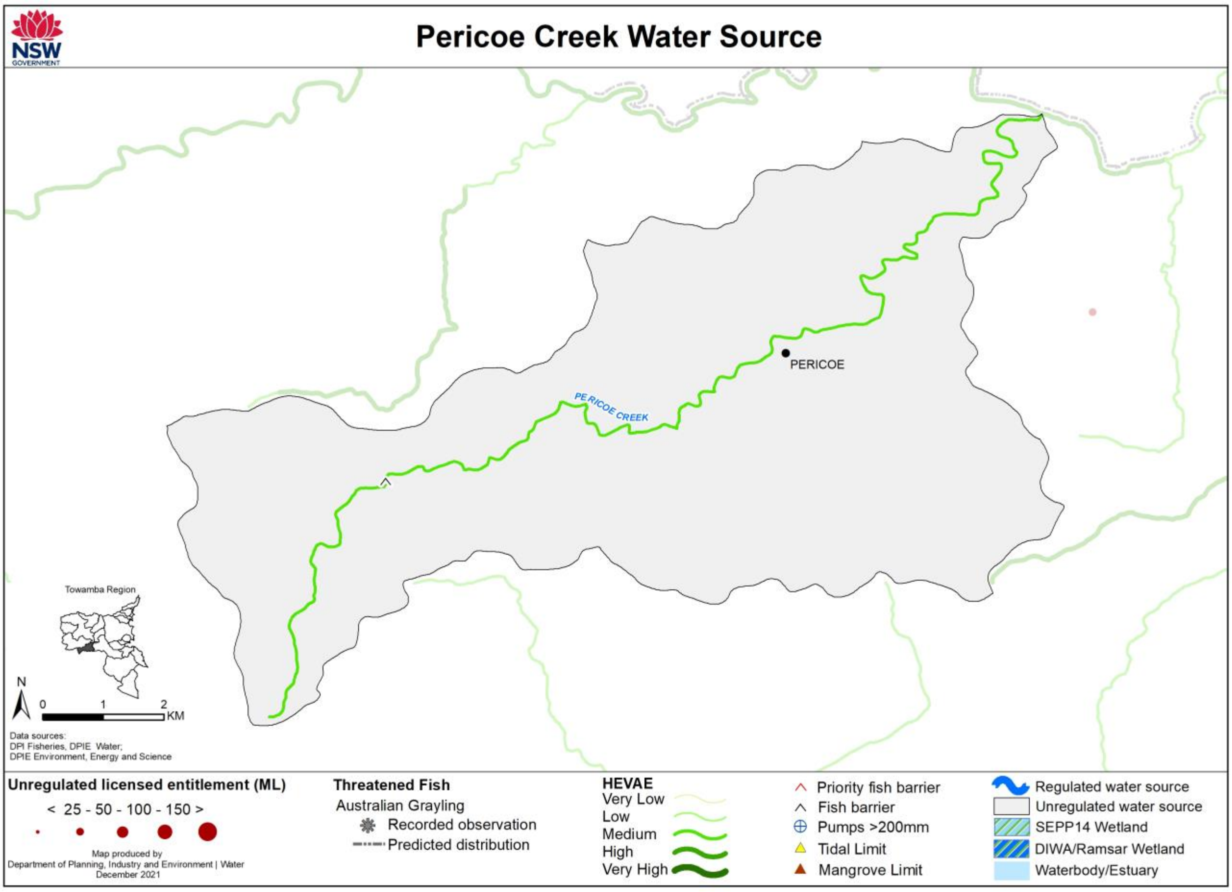
The current mapping of geomorphic river condition in the Pambula Lake Tributaries Water Source indicates that condition is generally ‘good' in the upper water source and 'moderate' in the mid to lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Pericoe 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to Medium, Naturalness = High to Very High, Diversity = Very Low to Low. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (known), Stuttering barred frog (known), Littlejohns tree frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
L0	L0	L0	L0	L0	L0

Drivers (hydrologic alteration)	There is no entitlement in the water source.

Level of Risk

L0	L0	L0	L0	L0	L0

Comparison of previous risk rating and this rating

Same risk rating.

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	High distinctiveness, very high diversity, low naturalness and very low vital habitat.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Pericoe Creek Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Pericoe Creek Water Source contains the main channel of Pericoe Creek and its tributaries. The main channel of the Pericoe Creek is confined by bedrock. The river bed is bedrock. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris. 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 (e.g. 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.

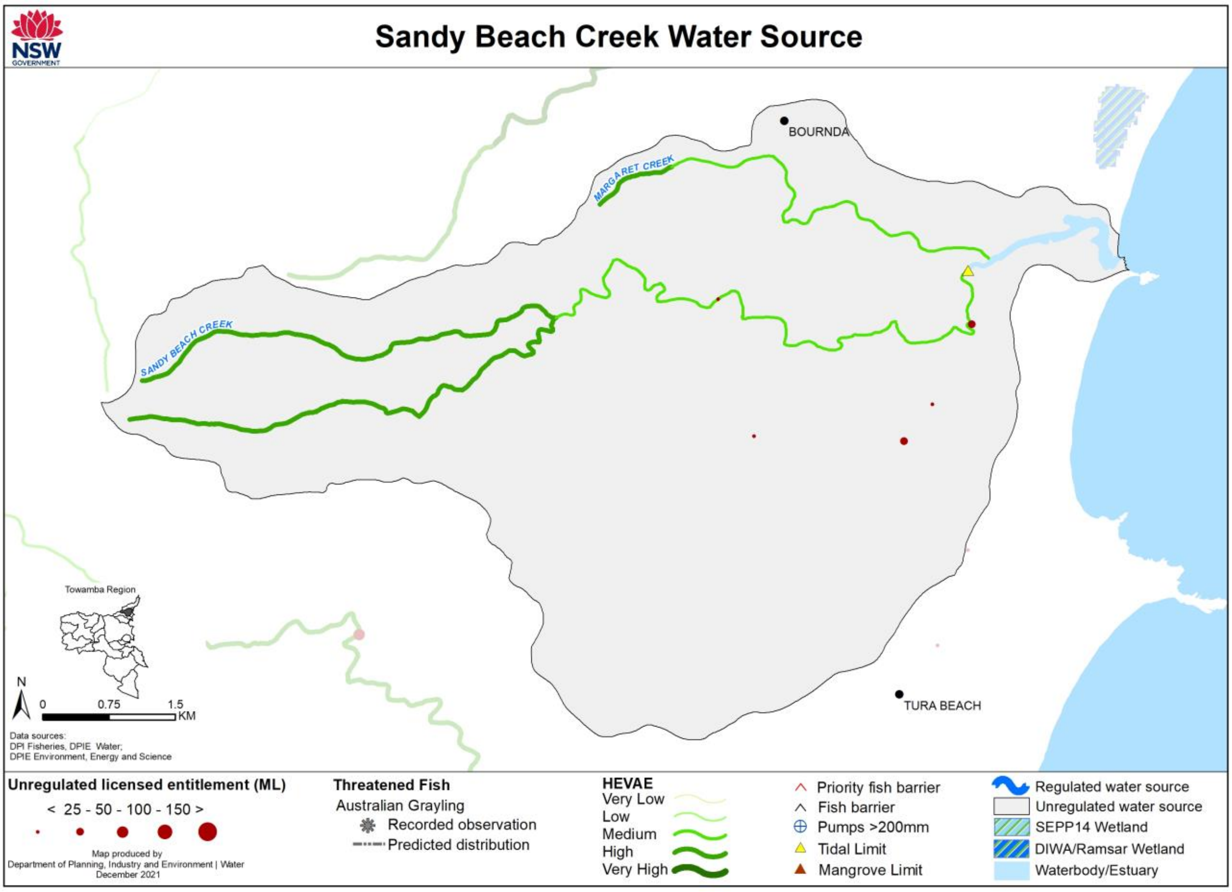
The current mapping of geomorphic river condition indicates that Pericoe Creek is generally ‘good' in the upper water source and 'moderate' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation. Lack of appropriate vegetation within and 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Sandy Beach 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Low to Medium, Naturalness = High to Very High, Diversity = Very Low to Low. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (known), Stuttering barred frog (known), Littlejohns tree frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
H^+	H^-	L^-	L^0	L^0	L^0
Drivers (hydrologic alteration)	Combination of all licences taking from dams and from alluvial sources reduce the low flows, resulting in increased number of years with zero flow events in the development scenario.				
Level of Risk					
H^+	H^-	L^-	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating, but HEVAE consequence rated lower and modelled likelihood rated higher. The balance of the HEVAE consequence rating is different, as the high value river reaches were above the few extraction points and not impacted by them. The modelled likelihood identified that irrigation directly from the creek, in combination with irrigation from the associated alluvium, is quite high relative to the low flows in the small creek, which may have not been adequately considered in the previous hydro stress rating.

Estuary inflow risk

Bournda Lagoon Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
High	Low
Drivers (value)	Bournda Lagoon value rating is medium, low hydro stress
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
H	L
Level of Risk	

Bournda Lagoon Estuary	
H	L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Low distinctiveness, very high diversity, high naturalness and medium vital habitat.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Sandy Beach Creek Water Source flows directly into Bournda Lagoon estuary.

Riverbed and riverbanks

Sandy Beach Creek Water Source contains Sandy Beach Creek and its tributaries. The main channel of the Sandy Beach Creek is confined by bedrock. The river bed is bedrock and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars, vegetated islands and large woody debris and flood channels, backswamps, chute channels. 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 (e.g. 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.

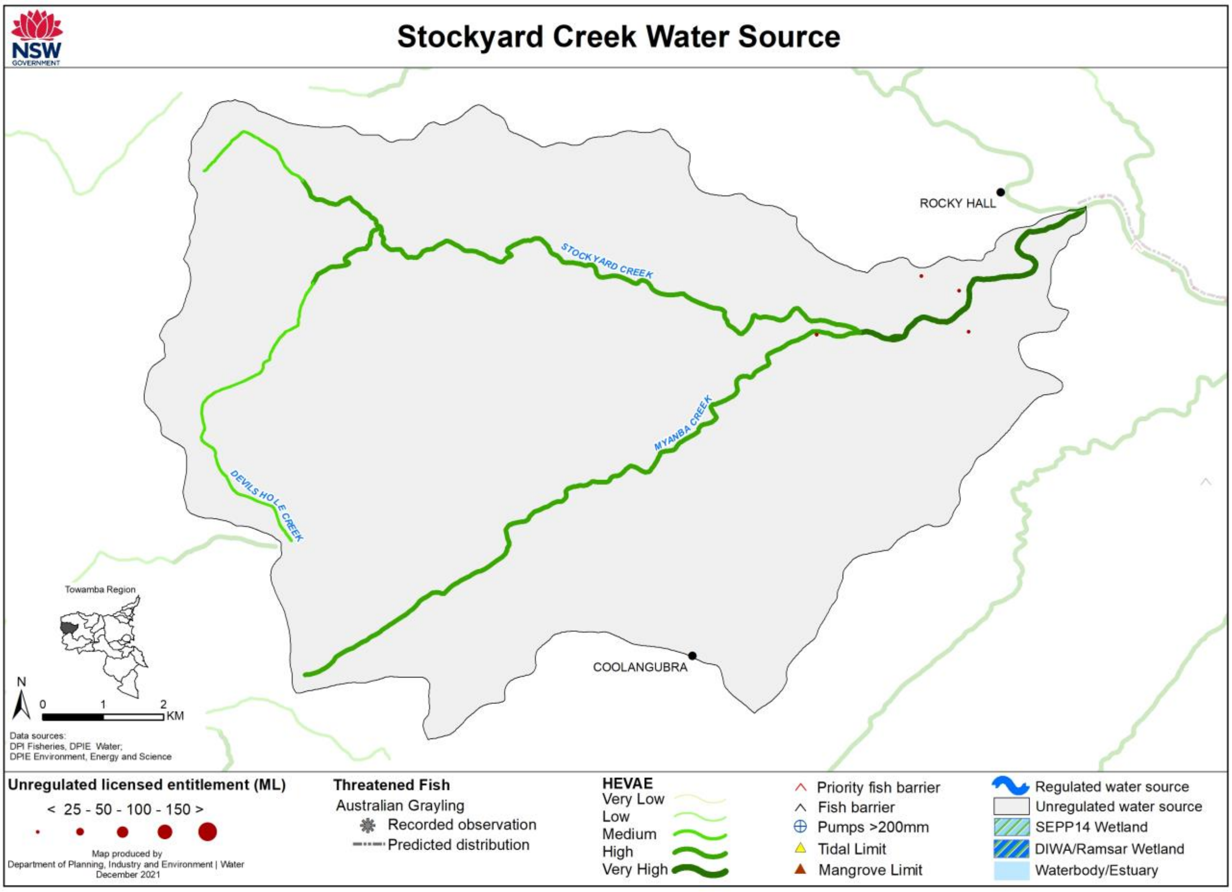
The current mapping of geomorphic river condition indicates that Sandy Beach Creek is generally ‘good' in the upper water source, 'moderate' in the mid water source and 'good' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation. Lack 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Stockyard 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (recorded), Stuttering barred frog (known), Littlejohns tree frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^{0}	L^{0}	L^{0}	L^{0}	L^{0}	L^{0}

Drivers (hydrologic alteration)	There is very little entitlement in the water source, presenting a low risk of altering hydrology.

Level of Risk

L^{0}	L^{0}	L^{0}	L^{0}	L^{0}	L^{0}

Comparison of previous risk rating and this rating

Risk rating decreased with HEVAE consequence rated lower. The balance of the HEVAE consequence rating is different, as the water source was identified to not having base flow impacted by extraction (step 6 in decision tree). This shifted the instream value down to a "medium" instream value classification.

Upland alluvium groundwater level risk

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

Likelihood (presence of licenced entitlement)

L

Level of Risk

L

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 Stockyard Creek Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Stockyard Creek Water Source contains the main channel of Stockyard Creek and its tributaries. The main channel of the Stockyard Creek is confined by a gorge throughout the water source. The river bed is bedrock. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris. 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 (e.g. 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.

