NSW GOVERNMENT

MACQUARIE–CASTLEREAGH SURFACE WATER RESOURCE PLAN

Risk assessment for the Macquarie–Castlereagh water resource plan area (SW11): Part 1

Schedule D

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Risk Assessment for the Macquarie-Castlereagh water resource plan Area (SW11)

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More information

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Murray–Darling Basin Authority

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NSW Office of Environment and Heritage 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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Contents

Figures

Tables

Executive summary

The Murray–Darling *Basin Plan 2012* (the Basin Plan) requires NSW to prepare Water Resource Plans (WRP). The *Risk assessment for the Macquarie–Castlereagh water resource plan area (SW11)* has been prepared to meet the requirements of the Basin Plan, assessing current and future risks to the condition and continued availability of the water resources. This document will be used to guide the development of the Macquarie-Castlereagh WRP. Part 9, Chapter 10 of the Basin Plan sets out the key requirements for WRP risk assessments.

Table 1. Chapter 10, Part 9 of the Basin Plan

10.41 Risk identification and assessment methodology
(1) Regard to current and future risks
(2) (a) Risks to meeting environmental watering requirements
(b) Risks arising from matters referred to in subsection 10.20(1) (productive base of groundwater)
(c) Risks arising from potential interception activities
(d) Risks arising from elevated levels of salinity or other types of water quality degradation
(3) (a) Risks identified in Section 4.02
(4) List the identified risks
(5) Assess each risk
(6) Categories of level of risk
(7) Description of the data and methods
(8) Description of uncertainty
10.42 Description of risks
10.43 Strategies for addressing risks
(1) Water resource plan risk mitigation strategies
(2) Strategies take account of Chapter 10 requirements
(3) (a) WRP have regard to strategies listed in section 4.03(3)

The risk assessment framework adopts a cause/threat/impact model that describes the risk pathway of impacts to a receptor. 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. The risk level is assessed with the current strategies and rules in place, as provided for under the NSW *Water Management Act 2000* and the relevant water sharing plan/s (WSP). The relevant water management actions and mechanisms in place to address particular risks are listed in each chapter.

The Basin Plan requires a water resource plan (WRP) to describe strategies to manage medium or high risks in a manner commensurate with the level of risk. A strategy is commensurate with the level of risk if it results in the level of risk being tolerable. If the risk cannot be addressed to a tolerable level, an explanation should be provided. For example, there may be instances where an identified risk cannot be mitigated due to a range of constraints including, but not limited to infrastructure, third party economic or social impacts, or sustainable diversion limits.

Risk-based management assists water managers to prioritise and plan and direct resources to monitor, mitigate or respond to the factors that pose the highest overall risks. It ensures that strategies (both existing and proposed) are targeted at the appropriate part of the water system. In the context of the NSW risk assessment process, a medium or high risk does not automatically imply that existing WSP rules are inadequate or require change, or that new strategies are required. Rather, the risk assessment can be

considered a ‘red flag’ process to provide guidance for where more detailed investigation may be required during the life of the Plan.

Medium and high-risk results that were identified in this risk assessment were reviewed to determine whether they are adequately addressed by existing strategies, or whether modifications or new strategies may be required. Risk treatment options were developed following a systematic approach outlined in Figure 1 (Risk Treatment Pathway). Defining tolerable risk results (i.e. those high or medium results NSW considers are acceptable or adequately managed by existing water resource management strategies) were also part of this approach. Explanations for risk results that the WRP cannot address in a manner commensurate with the level of risk are provided in the Consolidated Risk Table (Table 1). Consolidated risk maps are provided in Figures 2 and 3.

As strategies are not required for risk results that are low, they have not been further considered in the risk treatment overview.

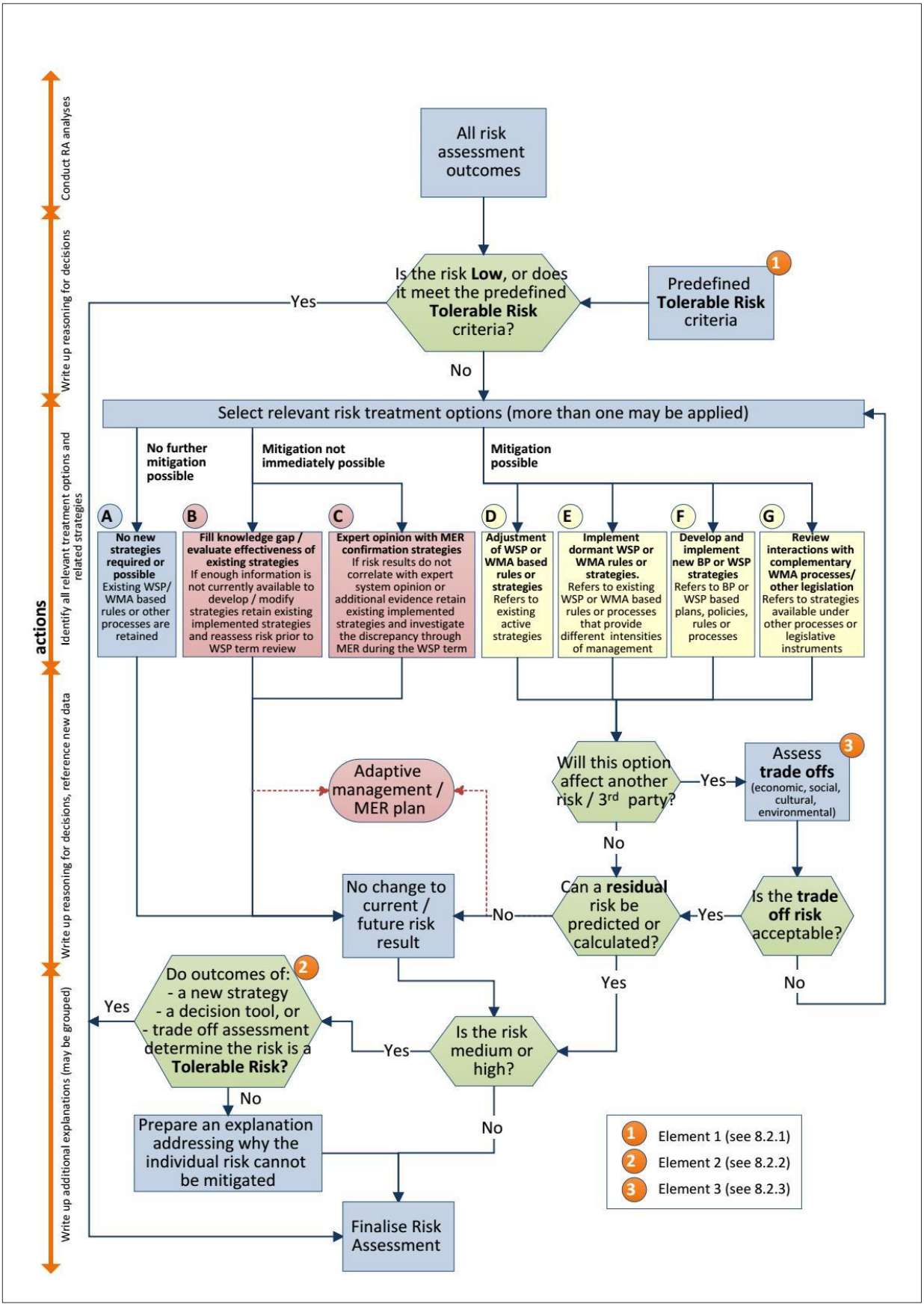
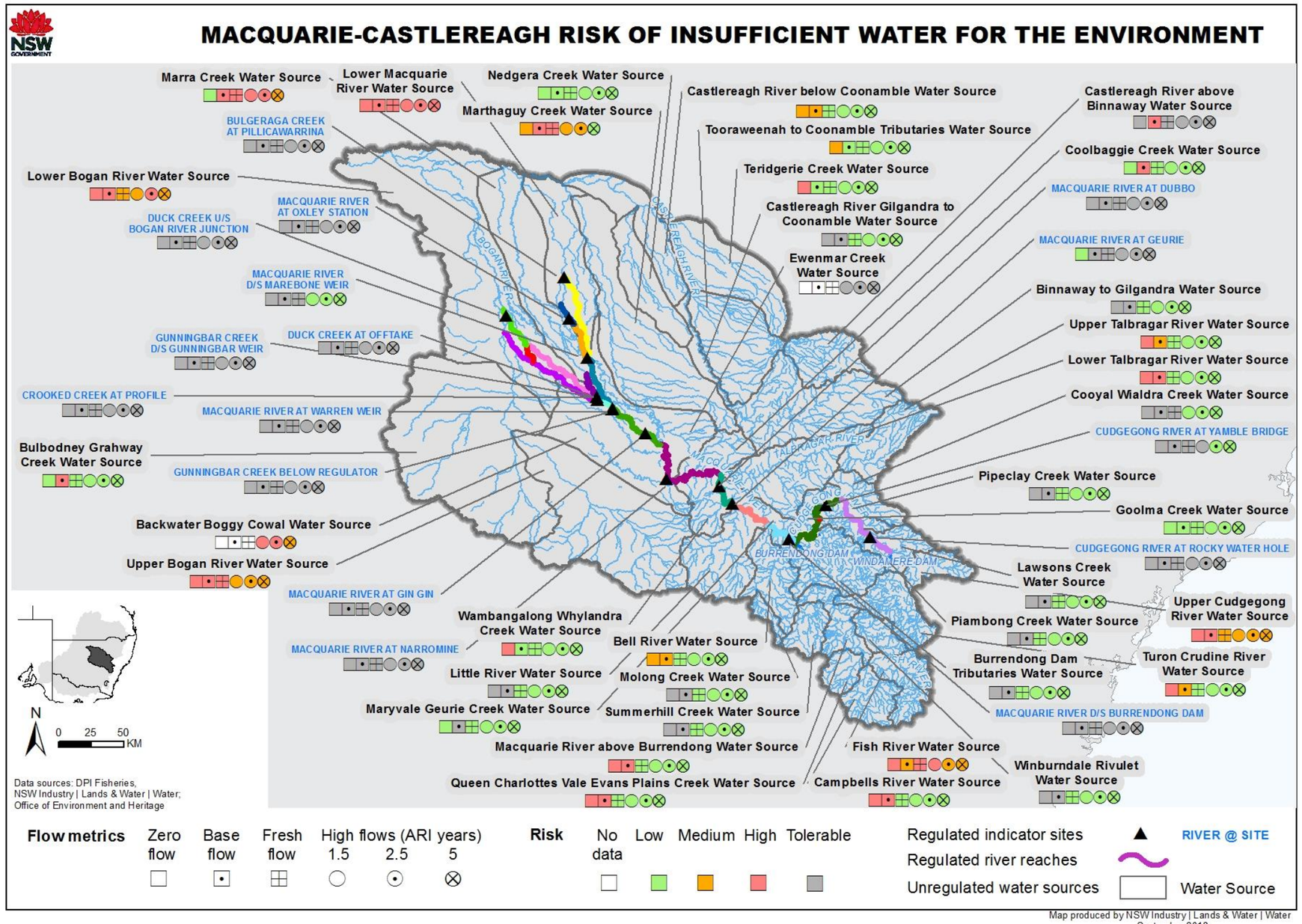


Figure 1. Risk treatment pathway



Consolidated risk maps

Figure 2. Consolidated risk map – insufficient water for the environment

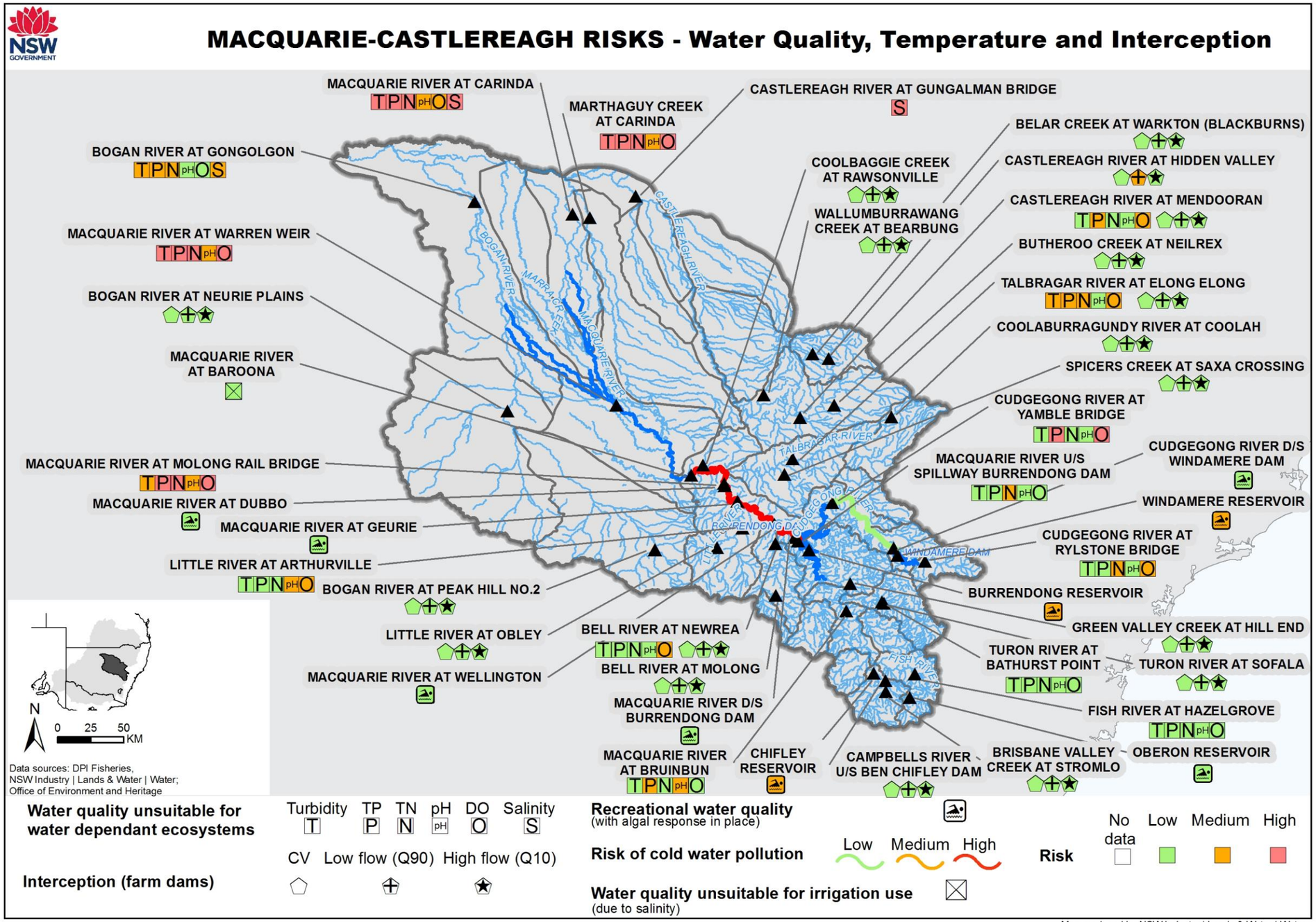


Figure 3. Consolidated risk map – water quality, temperature and interception

Consolidated risk tables

The Consolidated Risk Tables have been developed in conjunction with the MDBA and in response to stakeholder feedback on risk assessment drafts. They present a summary of risk outcomes for each risk assessed in this report and contain contextual information to meet Basin Plan accreditation requirements. They provide a line of sight for each regulated reach or unregulated water source within each WRP area between the following elements which reflect the requirements of the Basin Plan Chapter 10 Part 9 Approaches to addressing risks to water resources:

- **Risk Assessment** including risk identification and the risk calculation basis (current critical mechanisms mitigating risk at the time the risk was assessed, consequence, likelihood, risk outcome and data confidence),
- **Risk Treatment Pathway** including predefined tolerable risk level, risk treatment option, strategies to address all medium and high-risk outcomes and new critical mechanisms introduced as a result of WRP development or available to manage risk but not active when risk was assessed,
- **Tolerability Assessment** provided for each medium and high-risk result and associated explanations, and
- **Ongoing risk monitoring** provided by indicating where monitoring and evaluation is expected for the water resource plan and associated water sharing, water quality management and long-term watering plans.

The Consolidated Risk Tables should be used in conjunction with Table 8-7. Summary of strategies to address risk and the Consolidated risk maps. This table is an overview of strategy and mechanism relationships and provides line of sight between the strategies used in the Consolidated Risk Tables, associated management plan and other legislative instrument part or section references (including the Basin Plan), and the relevant water sharing plan and water quality management plan objectives. The following table describes the content of the Consolidated Risk Tables; also refer to Appendix H for an overview of the risk assessment process and further explanation of risk assessment drivers and terms.

Table 2. Consolidated risk table interpretation

General information

Each risk has a separate Consolidated table. The title contains the relevant report section, risk title and abbreviation used in tables within this report.

The Consolidated tables are divided into two sections (**Risk assessment** and **Risk treatment pathway**) to clearly show the transition from risk assessment to risk treatment, including which critical water management mechanisms were in place when the risk was assessed, prior to WRP commencement.

The configuration of columns may vary slightly depending on the risk assessed.

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach or water source within WRP area	Flow or extraction characteristics	Current critical mechanisms (mechanisms active when risk was assessed)	Consequence	Likelihood	Risk rating	Data confidence (consequence/ likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies (refer to Table 8-7 for further information)	New critical mechanisms (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	Tolerable / residual risk rating	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed (refer to Table 8-3)	Monitoring and evaluation
Risk assessment							**Risk treatment pathway**						

Location information and flow or extraction characteristic

Water sharing plan water management unit within the SDL resource unit.

For each water management unit, risk has been assessed for a variety of flow metrics or other characteristics. These flow metrics or other characteristics are also displayed in the consolidated risk maps.

Information on the calculation basis of the Risk outcome

Current critical mechanisms are included here as the risk outcomes were calculated with these water sharing plan or *WM Act* based water management controls in place. These key active mechanisms currently address the risk. Mechanisms have been included to provide further detail on the **Strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms.

Consequence and Likelihood are used to determine the risk outcome via the matrices described in the relevant section of the report. The column entry abbreviations are:

VH Very High (consequence scores only)

H High

M Medium

L Low

VL Very Low (consequence scores only)

The likelihood score also includes whether there has been an increase (+), decrease (-) or no change (^{0}) from base case (no development).