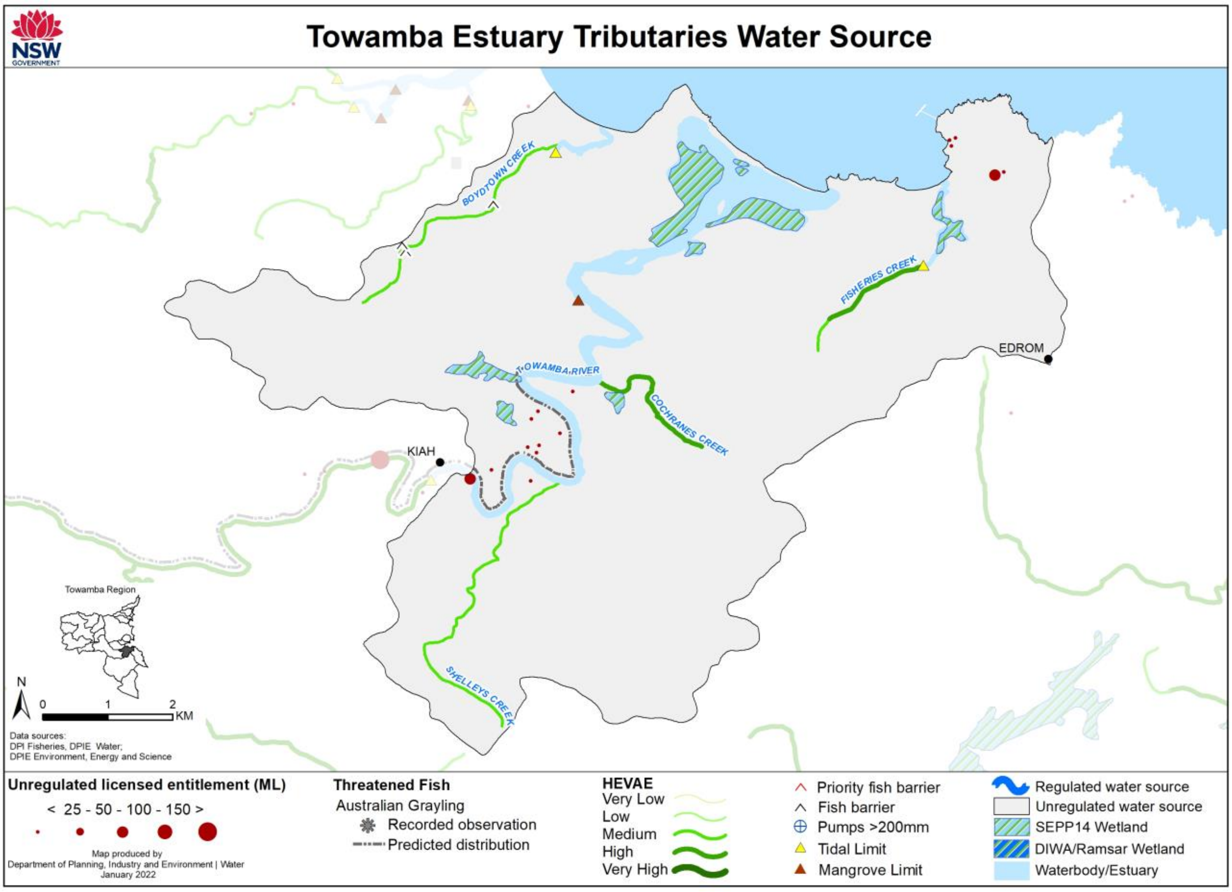
The current mapping of geomorphic river condition indicates that condition is generally ‘good' throughout Stockyard Creek and tributaries, except for Devils Hole Creek which is 'moderate'. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation. Lack of appropriate 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Towamba Estuary Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (recorded), Stuttering barred frog (known), Littlejohns tree frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
L^0	L^0	L^0	L^0	L^0	L^0

Drivers (hydrologic alteration)	There is very little entitlement in the water source. The location of entitlement on the trunk of the stream below the tidal limit and in tributaries very close to the coast, indicates a low likelihood of extraction altering hydrology.

Level of Risk

L^0	L^0	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Risk rating decreased due to both HEVAE consequence rated lower and modelled likelihood rated lower. The balance of the HEVAE consequence rating is different due to i) Australian grayling not occurring on the tributaries assessed in current process (is found in main Towamba River reaches but these not assessed in current process), ii) no extraction in any of the reaches assessed using decision tree approach. The entitlement in this water source is not associated with the tributaries, but the main stream near the tidal limit. This was identified in the modelled likelihood, but not in the previous hydro stress.

Estuary inflow risk

Boydtown Creek Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
Low	Low

Drivers (value)	Multiple estuaries - Towamba River value rating is high (indigenous lands, declared locations, recreational fishing haven, fish species richness, threatened species). Boydtown Creek/Fisheries Creek value ratings are medium, low/medium hydro stress.

Likelihood (degree of hydrological alteration)

Boydtown Creek Estuary	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
L	L

Towamba River Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
High		High
Drivers (value)	Multiple estuaries - Towamba River value rating is high (indigenous lands, declared locations, recreational fishing haven, fish species richness, threatened species). Boydtown Creek/Fisheries Creek value ratings are medium, low/medium hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
M		L
Level of Risk		
H		M

Fisheries Creek Estuary		
Consequence (estuary value adjusted for sensitivity)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
High		Low
Drivers (value)	Multiple estuaries - Towamba River value rating is high (indigenous lands, declared locations, recreational fishing haven, fish species richness, threatened species). Boydtown Creek/Fisheries Creek value ratings are medium, low/medium hydro stress.	
Likelihood (degree of hydrological alteration)		
Low inflows (Base/Low Flows)		High inflows (Freshes)
L		L
Level of Risk		
M		L

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Medium distinctiveness, high diversity, high naturalness, medium vital habitat and many fauna species with low mobility.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Towamba Estuary Tributaries Water Source flows directly into Towamba River estuary and Twofold Bay.

Riverbed and riverbanks

Towamba Estuary Tributaries Water Source contains the Towamba River Estuary and its tributaries. The main channel of the Towamba River Estuary is partly confined by a bedrock valley. 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 benches, sediment bars, vegetated islands, pools on river bends and large woody debris and flood channels, oxbow lakes. Large woody debris (e.g. 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. 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.

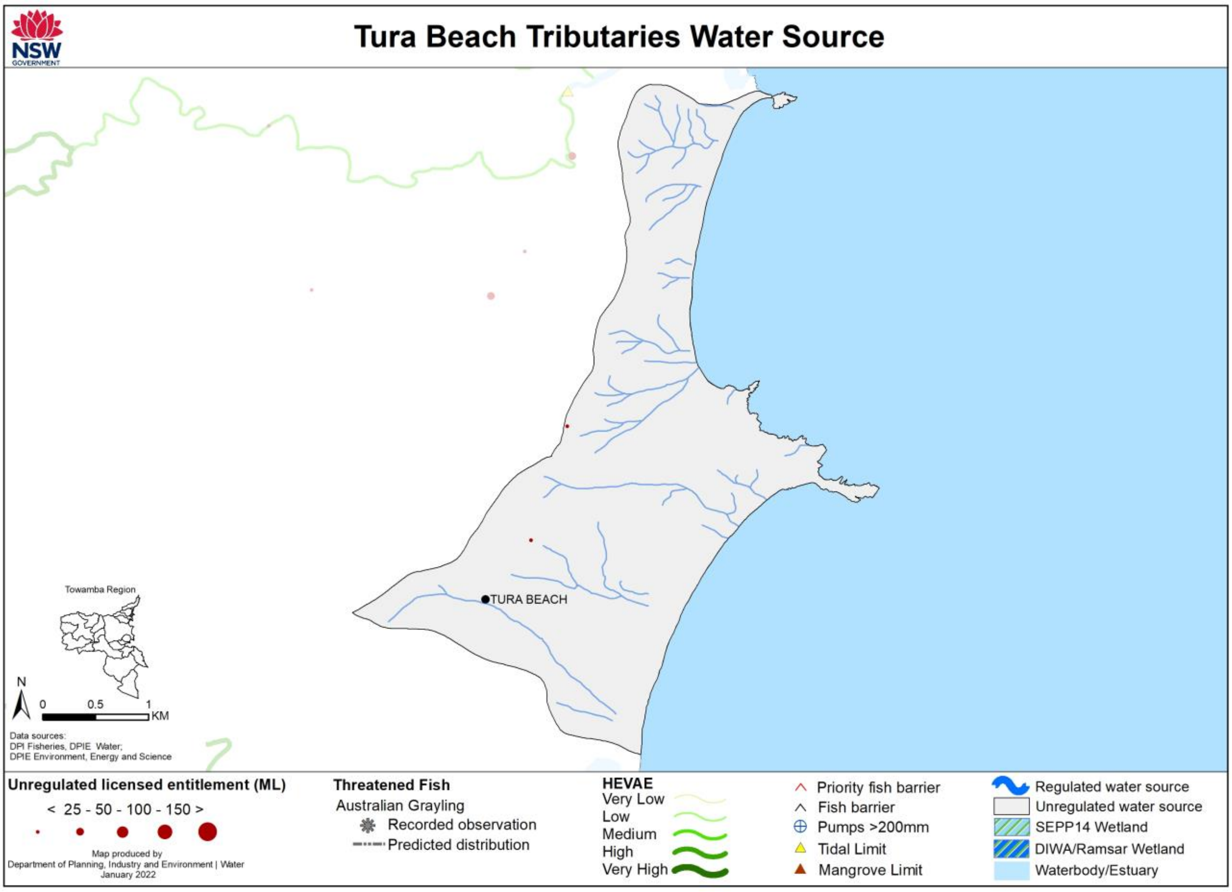
The current mapping of geomorphic river condition indicates that Towamba River Estuary is generally ‘moderate' in the main channel, with pockets in 'poor' condition in the tributaries. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability, sediment slugs and altered flow regime. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches. Dams and water storages alter rates of water and sediment transport, affecting the processes that maintain river channels and their associated habitats. Artificial rates of rise and fall in river levels may destabilise river banks and cause collapse.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Tura Beach Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Low
Drivers (ecological value)	Not assessed. No HEVAE river reaches mapped in the water source. See Appendix H2 for further details.

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L0	L0	L0	L0	L0	L0
Drivers (hydrologic alteration)	There is very little entitlement in the water source and the location on small tributaries presents a low risk of hydrological alteration.				
Level of Risk					
L0	L0	L0	L0	L0	L0

Comparison of previous risk rating and this rating

Macro ratings were not finalised for this water source, as it was considered as part of the Bega Water Sharing Plan at a latter point in time to other water sharing plans.

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Medium distinctiveness, high diversity, high naturalness, medium vital habitat and many fauna species with low mobility.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Tura Beach Tributaries Water Source flows directly into a number of small coastal estuaries.

Riverbed and riverbanks

Tura Beach Tributaries Water Source contains the tributaries of Tura Beach. The main channel of the Tura Beach Tributaries is situated in a broad valley. 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 sediment bars, vegetated islands and flood channels. Islands are vegetated sediment bars. They provide instream habitat by modifying water depth and providing substrate for instream vegetation. 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.

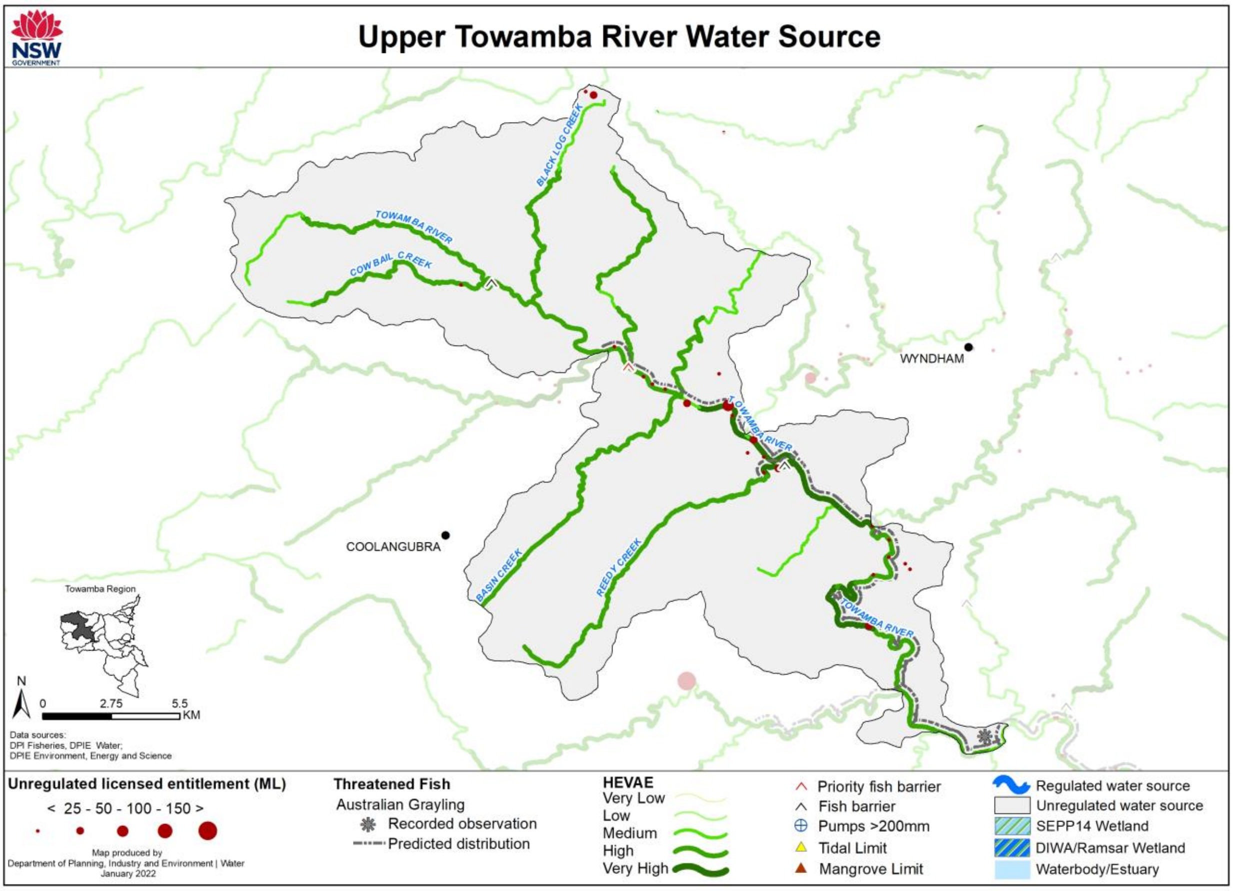
The current mapping of geomorphic river condition in the Tura Beach Tributaries Water Source indicates that condition in Tura Beach Tributaries has not been defined. Habitat values in the main channel are threatened by lack of appropriate riparian cover and urban encroachment. Lack of appropriate vegetation 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) have the same cease to pump restrictions as other licences.
- The drawing down of pools is **not** permitted in the water source.
- No water supply work approvals granted in water source.

Upper Towamba 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium to High, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Australian grayling (recorded), Giant burrowing frog (known), Stuttering barred frog (known), Littlejohns tree frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^{+}	L^{-}	L^{-}	L^{0}	L^{0}	L^{0}

Drivers (hydrologic alteration)	Slight decrease in number of freshes per year in high and low flow seasons resulting from harvesting of higher flows. Majority of extraction is run-of-river. No alteration to low or zero flows suggests that cease to pump is protecting low flows.

Level of Risk

L^{+}	L^{-}	L^{-}	L^{0}	L^{0}	L^{0}

Comparison of previous risk rating and this rating

Risk rating decreased due to both HEVAE consequence rated lower and modelled likelihood rated lower. The balance of the HEVAE consequence rating is different, as the water source was identified to not having base flow impacted by extraction (step 6 in decision tree). This shifted the instream value down to a "medium" instream value classification. The modelled likelihood suggested that extraction from the low flows is relative in this river, based on the 20 years that were simulated, where the previous hydro stress rating considered a longer period of climate. This provides some uncertainty, as dry years may not be well represented in the modelling.

Upland alluvium groundwater level risk

Consequence (GDE value)	Medium
Drivers (ecological value)	Low distinctiveness, high diversity, high naturalness and medium vital habitat.

Likelihood (presence of licenced entitlement)

H

Level of Risk

H

Water Quality

Riverine water quality risk

Consequence	
Rating	Very High

Likelihood (frequency of exceeding targets)

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)
L	L	L	L	L	L	L	L
Level of Risk							
M	M	M	M	M	M	M	M

Physical Structure

The Upper Towamba River Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Upper Towamba River Water Source contains the main channel of the upper reaches of the Towamba River and its tributaries. The main channel of the Towamba River is confined into gorges in its upper reaches and then becomes bedrock controlled in its lower reaches. 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, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps, chute channels. 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 (e.g. 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.

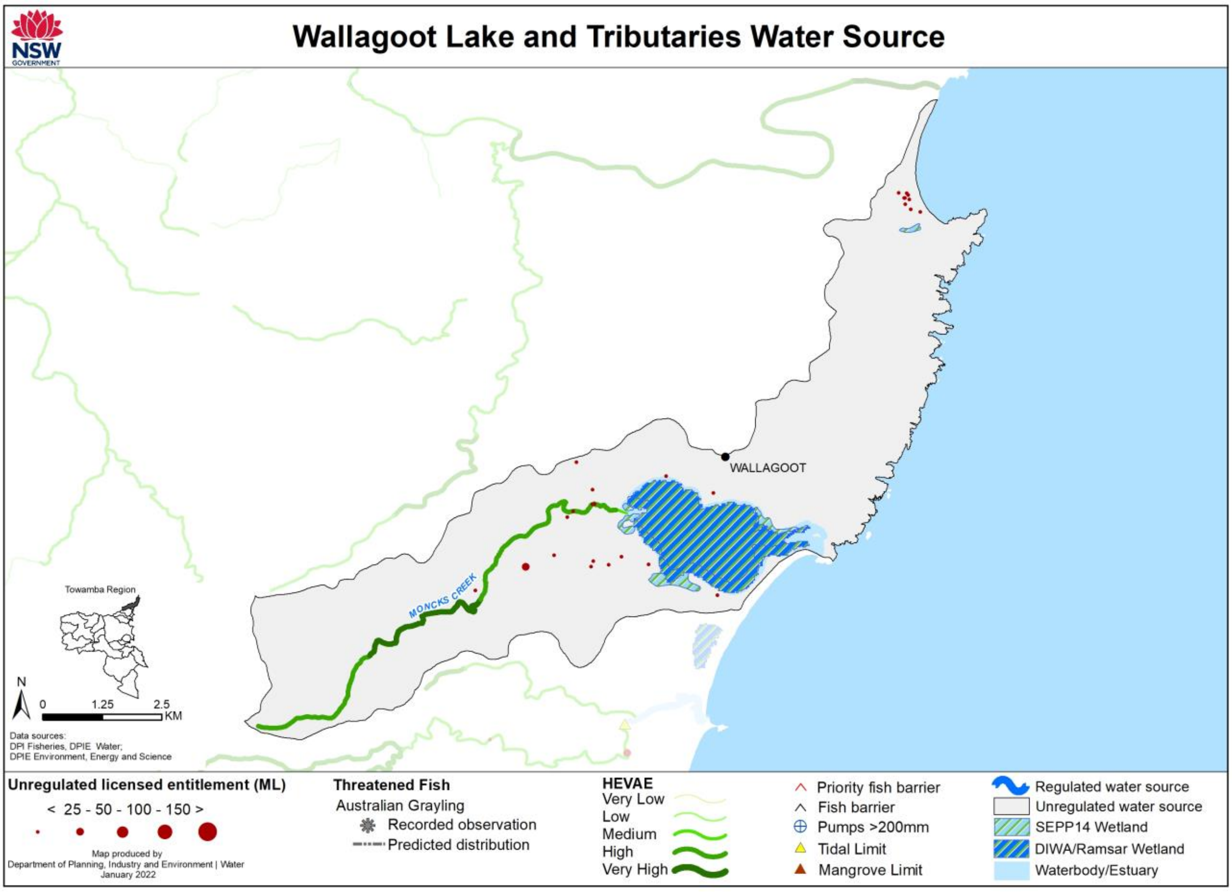
The current mapping of geomorphic river condition indicates that the upper reaches of Towamba River is generally ‘poor' in the main channel with some reaches in 'moderate' condition and 'good' to 'moderate' in the tributaries. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability and sediment slugs. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are flow classes established in the water source up to the B flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is a cease to pump.

Wallagoot Lake and Tributaries 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium, Naturalness = High, Diversity = Low to High. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (known), Littlejohns tree frog (known), Stuttering barred frog (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows 1.5 YR ARI	High and Infrequent Flows 2.5 YR ARI	High and Infrequent Flows 5.0 YR ARI
L^0	M^-	L^-	L^0	L^0	L^0

Drivers (hydrologic alteration)	Slight decrease in number of freshes per year resulting from alluvial extraction and recharge of aquifer in higher flows. Very little entitlement in the catchment.

Level of Risk

Zero Flows	Base/Low Flows	Freshes	1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	M^-	L^-	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Same risk rating, but HEVAE consequence rated lower and modelled likelihood rated higher. The balance of the HEVAE consequence rating is different, as this water source had no site-based records for threatened aquatic species. The modelled likelihood identified that basic landholder rights, in combination with stock and domestic licences, is quite high relative to the low flows in the small stream, which may have not been adequately considered in the previous hydro stress rating.

Estuary inflow risk

Wallagoot Lake Estuary

Consequence (estuary value adjusted for sensitivity)

Low inflows (Base/Low Flows)	High inflows (Freshes)
High	High

Drivers (value)	Wallagoot Lake value rating is medium, low hydro stress.

Likelihood (degree of hydrological alteration)

Low inflows (Base/Low Flows)	High inflows (Freshes)
M	L

Level of Risk

Low inflows (Base/Low Flows)	High inflows (Freshes)
H	M

Upland alluvium groundwater level risk

Consequence (GDE value)	Very High
Drivers (ecological value)	Medium distinctiveness, very high diversity, high naturalness, medium vital habitat and DIWA wetlands.
Likelihood (presence of licenced entitlement)	
H	
Level of Risk	
H	

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 Wallagoot Lake and Tributaries Water Source flows directly into Wallagoot Lake estuary.

Riverbed and riverbanks

Wallagoot Lake and Tributaries Water Source contains Moncks Creek and its tributaries. The main channel of Moncks Creek is 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, sandy and fine grained. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include runs or glides, occasional steps, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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.

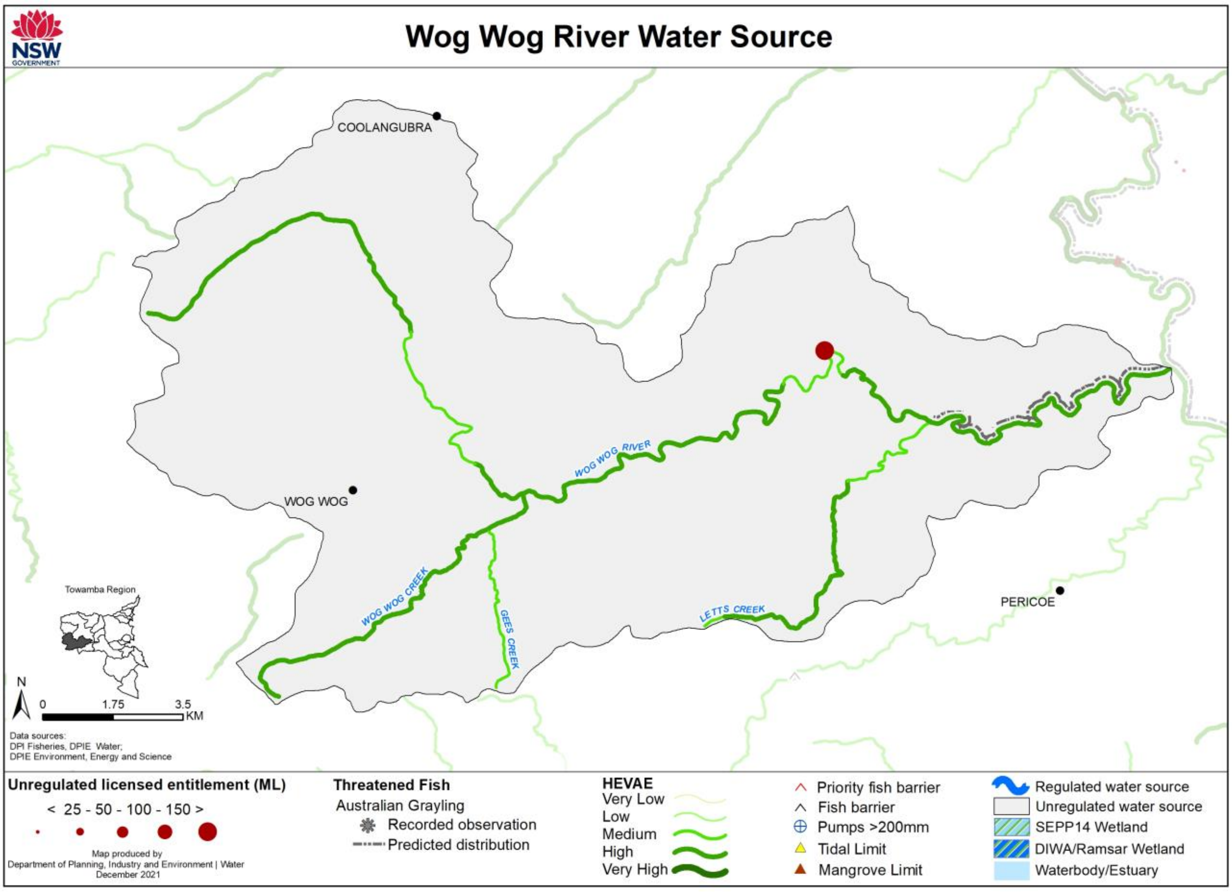
The current mapping of geomorphic river condition in Moncks Creek indicates that condition is generally ‘good' in the upper water source, 'moderate' in the mid water source and 'poor' to 'moderate' in the lower water source. Habitat values in the main channel are threatened by lack of appropriate riparian cover and sediment slugs. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Wog Wog 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)

Rating	Medium
Drivers (ecological value)	Distinctiveness = Very Low to Medium, Naturalness = Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Giant burrowing frog (recorded), Stuttering barred frog (known), Littlejohns tree frog (known), Montane Peatlands and Swamps EEC (known), Australian grayling (predicted) Next highest flow sensitivity of 3 = Green and golden bell frog (known).

Likelihood (degree of hydrological alteration)

Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
L^0	L^-	L^0	L^0	L^0	L^0

Drivers (hydrologic alteration)	Little alteration of hydrology by extraction due to low level of entitlement in water source.

Level of Risk

L^0	L^-	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Risk rating decreased due to HEVAE consequence rated lower. The balance of the HEVAE consequence rating is different, as the water source was identified as not having base flow impacted by extraction (step 6 in decision tree). This reduced the instream value to a medium value classification.

Upland alluvium groundwater level risk

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

Likelihood (presence of licenced entitlement)

L

Level of Risk

M

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 Wog Wog River Water Source contributes flow through several other water sources into Towamba River estuary.

Riverbed and riverbanks

Wog Wog River Water Source contains the main channel of Wog Wog River and its tributaries. The main channel of the Wog Wog River is confined by bedrock. The river bed is bedrock and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, benches, sediment bars, vegetated islands and large woody debris and occasional chute channels. 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 (e.g. 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.