Risk rating or outcome (result) and confidence ranking

Risk outcome is a function of consequence and likelihood, the following coding is used.

For further information on data confidence refer to Appendix A

H	High
M	Medium
L	Low

Information on the application of the Risk treatment pathway

Predefined tolerable risk level or ratings apply to select regulated river locations where NSW cannot address the risk assessed. These results are automatically assigned risk treatment option A as no new strategies are required or possible. The tolerable status is indicated by paler shading of the risk outcome as described in the **Outcomes of Risk Treatment** column, and further information is provided in Table 8-3

Risk treatment option refers to options A-G listed in the Risk Treatment Pathway and summarised below; more than one may apply. See Table 8-1.

A No new strategies required or possible.
B Fill knowledge gap and evaluate effectiveness of existing strategies.
C Knowledge improvement via MER plan is proposed.
D Adjustment of WSPs or WMA based rules.
E Implementation dormant WSP or WMA rules.
F Develop and implement new BP or WSP strategies.
G Review interactions with complementary WMA processes/other legislation.

Strategies to address risk are required by the Basin Plan to be identified for all Medium and High risk outcomes. These are the broad water management and knowledge improvement approaches NSW uses to identify and address risks to water resources. A summary of strategies and their related existing and additional critical mechanisms can be found in Table 8-7.

New critical mechanisms are water sharing plan or WM Act based water management controls that have been developed, modified, substantially changed in implementation status as a result of WRP development, OR are inactive but available if required. Each mechanism has an associated risk treatment option on the Risk Treatment Pathway. Mechanisms have been included to provide further detail on the **Strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms.

Outcomes of Risk treatment

Tolerable / residual risk rating refers to:

1 Any change to the **Risk rating** after the application of **new critical mechanisms** and recalculation of (residual) risk.

2 The tolerable status of the **Risk rating**. NSW has considered whether risk ratings are acceptable on the basis the risk is adequately managed by the existing and new critical mechanisms. This is in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* The tolerable status is indicated by paler shading of the risk outcome as below. Explanations are included in the second column of this section. Low risk outcomes have N/A as they do not require a tolerable status. Refer to Table 8-3 for a summary of explanations.

H	High – Tolerable
H	High – not Tolerable
M	Medium – Tolerable
M	Medium – not Tolerable

Link to monitoring and management plans

Information regarding the ongoing monitoring, evaluation and reporting for water management plan performance including the water resource plan, water sharing plan, water quality management plan and long-term watering plan (where relevant). Refer to the MER Plan for further information.

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Cudgegong River at Rocky Waterhole	Zero Flow Periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling. E08 Planned Environmental Water (Translucent) releases from Windamere Dam. * to be repealed E13 Within operational constraints, plan bulk water transfers from Windamere Dam to Burrendong Dam to mimic natural flow events to maximise environmental benefits	H	H+*	H	H / H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Cudgegong River at Rocky Waterhole	Base-flow or Low Flows		H	H+*	H	H / H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Cudgegong River at Rocky Waterhole	Fresh Flows		H	H+*	H	H / H	H	F(i)		E08 replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	No change can be predicted	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam. The introduction of a discretionary environmental water allowance will allow for greater flexibility to address the risks at the fresh flow level however this risk is inherent to a regulated river	MER planned for WSP objectives
Cudgegong River at Rocky Waterhole	High and Infrequent Flows - Bank Full 1.5 years ARI		H	H-*	H	H / H	H	Predefined Tolerable		None required – risks are tolerable.	N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. Volumes of PEW available as translucent (or possibly discretionary) are insufficient to mitigate risk. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Cudgegong River at Rocky Waterhole	High and Infrequent Flows - 2.5 years ARI		H	H-*	H	H / H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Cudgegong River at Rocky Waterhole	High and Infrequent Flows - 5.0 years ARI		H	H-*	H	H / H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Cudgegong River at Yamble Bridge	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when	M	H+	H	H / H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

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Cudgegong River at Yamble Bridge	Base-flow or Low Flows	flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling. E08 Planned Environmental Water (Translucent) releases from Windamere Dam. * to be repealed E13 Within operational constraints, plan bulk water transfers from Windamere Dam to Burrendong Dam to mimic natural flow events to maximise environmental benefits	M	H+*	H	H / H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Cudgegong River at Yamble Bridge	Fresh Flows		M	M-*	M	H / H	M	F(i)		E08 replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	No change can be predicted	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam. The introduction of a discretionary environmental water allowance will allow for greater flexibility to address the risks at the fresh flow level however this risk is inherent to a regulated river	MER planned for WSP objectives
Cudgegong River at Yamble Bridge	High and Infrequent Flows - Bank Full 1.5 years ARI		M	M-*	M	H / H	M	Predefined Tolerable		None required – risks are tolerable	N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam. The introduction of a discretionary environmental water allowance will allow for greater flexibility to address the risks at the fresh flow level however this risk is inherent to a regulated river	MER planned for WSP objectives
Cudgegong River at Yamble Bridge	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L-*	L	H / H	N/A	N/A		None required – risk is low	N/A	Low risk, no mitigation required	No MER planned
Cudgegong River at Yamble Bridge	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L-*	L	H / H	N/A	N/A			N/A	Low risk, no mitigation required	No MER planned
Macquarie River d/s Burrendong Dam	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of	M	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows. This risk result is also driven by a very high consequence and a low likelihood. The risk is tolerable because of the low likelihood.	MER planned for WSP objectives
Macquarie River d/s Burrendong Dam	Base-flow or Low Flows		M	H+	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives

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River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Macquarie River d/s Burrendong Dam	Fresh Flows	environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes	M	H+	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River d/s Burrendong Dam	High and Infrequent Flows - Bank Full 1.5 years ARI		M	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River d/s Burrendong Dam	High and Infrequent Flows - Over Bank 2.5 years ARI		M	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River d/s Burrendong Dam	High and Infrequent Flows - Over Bank 5.0 years ARI		M	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Geurie	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie	M	L0	L	H/H	N/A	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are low.	N/A	N/A	No MER planned
Macquarie River at Geurie	Base-flow or Low Flows		M	H+	H	H/H	H	Predefined Tolerable		None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River at Geurie	Fresh Flows		M	H+	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River at Geurie	High and Infrequent Flows - Bank Full 1.5 years ARI		M	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. Volumes of PEW available as translucent (or possibly discretionary) are insufficient to mitigate risk. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives

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Macquarie River at Geurie	High and Infrequent Flows - Over Bank 2.5 years ARI	Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	M	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Geurie	High and Infrequent Flows - Over Bank 5 years ARI		M	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Dubbo	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	L0	M	H/N/A	M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows. This risk result is also driven by a very high consequence and a low likelihood. The risk is tolerable because of the low likelihood.	MER planned for WSP objectives
Macquarie River at Dubbo	Base-flow or Low Flows		VH	H+	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River at Dubbo	Fresh Flows		VH	H+	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River at Dubbo	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Dubbo	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
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SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Macquarie River at Narromine	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Macquarie River at Narromine	Base-flow or Low Flows		VH	H+*	H	H/H	H	D; F(ii)			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River at Narromine	Fresh Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River at Narromine	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Narromine	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Narromine	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	M-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Gin Gin	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren.	VH	H-	H	H/N/A	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Macquarie River at Gin Gin	Base-flow or Low Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Macquarie River at Gin Gin	Fresh Flows	E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	H+*	H	H/H	H	Predefined Tolerable	meet flow targets specified in the Macquarie LTWP.		N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River at Gin Gin	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Gin Gin	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Gin Gin	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	M-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Warren Weir	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of	VH	H+*	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Macquarie River at Warren Weir	Base-flow or Low Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River at Warren Weir	Fresh Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Macquarie River at Warren Weir	High and Infrequent Flows - Bank Full 1.5 years ARI	environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	M-*	H	H/H	H	Predefined Tolerable	regulated river water source.		N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Warren Weir	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Warren Weir	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River d/s Marebone Weir	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	M	H+*	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Macquarie River d/s Marebone Weir	Base-flow or Low Flows		M	H-*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River d/s Marebone Weir	Fresh Flows		M	H+*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River d/s Marebone Weir	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L-*	L	H/H	N/A	N/A		None required – risks are low.	N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	No MER planned
Macquarie River d/s Marebone Weir	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L-*	L	H/H	N/A	N/A			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	No MER planned
Macquarie River d/s Marebone Weir	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L	H/H	N/A	N/A			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	No MER planned

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Macquarie River at Oxley Station	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Macquarie River at Oxley Station	Base-flow or Low Flows		VH	H-	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Macquarie River at Oxley Station	Fresh Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Macquarie River at Oxley Station	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Oxley Station	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Macquarie River at Oxley Station	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Gunningbah Creek below regulator	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1	H	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Gunningbah Creek below regulator	Base-flow or Low Flows		H	H-	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives

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Gunningbah Creek below regulator	Fresh Flows	Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	H	H-	H	H/H	H	Predefined Tolerable	8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.		N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Gunningbah Creek below regulator	High and Infrequent Flows - Bank Full 1.5 years ARI		H	H-	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Gunningbah Creek below regulator	High and Infrequent Flows - Over Bank 2.5 years ARI		H	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Gunningbah Creek below regulator	High and Infrequent Flows - Over Bank 5.0 years ARI		H	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Gunningbah Creek d/s Gunningbah Weir	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water	H	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Gunningbah Creek d/s Gunningbah Weir	Base-flow or Low Flows		H	H+*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Gunningbah Creek d/s Gunningbah Weir	Fresh Flows		H	H-	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Gunningbah Creek d/s Gunningbah Weir	High and Infrequent Flows - Bank Full 1.5 years ARI		H	H-	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives

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Gunningbah Creek d/s Gunningbah Weir	High and Infrequent Flows - Over Bank 2.5 years ARI	entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	H	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Gunningbah Creek d/s Gunningbah Weir	High and Infrequent Flows - Over Bank 5.0 years ARI		H	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek at Offtake	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	L	H-	M	H/H	M	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Duck Creek at Offtake	Base-flow or Low Flows		L	H+*	M	H/H	M	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Duck Creek at Offtake	Fresh Flows		L	H-	M	H/H	M	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Duck Creek at Offtake	High and Infrequent Flows - Bank Full 1.5 years ARI		L	H-	M	H/H	M	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek at Offtake	High and Infrequent Flows - Over Bank 2.5 years ARI		L	H-	M	H / H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek at Offtake	High and Infrequent Flows - Over Bank 5.0 years ARI		L	H-	M	H / H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Crooked River at profile	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Crooked River at profile	Base-flow or Low Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Crooked River at profile	Fresh Flows		VH	H-	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Crooked River at profile	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Crooked River at profile	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Crooked River at profile	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek u/s Bogan River Junction	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1	M	H-	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Duck Creek u/s Bogan River Junction	Base-flow or Low Flows		M	H+*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM

River reach within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Predefined tolerable risk level	Risk treatment option	Strategies	New critical mechanisms	Residual risk rating	Explanation of tolerable risk application Explanation of why risk cannot be addressed	Monitoring and evaluation
Duck Creek u/s Bogan River Junction	Fresh Flows	Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	M	H-	H	H/H	H	Predefined Tolerable	8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.		N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Duck Creek u/s Bogan River Junction	High and Infrequent Flows - Bank Full 1.5 years ARI		M	H-	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek u/s Bogan River Junction	High and Infrequent Flows - Over Bank 2.5 years ARI		M	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Duck Creek u/s Bogan River Junction	High and Infrequent Flows - Over Bank 5.0 years ARI		M	H-	H	H/H	H	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Bulgeraga Creek at Pillicawarrina	Zero flow periods	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW. E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren. E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E11 - Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events. E12 CEWH and NSW OEH held environmental water	VH	H+	H	H/H	H	Predefined Tolerable	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. 3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area. 4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. 8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. 9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source.	None required – risks are tolerable.	N/A	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows.	MER planned for WSP objectives
Bulgeraga Creek at Pillicawarrina	Base-flow or Low Flows		VH	H-*	H	H/H	H	Predefined Tolerable			N/A	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows	MER planned for WSP objectives
Bulgeraga Creek at Pillicawarrina	Fresh Flows		VH	H+*	H	H/H	H	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer due to irrigation water delivery and fewer events in winter due to capture by the dam.	MER planned for WSP objectives
Bulgeraga Creek at Pillicawarrina	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	Water ordering patterns have altered the duration and timing of bank full events to unnaturally long events in summer and fewer events in winter. The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – REGULATED SYSTEM													
River reach within WRP area	**Flow or extraction characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Predefined tolerable risk level**	**Risk treatment option**	**Strategies**	**New critical mechanisms**	**Residual risk rating**	**Explanation of tolerable risk application** **Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Bulgeraga Creek at Pillicawarrina	High and Infrequent Flows - Over Bank 2.5 years ARI	entitlements in the Macquarie Cudgegong Regulated River Water Source (Regulated River (High Security), Regulated River (General Security, Supplementary Water) are discretionally used for environmental flow outcomes.	VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives
Bulgeraga Creek at Pillicawarrina	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	L-*	M	H/H	M	Predefined Tolerable			N/A	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows The ability to mitigate the likelihood is low, hence the risk is tolerable	MER planned for WSP objectives

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Backwater Boggy Cowal	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	No data available (cannot be modelled accurately)	Not Available	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	Low to medium flows cannot be modelled. Risk cannot be determined	N/A	Low to medium flows cannot be modelled. Risk cannot be determined	
Backwater Boggy Cowal	Base-flow or Low Flows		M			H/M	N/A			N/A		
Backwater Boggy Cowal	Fresh Flows		M			H/M	N/A			N/A		
Backwater Boggy Cowal	High and Infrequent Flows - Bank Full 1.5 years ARI	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	H-	H-	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Backwater Boggy Cowal	High and Infrequent Flows - Over Bank 2.5 years ARI		M	H-	H-	H/M	C			H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Backwater Boggy Cowal	High and Infrequent Flows - Over Bank 5.0 years ARI		M	M-	M-	H/M	C			M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Bell River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H+	M+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. Risk largely driven by hydrological change as ecological consequence is low. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N4 MER for N5
Bell River	Base-flow or Low Flows		L	H-*	M-*	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M		MER planned for WSP objectives MER for N4 MER for N5
Bell River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bell River	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Bell River	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bell River	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bulbodney Grahway Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L+	L+	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Bulbodney Grahway Creek	Base-flow or Low Flows		H	H-*	H-*	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Bulbodney Grahway Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bulbodney Grahway Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bulbodney Grahway Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Bulbodney Grahway Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Burrendong Dam Tributaries	Zero Flow Periods	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Burrendong Dam Tributaries	Base-flow or Low Flows		M	H-*	H-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Burrendong Dam Tributaries	Fresh Flows	No existing mechanisms targeting higher flows	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Burrendong Dam Tributaries	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Burrendong Dam Tributaries	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Burrendong Dam Tributaries	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Campbells River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Campbells River	Base-flow or Low Flows		M	H-*	H-*	H/M	B/C		N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H		MER planned for WSP objectives MER for N5
Campbells River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Campbells River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Campbells River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Campbells River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Coolbaggie Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L0	L°	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Coolbaggie Creek	Base-flow or Low Flows		H	H-	H-	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Coolbaggie Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	L-	L-	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Coolbaggie Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Coolbaggie Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Coolbaggie Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Cooyal Wialdra Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Cooyal Wialdra Creek	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Cooyal Wialdra Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Cooyal Wialdra Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Cooyal Wialdra Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Cooyal Wialdra Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Ewenmar Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	N/A	No data available (cannot be modelled accurately)	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	Low to medium flows cannot be modelled. Risk cannot be determined	N/A	Low flows cannot be modelled. Risk cannot be calculated	
Ewenmar Creek	Base-flow or Low Flows		H	N/A		H/M	C		Low to medium flows cannot be modelled. Risk cannot be determined	N/A	Low flows cannot be modelled. Risk cannot be calculated	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
		E24 Protection of Environmental Water Allowance released from Burrendong Dam.										
Ewenmar Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E24 Protection of Environmental Water Allowance released from Burrendong Dam.	H	N/A		H/M	N/A		Low to medium flows cannot be modelled. Risk cannot be determined	N/A	Low flows cannot be modelled. Risk cannot be calculated	
Ewenmar Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		H	H-	H-	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Ewenmar Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		H	H-	H-	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Ewenmar Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		H	M-	M-	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Fish River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams.	H	H-	H-	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Fish River	Base-flow or Low Flows	E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	M-	M-	H/M	B/C			M		MER planned for WSP objectives MER for N5
Fish River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	H-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5
Fish River	High and Infrequent Flows - Bank Full 1.5 years ARI		H	H-	H-	H/M	**B/C**			H		MER planned for WSP objectives MER for N5
Fish River	High and Infrequent Flows - Over Bank 2.5 years ARI		H	M-	M-	H/M	B/C			M		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Fish River	High and Infrequent Flows - Over Bank 5.0 years ARI		H	M-	M-	H/M	B/C			M		MER planned for WSP objectives MER for N5
Goolma Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	L0	L°	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Goolma Creek	Base-flow or Low Flows		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Goolma Creek	Fresh Flows		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Goolma Creek	High and Infrequent Flows - Bank Full 1.5 years ARI	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Goolma Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Goolma Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lawsons Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Lawsons Creek	Base-flow or Low Flows		L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Lawsons Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lawsons Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Lawsons Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lawsons Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Little River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	M+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Little River	Base-flow or Low Flows		H	H-*	H-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Little River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Little River	High and Infrequent Flows - Bank Full 1.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Little River	High and Infrequent Flows - Over Bank 2.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Little River	High and Infrequent Flows - Over Bank 5.0 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lower Bogan River*	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E24 Protection of Environmental Water Allowance released from Burrendong Dam.	H	H-	H-	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Lower Bogan River*	Base-flow or Low Flows		H	H+*	H+*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Bogan River*	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	M-	M-	H/M	B/C			M		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Lower Bogan River*	High and Infrequent Flows - Bank Full 1.5 years ARI	E24 Protection of Environmental Water Allowance released from Burrendong Dam.	H	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Lower Bogan River*	High and Infrequent Flows - Over Bank 2.5 years ARI		H	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Bogan River*	High and Infrequent Flows - Over Bank 5.0 years ARI		H	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Lower Macquarie River*	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	VH	H-	H-	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Lower Macquarie River*	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E24 Protection of Environmental Water Allowance released from Burrendong Dam.	VH	M-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Macquarie River*	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E24 Protection of Environmental Water Allowance released from Burrendong Dam.	VH	M-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Macquarie River*	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	H-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Macquarie River*	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	M-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Macquarie River*	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	M-	H-	H/M	B/C			H		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Lower Talbragar River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Lower Talbragar River	Base-flow or Low Flows		M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Lower Talbragar River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lower Talbragar River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lower Talbragar River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Lower Talbragar River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Macquarie River above Burrendong	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Macquarie River above Burrendong	Base-flow or Low Flows		M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Macquarie River above Burrendong	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Macquarie River above Burrendong	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L-*	L	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Macquarie River above Burrendong	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L-*	L	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Macquarie River above Burrendong	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L-*	L	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Marra Creek*	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E24 Protection of Environmental Water Allowance released from Burrendong Dam.	M	L+*	L	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Marra Creek*	Base-flow or Low Flows		M	H+*	H	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Marra Creek*	Fresh Flows		M	H+*	H	H/M	B/C			H		MER planned for WSP objectives MER for N5
Marra Creek*	High and Infrequent Flows - Bank Full 1.5 years ARI		M	H-*	H	H/M	B/C			H		MER planned for WSP objectives MER for N5
Marra Creek*	High and Infrequent Flows - Over Bank 2.5 years ARI		M	H-*	H	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H		MER planned for WSP objectives MER for N5
Marra Creek*	High and Infrequent Flows - Over Bank 5.0 years ARI		M	M-*	M	H/M	B/C			M		MER planned for WSP objectives MER for N5
Marthaguy Creek*	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E24 Protection of Environmental Water Allowance released from Burrendong Dam.	H	M+*	M+*	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Marthaguy Creek*	Base-flow or Low Flows		H	H+*	H+*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Marthaguy Creek*	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	H+*	H+*	H/M	B/C			H		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Marthaguy Creek*	High and Infrequent Flows - Bank Full 1.5 years ARI	E24 Protection of Environmental Water Allowance released from Burrendong Dam.	H	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Marthaguy Creek*	High and Infrequent Flows - Over Bank 2.5 years ARI		H	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Marthaguy Creek*	High and Infrequent Flows - Over Bank 5.0 years ARI		H	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Maryvale Geurie Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	L+	L+	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Maryvale Geurie Creek	Base-flow or Low Flows		L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Maryvale Geurie Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Maryvale Geurie Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Maryvale Geurie Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Maryvale Geurie Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Molong Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Molong Creek	Base-flow or Low Flows		L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4