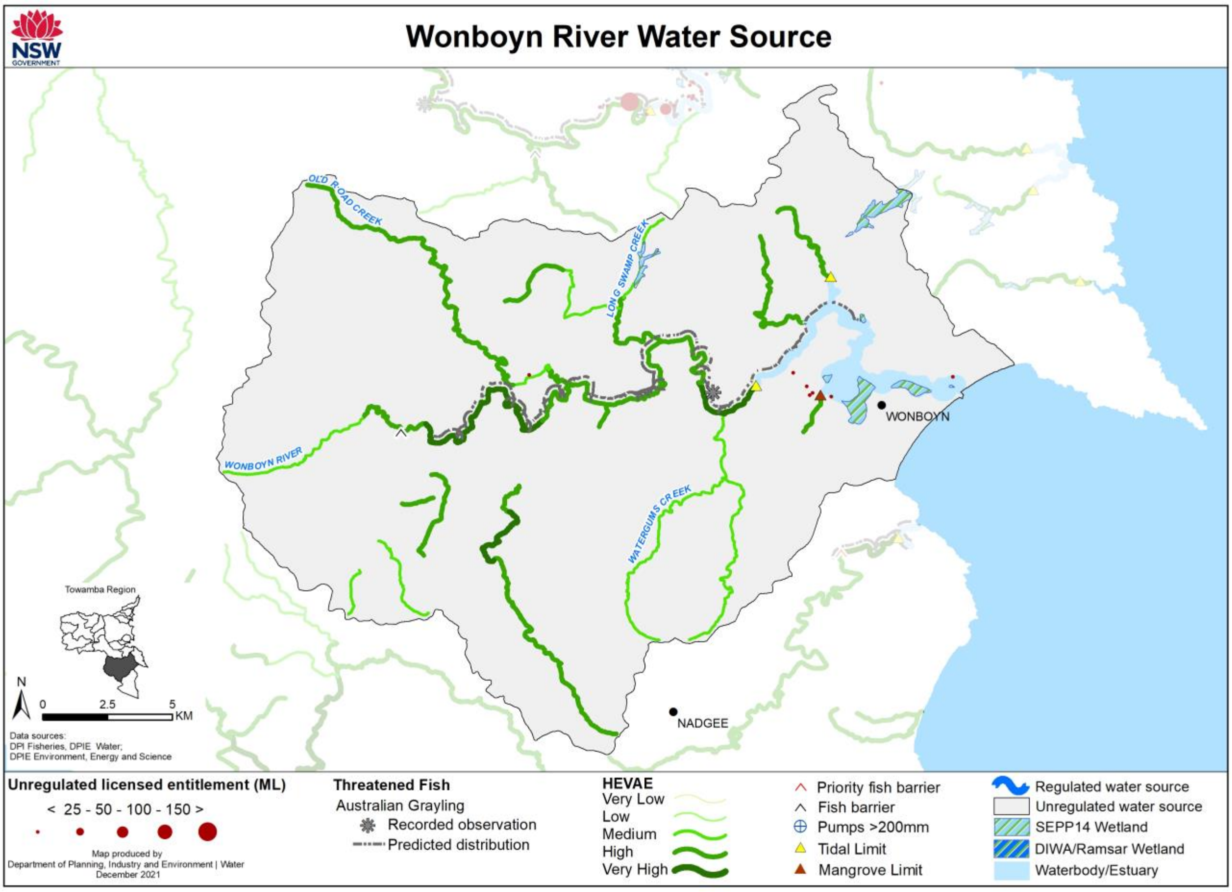
The current mapping of geomorphic river condition indicates that Wog Wog River is generally ‘good' throughout the water source. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation. Lack of appropriate vegetation within and surrounding the river channel increases 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.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are flow classes established in the water source up to the B flow class, but are not used to limit water access.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- No in-river dams on 3rd order or higher. No take in A class on rising river. No specific pool access rules, because there is a cease to pump.

Wonboyn 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:

1. Water quantity (either streamflow or groundwater level) and how it varies
2. Water quality and how it varies
3. 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 and strategies that could be considered to address risk.

Water Quantity

Riverine streamflow risk

Consequence (potential loss of ecological value)	
Rating	Medium
Drivers (ecological value)	Distinctiveness = Medium to Very High, Naturalness = High to Very High, Diversity = Very Low to Medium. For threatened species with the highest flow sensitivity weighting of 4 = Australian grayling (recorded), Giant burrowing frog (recorded), Stuttering barred frog (recorded), Littlejohns tree frog (known), Montane Peatlands and Swamps EEC (known). Next highest flow sensitivity of 3 = Green and golden bell frog (recorded).

Likelihood (degree of hydrological alteration)					
Zero Flows	Base/Low Flows	Freshes	High and Infrequent Flows		
			1.5 YR ARI	2.5 YR ARI	5.0 YR ARI
H^+	L^-	L^0	L^0	L^0	L^0
Drivers (hydrologic alteration)	Increase in zero flow events in low and high flow seasons result of extraction of low flows by run of river irrigation and location of entitlement downstream of majority of feeding tributaries.				

Level of Risk					
H^+	L^-	L^0	L^0	L^0	L^0

Comparison of previous risk rating and this rating

Risk rating increased due to HEVAE consequence rating higher. The balance of the HEVAE consequence rating is different, as aspects such as distinctiveness are included, where in the previous instream value rating naturalness may have been the main influence on the rating.

Estuary inflow risk

Wonboyn River Estuary	
Consequence (estuary value adjusted for sensitivity)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
Medium	High
Drivers (value)	Wonboyn River estuary value rating is medium (high naturalness), low hydro stress.
Likelihood (degree of hydrological alteration)	
Low inflows (Base/Low Flows)	High inflows (Freshes)
L	L
Level of Risk	
L	M

Upland alluvium groundwater level risk

Consequence (GDE value)	High
Drivers (ecological value)	Very low distinctiveness, medium diversity, high naturalness, very high vital habitat and SEPP14 wetlands.
Likelihood (presence of licenced entitlement)	
L	
Level of Risk	
L	

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 Wonboyn River Water Source flows directly into Wonboyn River estuary.

Riverbed and riverbanks

Wonboyn River Water Source contains the main channel of the Wonboyn River and its tributaries. The main channel of the Wonboyn River transitions from a gorge into a discontinuous, swampy channel network near Narrabarba and back into a gorge in the lower water source. The river bed is bedrock and sandy. Geomorphic features, or river features, that provide habitat for the river types in this water source typically include bedrock steps, waterfalls and/or cascades, bedrock pools, runs and glides, deep pools and shallow riffles, sediment bars and large woody debris and flood channels, backswamps and chute channels. 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 (e.g. 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 Wonboyn River is generally ‘good' throughout the water source with a few reaches in 'poor' to 'moderate' condition. Habitat values in the main channel are threatened by lack of appropriate riparian vegetation, channel instability, sediment slugs and altered flow regime. 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. 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. Excess sediment in the form of 'sediment slugs' smothers key instream habitats including pools and reduces the diversity of available habitat. Sediment slugs will migrate downstream, threatening connected river reaches. Dams and water storages alter rates of water and sediment transport, affecting the processes that maintain river channels and their associated habitats. Artificial rates of rise and fall in river levels may destabilise river banks and cause collapse.

Water Quantity Management

Current water sharing plan mechanisms

- There is a visible flow cease to pump rule at a specific site in the water source.
- There are no flow classes established in the water source.
- There is a visible flow condition at the pump site (inflow and outflow from the pool which the pump extracts) in the water source.
- The cease to pump rule applies to the upland alluvial groundwater licences within 40m of the rivers in the water source.
- Pumping from in-river dams (e.g. weirs) is permitted when cease to pump restrictions are in place.
- The drawing down of pools is **not** permitted in the water source.
- No in-river dams on 3rd order or higher. No water supply work approvals granted in water source.

Appendix B Rating freshwater riverine ecological values and consequences

B1: High Ecological Value Aquatic Ecosystems (HEVAE)

The NSW *Water Management Act 2000* requires Water Sharing Plans (WSPs). These plans aim to protect, enhance and restore water systems and their associated ecosystems. DPE-Water are remaking coastal Water Sharing Plans after their initial ten-year term. The Department developed the original plans using a 'Macro approach' based on economic, ecological and human use values.

The current assessments extend upon the risk-based framework used in the macro-approach (NSW Office of Water, 2009). This framework rates both the consequence of an event on a scale from "Very Low" to "Very High", and likelihood of an event as "High", "Medium" or "Low". The risk outcome is then determined using a matrix (Table B1) that combines these scores. The Department uses these outcomes to focus management needs on high priority areas. This assists in objective decision making for water sharing rules.

Table B1: Risk rating matrix used to predict the severity of the risk outcome on an ecosystem

Consequence of impact on ecosystem function	Likelihood of impact on key ecosystem function		
	Low	Medium	High
Very Low	**Low**	**Low**	**Low**
Low	**Low**	**Low**	**Medium**
Medium	**Low**	**Medium**	**High**
High	**Low**	**Medium**	**High**
Very High	**Medium**	**High**	**High**

The consequence rating is determined by combining the ecological value and sensitivity of an ecosystem. Ecological value is how we perceive the importance of an ecosystem. The Department assesses the ecological value of rivers using the High Ecological Value Aquatic Ecosystems (HEVAE) framework. This framework is derived from the National Aquatic Ecosystems Toolkit Module 3, Guidelines for Identifying HEVAE (Aquatic Ecosystems Task Group 2012).

The HEVAE framework consists of five key criteria, each with associated attributes. These are:

- diversity
- distinctiveness
- naturalness
- vital habitat
- representativeness

When analysed together, these criteria give a score representing relative ecological value. The HEVAE criteria are applicable at the regional level and meet NSW jurisdictional needs (Aquatic Ecosystems Task Group 2012).

B2: Value Rating for Riverine Ecosystems

Coastal Riverine HEVAE assessments use only the diversity, distinctiveness and naturalness criteria (Figure B1). The department excluded vital habitat and representativeness due to limited data availability.

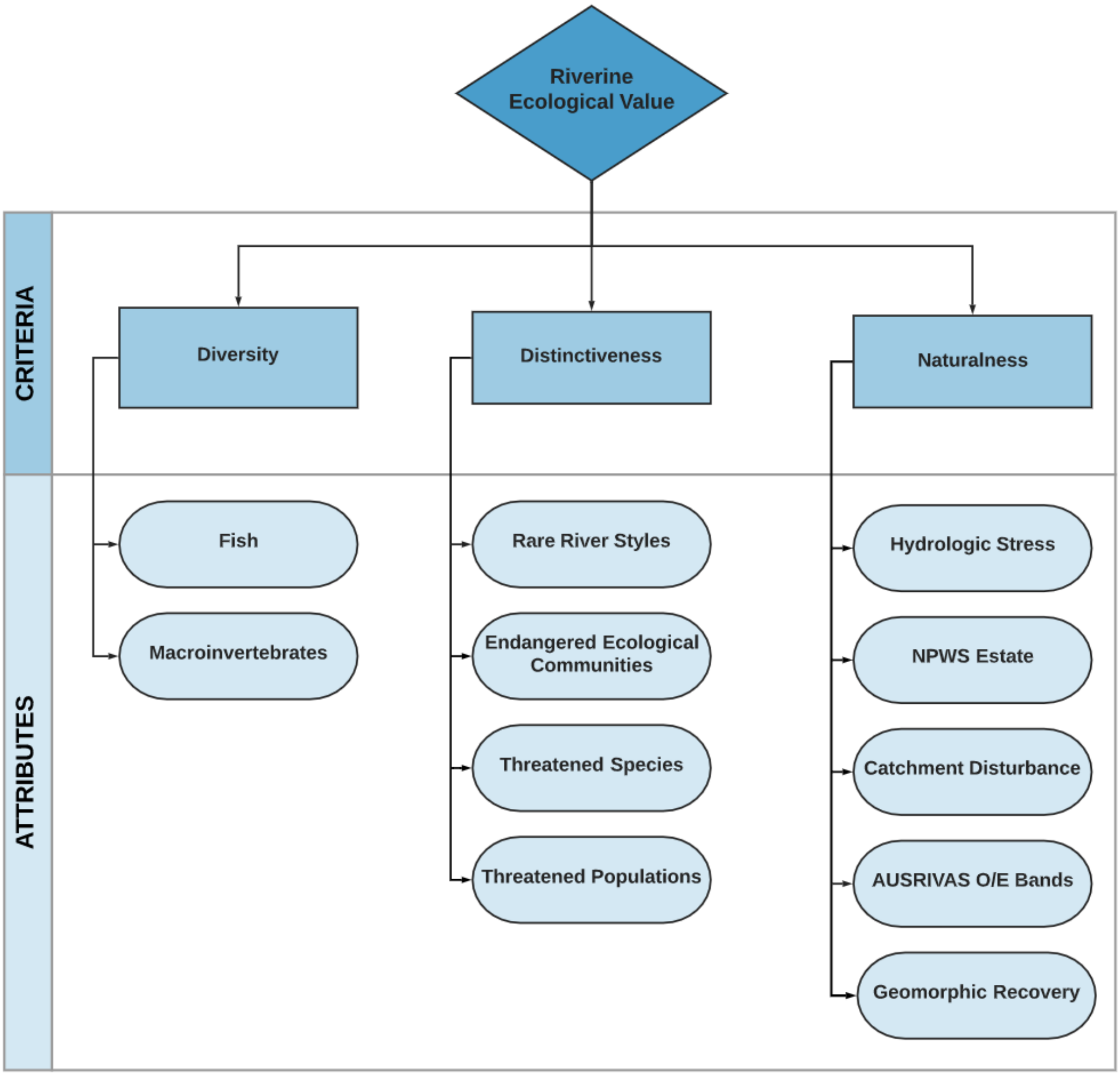


Figure B1: HEVAE Criteria for Freshwater Riverine Ecosystems

As described in Appendix B1, these criteria are assessed and combined to give a value rating (full methods available in Healey et al. 2018). Natural variation in attribute scores can cause or influence clumping in data sets. To reduce this clumping effect, data-rich outcomes were standardised (Bennett et al. 2002; Macgregor et al. 2011). This enables each attribute in a WSP catchment to be scored against the same scale (Macgregor et al. 2011).

Each attribute was weighted to reflect its relative importance (Macgregor et al. 2011) and contribution (Hughey 2013). Weightings are evidence-based and reflect both the purpose of the assessment and the views of stakeholders (Bennett et al. 2002).

Macro Water Sharing Plans in NSW weighted threatened species, populations and communities (DIPNR 2005; NSW Office of Water 2011). These weightings described the flow sensitivity of each species, with consideration to legislation. The Department used these weightings in the current HEVAE Distinctiveness assessment.

To determine which threatened species were dependent on river flow, the Department searched for:

- Listings under the NSW *Threatened species Conservation Act 1995* (OEH 2015)
- Listing under the NSW *Fisheries Management Act 1994* (DPI 2020)

- Listings under the *Environment Protection and Biodiversity Conservation Act 1999* (DoE 2020).

The attributes with the highest flow sensitivity weighting were limited to those where alteration to natural flow is a key threatening process. Appendix C lists the threatened species, endangered populations, and communities used in the HEVAE assessment. It also details the associated flow and status weightings.

The Department used various site-based threatened species data in the assessment. These included:

- Site records of threatened species from the Atlas of NSW Wildlife (OEH 2015b) and distribution information from the NSW EES threatened species website.
- Vegetation communities from the NSW vegetation mapping program and associated spatial data (OEH 2016). Spatial data were provided by OEH (Bob Denholm pers. comm.).
- Fish species from predictive model outputs provided by NSW Department of Primary Industries (DPI-Fisheries) (DPI 2016; DPI 2020b).
- Species listed under the NSW *Fisheries Management Act 1994* from NSW DPI Fisheries spatial layers and website information.

B3: Consequence Rating for Riverine Ecosystems

The ecological value rating is adjusted according to the sensitivity of the ecosystem to give a consequence rating. This considers external conditions, such as the location and size of extraction pressures. A decision tree (Figure B2) was used to adjust value ratings, considering the:

- presence of Ramsar habitat
- relative location of extraction pressures
- presence of freshwater-dependent flora and fauna
- cumulative HEVAE values for river reaches in the assessment area.

Freshwater-dependent fauna and flora records used in the decision tree model were site-based data, obtained from agency databases. As this is recorded data, it can be used with a high level of confidence. The confidence in non-site-based data, such as predicted occurrences and “known records”, is lower (“known records” are predicted occurrences within the vicinity of recorded data; see Healey et al. 2018). Thus, these were not used in the consequence decision tree model. If there were no site-based records, the consequence rank was lowered to the next category. For example, if a high HEVAE score had records only based upon predicted or known data, the consequence category became medium.

Each split in the decision tree was annotated. This allowed each score to be tracked through the decision tree during the assessment. The rationale for each decision is provided in Table B2.

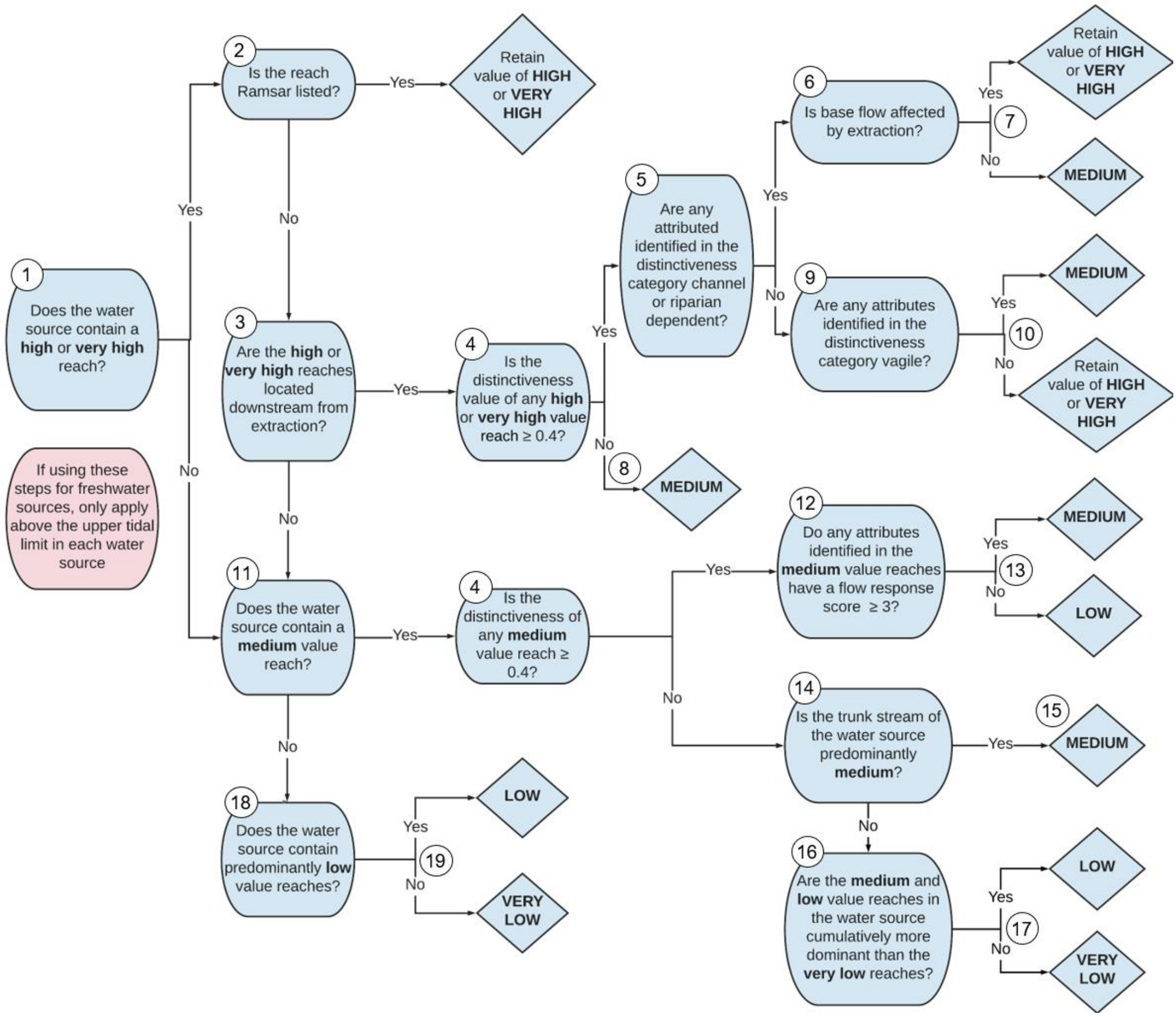


Figure B2 Consequence decision tree used to convert river reach HEVAE outputs to an overall consequence ranking

Table B2 Rationale for each split in the decision tree (Figure B2) used for converting HEVAE scores to a 'consequence' ranking for a whole water source

DECISION ANNOTATION	RATIONALE
1	• Management for retention of conservation values is a higher priority in high and very high value reaches. Highlights the extent to which the highest intrinsic value warrants protection from the risk of hydrologic stress (extraction). • Limiting extraction is easier to justify in high and very high value reaches, than it is in medium reaches.
2	• Ramsar sites are valued for their contribution to international conservation efforts for migratory species. Australia is a signatory country and has an obligation to maintain these sites. This includes maintenance of flows. • Check location against the five Ramsar wetlands across the NSW coastal catchments.
3	• The attributes of high or very high value sites are influenced by extraction pressure. • Sites that are upstream of extraction points are assumed to be unaffected by extraction pressure, so the assessment focus shifts to whether there are medium value reaches in the water source. • If a high or very high value site is likely to be affected by extraction pressure the focus shifts to whether any threatened species, populations, communities or rare river styles could be affected.
4	• The attributes of high or very high value sites are influenced by extraction pressure. • The most 'at risk' HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the reach (i.e. threatened species, populations, communities and rare River Styles). • A distinctiveness score of ≥ 0.4 in the HEVAE means the reach has a medium, high or very high value as habitat for threatened species, populations, or communities, or a rare river style. • Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
5	• Distinguishes between species, populations, communities and/or rare river styles that occur on the floodplain versus the channel and riparian zone because (it was assumed) extraction pressure is more likely to affect attributes that occur in the channel and riparian zone, rather than the floodplain. • Focus on using the site records (recorded data) for any threatened fish, frogs, birds that have a flow sensitivity of 3 and 4 (highest weightings). • If predicted MAXENT outcomes for fish are detected in this step, record the details in the comments for further discussion with DPI Fisheries where the draft consequence outcomes can be discussed and reconsidered. • *This is a decision that relies on expert understanding of the attribute's ecology and biology.*
6	• Given the attribute is identified as relying on channel and riparian habitat (from 5), this step assumes the least possible habitat available to the attribute occurs under low flow conditions and asks whether the lowest flows in the system are affected by extraction or disruption to natural flows through river regulation. • Use the new likelihood metrics and the baseflow (BF) outputs to inform this step. If those data are unavailable, use the hydrologic stress (80^{th} percentile flows) derived for unregulated river water sources during the macro WSP process in 2006.
7	• Any attributes that are channel and/or riparian dependent and are considered vulnerable to extraction of low flows retain their original high or very high value category. • Any attributes that are channel and/or riparian dependent and are considered resilient to extraction of low flows are allocated a 'medium' consequence category.

DECISION ANNOTATION	RATIONALE
8	• High or very high value reaches that have low distinctiveness are assumed to have attributes that are more resilient to extraction pressure (at least in the short-term) and are assigned a 'medium' consequence category.
9	• Establishes that attributes are floodplain dependent and asks whether they are able to move (i.e. birds, bats) or not (i.e. plant). The assumption is that more mobile species/population/community can move to avoid changes in habitat owing to extraction pressure.
10	• If the species can move, they are assigned a risk category of 'medium'. • If the species/population/community is sessile, it is assumed to be at greater risk of harm from extraction pressure (because it can't move to avoid the pressure) and retains its original categorisation of 'high' or 'very high'.
11	• Establishes that the water source either doesn't have 'high' or 'very high' reaches, OR there are 'high' or 'very high' reaches but they are above extraction points (and therefore assumed unaffected by extraction pressure), and asks whether there are 'medium' value reaches in the water source. • This allows the risk of extraction pressure on medium value aquatic ecosystems to be assessed independently of the 'low' and 'very low' value aquatic ecosystems.
12	• Asks whether species/populations/communities in the reach are moderately to highly sensitive to extraction, primarily because their specific flow requirements and limited ability to move if those flow requirements are not met (e.g. fish, frogs, turtles, macrophytes). • This information is in the MS Excel Distinctiveness file for each catchment, in the column labelled 'Flow Sensitivity Weighting'.
13	• If a species/population/community has a flow response score ≥3 (i.e. it is sensitive to extraction), it is assigned risk category 'medium'. • If a species/population/community has a flow response score <3 (i.e. it is less sensitive to extraction), it is assigned risk category 'low'.
14	• Deals with 'medium' value reaches that don't have high Distinctiveness (i.e. ≥0.4). • Asks whether the main river in the water source has a predominantly 'medium' value. This question weights the value of the main river higher than any tributaries, because it is assumed the main river is likely more affected by extraction pressure than tributaries.
15	• If the main river in a water source has a predominantly medium HEVAE condition, the consequence ranking is also medium.
16	• Asks whether the combined length of medium and low HEVAE reaches in a main river in an assessment area is less than the length of reaches in the same main river with a very low HEVAE rank. • The rationale is if the main river is comprised of mostly low with some medium HEVAE reaches, then a conservative approach should be adopted, and the low consequence rank prevails.
17	• If the reach has a mainly very low HEVAE rank, and there is little apparent reliance on the reach by freshwater-dependent flora and fauna, the consequence awarded is 'very low'.
18	• There are no very high, high or medium HEVAE ranked reaches in the assessment area – only low and very low. • It is assumed there is little reliance on habitats in these reaches by freshwater-dependent flora and fauna.
19	• The assessment area is awarded the same consequence rank as the predominant HEVAE rank for the area. • It is assumed there is little reliance on habitats in these reaches by freshwater-dependent flora and fauna.

Appendix C Threatened species populations and endangered ecological communities

Table C1 List of threatened species populations and endangered ecological communities used in the Distinctiveness Criteria for the South Coast area. Note that the Towamba Water Sharing Plan is a subset of this list. Note that flow sensitivity weightings rank the reliance of a threatened species, population or 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
Montane Peatlands and Swamps		MPSeec	EEC	Endangered	Endangered	4	3
Snowy River aquatic ecological community		SReec	EEC	Endangered	Not listed	4	3
River blackfish in the Snowy River catchment	*Gadopsis marmoratus*	RBep	EP	Endangered Population	Not listed	4	3
Australian Grayling	*Prototroctes maraena*	AGYfish	Fish	Not listed	Vulnerable	4	2
Alpine tree frog	*Litoria verreauxii alpina*	ATfrog	Frog	Endangered	Vulnerable	4	3
Giant barred frog	*Mixophyes iteratus*	GBAfrog	Frog	Endangered	Endangered	4	3
Giant burrowing frog	*Heleioporus australiacus*	GBUfrog	Frog	Vulnerable	Vulnerable	4	2
Litlejohn's tree frog	*Litoria littlejohni*	LJTfrog	Frog	Vulnerable	Vulnerable	4	2
Southern bell frog	*Litoria raniformis*	SBfrog	Frog	Endangered	Vulnerable	4	3
Southern Corroboree Frog	*Pseudophryne corroboree*	SCfrog	Frog	Critically Endangered	Critically Endangered	4	4
Stuttering barred frog	*Mixophyes balbus*	STBfrog	Frog	Endangered	Vulnerable	4	3
Red-crowned Toadlet	*Pseudophryne australis*	RCTfrog	Frog	Vulnerable	Not Listed	4	2
Green and golden bell frog	*Litoria aurea*	GGBfrog	Frog	Endangered	Vulnerable	3	3

Common Name	Scientific Name	Abbreviation	Distinctiveness Parameter	NSW Status	Commonwealth listing	Flow Sensitivity Weighting	Status Weights
Yellow-spotted tree frog	*Litoria castanea*	YSTfrog	Frog	Critically Endangered	Endangered	3	4
Alpine redspot dragonfly	*Austropetalia tonyana*	ARDaqua	Other Aquatic	Vulnerable	Not Listed	3	2
Giant Dragonfly	*Petalura gigantea*	GDaqua	Other Aquatic	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
Black-tailed Godwit	*Limosa limosa*	BTbird	Bird	Vulnerable	Not Listed	2	2
Comb-crested Jacana	*Irediparra gallinacea*	CCJbird	Bird	Vulnerable	Not Listed	2	2
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

Common Name	Scientific Name	Abbreviation	Distinctiveness Parameter	NSW Status	Commonwealth listing	Flow Sensitivity Weighting	Status Weights
Sanderling	*Calidris alba*	SDbird	Bird	Vulnerable	Not Listed	2	2
Terek Sandpiper	*Xenus cinereus*	TSbird	Bird	Vulnerable	Not Listed	2	2
White-fronted Chat	*Epthianura albifrons*	WFCbird	Bird	Vulnerable	Not Listed	2	2
Freshwater Wetlands on Coastal Floodplains		FWCFeec	EEC	Endangered	Not listed	2	3
Swamp Oak Floodplain Forest		SOFFeec	EEC	Endangered	Not listed	2	3
Swamp Sclerophyll Forest on Coastal Floodplains		SSFCFeec	EEC	Endangered	Not listed	2	3
Greater Broad-nosed Bat	*Scoteanax rueppellii*	GBBmam	Mammal	Vulnerable	Not listed	2	2
Southern Myotis	*Myotis aelleni*	SMmam	Mammal	Vulnerable	Not listed	2	2
Austral pipewort	*Pilularia novae-hollandiae*	APpl	Plant	Endangered	Endangered	2	3
Broad-leaved Sally	*Eucalyptus aquatica*	BLSpl	Plant	Vulnerable	Vulnerable	2	2
Deane's Boronia	*Boronia deanei*	DBpl	Plant	Vulnerable	Vulnerable	2	2
Perisher Wallaby Grass	*Rytidosperma vickeryae*	PWGpl	Plant	Endangered	Not Listed	2	3
Tall Knotweed	*Persicaria elatior*	TKpl	Plant	Vulnerable	Vulnerable	2	2

Appendix D Riverine flow components and features

Streamflow varies in response to climate, season, landform and land use, and supports key environmental assets and underpins ecosystem functions within the riverine environment.