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Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Molong Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	M-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Molong Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Molong Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Molong Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Piambong Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	H+	M+	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Piambong Creek	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H-*	M-*	H/M	N/A		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Piambong Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Piambong Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Piambong Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Piambong Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Pipeclay Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams.	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Pipeclay Creek	Base-flow or Low Flows	E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable -Recommend monitoring of WAL activation (likelihood is low as assets / values are above WAL locations)	MER planned for WSP objectives MER for N4
Pipeclay Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Pipeclay Creek	High and Infrequent Flows - Bank Full 1.5 years ARI	entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Pipeclay Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Pipeclay Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Queen Charlottes Vale Evans Plains	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Queen Charlottes Vale Evans Plains	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Queen Charlottes Vale Evans Plains	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Queen Charlottes Vale Evans Plains	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Queen Charlottes Vale Evans Plains	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Queen Charlottes Vale Evans Plains	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Summerhill Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Summerhill Creek	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Not Tolerable - Recommend strategy review during WRP development (active gauge is not available)	MER planned for WSP objectives MER for N4
Summerhill Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	M-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Summerhill Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Summerhill Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Summerhill Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Turon Crudine River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams.	M	H+	H+	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Turon Crudine River	Base-flow or Low Flows	E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M-*	M-*	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M		MER planned for WSP objectives MER for N5
Turon Crudine River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Turon Crudine River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Turon Crudine River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Turon Crudine River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Upper Bogan River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Upper Bogan River	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Upper Bogan River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Upper Bogan River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Upper Bogan River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Upper Bogan River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Upper Cudgegong River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Upper Cudgegong River	Base-flow or Low Flows		M	H-*	H-*	H/M	B/C			H		MER planned for WSP objectives MER for N5
Upper Cudgegong River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	M-*	M-*	H/M	B/C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M		MER planned for WSP objectives MER for N5
Upper Cudgegong River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Upper Cudgegong River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5
Upper Cudgegong River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	M-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Upper Talbragar River	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Upper Talbragar River	Base-flow or Low Flows		M	M-*	M-*	H/M	B/C			M	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Upper Talbragar River	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Upper Talbragar River	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Upper Talbragar River	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Upper Talbragar River	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Wambangalong Whylandra Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L_	L	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Wambangalong Whylandra Creek	Base-flow or Low Flows		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Wambangalong Whylandra Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Wambangalong Whylandra Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Wambangalong Whylandra Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Wambangalong Whylandra Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		H	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Winburndale Rivulet	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H+	H+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Winburndale Rivulet	Base-flow or Low Flows		M	H-*	H-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	H	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Winburndale Rivulet	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Winburndale Rivulet	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Winburndale Rivulet	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Winburndale Rivulet	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Binnaway to Gilgandra	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E35 while there is no visible flow at the location at which water is proposed to be taken, water must not be taken for any 24-hour period starting at 18:00 on an even-numbered calendar day under an access licence that nominates a water supply work (spearpoint) within the alluvial sand beds	L	H+	M+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. Risk largely driven by hydrological change as ecological consequence is low. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N4 MER for N5
Castlereagh River Binnaway to Gilgandra	Base-flow or Low Flows		L	H-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N4 MER for N5
Castlereagh River Binnaway to Gilgandra	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Castlereagh River Binnaway to Gilgandra	High and Infrequent Flows - Bank Full 1.5 years ARI	entitlement growth	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Binnaway to Gilgandra	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Binnaway to Gilgandra	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River above Binnaway	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	VH	L0	M°	H/M	B/C/D	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend monitoring of WAL activation (likelihood is low but water source contains very high value assets and/or values)	MER planned for WSP objectives MER for N4
Castlereagh River above Binnaway	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	M-	H-	H/M	B/C/D		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	H	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N5
Castlereagh River above Binnaway	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	VH	L-	M-	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend monitoring of WAL activation (likelihood is low but water source contains very high value assets and/or values)	MER planned for WSP objectives MER for N4
Castlereagh River above Binnaway	High and Infrequent Flows - Bank Full 1.5 years ARI		VH	L0	M°	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend monitoring of WAL activation (likelihood is low but water source contains very high value assets and/or values)	MER planned for WSP objectives MER for N4
Castlereagh River above Binnaway	High and Infrequent Flows - Over Bank 2.5 years ARI		VH	L0	M°	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend monitoring of WAL activation (likelihood is low but water source contains very high value assets and/or values)	MER planned for WSP objectives MER for N4
Castlereagh River above Binnaway	High and Infrequent Flows - Over Bank 5.0 years ARI		VH	L0	M°	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend monitoring of WAL activation (likelihood is low but water source contains very high value assets and/or values)	MER planned for WSP objectives MER for N4
Castlereagh River below Coonamble	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth E15 Cease / commence to pump rules for streams.	L	H+	M+	H/M	B/C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies N5 - Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies	M	Decision tool indicates risk is not tolerable as there is high potential for extraction to impact ecological values and a river gauge is available. Frequent likelihood monitoring is recommended. Risk largely driven by hydrological change as ecological consequence is low. These risk results cannot be addressed during WRP development as NSW planning principles minimise change for WSPs within their initial ten year period to provide certainty for water users.	MER planned for WSP objectives MER for N4 MER for N5
Castlereagh River below Coonamble	Base-flow or Low Flows	E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H-*	M-*	H/M	B/C			M		MER planned for WSP objectives MER for N4 MER for N5

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM

Water source within WRP area	Flow or extraction characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Castlereagh River below Coonamble	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River below Coonamble	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River below Coonamble	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River below Coonamble	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Gilgandra to Coonamble	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	H+	M+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Tolerable - Recommend frequent monitoring of WAL activation (impact is likely to occur with growth in use)	MER planned for WSP objectives MER for N4
Castlereagh River Gilgandra to Coonamble	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams. E35 while there is no visible flow at the location at which water is proposed to be taken, water must not be taken for any 24-hour period starting at 18:00 on an even-numbered calendar day under an access licence that nominates a water supply work (spearpoint) within the alluvial sand beds	L	H-*	M-*	H/M	C		N4 – Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies	M	Not Tolerable - Recommend strategy review during WRP development (active gauge is not available)	MER planned for WSP objectives MER for N4
Castlereagh River Gilgandra to Coonamble	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Gilgandra to Coonamble	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Gilgandra to Coonamble	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Castlereagh River Gilgandra to Coonamble	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L-*	L-*	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Nedgera Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L0	L°	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and	None required – risks are low	N/A	None required – risks are low	
Nedgera Creek	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM												
Water source within WRP area	**Flow or extraction characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
		pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.						floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.				
Nedgera Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Nedgera Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Nedgera Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Nedgera Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L+	L+	H/M	C		None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L0	L°	H/M	N/A	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated sections of the WRP area.	None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	High and Infrequent Flows - Bank Full 1.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	High and Infrequent Flows - Over Bank 2.5 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Teridgerie Creek	High and Infrequent Flows - Over Bank 5.0 years ARI		M	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Tooraweenah to Coonamble Tributaries	Zero Flow Periods	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L+	L+	H/M	C	1 Limit consumptive water extractions in the WRP area to the predefined share of available water. 5 Protect low flow habitats from accelerated rates of drying. 6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. 18 Improve knowledge to assess risk in unregulated	None required – risks are low	N/A	None required – risks are low	
Tooraweenah to Coonamble Tributaries	Base-flow or Low Flows	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E18 Restrict construction of in-river dams on 3rd order or	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.3. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT and CAPACITY TO MEET EWRS [E(W)] – UNREGULATED SYSTEM												
Water source within WRP area	**Flow or extraction characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
		higher streams.						sections of the WRP area.				
Tooraweenah to Coonamble Tributaries	Fresh Flows	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth	L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Tooraweenah to Coonamble Tributaries	High and Infrequent Flows - Bank Full 1.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Tooraweenah to Coonamble Tributaries	High and Infrequent Flows - Over Bank 2.5 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	
Tooraweenah to Coonamble Tributaries	High and Infrequent Flows - Over Bank 5.0 years ARI		L	L0	L°	H/M	N/A		None required – risks are low	N/A	None required – risks are low	

SECTION 4.4. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM EXTRACTION UNDER BLR [E(BLR] – UNREGULATED WATER SOURCES ONLY											
Water source within WRP area	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategy**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation (required if risk is above tolerable level)**	**Monitoring and evaluation**
Backwater Boggy Cowal*	BLR (D&S) extraction	M	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Bell River	BLR (D&S) extraction	L	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Bulbodney Grahway Creek	BLR (D&S) extraction	H	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Burrendong Dam Tributaries	BLR (D&S) extraction	M	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Campbells River	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	See below.	MER planned for WSP objectives
Coolbaggie Creek	BLR (D&S) extraction	H	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Cooyal Wialdra Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Ewenmar Creek*	BLR (D&S) extraction	H	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Fish River	BLR (D&S) extraction	H	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Goolma Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Lawsons Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Little River	BLR (D&S) extraction	H	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Lower Bogan River*	BLR (D&S) extraction	H	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Lower Macquarie River*	BLR (D&S) extraction	VH	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Lower Talbragar River	BLR (D&S) extraction	M	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Macquarie River above Burrendong	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Marra Creek*	BLR (D&S) extraction	M	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Marthaguy Creek	BLR (D&S) extraction	H	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Maryvale Geurie Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives

SECTION 4.4. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM EXTRACTION UNDER BLR [E(BLR] – UNREGULATED WATER SOURCES ONLY											
Water source within WRP area	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategy**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation (required if risk is above tolerable level)**	**Monitoring and evaluation**
Molong Creek	BLR (D&S) extraction	L	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Piambong Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Pipeclay Creek	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Queen Charlottes Vale Evans Plains	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Summerhill Creek	BLR (D&S) extraction	L	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Turon Crudine River	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Upper Bogan River	BLR (D&S) extraction	M	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Upper Cudgegong River	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Upper Talbragar River	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Wambangalang Whylandra Creek	BLR (D&S) extraction	H	H	H	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Winburndale Rivulet	BLR (D&S) extraction	M	L	L	H/M	N/A	None required. Risk is low.		N/A	N/A	
Castlereagh River Binnaway to Gilgandra	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Castlereagh River above Binnaway	BLR (D&S) extraction	VH	L	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives
Castlereagh River below Coonamble*	BLR (D&S) extraction	L	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Castlereagh River Gilgandra to Coonamble	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	H	See below.	MER planned for WSP objectives
Nedgera Creek*	BLR (D&S) extraction	L	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Teridgerie Creek*	BLR (D&S) extraction	M	N/A	N/A	H/M	N/A	No data available.		N/A	N/A	
Tooraweenah to Coonamble Tributaries	BLR (D&S) extraction	L	H	M	H/M	F	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	See below.	MER planned for WSP objectives

SECTION 4.4. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM EXTRACTION UNDER BLR [E(BLR] – UNREGULATED WATER SOURCES ONLY											
Water source within WRP area	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategy**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation (required if risk is above tolerable level)**	**Monitoring and evaluation**
Current Critical Mechanisms: E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E2 Available Water Determinations (AWD) adjust extractive use according to water availability. E34 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA*											
Explanation of Tolerable Risk Application: Domestic and stock rights are established and controlled under the WM Act. Take from surface waters for this purpose does not require either a water access licence or a work approval. Generally domestic and stock rights estimations are a small component of the consumptive demand on a water source. WSPs recognise and prioritise these rights in the management of long term extraction limits by including estimations in calculations and reducing licensed water use if corrective action is required. Risk to the environment from growth in domestic and stock rights is generally tolerable because it is managed within long term extraction limits and the SDL. In some circumstances, where demand is stronger or when water shortages occur, domestic and stock rights can be restricted by the Minister either temporarily, or through the establishment of a mandatory guideline. Domestic and stock rights may also be limited by the Minister where high hydrologic stress on a water source may result from increased demand due to property subdivision. Risk to other users and the environment from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required. N/A no data available or not applicable											

SECTION 4.5. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM INTERCEPTION ACTIVITIES [E(I-FD)]												
Risk	**Water source type**	**Location, reach or extraction type within WRP area**	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Risk to water available for the environment from farm dam interception E(I-FD)	Regulated	Macquarie Marshes		Negligible	Possible	L	L/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Regulated	Wilgara Wetlands		Negligible	Possible	L	L/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Belar Creek @ Warkton (Blackburns)	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Belar Creek @ Warkton (Blackburns)	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Belar Creek @ Warkton (Blackburns)	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Mendooran	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Mendooran	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Mendooran	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Wallumburrawang Creek @ Bearbung	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Wallumburrawang Creek @ Bearbung	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Wallumburrawang Creek @ Bearbung	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Butheroo Creek @ Neilrex	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Butheroo Creek @ Neilrex	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Butheroo Creek @ Neilrex	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	

SECTION 4.5. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM INTERCEPTION ACTIVITIES [E(I-FD)]												
Risk	**Water source type**	**Location, reach or extraction type within WRP area**	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Hidden Valley	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Hidden Valley	Low Flow Index Q90	M	M	M	H/M	A	16 Protect the environment from changes in flow attributable to growth in BLR extractive use.	N1 Sustainable diversion limits	M	None required Risk is tolerable The taking of water from farm dams is regulated by the Harvestable Rights Policy. Any take above that allowed under the policy must be licensed.	MER planned for WSP objectives
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Castlereagh River @ Hidden Valley	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Newrea	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Newrea	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Newrea	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Turon River @ Sofala	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Turon River @ Sofala	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Turon River @ Sofala	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Neurie Plains	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Neurie Plains	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Neurie Plains	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception	Unregulated	Talbragar River @ Elong	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	

SECTION 4.5. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM INTERCEPTION ACTIVITIES [E(I-FD)]												
Risk	**Water source type**	**Location, reach or extraction type within WRP area**	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
E(I-FD)													
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Talbragar River @ Elong Elong	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Talbragar River @ Elong Elong	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Little River @ Obley No.2	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Little River @ Obley No.2	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Little River @ Obley No.2	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Molong	Variation Annual Index CV	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Molong	Low Flow Index Q90	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bell River @ Molong	High Flow Index Q10	M	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Coolbaggie Creek @ Rawsonville	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Coolbaggie Creek @ Rawsonville	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Coolbaggie Creek @ Rawsonville	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Coolaburragundy River @ Coolah	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Coolaburragundy River @ Coolah	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception	Unregulated	Coolaburragundy River @ Coolah	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	

SECTION 4.5. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM INTERCEPTION ACTIVITIES [E(I-FD)]												
Risk	**Water source type**	**Location, reach or extraction type within WRP area**	**Flow or extraction characteristic**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
E(I-FD)													
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Green Valley Creek @ Hill End	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Green Valley Creek @ Hill End	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Green Valley Creek @ Hill End	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Spicers Creek @ Saxa Crossing	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Spicers Creek @ Saxa Crossing	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Spicers Creek @ Saxa Crossing	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Peak Hill No.2	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Peak Hill No.2	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Bogan River @ Peak Hill No.2	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Campbells River u/s Ben Chifley Dam	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Campbells River u/s Ben Chifley Dam	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Campbells River u/s Ben Chifley Dam	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Brisbane Valley Creek @ Stromlo	Variation Annual Index CV	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from farm dam interception	Unregulated	Brisbane Valley Creek @ Stromlo	Low Flow Index Q90	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	

SECTION 4.5. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT FROM INTERCEPTION ACTIVITIES [E(I-FD)]