Table D1 Key features of flow regimes which impact on ecosystem functions and environmental assets

Flow regime component	Key feature
Cease to flow events for pools and refugia	Pools can provide important refugia for a range of taxa during periods of no flow. Continued extraction of water from pools can lead to greater competition for resources by aquatic biota, as well as changes to water quality.
Base flows	Base flows (low flows) are those flows that are confined to the low flow part of the channel. They persist after rain has stopped as a result of connection to groundwater aquifers. Protection of low flows protects longitudinal connectivity, as well as important flowing water habitat types (riffles and pools) that support specialist feeding groups including macroinvertebrate communities and fish. Base flows are important to fish communities because they: • Provide a diversity of habitats for sheltering, feeding and spawning. • Establish connectivity and enable longitudinal movement of fish between pools. Large bodied fish may not move during base flows due to inadequate water depth within riffles, but small bodied fish may move if conditions are suitable. • Constantly exchange and refresh water in pools and therefore maintaining reasonable water quality.
Freshes	Freshes are larger flows that inundate the sides of the banks and any in-channel bars and benches that may be present. These are often caused by a rain event leading to increased inflows to the river that travel as a pulsed flow down the system. Freshes are required to support instream processes and biota in the same way as bank full and over bank flows, in terms of flow magnitude, duration, timing and frequency. Freshes are a distinct event.
Large and infrequent flows (High flows 1.5, 2.5, 5.0 ARI)	Large flow events occur on an average recurrence interval (ARI) of greater than a year. These flow events are distinct from base flows and freshes because they can generate bank full and over bank flows. Bank full flows are regarded as important for maintaining river geomorphology and are often termed the “channel forming” flows, as they help maintain channel dimensions such as width, depth and slope, and in-channel habitats such as benches and bars. High flows and freshes also act as a natural disturbance in river systems, helping to remove vegetation, aquatic plants and organic matter and resetting successional processes. Over bank flows deliver water, sediment and dissolved material, including plant nutrients, to the floodplain and provide temporary access to floodplain aquatic habitats. Water returning from the floodplain to the channel may carry carbon in the form of dissolved carbon and organic detritus, micro-organisms and small plankton animals. All are generated by the productive floodplain ecosystem and supported by inputs of water from the channel.

Reference: MDBA 2010, 2012b; Alluvium 2010, Chessman et al*.* 2006a

Appendix E Rating alluvial groundwater dependant ecological values and consequences

E1: Value Rating for GDE Ecosystems

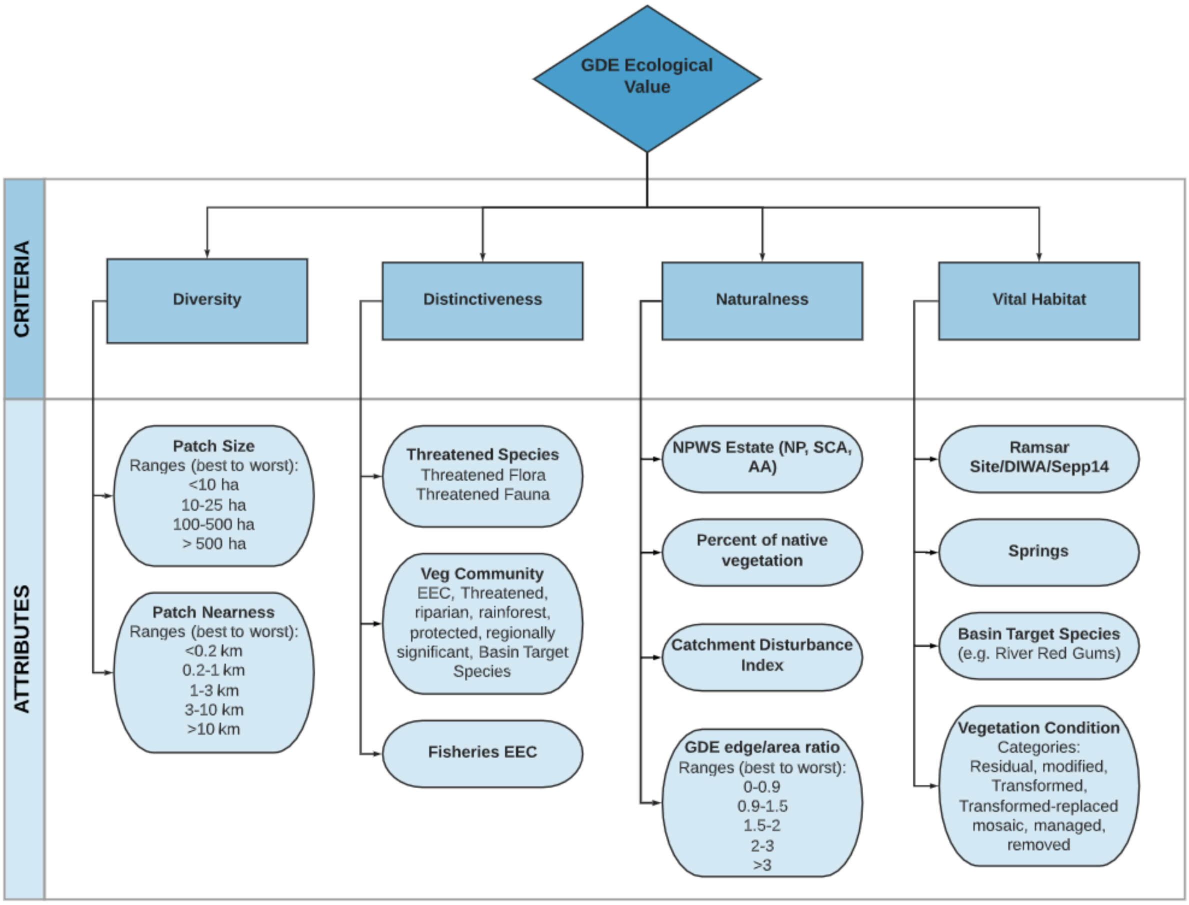


Figure E1 HEVAE criteria for groundwater dependent ecosystems

The HEVAE methods in Appendix B1 were applied to Groundwater Dependent Ecosystems (GDEs). Detailed methods are available in the GDE ecological value method paper (Dabovic et al. 2019).

HEVAE assessments of GDEs use the diversity, distinctiveness, naturalness and vital habitat criteria (Figure E1). Representativeness is not included due to limited data availability.

E2: Consequence Rating for GDE Ecosystems

The value rating is adjusted according to the sensitivity of the ecosystem to give a consequence rating. This approach considers the need to balance water use for human extractive needs and water requirements to maintain GDEs. It also considers external conditions, such as the location and size of extraction pressures and how these influence GDE condition.

A decision tree was used to adjust value ratings, considering:

- The presence of Ramsar/Directory of Important Wetlands in Australia (DIWA) habitats.
- The relative location and size of groundwater extraction pressures. The assumption was that if there was high extraction then there was a potential for a decrease in groundwater level.
- The presence of freshwater dependent and flow-sensitive threatened flora and fauna.
- The cumulative HEVAE values for vegetation patches in the assessment area.

Water-dependent fauna and flora records were site-based data, obtained from agency databases. As this is recorded data, it can be used with a high level of confidence. Predicted and known records (see Dabovic et al*.* 2019) were not considered when progressing through the decision tree. This was due to the lower confidence in those types of datasets. If there were no site-based records, the consequence rank was lowered to the next category. For example, if a high HEAVE score had details only based upon predicted or known data, the consequence category became medium.

Each split in the decision tree was annotated. This allowed each consequence rank to be tracked through the decision tree during the assessment. The rationale for each decision is provided in Table E1.

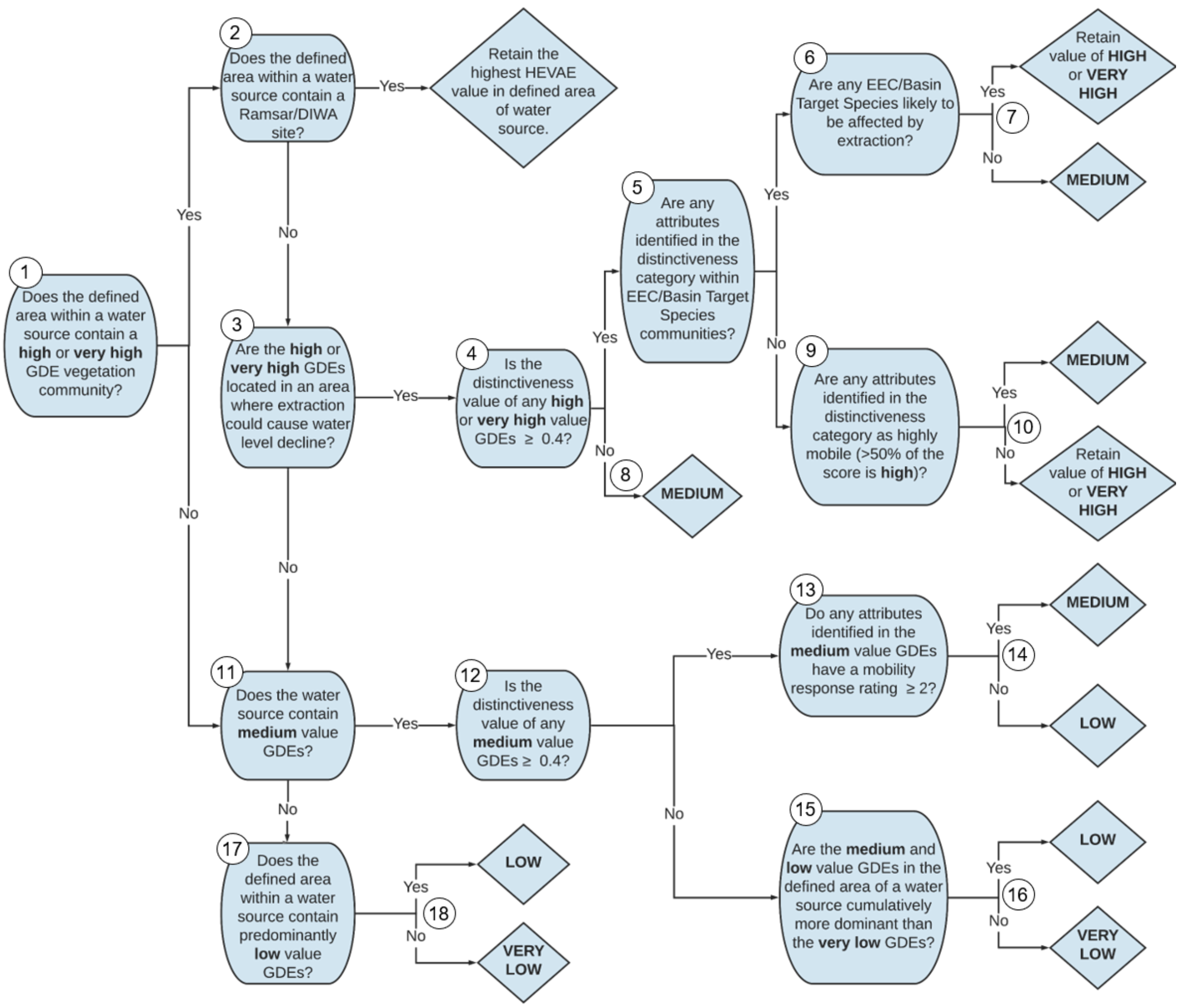


Figure E2 Consequence decision tree used to convert GDE HEVAE outputs to an overall consequence ranking

Table E1 Rationale for each bifurcation in the decision tree used for converting HEVAE ranks to 'consequence of extraction pressure on GDE condition' ranks

DECISION ANNOTATION	RATIONALE
1	• Management for retention of conservation values is a higher priority in high and very high value reaches. • Limiting extraction is easier to justify in high and very high value reaches, than it is in medium reaches.
2	• Ramsar/DIWA/SEPP14 sites are valued for their contribution to international conservation efforts for migratory species. Australia is a signatory country and has an obligation to maintain these sites.
3	• Water level decline is assumed to potentially occur if there is entitlement within the water source. • The attributes of high or very high value sites are influenced by extraction pressure. • GDEs that are in areas where there is no entitlement are assumed to be unaffected by extraction pressure, so the assessment focus shifts to whether there are medium value reaches in the water source. • If a high or very high value site is likely to be affected by extraction pressure the focus shift to whether any threatened species, populations, communities or rare river styles could be affected.
4	• The attributes of high or very high value sites are influenced by extraction pressure. • The most 'at risk' HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the GDE (i.e. threatened species, populations and communities). • A distinctiveness score of ≥ 0.4 in the HEVAE means the GDE has a medium, high or very high value as habitat for threatened species, populations, or communities. • Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
5	• Distinguishes between species, populations, communities that are Endangered Ecological Communities (EEC).
6	• Given the attribute is identified as being an EEC (from 5), this step assumes that the habitat is at risk from extraction which causes altered groundwater availability.
7	• Any attributes that are considered vulnerable to extraction of groundwater retain their original high or very high value category. • Any attributes that are considered resilient to extraction of low flows are allocated a 'medium' consequence category.
8	• High or very high value GDEs that have low distinctiveness are assumed to have attributes that are more resilient to extraction pressure (at least in the short-term) and are assigned a 'medium' consequence category.
9	• Establishes if attributes are highly mobile (i.e. birds, bats) or not (i.e. plant, frogs). The assumption is that more mobile species/population/community can move to avoid changes in habitat owing to extraction pressure.
10	• Due to all threatened species being used in Distinctiveness, a threshold of 50% highly mobile was used to assign a score. • If the species can move, they are assigned a risk category of 'medium'. • If the species/population/community is sessile (cannot move), it is assumed to be at greater risk of harm from extraction pressure (because it can't move to avoid the pressure) and retains its original categorisation of 'high' or 'very high'.
11	• Establishes that the water source either doesn't have 'high' or 'very high' GDEs, OR there are 'high' or 'very high' GDEs but they are in areas of low or no extraction (and therefore assumed unaffected by extraction pressure), and asks whether there are 'medium' value GDEs in the water source. • This allows the risk of extraction pressure on medium value GDEs to be assessed independently of the 'low' and 'very low' value aquatic ecosystems.