Risk	Water source type	Location, reach or extraction type within WRP area	Flow or extraction characteristic	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
E(I-FD)													
Risk to water available for the environment from farm dam interception E(I-FD)	Unregulated	Brisbane Valley Creek @ Stromlo	High Flow Index Q10	L	L	L	H/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from interception due to plantation forestry (regulated river only) E(I-PF)	Regulated	Macquarie Marshes		Negligible	Probable	L	L/M	N/A	None required. Risk is low		N/A	N/A	
Risk to water available for the environment from interception due to plantation forestry (regulated river only) E(I-PF)	Regulated	Wilgara Wetlands		Negligible	Probable	L	L/M	N/A	None required. Risk is low		N/A	N/A	

Current Critical Mechanisms - E(I-FD)
E21 Require farm dams with a capacity above the maximum harvestable right dam capacity (MHRDC) to be licensed and comply with extraction limits as described in Strategy 1 (E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs) & E2 Available Water Determinations (AWD) adjust extractive use according to water availability)

Strategy: None required. Risks are low. Refer to MER.
N/A no data available or not applicable

Explanation of Tolerable Risk Application:
Domestic and stock rights are established and controlled under the WM Act. Take from surface waters for this purpose does not require either a water access licence or a work approval provided farm dam capacity is within the maximum harvestable right capacity. WSPs recognise and prioritise these rights in the management of long term extraction limits by including estimations in calculations and reducing licensed water use if corrective action is required. Risk to the environment from growth in domestic and stock rights is generally tolerable because it is managed within long term extraction limits and the SDL.
In some circumstances, where demand is stronger or when water shortages occur, domestic and stock rights can be restricted by the Minister either temporarily, or through the establishment of a mandatory guideline. Domestic and stock rights may also be limited by the Minister where high hydrologic stress on a water source may result from increased demand due to property subdivision. Risk to other users and the environment from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.
N/A no data available or not applicable

SECTION 4.6. RISKS TO WATER AVAILABLE FOR THE ENVIRONMENT DUE TO CLIMATE CHANGE [E(CC)]

Risk	Location, reach or extraction type within WRP area	Climate change scenario (MDBSY)	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategy	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Risk to water available for the environment due to climate change E(CC)	Macquarie Marshes	Wet climate change scenario	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E02 Available Water Determinations (AWD) adjust extractive use according to water availability.	Severe	Probable	H	L/M	F	15 Protect the environment and water users from changes in flow attributable to climate change.	N1 Sustainable Diversion Limits	H	An individual licence holder's annual access to water is governed by their entitlement and climatic availability. The volume of water available to meet all competing environmental and extractive needs varies on a yearly and daily basis, depending on the weather, river flows and aquifer characteristics.	
Risk to water available for the environment due to climate change E(CC)	Macquarie Marshes	Median climate change scenario		Severe	Possible	H	L/M	F			H		
Risk to water available for the environment due to climate change E(CC)	Macquarie Marshes	Dry climate change scenario		Severe	Unlikely	M	L/M	F			M		
Risk to water available for the environment due to climate change E(CC)	Wilgara Wetlands	Wet climate change scenario	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E02 Available Water Determinations (AWD) adjust extractive use according to water availability.	Severe	Probable	H	L/M	F	None required. Risk is low. 15 Protect the environment and water users from changes in flow attributable to climate change.	N1 Sustainable Diversion Limits	H	An individual licence holder's annual access to water is governed by their entitlement and climatic availability. The volume of water available to meet all competing environmental and extractive needs varies on a yearly and daily basis, depending on the weather, river flows and aquifer characteristics.	
Risk to water available for the environment due to climate change E(CC)	Wilgara Wetlands	Median climate change scenario		Severe	Possible	H	L/M	F			H		
Risk to water available for the environment due to climate change E(CC)	Wilgara Wetlands	Dry climate change scenario		Severe	Unlikely	M	L/M	F			M		

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	42110171 Fish River at Hazelgrove	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110171 Fish River at Hazelgrove	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110171 Fish River at Hazelgrove	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110171 Fish River at Hazelgrove	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	42110171 Fish River at Hazelgrove	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110170 Turon River at Bathurst Point	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110170 Turon River at Bathurst Point	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110170 Turon River at Bathurst Point	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	42110170 Turon River at Bathurst Point	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	42110170 Turon River at Bathurst Point	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421025 Macquarie River at Bruinbun	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421025 Macquarie River at Bruinbun	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421025 Macquarie River at Bruinbun	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421025 Macquarie River at Bruinbun	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421025 Macquarie River at Bruinbun	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421038 Cudgegong River at Rylstone Bridge	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421038 Cudgegong River at Rylstone Bridge	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421038 Cudgegong River at Rylstone Bridge	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421038 Cudgegong River at Rylstone Bridge	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421038 Cudgegong River at Rylstone Bridge	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421018 Bell River at Neurea	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421018 Bell River at Neurea	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421018 Bell River at Neurea	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421018 Bell River at Neurea	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421018 Bell River at Neurea	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421176 Little River at Arthurville No. 2	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421176 Little River at Arthurville No. 2	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421176 Little River at Arthurville No. 2	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	L	L	M/H	N/A	None required. Risk is low		.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421176 Little River at Arthurville No. 2	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421176 Little River at Arthurville No. 2	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	H	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421042 Talbragar River at Elong Elong	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421042 Talbragar River at Elong Elong	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421042 Talbragar River at Elong Elong	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421042 Talbragar River at Elong Elong	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421042 Talbragar River at Elong Elong	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421011 Marthaguy Creek at Carinda*	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421011 Marthaguy Creek at Carinda*	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421011 Marthaguy Creek at Carinda*	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421011 Marthaguy Creek at Carinda*	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421011 Marthaguy Creek at Carinda*	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421012 Macquarie River at Carinda (Bells Bridge)	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421012 Macquarie River at Carinda (Bells Bridge)	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421012 Macquarie River at Carinda (Bells Bridge)	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421012 Macquarie River at Carinda (Bells Bridge)	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421012 Macquarie River at Carinda (Bells Bridge)	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421023 Bogan River at Gongolgon	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421023 Bogan River at Gongolgon	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Unregulated	421023 Bogan River at Gongolgon	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	421023 Bogan River at Gongolgon	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	421023 Bogan River at Gongolgon	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	420004 Castlereagh River at Mendooran	Turbidity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	420004 Castlereagh River at Mendooran	Total Phosphorus	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Unregulated	420004 Castlereagh River at Mendooran	Total Nitrogen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	420004 Castlereagh River at Mendooran	pH	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Unregulated	420004 Castlereagh River at Mendooran	Dissolved Oxygen	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	421019 Cudgegong River at Yamble Bridge	Turbidity	E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling E08 Planned Environmental Water (Translucent) releases from Windamere Dam. E14 Rates of change to storage release protocol. E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	H	L	L	M/H	N/A	Note: E08 to be replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	.			MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Regulated	421019 Cudgegong River at Yamble Bridge	Total Phosphorus	E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling E08 Planned Environmental Water (Translucent) releases from Windamere Dam. E14 Rates of change to storage release protocol. E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	H	H	H	M/H	F	Note: E08 to be replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	421019 Cudgegong River at Yamble Bridge	Total Nitrogen	E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling E08 Planned Environmental Water (Translucent) releases from Windamere Dam. E14 Rates of change to storage release protocol. E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	H	L	L	M/H	N/A	Note: E08 to be replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system				MER planned for WSP objectives
E(WQ)	Regulated	421019 Cudgegong River at Yamble Bridge	pH	E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling E08 Planned Environmental Water (Translucent) releases from Windamere Dam. E14 Rates of change to storage release protocol. E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	H	L	L	M/H	N/A	Note: E08 to be replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system				MER planned for WSP objectives
E(WQ)	Regulated	421019 Cudgegong River at Yamble Bridge	Dissolved Oxygen	E06 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren and Burrendong Dam is spilling E08 Planned Environmental Water (Translucent) releases from Windamere Dam. E14 Rates of change to storage release protocol. E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	H	H	H	M/H	F	Refer to WQM Plan Note: E08 to be replaced by: N3 Environmental Water Allowance from Windamere Dam for Cudgegong system		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Regulated	421077 Macquarie River at u/s Spillway Burrendong Dam	Turbidity	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	L	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Regulated	421077 Macquarie River at u/s Spillway Burrendong Dam	Total Phosphorus	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	L	M	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Regulated	421077 Macquarie River at u/s Spillway Burrendong Dam	Total Nitrogen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	L	H	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.	MER planned for WSP objectives	WRP 1, 2, 4, 5 WQ 1, 2, 4, 5

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]

Risk code	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	New strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Regulated	421077 Macquarie River at u/s Spillway Burrendong Dam	pH	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	L	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Regulated	421077 Macquarie River at u/s Spillway Burrendong Dam	Dissolved Oxygen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	L	L	L	M/H	N/A	None required. Risk is low				MER planned for WSP objectives
E(WQ)	Regulated	42110101 Macquarie River at Molong Rail Bridge	Turbidity	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.	MER planned for WSP objectives	WRP 1, 2, 4, 5 WQ 1, 2, 4, 5

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Regulated	42110101 Macquarie River at Molong Rail Bridge	Total Phosphorus	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	42110101 Macquarie River at Molong Rail Bridge	Total Nitrogen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	42110101 Macquarie River at Molong Rail Bridge	pH	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	42110101 Macquarie River at Molong Rail Bridge	Dissolved Oxygen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
				Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures										
E(WQ)	Regulated	421004 Macquarie River at Warren Weir	Turbidity	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	421004 Macquarie River at Warren Weir	Total Phosphorus	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	421004 Macquarie River at Warren Weir	Total Nitrogen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	M	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
E(WQ)	Regulated	421004 Macquarie River at Warren Weir	pH	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	L	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ)	Regulated	421004 Macquarie River at Warren Weir	Dissolved Oxygen	E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Rivers Water Source 2016. Announced events only when flow exceeds 5000ML/day above other listed requirements at Warren E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. E14 Rates of change to storage release protocol. E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ-S)	Unregulated	421023 Bogan River at Gongolgon	Salinity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	M	M	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ-S)	Unregulated	421012 Macquarie River at Carinda	Salinity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or	VH	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives

SECTIONS 5.3, 5.4, 5.5. RISKS TO THE HEALTH OF WATER-DEPENDENT ECOSYSTEMS FROM POOR WATER QUALITY [E(WQ), E(WQ-S), (E(WQ-CWP)]														
Risk code	**Water source type**	**Location, reach or extraction type within WRP area**	**Water quality characteristic**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**New strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
										The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				**WQ 1, 2, 3, 4, 5, 6, 7**
				higher streams.										
E(WQ-S)	Unregulated	420020 Castlereagh River at Gungalman Bridge	Salinity	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E18 Restrict construction of in-river dams on 3rd order or higher streams.	M	H	H	M/H	F	Refer to WQM Plan		Refer to WQM Plan.		MER planned for WSP objectives
E(WQ-CWP)	Regulated	Windamere Dam	Temperature	E20 Manage water releases from the multi-level offtake at Windamere Dam so that water releases are more closely matched to natural river ambient temperatures	M	L	L	M/H	N/A	Low risk, new strategy not required				MER planned for WSP objectives
E(WQ-CWP)	Regulated	Burrendong Dam (400km)	Temperature	E21 Manage water releases through the thermal curtain at Burrendong Dam so that water releases are more closely matched to natural river ambient temperatures	VH	H	H	M/H	F	Reinstall and maintain thermal curtain		Refer to WQM Plan.	Risk rating does not take into account the successful operation of the thermal curtain and is likely to drop to Low if thermal curtain proves reliable	MER planned for WSP objectives

SECTION 6.4. RISKS TO OTHER WATER USERS DUE TO UNSUITABLE WATER QUALITY [O(WQ-BGA)]

Risk code	Risk	Water source type	Location, reach or extraction type within WRP area	Water quality characteristic	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategies	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
											The primary strategy for addressing risks associated with water quality is the implementation of the Water Quality Management Plan for Macquarie-Castlereagh WRPA. Additional actions and mechanisms relevant to the WRP are listed below				WQ 1, 2, 3, 4, 5, 6, 7
O(WQ-BGA)	Risks to recreational water quality	Reservoir	Oberon Reservoir	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Reservoir	Chifley Reservoir	Recreational Water Quality (BGA)	Refer to WQM Plan	L	H	M	H/M	F	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Reservoir	Windamere Reservoir	Recreational Water Quality (BGA)	Refer to WQM Plan	L	H	M	H/M	F	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Cudgegong River. d/s of Windamere Dam	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Burrendong Reservoir	Recreational Water Quality (BGA)	Refer to WQM Plan	L	H	M	H/M	F	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Macquarie River d/s of Burrendong Dam	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Macquarie River@Geurie	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Macquarie River@Wellington	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		
O(WQ-BGA)	Risks to recreational water quality	Regulated	Macquarie River@Dubbo	Recreational Water Quality (BGA)	Refer to WQM Plan	L	L	L	H/M	N/A	Refer to WQM Plan		Refer to WQM Plan.		

SECTION 7.2. RISKS TO WATER AVAILABLE FOR OTHER USES DUE TO INTERCEPTION ACTIVITY [O(I-FD)]												
Risk	**Water source type**	**Location, reach or extraction type within WRP area**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategies**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Risk to water available for other uses due to farm dam interception (regulated rivers) O(I-FD)	Regulated	High Security	Negligible	Possible	L	M/H	N/A	None required. Risk is low.		N/A	N/A	
Risk to water available for other uses due to farm dam interception (regulated rivers) O(I-FD)	Regulated	General Security Water	Minor	Possible	L	M/H	N/A	None required. Risk is low.		N/A	N/A	
Risk to water available for other uses due to farm dam interception (regulated rivers) O(I-FD)	Regulated	Supplementary Water	Negligible	Possible	L	M/H	N/A	None required. Risk is low.		N/A	N/A	
Current critical mechanisms – O(I-FD) E21 Require farm dams with a capacity above the maximum harvestable right dam capacity (MHRDC) to be licensed and comply with extraction limits as described in Strategy 1 (E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs) & E2 Available Water Determinations (AWD) adjust extractive use according to water availability) N/A no data available or not applicable												

SECTION 7.3. RISKS TO WATER AVAILABLE FOR OTHER USES DUE TO CLIMATE CHANGE [O(CC)]

Risk	Location, reach or extraction type within WRP area	Climate change scenario (MDBSY)	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategy	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Risk to water available for other uses due to climate change O(CC)	High Security	Wet climate change scenario	E02 Available Water Determinations (AWD) adjust extractive use according to water availability.	Negligible	Unlikely	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	General Security Water	Wet climate change scenario		Negligible	Unlikely	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	Supplementary Water	Wet climate change scenario		Negligible	Unlikely	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	High Security	Median climate change scenario		Negligible	Possible	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	General Security Water	Median climate change scenario		Minor	Possible	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	Supplementary Water	Median climate change scenario		Minor	Possible	L	M/M	N/A	None required. Risk is low.		N/A		
Risk to water available for other uses due to climate change O(CC)	High Security	Dry climate change scenario		Negligible	Likely	M	M/M	N/A	15 Protect the environment and water users from changes in flow attributable to climate change.	N1 Sustainable diversion limits	N/A		
Risk to water available for other uses due to climate change O(CC)	General Security Water	Dry climate change scenario		Major	Likely	H	M/M	N/A	15 Protect the environment and water users from changes in flow attributable to climate change.	N1 Sustainable diversion limits	N/A		
Risk to water available for other uses due to climate change O(CC)	Supplementary Water	Dry climate change scenario		Major	Likely	H	M/M	N/A	15 Protect the environment and water users from changes in flow attributable to climate change.	N1 Sustainable diversion limits	N/A		

SECTION 7.4. RISKS TO WATER AVAILABLE FOR OTHER USES DUE TO GROWTH IN BLR [O(BLR)]

Water source type	Location, reach or extraction type within WRP area	Current critical mechanisms	Consequence	Likelihood	Risk rating	Data confidence (consequence / likelihood)	Risk treatment option	Strategy	New critical mechanisms	Tolerable risk level	Explanation of tolerable risk application OR Explanation of why risk cannot be addressed	Monitoring and evaluation
Unregulated	Backwater - Boggy Cowal	E26 Restrict BLR access through the establishment of mandatory guidelines under the WMA s. 52(2) and S. 336B E31 Temporarily restrict access under the WMA s. 324 when there are water shortages.	L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Bell River		M	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Bulbodney - Grahway Creek		M	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Burrendong Dam Storage tributaries		L	M	L	N/A	N/A	No data available to assess.		N/A		
Unregulated	Campbell's River		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Coolbaggie Creek system		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Cooyal Wialdra Creek		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Ewenmar Creek		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Fish River		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Goolma Creek		L	L	L	N/A	N/A	No data available to assess.		N/A		
Unregulated	Lawsons Creek	E26 Restrict BLR access through the establishment of mandatory guidelines under the WMA s. 52(2) and S. 336B E31 Temporarily restrict access under the WMA s. 324 when there are water shortages.	L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Little River		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Lower Bogan River		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Lower Talbragar		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Macquarie above Burrendong		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Marra Creek		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Marthaguy Creek		L	L	L	M/M	N/A	None required. Risk is low.		N/A		

SECTION 7.4. RISKS TO WATER AVAILABLE FOR OTHER USES DUE TO GROWTH IN BLR [O(BLR)]												
Water source type	**Location, reach or extraction type within WRP area**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategy**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Unregulated	Maryvale-Geurie		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Molong Creek and tributaries		M	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Piambong Creek		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Pipeclay Creek		L	L	L	M/M	N/A	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Queen Charlottes Vale Creek/Evans Plains Creek		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Summerhill Creek		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Turon/Crudine River		L	M	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Unregulated Lower Macquarie		H	L	M	M/M	D	17 Protect the other water users from changes in flow attributable to growth in BLR extractive use.	N4 Limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer.	M	Risk to other users from growth in domestic and stock rights in these circumstances is tolerable because there are mechanisms available to manage demand if required.	
Unregulated	Upper Bogan River Catchment	E26 Restrict BLR access through the establishment of mandatory guidelines under the WMA s. 52(2) and S. 336B E31 Temporarily restrict access under the WMA s. 324 when there are water shortages.	L	L	L	N/A	N/A	None required. Risk is low.		N/A		
Unregulated	Upper Cudgegong River above Windamere		M	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Upper Talbragar River/Coolaburragundy River		L	M	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Wambangalang - Whylandra		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Winburndale Rivulet		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Castlereagh River Binnaway to Gilgandra		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Castlereagh River above Binnaway		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Castlereagh River below Coonamble*		L	L	L	M/M	N/A	None required. Risk is low.		N/A		

SECTION 7.4. RISKS TO WATER AVAILABLE FOR OTHER USES DUE TO GROWTH IN BLR [O(BLR)]												
Water source type	**Location, reach or extraction type within WRP area**	**Current critical mechanisms**	**Consequence**	**Likelihood**	**Risk rating**	**Data confidence (consequence / likelihood)**	**Risk treatment option**	**Strategy**	**New critical mechanisms**	**Tolerable risk level**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed**	**Monitoring and evaluation**
Unregulated	Castlereagh River Gilgandra to Coonamble		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Nedgera Creek*		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Teridgerie Creek*		L	L	L	M/M	N/A	None required. Risk is low.		N/A		
Unregulated	Tooraweenah to Coonamble Tributaries		L	L	L	M/M	N/A	None required. Risk is low.		N/A		

Current critical mechanisms – O(BLR):
E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs).
E2 Available Water Determinations (AWD) adjust extractive use according to water availability.
E24 Restrict BLR access through the establishment of mandatory guidelines under the WMA s. 52(2) and S. 336B.
E25 Temporarily restrict access under the WMA s. 324 when there are water shortages.
N/A no data available or not applicable

1. Introduction

1.1. Background

The Basin Plan is an adaptive management framework that has been developed by the Murray–Darling Basin Authority (MDBA) to provide a coordinated approach to managing water resources across the four member states and territory in the Murray–Darling Basin (MDB).

A risk assessment is a key step in the development of a water resource plan (WRP) for each valley and groundwater source in the MDB. Chapter 4, Part 2 of the Basin Plan (Risks and strategies to address risks) sets out matters that must be considered in terms of risk and management strategies in WRPs. Chapter 10, Part 9 (Approaches to addressing risk to water resources) outlines how Basin States must undertake risk assessments as well as the MDBA's associated accreditation requirements.

The Basin Plan requires that a WRP must be prepared having regard to current or future risks to the condition and continued availability of water resources of a water resource plan area. This risk assessment will form Schedule D of the WRP.

Figure 1-1 illustrates the relationship of the risk assessment document with the other elements of the WRP.

1.2. Document map

This risk assessment identifies and addresses risks to water resources to meet the requirements of Chapter 10, Part 9. Table 1-1 summarises where the Basin Plan requirements are addressed in this risk assessment.

The document is organised according to receptors, such that the risks to the environment (Sections 4 and 5) and risks to other water-dependent values and users (Sections 6 and 7) are assessed together.

These sections address risk to the condition or continued availability of Basin water resources and the consequences of the materialisation of these risks as identified in Chapter 4.02 of the Basin Plan; namely, that water quality or quantity is insufficient to meet consumptive, economic, environmental, and public benefit (social, cultural, Indigenous) uses and values.

Risks are analysed in Sections 4 to 7 of this report. Five basic steps are described for each risk (10.41(5)); these are:

- The risk pathway, with a summary of how the cause and threat may arise (10.41(2), (3); 10.42(b))
- Identification of likelihood and consequence metrics, and description of how low, medium and high categories were defined for each metric (10.41(5); 10.42(a))
- Summary of the data and method used to fulfil each likelihood and consequence metric (10.41(7))
- Identification and discussion of strategies that are in place to address risks (10.43)
- Combination of likelihood and consequence ratings to derive an overall risk rating (10.41(5),(6)).

Note that where a risk result is highlighted as medium or high, it does not necessarily imply that existing management actions and mechanisms require change or are inadequate. In many circumstances these risks will already have a level of management in place that is commensurate with the risk result.

Strategies for addressing risks as having a medium or higher level of risk (10.43(1)) are discussed in Section 8.

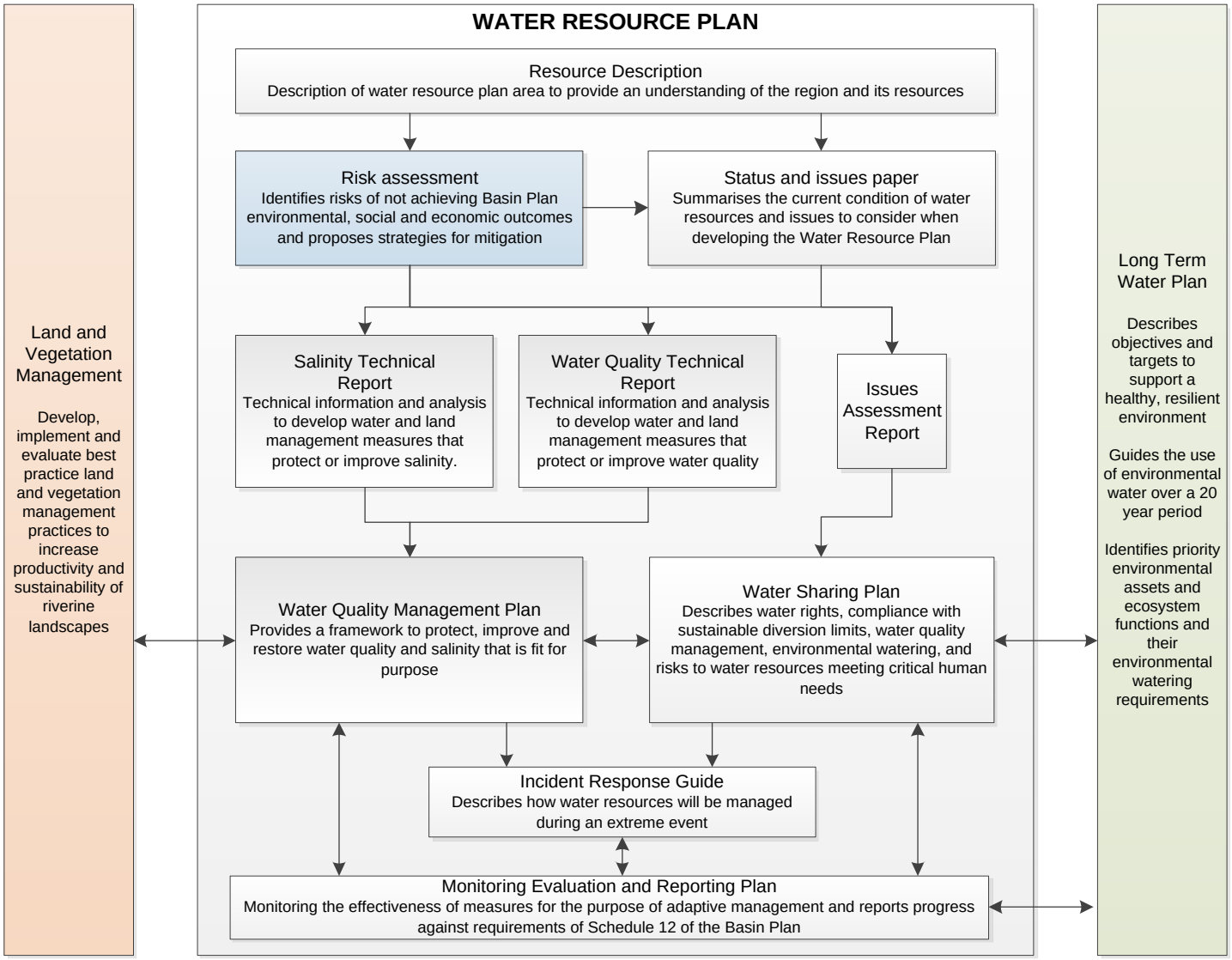


Figure 1-1. Components of the WRP

Table 1-1. Basin Plan requirements and where each is addressed in this risk assessment document

Basin Plan requirement		Location in risk assessment report	
Chapter 10, Part 9		Section 1	Introduction
10.41(1)	Having regard to current and future risks	Section 2	NSW risk assessment framework overview
		2.1	Introduction
10.41(7)	Describe the data and methods used	2.2	Risk assessment framework
		2.3	Risk assessment scope
10.41(8)	Describe the uncertainties	2.4	Limitations and uncertainties
		Section 3	Overview of the WRP area
10.02	Identification of the water resource plan area and water resources	3.1	Identification of the water resource plan area
10.03	Identification of SDL resource units and water resources		
		3.2	Characterisation of the WRPA
10.05 10.19 10.41(1), 10.41(2)(b), 10.20(1)(b) 10.23(1)(b)	Regard to other water resources Groundwater and surface water connections Risks arising from structural damage to an aquifer and the hydraulic relationships between groundwater and surface water systems	3.3	Connectivity within and between WRPAs
10.41(3)(a), 4.02(1)(a)	Insufficient water available for the environment	Section 4	Risk of insufficient water for the environment
10.41(1)	Regard to current and future risks	4.1	Background
Schedule 8, Schedule 9	Criteria for identifying an environmental asset and an ecosystem function	4.2	Assigning a consequence rating (HEVAE)
10.41(1), 10.41(2)(a), 10.41(5),(6)	Risks to water available for the environment and capacity to meet environmental watering requirements	4.3	Risks to water available for the environment due to river regulation and licensed extraction
10.41(1), 10.41(2)(a), 10.41(5),(6)	Risks to water available for the environment	4.4	Risks to water available for the environment from extraction by basic landholder rights
10.41(1), 10.41(2)(c), 10.23, 10.41(5),(6)		4.5	Risk to water available for the environment from interception activities (farm dams, plantation forestry, mining, floodplain harvesting)
10.41(1) , 10.41(5),(6)		4.6	Risk to water available for the environment due to climate change
10.41(3)(a), 4.02(1)(c)	Poor health of water-dependent ecosystems	Section 5	Risks to health of water-dependent ecosystems
10.41(1)	Regard to current and future risks	5.1	Risks to the health of water-dependent ecosystems

Basin Plan requirement		Location in risk assessment report	
Schedule 8, Schedule 9	Criteria for identifying an environmental asset and an ecosystem function	5.2	Assigning a consequence rating (HEVAE)
10.41(1), 10.41(1)(d) , 10.41(5),(6)	Risks arising from elevated levels of salinity or other types of water quality degradation	5.3	Risks due to water temperature outside natural ranges
		5.4	Risks due to turbidity, TP, TN, pH, turbidity and DO
		5.5	Risks due to elevated levels of in-stream salinity
10.41(3)(a), 4.02(1)(b), 4.02(2)(a)(b)	Risks identified in section 4.02 Risk arising from water being of a quality unsuitable for use Water is not suitable for consumptive and other economic uses of Basin water resources Water is not suitable to maintain social, cultural, Indigenous and other public benefit values	Section 6	Risk to other water uses due to unsuitable water quality
10.41(1), 10.41(2)(d) , 10.41(5),(6)	Risks arising from elevated levels of salinity or other types of water quality degradation	6.3	Risks to irrigation water from elevated in-stream salinity
		6.4	Risks to water used for recreational purposes
		6.5	Risks to water used for human consumption
		6.6	Other values
10.41(3)(a), 4.02(1)(b), 4.02(2)(a)(b)	Risks identified in section 4.02 Insufficient water available for consumptive and other economic uses of Basin water resources Insufficient water available to maintain social, cultural, Indigenous and other public benefit values	Section 7	Risk to water available for other uses
10.41(1), 10.41(2)(c), 10.23, 10.41(5),(6)	Risks arising from potential interception activities	7.1	Risks to other water users from interception activities
10.41(1), 10.41(5),(6)	Future risks	7.2	Risk to other water users due to climate change
		7.3	Risk to other water users due to growth in BLR
		7.4	Other values
10.41(1), 10.43	Lists the risks identified Strategies for addressing risks as having a medium or higher level of risk	Section 8	Summary of risks, tolerable discussion, revised risk tables identifying tolerable
		Table 1	Consolidated Risk Tables (Executive Summary)

Basin Plan requirement		Location in risk assessment report
10.41(7)(8)	Description of the data and methods Description of uncertainty	Appendix A

2. NSW Basin Plan risk assessment framework overview

2.1. Introduction

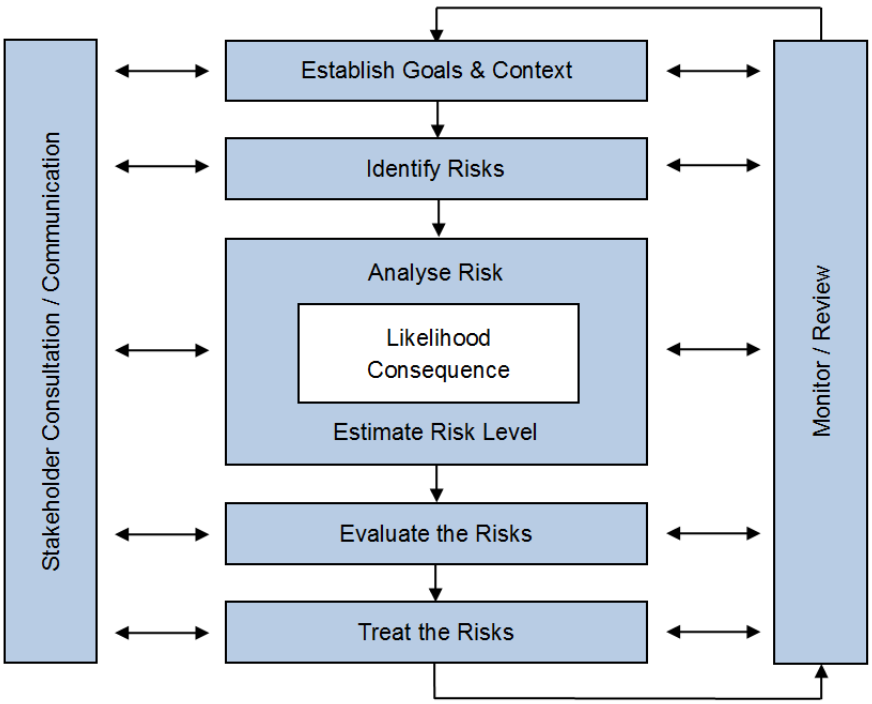
Risk-based management is not a new concept in water resource planning in NSW. Considerable work has been undertaken by State governments and under Commonwealth-level intergovernmental initiatives to design and implement risk-based water planning. The *National Water Initiative* (NWI) *Policy Guidelines for Water Planning and Management* (NWI 2010), endorsed by the Council of Australian Governments (COAG), adopts a risk-management approach.

Risk-based management assists water managers in prioritising and directing time and effort to monitor, mitigate or respond to the factors that pose the highest overall risks. It ensures that management is targeted at the appropriate part of the water system.

NSW has been implementing risk-based water planning processes since implementing water reform in the late 1990s. These approaches have included the initial Stressed Rivers and Aquifer Risk Assessments in 1998 (DLWC 1998a; DLWC 1998b). The macro-water planning process adopted in 2004 to complete water sharing plans across the State also used a risk-based approach (NOW 2011a; Raine *et al.* 2012).

2.2. The risk assessment framework

Risk assessments for each NSW WRP follow the process illustrated in Figure 2-1. This process is consistent with the NWI *Policy Guidelines for Water Planning and Management* and NSW's Basin Plan obligations.



Source: AS/NZS ISO 31000:2009

Figure 2-1. The NSW Basin Plan risk assessment framework

The risk assessment framework adopts a cause/threat/impact model that describes the pathway for impacts to a receptor. Adopting the cause/threat/impact pathway approach provides a systematic way to identify the full

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. Receptors are considered in an intergenerational context, that is, current and future uses and users, as required under subsection 10.41(1).

The causes, threats and impacts considered in this assessment are summarised in Table 2-1.

Table 2-1. Summary of causes, threats and impacts considered in this risk assessment

Cause	Threat	Impact
River regulation Licensed surface water extraction (regulated and unregulated) Growth in extraction under basic landholder rights Interception activities (including farm dams and plantation forestry) Change in runoff and rainfall from climate change Land management practices and natural landscape system processes	Alteration to ecologically significant flow regime components (zero flow periods, base flows, fresh flows, high flows) Reduced surface water availability Reduced runoff into surface water sources Poor in-stream water quality (temperature depression, suspended matter, nutrients, dissolved oxygen, pH)	Change to in-stream environmental assets and ecosystem functions Human health and recreational use Reduced water availability for other uses

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 2-2, for risks arising from river regulation and surface water extraction.

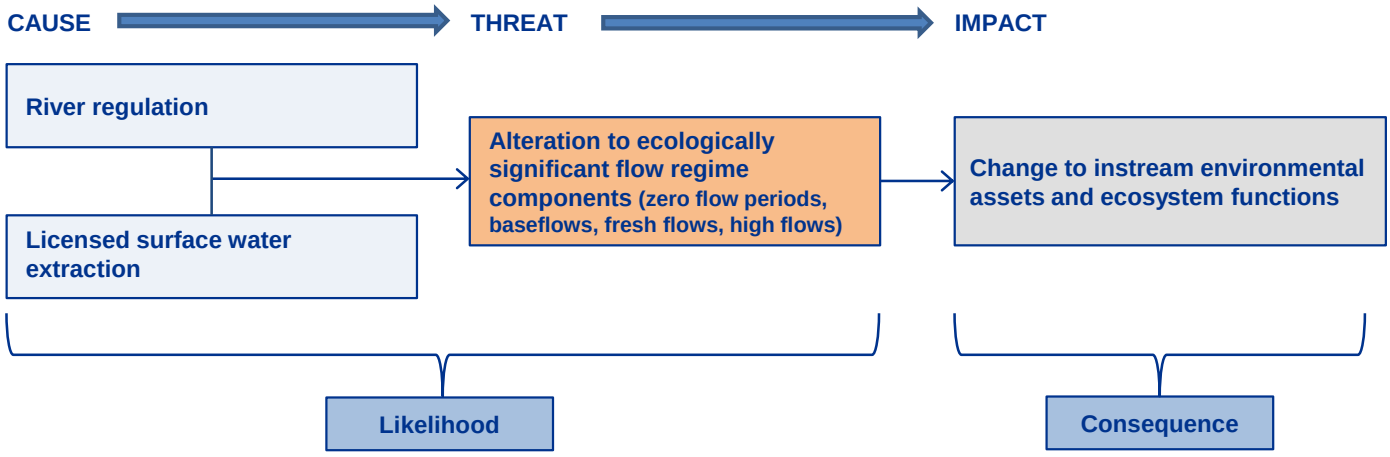


Figure 2-2. Example of an impact pathway for identifying risks to the environment associated with river regulation and licensed extraction

Risk levels are calculated using the standard risk assessment matrix used under the macro-planning approach (Table 2-2). Specific risk matrices for each risk are provided within this document.