DECISION ANNOTATION	RATIONALE
12	• The attributes of high or very high value sites are influenced by extraction pressure. • The most ‘at risk’ HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the GDE (i.e. threatened species, populations and communities). • A distinctiveness score of ≥ 0.4 in the HEVAE means the GDE has a medium, high or very high value as habitat for threatened species, populations, or communities. • Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
13	• Asks whether species/populations/communities in the GDEs are moderately too highly sensitive to extraction, and limited ability to move if watering requirements are not met (e.g. plants, frogs, turtles, small mammals, and small birds). • *Mobility ratings of 3 and 2 can be considered water dependant for species. A species must be known to occur (i.e. a score of 1 = present in distinctiveness attributes)* • *Furthermore, the presence of only one species alone is insufficient, other species, populations etc must be present.*
14	• If a species/population/community has a mobility response score ≥2 (i.e. it is sensitive to extraction), it is assigned risk category ‘medium’. • If a species/population/community has a mobility response score <2 (i.e. it is less sensitive to extraction), it is assigned risk category ‘low’.
15	• Asks whether the combined area of medium and low HEVAE GDEs in a defined area in the water source is less than the area of GDEs in the defined area with a very low HEVAE rank. • The rationale is if the defined area is comprised of mostly low with some medium HEVAE GDEs, then a conservative approach should be adopted, and the low consequence rank prevails.
16	• If the GDE has a mainly very low HEVAE rank, and there is little apparent reliance on the vegetation polygon by flora and fauna, the consequence awarded is ‘very low’.
17	• There are no very high, high or medium HEVAE ranked reaches in the assessment area – only low and very low. • It is assumed there is little reliance on habitats in these reaches by water-dependent flora and fauna.
18	• The assessment area is awarded the same consequence rank as the predominant HEVAE rank for the area. • It is assumed there is little reliance on habitats in these reaches by flora and fauna.

Appendix F Rating estuary values (ecological and instream use) and consequences

F1: Value Rating for Estuarine Ecosystems

Estuarine HEVAE assessments use the methods described in Appendix B1, only using values of “Low”, “Medium” and “High”. Estuarine assessments use all five criteria and consider other in stream values (Figure F1). The value rating was determined with reference to a combination of data sets for:

- Values that reflect estuary functions likely to be impacted by reduced flow.
- Values that were represented in data sets that covered the whole NSW coast.
- Values that could be impacted by management efforts.
- Values and data used in the earlier macro assessment.
- Data that could reasonably expected to be repeated, updated or maintained. This enables future comparisons.

The values, data and analysis methods are primarily relevant to water sharing. They may not be suited for use in other contexts, or comparable with estuary assessments completed for different purposes.

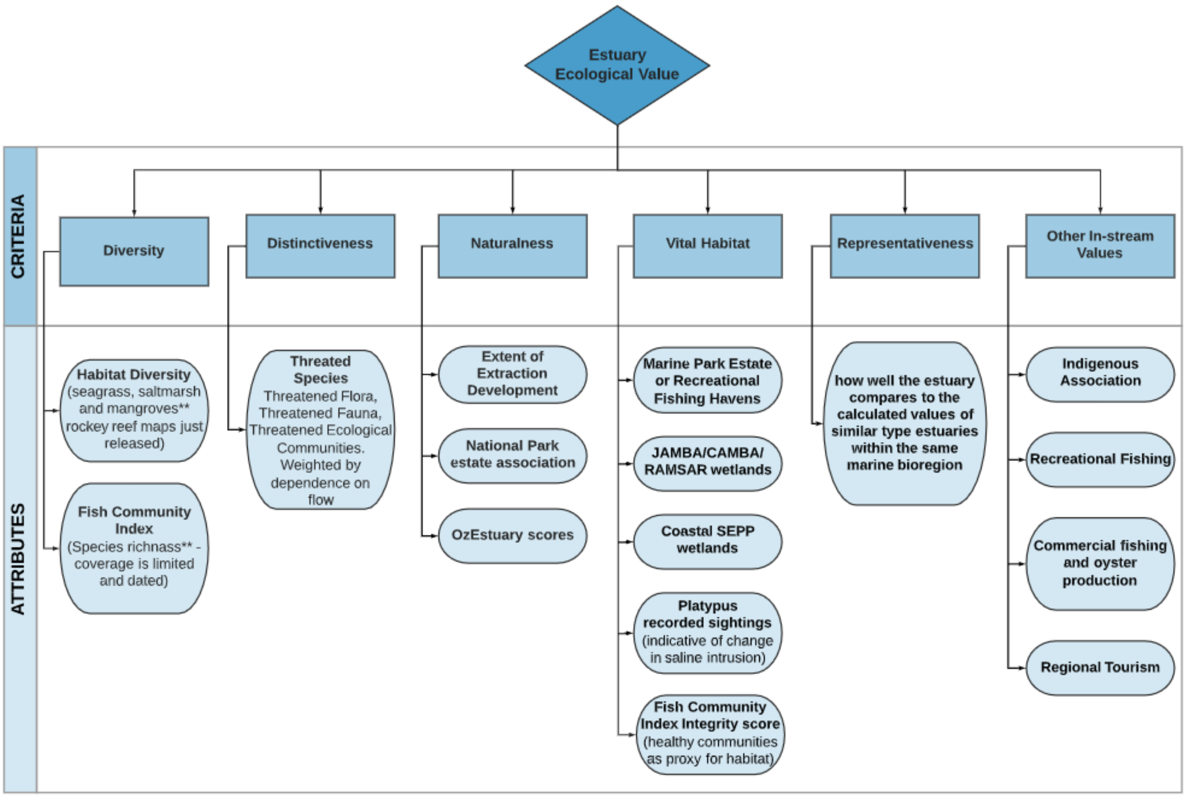


Figure F1: HEVAE Criteria for Estuarine Ecosystems

F2: Consequence Rating for Estuarine Ecosystems

The value rating is adjusted according to the sensitivity of the ecosystem to give a consequence rating. Some estuaries, for example intermittently opening estuaries, are more sensitive to changes in flow inputs. These may experience severe consequences if flow inputs are reduced. Others are dominated by marine conditions, and reduced inflows will have minimal impact on the function of these estuaries.

A decision tree (Figure F2) was used to calculate sensitivity based on physical attributes, including:

- estuary type
- surface and catchment area
- the ratio of surface and catchment area
- length of tidal reach
- mouth training and opening characteristics
- association with coastal wetlands

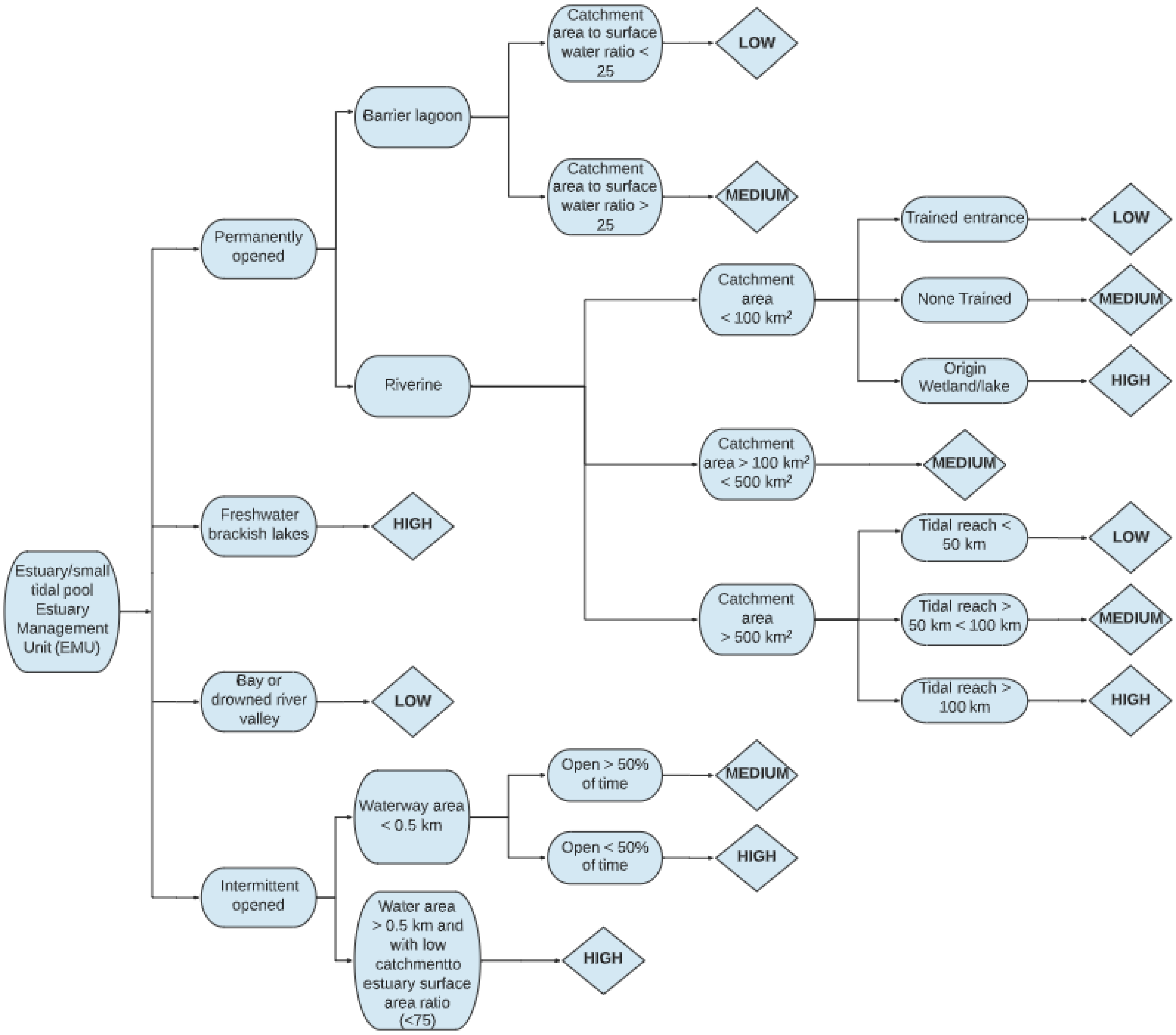


Figure F2 Decision tree for calculating estuary sensitivity (source NSW Office of Water, 2009).

This rationale was extended to consider estuary response and sensitivity for high-flow events. Once calculated, sensitivity is applied to the HEVAE value to give a consequence rating. High sensitivity increases the consequence category, while low sensitivity decreases the value. Medium sensitivity has no impact. For example, an ecosystem with a medium HEVAE value and a high sensitivity value receives a high consequence value.

F3: Updates from the Macro Assessment Process

The Department has updated the following in this version of estuary assessment:

- Created estuary sub-units aligning with Water Sharing Plan water sources.
- Rated risk for different parts of the flow regime.
- Considered a wider range of threats to flow alteration (i.e. licensed extraction, Basic Landholder Rights, interception, climate change).
- Updated data sets where appropriates, or new data sets sourced to fill data gaps.
- Amended method for calculation of value scores, with amended treatment of sensitivity.

In the future, the Department plans to:

- Include new data from NSW Estuarine Habitat Mapping (2020).
- Use indicators of catchment processes and threats in sensitivity ratings. This is particularly relevant for higher flows. Indicators may include: EES Estuary Health component data, inverse HEVAE/RCI upstream/water source rating.
- Incorporate Fisheries/EES data on coastal species based on functional groups.
- Include aquatic version of Bioindicator Program pending EES/Fisheries collaboration.

Appendix G Rating likelihood of inadequate water for GDEs occurring

The coverage of alluvial monitoring bores in Coastal Water Sharing Plans areas is limited, meaning that there are no measured groundwater levels in most water sources. In these water sources the precautionary principle is applied by looking at the entitlement for basic landholder rights, irrigation, and other water uses. The rating of likelihood is as follows:

- in water sources with entitlement it is assumed that the full entitlement is extracted, and they are assigned a high likelihood score, and
- in water sources with no entitlement a likelihood score of low is assigned.

In those alluvial water sources where monitoring bore data is available, the **rate** and **magnitude** of groundwater level change is evaluated based on the levels monitored during the term of the plan. This evaluation is based upon the research of Froend et al. (2004). Froend et al. (2004) determined what the watering requirements for groundwater dependent wetlands and vegetation are in the coastal zone of Western Australia. These coastal areas in Western Australia have similar alluvial characteristics to the coastal zone in New South Wales, including high groundwater extraction rates. Since our knowledge of environmental watering requirements for GDEs in NSW is limited, it has been assumed that the Western Australia watering requirements can be reasonably applied in NSW.

- The **magnitude of change** was calculated by assessing the largest drawdown during the term of the plan, with the baseline groundwater level assumed to be the level at the start.
- And the **rate of change** was calculated by determining the rate of change in each year of the plan and taking the average.

The magnitude and rate of change for each bore were then used to rate the likelihood of there being inadequate water levels. This is done by plotting them on the following graphs (Figures G1 to G4) to determine a likelihood score. The highest likelihood score in each water source was used to assign a risk rating.