Table 2-2. The risk assessment matrix

Risk level		Likelihood		
		1	2	3
Consequence	1	Low	Low	Medium
	2	Low	Medium	High
	3	Medium	High	High

A consolidated risk table has been developed for each water resource plan area (WRPA) to capture the risk assessment process. Key elements of the register 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 will also be used to assist in ongoing monitoring and evaluation.

2.3. Risk assessment scope

The Basin Plan sets out the risks to be included in a risk assessment. Based on these requirements, the criteria adopted for including cause/threat/impact combinations in this assessment are that:

- The risk directly relates to a change in the water resource, which may change the quantity or quality of the resource.
- Risks for which the cause or threat would be mitigated through the use of NSW water management tools, such as rules within a water sharing plan.

Risks identified in the Basin Plan that do not have an apparent cause/threat/impact pathway in a water resource context have not been qualitatively assessed; rather, appropriate commentary is provided to document a clear rationale. Alternatively, reference is made to other supporting documents.

Establishing the timeframe for the risk assessment determines the point from which the potential for impact will be assessed. As required by the Basin Plan, this risk assessment identifies and assesses current and future risks. The following definitions have been adopted:

- Current risk: the risk that exists prior to the commencement of the WRP and prior to the application of any new or altered water management actions and mechanisms and strategies. Current risk has been assessed with the existing water sharing plan (WSP) rules based on the *Water Management Act 2000* (WMA) set in place.
- Future risk: these risks may affect the condition or continued availability of water resources during or subsequent to the 10 year term of relevant WSPs. Future risk is also assessed with the existing WSP or WMA-based strategy set in place. Future risks that have been assessed include risk to the environment and to licensed water users from growth in water use by basic landholder rights (both domestic and stock and farm dam interception), interception activities (including plantation forestry and farm dams) and climate change.

As noted above, many water management actions and mechanisms are already in place, which may adequately address risk. The purpose of this risk assessment is therefore to review the risks and associated management measures for current and future effectiveness, and to verify whether the level of risk is matched by the level of water resource management. This purpose is underpinned in the WRPs through the inclusion of monitoring, review and adaptive management processes to confirm that the risk levels derived are appropriate, and the management of the risks is effective and commensurate with the level of risk.

Scale is important to the interpretation of risk results, as even within a water source or along a particular reach, risks for specific receptors will vary depending upon factors such as the level of development and use.

Generally, this risk framework has been applied at the finest scale for which data was available. In the unregulated system, a water source scale was adopted to match current WSP boundaries. A reach scale for regulated rivers within the Macquarie Cudgegong surface water sustainable diversion limit (SDL) resource unit was used to match MDBA gauge sites for hydrological modelling.

The qualitative risk values assigned to cause/threat/impacts should therefore be considered in this context. As much as possible, strategies identified to manage medium and high risks take into consideration any local-scale characteristics which may have some bearing on the assessed risks.

2.4. Limitations and uncertainties

A 'best available information' approach was used to undertake this risk assessment. As much as practically possible, the most current data available were used to assess risks. Where relevant data has been made available after the completion of the analyses and time constraints preclude its inclusion in this risk assessment, it will be considered in any future risk assessments. Similarly, any new or additional data will be integrated into future risk assessments after the WRP commences, where appropriate.

A description of the data sources used to quantify likelihood and consequence metrics is provided in Appendix A to meet subsection 10.41(7). Appendix A also discusses the uncertainties in risk and the confidence level of the metrics used, to meet subsection 10.41(8).

Confidence in the data used is rated according to the criteria in Table 2-3.

Table 2-3. Criteria used for rating confidence in data

Low	Moderate	High
Insufficient data/information available for assessment Data not applicable to the scale of the assessment Data/information based on estimates using methods/analytical models with a high degree of uncertainty Estimated data not based on any reliable measurements Anecdotal evidence only	Limited available data/information but applicable to the scale of the assessment Limited data based on reliable measurements Data/information based on estimates using methods/numerical models with moderate levels of certainty Limited documented evidence	Sufficient data/ information available for assessment Reliable data available for the scale of assessment Data based on reliable measurements Data/information based on estimates using methods/numerical models with a high degree of certainty Documented evidence available

Constraints around data availability and the scale of the risk assessment mean that uncertainty can be introduced within each step of the risk assessment. The reliability of the risk outcomes is influenced by:

- Risk metrics that do not accurately capture the impact pathway
- The way metrics categories are defined (i.e. low, medium, high)
- Lack of applicable data to analyse metrics
- Use of data that is 'best available' but is not strictly suitable.

The reliability of the risk outcomes therefore needs to recognise limitations in the framework, as well as data unavailability or mismatches. Consideration is given to confidence in data when developing strategies for medium or high level risks; for example, strategies might be based on addressing knowledge gaps or evaluating the effectiveness of water management actions and mechanisms where there is insufficient or limited data available and the confidence in the data used is low.

3. Overview of the Macquarie-Castlereagh water resource plan area (SW11)

3.1. Identification of the Macquarie-Castlereagh water resource plan area

For the purpose of section 10.02 of the Basin Plan, this Risk Assessment applies to the water resource plan area (WRPA) and the water resources identified in section 3.05 of the Basin Plan as the Macquarie-Castlereagh WRPA.

For the purpose of section 10.03 of the Basin Plan, the following are identified:

- The SDL resource unit in the Macquarie-Castlereagh WRPA is that described in section 6.02 and Schedule 2 to the Basin Plan within the Macquarie-Castlereagh WRPA, (being the Macquarie-Castlereagh surface water SDL resource unit SS20) and
- The water resources within that SDL resource unit are those described in section 6.02 and Schedule 2 to the Basin Plan within the Macquarie-Castlereagh WRPA.

3.2. Characterisation of the Macquarie-Castlereagh water resource plan area

The Macquarie-Castlereagh WRPA (Murray–Darling Basin reference number SW11), The WRPA is located in central western NSW and is based around the Castlereagh, Macquarie and Bogan Rivers. All three rivers flow generally north-west across central NSW to meet the Barwon River. The catchment is bounded by the Great Dividing Range to the east, the Barwon-Darling catchment to the west, the Namoi region to the north and the Lachlan region to the south (Figure 3-1).

The Macquarie River originates in the Great Dividing Range south of Bathurst, and the river flows in a north-westerly direction for 960 km until it joins the Barwon River near Brewarrina. The Bogan River rises in the Harvey Ranges near Peak Hill and flows roughly parallel to the Macquarie River across the north-western plains before joining the Barwon River downstream of Brewarrina. In the lower part of the catchment a series of creeks break away from the Macquarie River, connecting with the Bogan River (Green *et al.* 2011). The Castlereagh River begins in the Warrumbungle Ranges near Coonabarabran and flows north-west for 550 km to its confluence with the lower Macquarie River.

Average annual rainfall in the Macquarie-Bogan catchment ranges from over 1,200 mm in the south-east to around 300 mm in the north-west. Rainfall across most of the lower catchment averages 300-500 mm/year. Mean monthly rainfall at Trangie, in the middle of the catchment, shows slight summer dominance, with the highest rainfall occurring between October and March, and the lowest months of rainfall being August and September (Green *et al.* 2011).

The Macquarie-Castlereagh WRPA is comprised of regulated and unregulated rivers. Under the NSW *Water Management Act 2000*, a regulated river is a gazetted river where downstream flows are regulated by a major State-owned storage or dam to supply water. The Cudgegong Regulated River Water Source comprises water between the banks of all rivers from the wall of Windamere Dam through to the Burrendong Dam storage. The Macquarie Regulated River Water Source extends from the wall of Burrendong Dam downstream to the junction of the Monkeygar Creek, and includes the anabranches of Duck Creek and Gunningbah Creeks to their respective junctions with the Bogan River, and Bulgeraga Creek/Marebone Break to its downstream junction with the Macquarie River.

The Castlereagh River rises in rugged country in the Warrumbungle Ranges near Coonabarabran and flows south-west then north-west for 549 km to its confluence with the lower Macquarie River (NOW 2011b). The

river passes through Coonamble and at the far end of the catchment runs parallel to the Barwon River. The floodplain between the Barwon and Castlereagh Rivers is intersected by Wombat and Wanourie Creeks, which carry flows from the Barwon River to the Castlereagh River during major floods. The Castlereagh River joins the Macquarie system close to its confluence with the Barwon River near Brewarrina. The river's discharge is highly variable and its large sections of sandy riverbed are often dry (NOW 2011b).

The Macquarie-Castlereagh WRPA contains two major storages. Burrendong Dam on the Macquarie River, has a capacity of 1,190,110 megalitres (ML), whilst Windamere Dam on the Cudgegong River has a capacity of 353,000 ML. Both of these water storages provide water for irrigators, stock and domestic use, as well for town water. Figure 3-3 shows the spatial distribution of water access licence entitlements in the Macquarie Cudgegong Regulated River Water Source. For the purpose of this risk assessment in the Macquarie-Castlereagh WRPA, the Macquarie and Cudgegong regulated rivers were divided into reaches based upon hydrologic modelling at specific hydrologic indicator sites (Figure 4-2).

The remaining rivers in the Macquarie-Castlereagh WRPA not gazetted as regulated rivers fall under the category of unregulated rivers. The unregulated rivers were embargoed in the mid-1990s and their ecological water requirements progressively protected with the introduction of water sharing plans. The unregulated river water sources in the Macquarie-Castlereagh WRPA can be divided into three main sub areas (Figure 3-2). There are 37 water sources in the Macquarie-Bogan and Castlereagh water sharing plan areas. Figure 3-4 shows the unregulated water sources in the Macquarie-Castlereagh WRPA and the spatial distribution of licence entitlements.

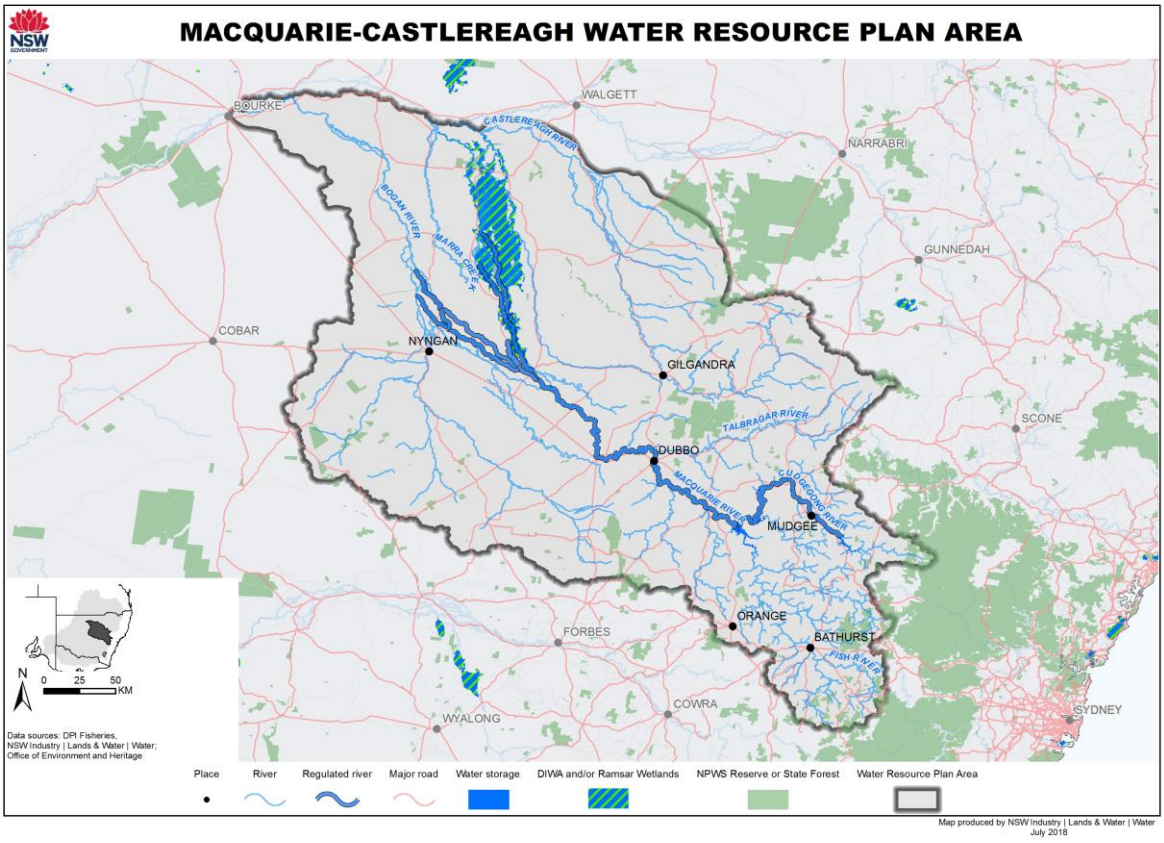


Figure 3-1. The Macquarie-Castlereagh WRPA (SW11)

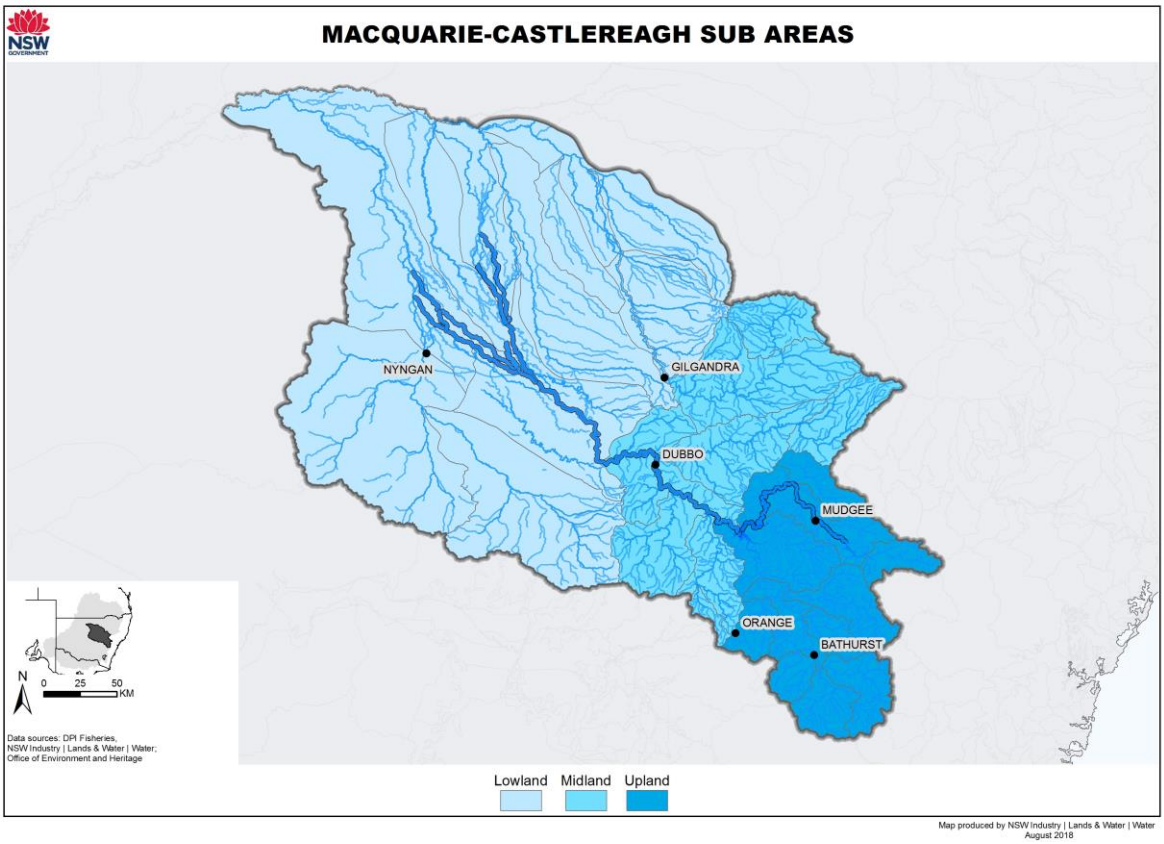


Figure 3-2. Sub areas of the Macquarie-Castlereagh WRPA (SW11) (upland, midland and lowland)

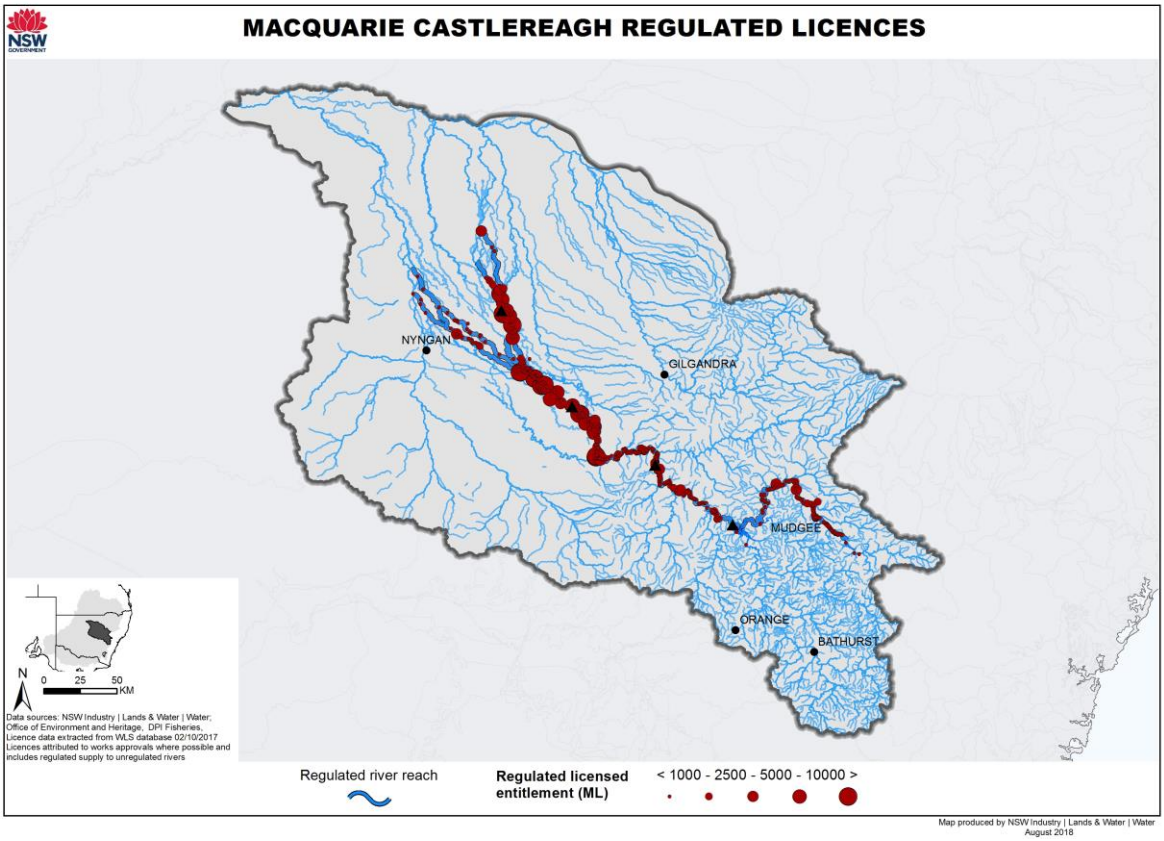


Figure 3-3. Regulated river entitlement in the Macquarie-Castlereagh WRPA (SW11)

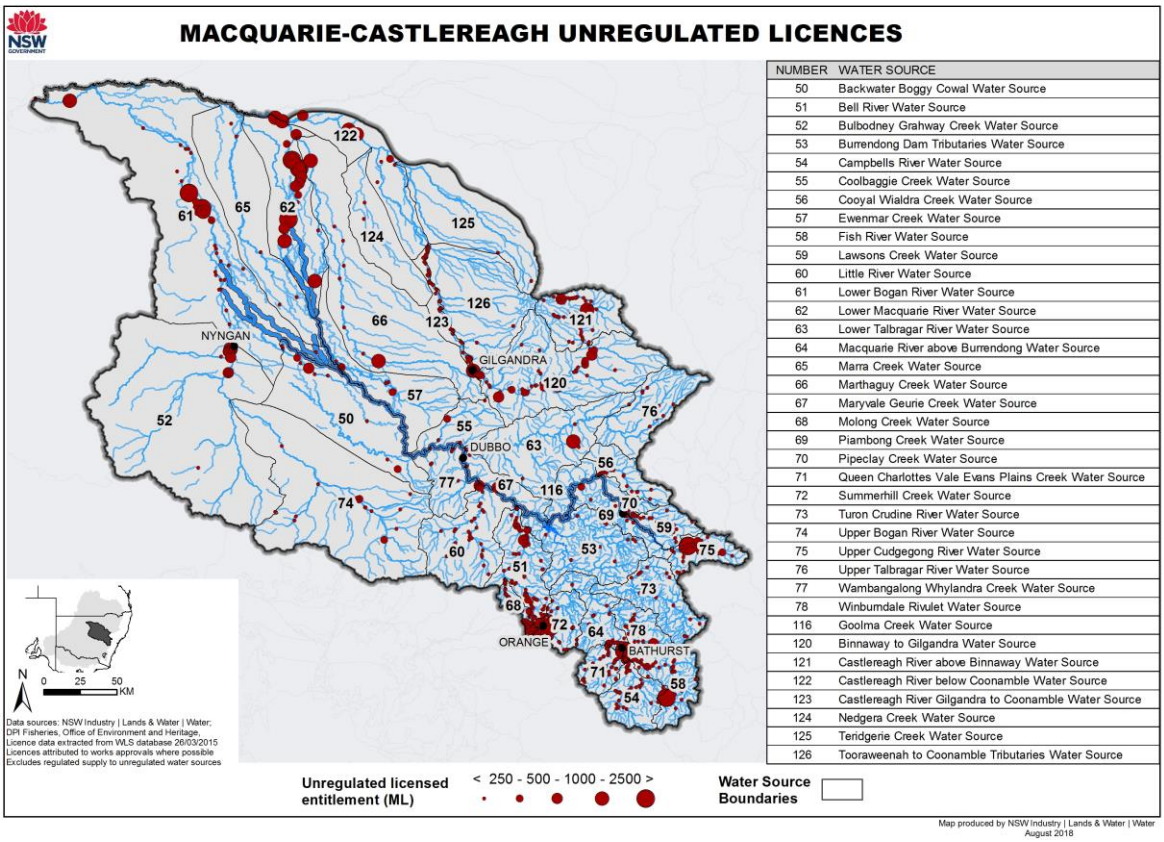


Figure 3-4. Unregulated water sources and entitlement in the Macquarie-Castlereagh WRPA (SW11)

3.3. Connectivity

The Macquarie-Castlereagh WRPA contains a single SDL resource unit, Macquarie-Castlereagh SS20. Within this resource unit, the two WSPs within the Macquarie-Castlereagh WRPA recognise and manage the hydrological connection between regulated and unregulated surface water sources. Water management actions and mechanisms to manage hydrological connections within the WRP area included in the *Water Sharing Plan for the Macquarie Cudgegong Regulated Rivers 2016*, the *Water Sharing Plan for the Castlereagh Unregulated and Alluvial Water Sources 2011* and the *Water Sharing Plan for the Macquarie Bogan Water Sources 2012* are discussed below.

Connectivity of the Macquarie-Castlereagh WRPA with adjacent WRPAs, including downstream surface waters and groundwater aquifers, is discussed in Section 3.3.2 below.

3.3.1. Connectivity between unregulated and regulated water sources within the Macquarie-Castlereagh water resource plan area

The connectivity between the Macquarie Bogan and Castlereagh unregulated water sources and the Macquarie Cudgegong regulated water source is managed by a suite of rules within the three WSPs. Unregulated water sources are both upstream and downstream of the Macquarie Cudgegong Regulated River Water Source and rules are applied to manage both connectivity situations.

In order to protect a portion of very low flows for the benefit of the environment, the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* and the *Water Sharing Plan for the Castlereagh Unregulated and Alluvial Water Sources 2011* provide cease to pump rules at the lowest downstream point for some water sources. Cease to pump rules specify a flow requirement to benefit important environmental attributes in that water source and provides for connectivity between water sources, including into the regulated river. Cease to pump rules ensure that very low flows are protected by requiring water users to stop taking water when flow declines below a set level.

The *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* also contains rules to protect replenishment flows released from the regulated system in several water sources in the lower Macquarie and Bogan valleys. Replenishment flows are for the purpose of refilling pools and waterholes in effluent river systems for household, town and stock use but may also provide environmental and connectivity benefits.

The *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* has commence to pump rules that are used to protect water until the Nyngan Weir pool is full and starts to spill.

The *Water Sharing Plan for the Macquarie Cudgegong Regulated River Water Source 2016* establishes provisions for an environmental water allowance which specifies a volume of water set aside in Burrendong Dam to improve environmental outcomes in the Macquarie Marshes and the Macquarie river between Burrendong Dam and the Macquarie Marshes. This allowance is made up of both a translucency and active component. A translucent environmental water allowance is also reserved in Windamere Dam which is released for the environmental benefit of the Cudgegong River once certain triggers are met.

The *Water Sharing Plan for the Macquarie Cudgegong Regulated River Water Sources 2016* also sets out rules for the use of supplementary river flows (flows entering from tributaries or from dam spills) within the Cudgegong and Macquarie Rivers. Supplementary flow access can be allowed following certain flow triggers but must be announced by the Minister. Flow triggers ensure some connectivity prior to access by licensed water users.

Lastly, the water sharing plans reserve water above the Plan limit which provides water for environmental benefits and incidentally for connectivity between the regulated rivers and unregulated rivers in the Macquarie valley.

3.3.2. Connectivity with other water resource plan areas

3.3.2.1. Surface water to surface water

For the purposes of section 10.05 of the Basin Plan, the Macquarie-Castlereagh WRPA (SW11) is considered to have a hydrological connection to surface water resource units within the downstream Barwon-Darling Watercourse WRPA (SW12) (Barwon Darling Watercourse SDL resource unit SS19).

Any potential risks to the Barwon-Darling Watercourse WRPA (SW12) from water management related activities in the Macquarie-Castlereagh water resource plan area are considered in the Barwon-Darling Watercourse WRPA (SW12) Risk Assessment.

The Barwon-Darling Unregulated. WSP identifies that the Briery Anabranch which joins the unregulated Macquarie River is governed by rules associated with flows in the Barwon-Darling River. The Basin-wide Watering Strategy has an expectation that the Macquarie-Castlereagh catchment contributes (along with other catchments) to a 10 % increase in flows in the Barwon Darling River.

3.3.2.2. Surface water to groundwater

For the purposes of section 10.05 of the Basin Plan, the Macquarie-Castlereagh WRPA (SW11) is considered to have hydrological connection to ground water resource units within the Macquarie-Castlereagh Alluvium WRPA (GW12) (includes the sustainable diversion limit resource units of Bell Valley Alluvium, Castlereagh Alluvium, Coolaburragundy-Talbragar Alluvium, Cudgegong Alluvium, Lower Macquarie Alluvium and Upper Macquarie Alluvium).

The Castlereagh, Bell and Cudgegong Alluvium resource units, and the Coolaburragundy reach of the Coolaburragundy - Talbragar Alluvium are highly connected to the associated rivers and major tributaries within their resource unit boundary. Of these systems only the Cudgegong Alluvium, where it is overlain by the regulated river, is linked to surface water rules. Linking extraction of groundwater to surface water availability according to the level of connectivity, limits to acceptable levels, groundwater extraction impacts on surface water users and the environment.

The Talbragar reach of the Coolaburragundy - Talbragar Alluvium is less connected to the downstream reaches of the river. The deeper alluvium has a much greater storage capacity and as a result, short term changes in surface water flows are not as significant to the overall groundwater store.

In the Upper Macquarie Alluvium, the Macquarie River varies between losing and gaining along its course depending on geology, topography, local conditions and prevailing long-term climatic conditions. Previous groundwater modelling (SKM 2010) of a number of 50 year scenarios over a range of pumping and climatic conditions suggests that the total predicted loss of river flow in the long terms corresponds to 80-90% of the volume of groundwater being extracted. For management purposes this connection is categorised as being less highly connected compared to those managed as highly connected systems due to the slower rate at which groundwater-surface water interactions occur so that within season access rules are not linked to surface water management.

The greater depth to the regional water table in the Lower Macquarie resource unit results in the Macquarie River and its tributaries being largely hydraulically disconnected from the alluvium for much of their reaches. That is, whilst the Macquarie River would lose water into the underlying alluvium, the rate of loss is not influenced by groundwater pumping. Further analysis of the interconnection between the Macquarie River and the alluvium is given in Lamontagne et al (2011) which characterised the 15 km reach of the river centred around Narromine as being losing-connected.

The regulated Cudgegong River is considered to be highly connected to the Cudgegong Alluvium. Any groundwater extractions beyond LTAAEL (average extraction) will decrease baseflows. To manage this connectivity and any possible impacts on surface water users and the environment, annual available water determinations (AWDs) for aquifer access licences are linked to AWDs for surface water access licences in the regulated river, recognising that a component of recharge is derived from the river system.

Any potential risks to surface water (including risks to the environment and risks to other users) as a result of ground water extraction are considered in the Risk Assessment for the Macquarie-Castlereagh Alluvium WRPA (DOIW 2018).

4. Risk of insufficient water available for the environment

4.1. Background

The Basin Plan establishes objectives in relation to environmental outcomes (Chapter 5.03). These include protecting and restoring water-dependent ecosystems and functions, and ensuring they are resilient to risks and threats.

Environmental assets of the Basin include the rivers, lakes, billabongs, wetlands, groundwater systems, floodplains and their flood-dependent forests, and include water-dependent ecosystems, ecosystem services and sites with ecological significance (MDBA 2010). Schedule 8 of the Basin Plan lists the criteria for identifying an environmental asset.

Ecosystem functions are the key physical, chemical and biological processes that support the Basin's environmental assets, and include the transport of nutrients, organic matter and sediment in rivers, wetting and drying cycles, and provision for migration and recolonisation by plants and animals along rivers and across floodplains (MDBA 2010). Schedule 9 of the Basin Plan lists the criteria for identifying an ecosystem function.

There are a number of causes and threats that will impact the availability of water for the environment which may in turn potentially impact in-stream ecological functions and assets. In the NSW MDB, these risks include:

- River regulation and licensed surface water extraction altering the timing, duration and frequency of flow components
- Growth in extraction of water required by basic landholder rights
- Interception activities (farm dams, commercial plantations, mining and floodplain harvesting)
- Climate change.

These threats could impact in-stream ecological functions and assets. The risk pathways for considering potential impacts of insufficient water for the environment are summarised in Figure 4-1. The risks are analysed and discussed in the following sections.

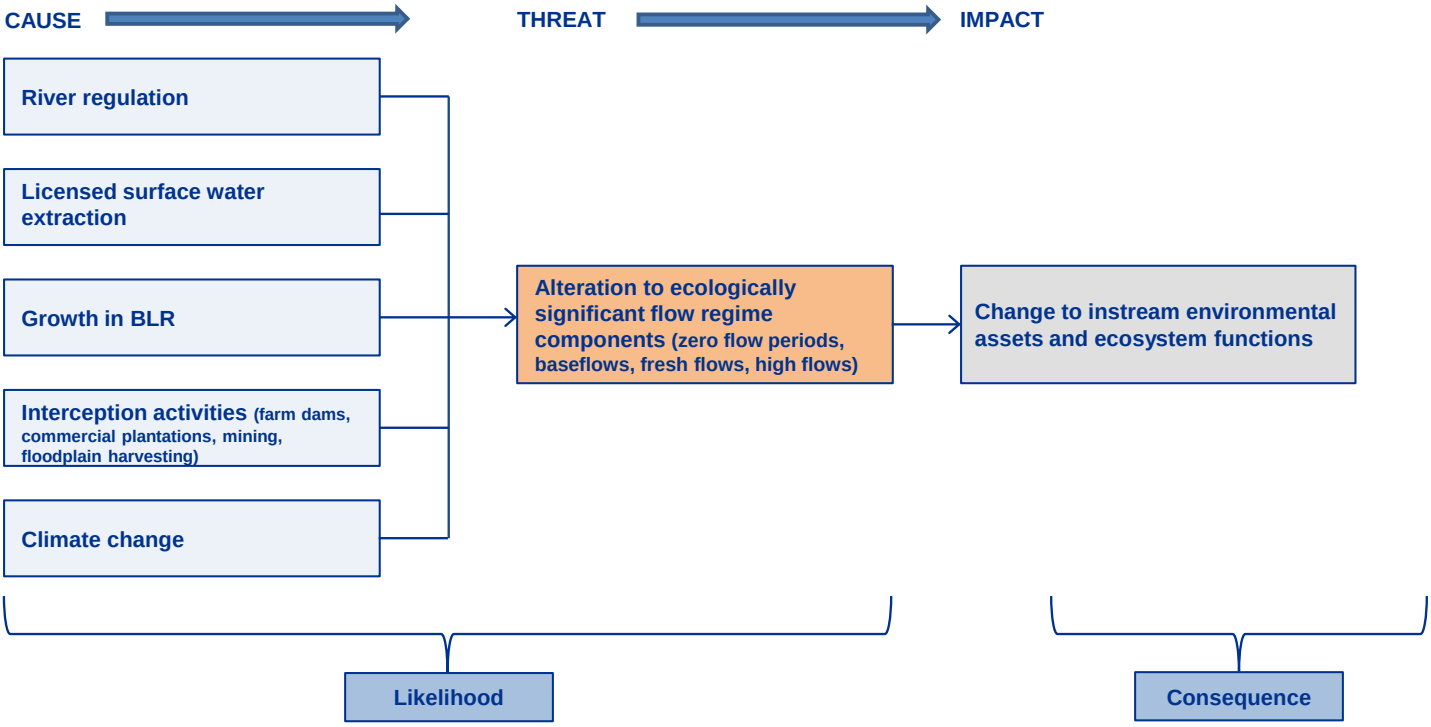


Figure 4-1. Risk pathways for risks of insufficient water for the environment and capacity to meet environmental watering requirements

4.2. Assigning a consequence rating

The consequence of impacts to ecological functions and assets was determined using the High Ecological Value Aquatic Ecosystems (HEVAE) score and the extraction pressure within an unregulated water source or regulated river reach. These two metrics describe the ecological value and their sensitivity to impacts.

HEVAE scores were derived from the National Aquatic Ecosystems Toolkit Module 3, guidelines developed by the Aquatic Ecosystems Task Group for the Department of Sustainability, Environment, Water Population and Communities (2012) (Aquatic Ecosystems Task Group 2012). HEVAE values were assigned at a reach scale. A decision tree was then used to assign a consequence rating at a reach scale for regulated rivers and a water source scale for unregulated rivers.

A consequence score is assigned at a reach scale for regulated rivers. The regulated river was broken into reaches that were represented by MDBA hydrologic indicator sites used for modelling (Figure 4-2). These sites correspond to selected streamflow gauging stations. The reaches represented by the hydrologic indicator sites were selected by identifying where significant tributaries, effluents or regulators both upstream and downstream of the site change the hydrology significantly. For example, in Figure 4-2, the reach assigned to the indicator site *421040 Macquarie River downstream of Burrendong Dam* extends upstream to the wall of Burrendong Dam and downstream to the confluence with the Bell River, a significant tributary of the Macquarie regulated river.

A consequence score is assigned at a water source scale for unregulated rivers. Single reach Integrated Quantity and Quality Models (IQQM) were applied at a water source scale for unregulated rivers. Where appropriate, unregulated flow gauges were also used for single reach models in adjacent water sources if a suitable gauge was not available. The exceptions were Backwater Boggy Cowal and Ewenmar Creek, both of which are effluent streams which could not be modelled for low flows. In these cases MDBA modelling of adjacent Macquarie River regulated reaches was used for the higher flows (Figure 4-3).