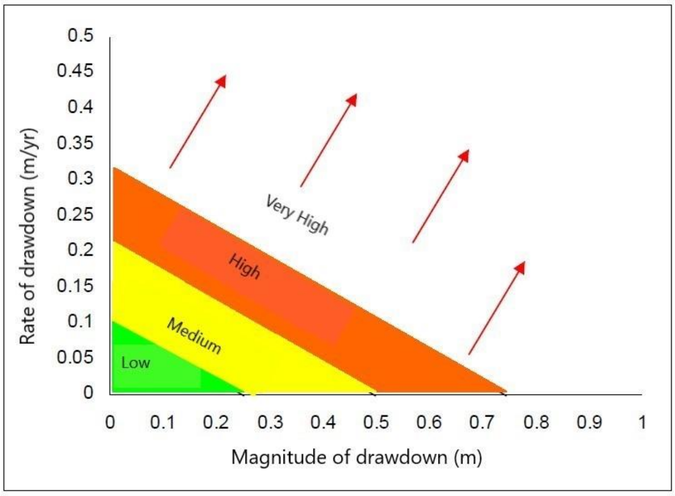


Figure G1: Likelihood of rate and magnitude of change in groundwater levels for wetlands (Adapted from Froend et al. (2004)).

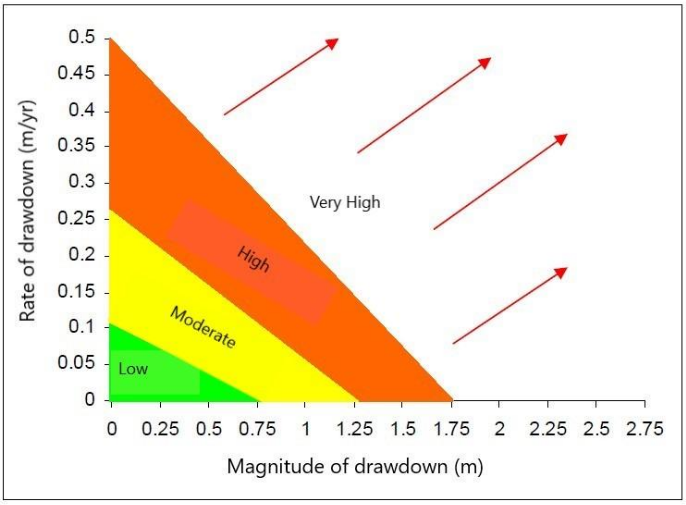


Figure G2: Likelihood of change in groundwater levels for vegetation at an initial groundwater level range of 0 to 3m (Adapted from Froend et al. (2004)).

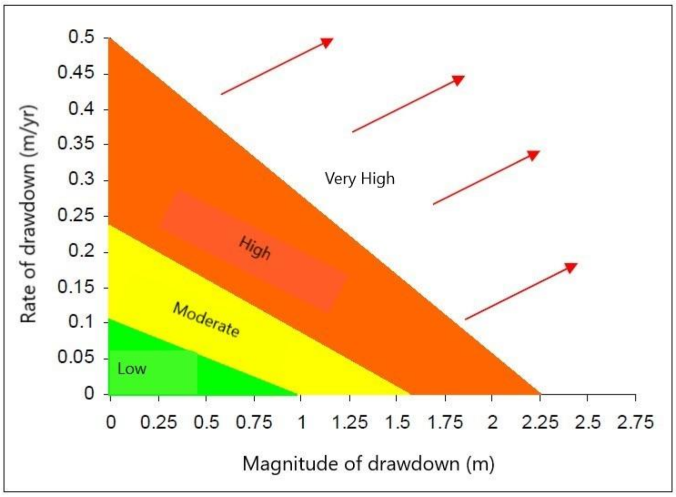


Figure G3: Likelihood of change in groundwater levels for vegetation at an initial groundwater level range of 3 to 6m (Adapted from Froend et al. (2004)).

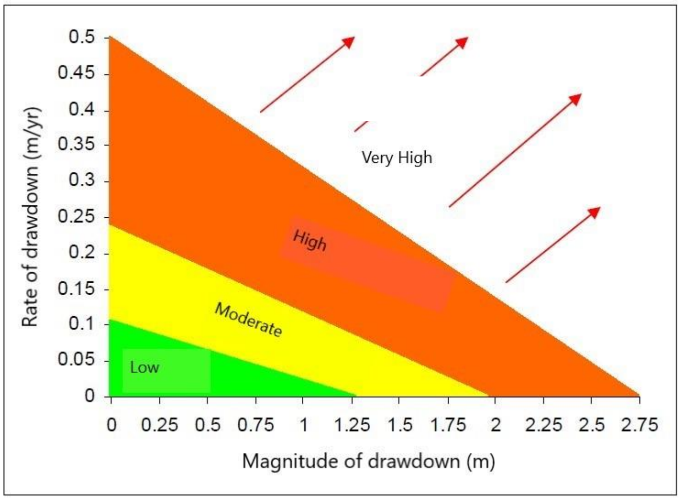


Figure G4: Likelihood of change in groundwater levels for vegetation at an initial groundwater level greater than 6m (Adapted from Froend et al. (2004)).

Appendix H Consequence rating where HEVAE not available

Two of the water sources in the Towamba WSP (Bondi Lake and tributaries, and Tura Beach and tributaries water sources) are small coastal catchments. Both have small drainage systems made up of lower order streams. This has led to them having no River Styles mapping and consequently no HEVAE rating for any of the small streams within them. Consequence rating have been made for these water source by reviewing the previous instream value ratings and investigating the information on these systems in lieu of the HEVAE based consequence rating.

H1: Bondi Lake and tributaries

Bondi Lake was initially assessed in the Bega macro classification process, where it was classified as having low instream value. This rating was increased by the Regional Interagency Panel to high instream value.

This was likely due to the single large wetland (Bondi Lake) being classified as a Directory of Important Wetlands, Australia (DIWA) listed wetland. The wetland considered to be locally/regionally important because of its fauna values within Bournda National Park. The lake is a perched lake meaning that its water level is mainly maintained by groundwater, but also supported by small surface water inflows. Although there is no extraction in this water source, the listing of this wetland as a DIWA indicates it is of high ecological value and significance.

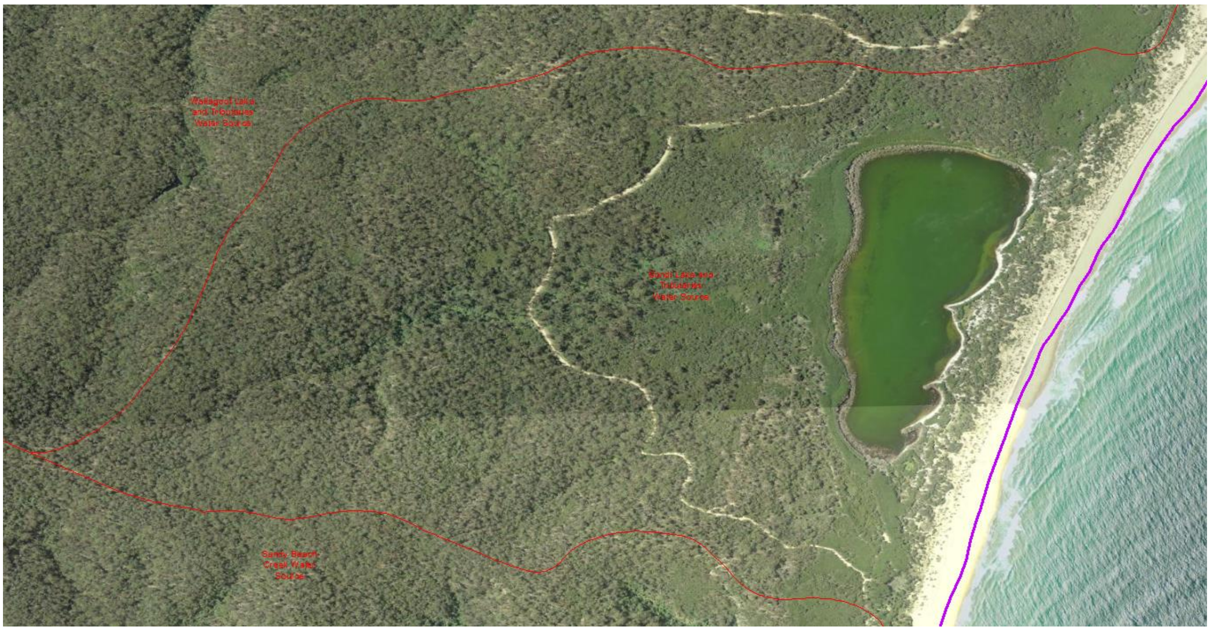


Figure H1: Bondi Lake and tributaries water source

Recommendation: Retain the final macro classification rating of high instream value and use it as the consequence rating for the risk assessment.

H2: Tura Beach and tributaries

Tura Beach water source was initially assessed in the Bega macro classification process, where it was classified as having low instream value. This is reinforced by the character of the system, which has urbanized catchment and small streams which would not support a large riverine ecosystem.

Figure H2: Tura Beach and tributaries water source

Recommendation: Retain the original macro classification spreadsheet of low instream value and use it as the consequence rating for the risk assessment.

Appendix I Water Quality Data

Table I1: Median Water Quality data for sites upstream of the tidal limits of the Towamba River Area

Water Quality Site	Year	Total Phosphorus (mg/L)	Filterable Reactive Phosphorus (mg/L)	Total Nitrogen (mg/L)	Nitrate + Nitrite (NOx) (mg/L)	Turbidity (NTU)	Dissolved oxygen (% sat)	pH	Electrical conductivity (µS/cm)	Total Suspended Solids (TSS)	Temperature (ºC)
Towamba River at Towamba (Upper Towamba)	2015/2016	0.03	0.01	0.16	0.02	1.1	99.4	7.6	178	10	19.3
	2016/2017	0.01	0.01	0.21	0.02	1.6	91.2	7.6	192	10	19.1
	2017/2018	0.01	0.01	0.16	0.02	0.7	88.8	7.6	220	10	18.3
	2018/2019	0.01	0.01	0.10	0.01	1.6	94.4	7.5	225	5	18.3
	2019/2020	0.01	0.01	0.20	0.02	1.8	79.1	7.1	256	5	15.1

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

Appendix J Assessment of the Towamba Coastal Floodplain Alluvial Water Source

Acid Sulfate Soils & Water Quality

The majority of the Towamba Floodplain Alluvium is mapped as Low to High probability of occurrence of Acid Sulfate Soils. The areas surrounding Pambula, Merimbula and further North toward Tathra are all mapped as having high probability of acid sulfate soils. Only the more inland sections of alluvium are mapped as low probability. This high probability for occurrence of acid sulfate soils on the Towamba Floodplain Alluvium has been considered in the undertaking of the risk assessment for the area.

Risk Assessments

The aquifer ecological risk assessment for the Towamba Floodplain Alluvium has identified a medium water quality risk due to potential disturbance of high probability acid sulfate soils near the coastline and brackish to saline groundwater.

The socio-economic assessment was determined to be low given the absence of any licenced users in the water source.

The risk assessment has been provided to the Planning Team for information.

Note: all new groundwater extraction approvals now require a detailed impact assessment investigation by the DPIE-W Groundwater & Science unit. A copy of the impact assessment criteria is publicly available from the following link:

https://www.industry.nsw.gov.au/__data/assets/pdf_file/0008/175931/Assessing-groundwater-applications-fact-sheet.pdf

Seawater intrusion and acid sulfate soils risk will need to be considered as part of a dealing assessment.

The Sustainability Index from the risk assessment was determined to be 25% of the total recharge of this Towamba Floodplain Alluvium Groundwater Source.

Long Term Average Annual Extraction Limit (LTAAEL) & Recharge

The estimated annual average aquifer recharge of the Towamba Floodplain Alluvium Water Source including National Parks was calculated at 967.9 ML/yr, and excluding National Parks is 808.4 ML/yr. The total area of the new Towamba Floodplain Alluvium Water Source is estimated as 11 square kilometres and the average annual rainfall across the area is 831 mm.

The recharge was calculated based on 10% of average annual rainfall calculated across the aquifer (excluding National Parks). The climate change prediction is for a 0- 5% increase in the annual period in the Towamba area. As a conservative approach, no additional rainfall has been added to account for the anticipated increase in mean precipitation over the next 20 years.

The Sustainability Index from the Risk Assessment was 25%, this being the proportional amount of aquifer recharge in non-National Park areas to be made available. This volume is defined as the Long-Term Average Annual Extraction Limit (LTAAEL).

As a result the LTAAEL is derived from 25% of the rainfall recharge which equates to 202 ML for the Towamba Floodplain Alluvium Water Source.

Table J1 LTAAEL calculations for the Towamba Coastal Floodplain Alluvial Groundwater Water Source

LTAAEL for the Towamba Coastal Floodplain Alluvial Water Source	
Total Aquifer Rainfall Recharge (inc. National Parks)	967.9 ML/year
Total Aquifer Rainfall Recharge (exc. National Parks)	**808.4 ML/year**
Climate Change 2020-2039 Annual Prediction 0-5%	No change i.e minimum is 0%
Sustainability Index %	25%
Recommended Long-Term Annual Extraction Limit	**202 ML/year**

Conclusions

The Water Sharing Plan for the Towamba River Unregulated and Alluvial Water Sources 2022 will replace the Water Sharing Plan for the Towamba River Unregulated and Alluvial Water Sources 2010. The plan combines groundwater management with management within the upriver alluvium. It also integrates the management of surface water extraction and groundwater extraction and capped extraction at existing limits.

The creation of a new coastal floodplain alluvial area is to have minimal impact on license holders, with only eight BLR holders present in the newly created Coastal Floodplain Alluvium area. It should be noted that these groundwater works will require changes to their water source classification registered in the WaterNSW system. There are no production or town water supply bores within the Towamba Floodplain area.

For the newly mapped Towamba Floodplain Alluvium Water Source a separate Long Term Average Annual Extraction Limit (LTAAEL) has been calculated based on a percentage of recharge. A risk assessment process was used to determine the LTAAEL from recharge using a 25% sustainability index applied as a percentage of available recharge. The new LTAAEL for the Towamba Floodplain Alluvium was calculated as 202 ML/yr.