To ensure the HEVAE outcomes developed by the NSW Department of Industry (Healey *et al.* 2012; Healey *et al.* 2018) could be useful spatially and report consistently across a WRPA and water sources, available data was attached to the River Styles® spatial layer. The River Styles® mapping has been undertaken across all

catchments in NSW to third or fourth order streams and greater. It is the primary spatial layer to which the HEVAE data are applied, enabling in-stream value to be represented on a spatial scale.

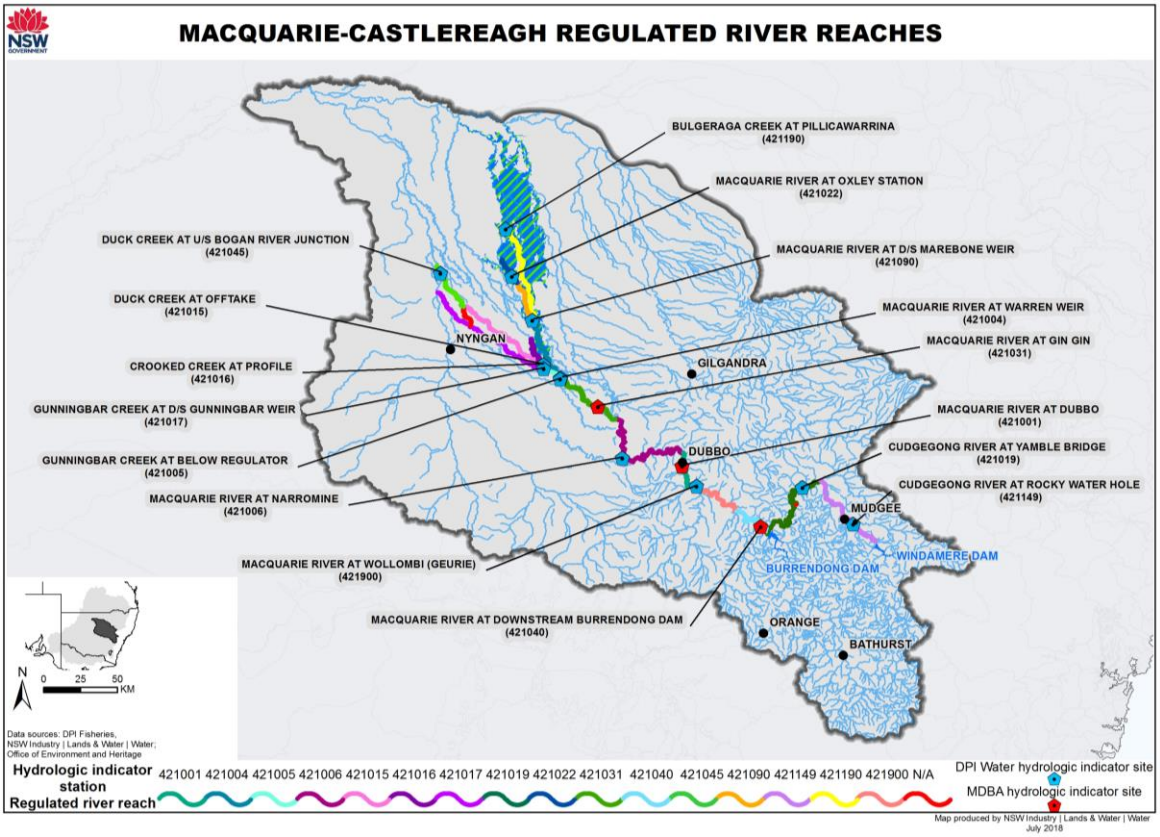


Figure 4-2. MDBA hydrologic indicator sites and representative regulated reaches for the Macquarie-Castlereagh WRPA

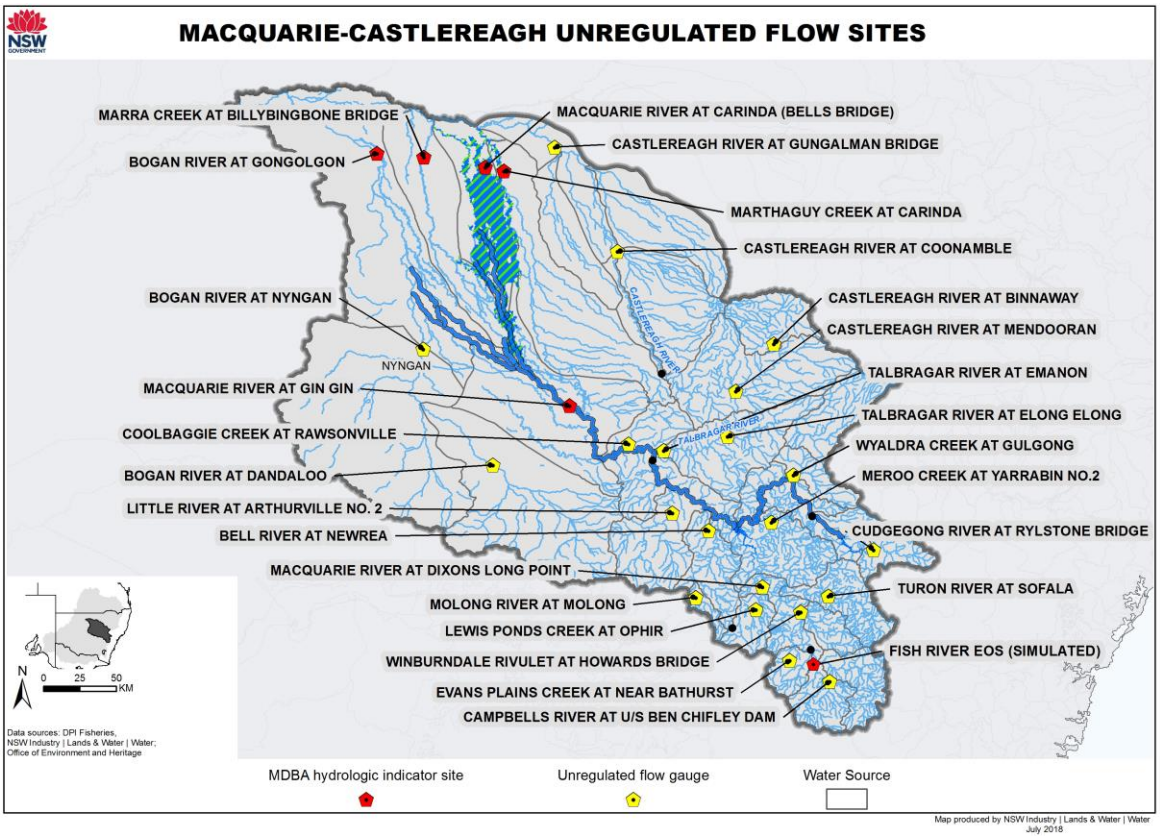


Figure 4-3. Location of unregulated flow gauges and the MDBA hydrologic indicator site used for generating flow sequences in unregulated rivers in the Macquarie-Castlereagh WRPA

4.2.1. HEVAE

Ecological scoring was derived from the National Aquatic Ecosystems Toolkit Module 3 (Aquatic Ecosystems Task Group 2012). For the purposes of the toolkit, HEVAE are aquatic ecosystems that are considered to be of high ecological value as determined by a consistent and objective process such as that provided by Module 3. A standardised HEVAE method was applied to every MDB WRPA. Detailed methodology is provided in (Healey *et al.* 2018)

The criteria used in the HEVAE framework aligns to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions. The alignment of the two sets of criteria is provided in Appendix B. The assigning of HEVAE scoring was developed using the same data and mobility weightings used by the Office of Environment and Heritage (OEH) to identify environmental assets and functions for the Long Term Water Plan (LTWP).

The HEVAE framework consists of five key criteria that can be used at a range of scales; diversity, distinctiveness, naturalness, vital habitat and representativeness. It should be noted that NSW does not currently use the key criteria of "representativeness" due to insufficient data availability.

HEVAE criteria are applicable at the regional level and meet NSW jurisdictional needs (Aquatic Ecosystems Task Group 2012). Each of the four criteria had a number of associated attributes (Figure 4-4); a score between 0 and 1.0 was assigned to each attribute based on the data type and source. A weighting was applied to each metric to give an overall criteria score. The four criteria were then combined into a final score between 0 and 1.0 to give an overall in-stream value score (i.e. a HEVAE score).

Natural variation in attribute scores can occur and may 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) to enable each assessed attribute to be scored against the same scale.

Weightings were applied to the attributes to reflect the purpose of the assessment and the views of stakeholders. Applying a weighting process also allowed the final scoring to reflect the importance of the

factors used in this assessment and to assist with identifying attributes that have a greater contribution to the assessment (Bennett *et al.* 2002; Macgregor *et al.* 2011; Hughey 2013).

During the development of macro WSPs in NSW, specific weightings were linked to the flow sensitivity (Table 4-1) of in-stream flow dependent threatened species, populations and communities (DIPNR 2005). The weightings for each species were agreed upon through discussions with participating NSW agencies with consideration to the importance of flow alteration as a key threatening process (NOW 2011b). These same flow sensitivity weightings were applied in the HEVAE scoring. Evidence was collated to support the weightings associated with attributes. For example, if a threatened species population or endangered ecological community had alteration to natural flow listed as a key threat, it receives a flow sensitivity weighting of 4.

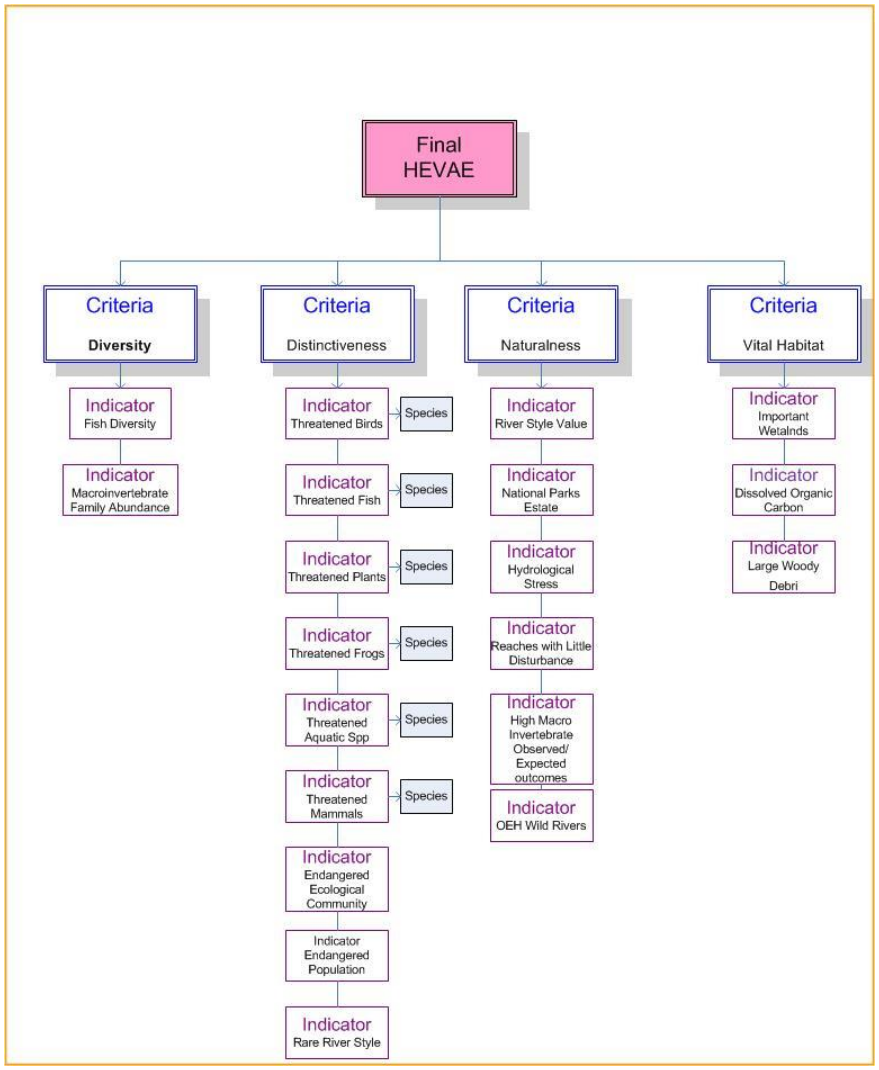


Figure 4-4. The four HEVAE criteria and associated attributes used in assessing HEVAE in NSW

Table 4-1. Examples of flow sensitivity weightings used in the HEVAE process

Score/ weighting	Definition	Typical examples
4	Highly sensitive to extraction and/or flow, with specific flow requirements - less able to move to alternative refuge	Fish; stream breeding threatened frogs; threatened listings where alteration to flow is listed as a key threat, Ramsar wetlands
3	Moderately sensitive to extraction and/or flow - some ability to adjust to flow changes or relocate	Macroinvertebrates, some threatened frogs; frogs, turtles, wet flora; threatened listings where alteration to flow is listed as a key threat, but profile details indicate moderate influence
2	Slightly sensitive to extraction and/or flow - can generally survive across a wider range of flow conditions, or can move elsewhere to seek refuge	Wading/water birds; threatened listings where alteration to flow considered as a potential threat, but profile details indicate lesser influence
1	Low sensitivity to extraction and/or flow - secondary relationship to flow and extraction	Riparian and some floodplain vegetation; birds that nest in riparian trees; threatened listings where alteration to flow may not be considered to be a threat, but profile details indicate lesser influence, geomorphology
Reference: (Healey *et al.* 2018).		

4.2.2. Consequence decision tree

To determine the impact on in-stream ecological functions and assets consideration has to be given to where and how much extraction pressure (individual licence entitlement) has occurred and whether this had the potential to influence the HEVAE score.

A decision tree was used which prioritised Ramsar habitat, converting high and very high HEVAE scores into high and very high consequence ranks. Non-Ramsar high and very high value reaches were ranked according to whether they were upstream or downstream of extraction, and whether freshwater-dependent fauna and flora occurred in the assessment area.

Medium HEVAE scores either retained their rank or were downgraded to a low or very low consequence using a similar rationale as the high and very high HEVAE scores described above. That is, if freshwater-dependent fauna and flora occurred in the assessment area, the HEVAE score remained medium. If there were no freshwater-dependent fauna and flora in the assessment area the consequence score became either low or very low, depending on whether the assessment area had cumulatively more medium and low HEVAE reaches, or mostly very low HEVAE reaches.

Freshwater-dependent fauna and flora records used in the decision tree process were site-based data (recorded data), obtained from agency databases and with a high level of confidence. Predicted occurrences and “known records” (‘known records’ are predicted occurrences within the vicinity of recorded data: see (Healey *et al.* 2018) used in the HEVAE model were not considered when progressing through the decision tree, as the confidence in those data was not as high. In the event that there were no site-based records, the consequence rank was lowered to the next category. That is, if a high HEVAE score had records only based upon predicted or known data, the consequence category became medium.

Each bifurcation in the decision tree was annotated to allow each score to be tracked through the decision tree during the assessment. The decision tree and the rationale for each bifurcation are provided in Appendix C.

4.2.3. Consequence score

Regulated river water source

Key aquatic ecological assets in the Macquarie-Castlereagh WRPA include:

- Wetlands of international significance listed under the Ramsar Convention (Macquarie Marshes)
- A number of endangered ecological communities (EEC) including carex sedgeland, coolibah-black box woodlands, carbeen open forest and the lowland Darling River EEC

- A diverse range of vegetation including river red gum forest and woodland, black box woodland and lignum
- Threatened bird species including Australasian bittern, Australian painted snipe, black-necked stork, black-tailed godwit, blue-billed duck, brolga, cotton pygmy-goose, curlew sandpiper, eastern osprey, freckled duck and magpie geese
- Threatened native fish species including Murray cod, olive perchlet, silver perch, trout cod and purple spotted gudgeon, and threatened populations of eel-tailed catfish
- Threatened species such as the green and golden bell frog, Booroolong frog, yellow-spotted tree frog, southern bell frog, greater broad-nosed bat and river snail
- Other flow-dependent assets including the Macquarie River channel, the lower Macquarie River, and the effluent Creeks (e.g. Marra Creek, Crooked Creek and Duck Creek) on the western side of the Marshes.

Consequence scoring shows that most of the Macquarie regulated river has high to very high consequences (Figure 4-5; Table 4-2) due to a number of factors including high fish diversity, presence of threatened fish species and large tracts of riparian vegetation and relatively undisturbed river reaches contributing to the provision of habitat and primary production. There is also the presence of endangered ecological communities, the most widespread of these being the Lowland Darling River Aquatic EEC and the Coolabah-Black box Woodland EEC.

Table 4-2. Consequence results for the Macquarie Cudgegong regulated water source in the Macquarie-Castlereagh WRPA

Regulated river reach	Consequence Rating (HEVAE consequence score)
Cudgegong River at Rocky Water Hole	High
Cudgegong River at Yamble Bridge	Medium
Macquarie River downstream Burrendong Dam	Medium
Macquarie River at Geurie	Medium
Macquarie River at Dubbo	Very high
Macquarie River at Narromine	Very high
Macquarie River at Gin Gin	Very high
Macquarie River at Warren Weir	Very high
Macquarie River downstream Marebone Weir	Medium
Macquarie River at Oxley Station	Very high
Gunningbah Creek below regulator	High
Gunningbah Creek downstream Gunningbah Weir	High
Duck Creek at Offtake	Low
Crooked Creek at Profile	Very high
Duck Creek upstream Bogan River junction	Medium
Bulgeraga Creek at Pillicawarrina	Very high
Reference:(Healey et al. 2018).	

Fish data from the MDB Sustainable Rivers Audit (Davies *et al.* 2012) and other sources were analysed by DPI Fisheries to assess the distribution of threatened fish species and to identify areas of relative high fish biodiversity within the Macquarie-Castlereagh WRPA. These data are included in the HEVAE assessment; results are provided in Appendix D.

Unregulated water sources

Unregulated rivers in the Macquarie-Castlereagh WRPA have very high or high consequence scores in the following water sources (Table 4-3):

- In the upland zone the Fish River has high values due to the presence of several species of threatened frogs and the Castlereagh River above Binnaway has very high value due to threatened fish.;
- In the midland zone, Wambangalang Whylandra system and Coolbaggie Creek have high values due to the presence of endangered ecological communities and threatened fish;
- In the lowland zones the Upper Bogan, the Lower Bogan River, Bulbodney-Grahway Creek, Backwater-Boggy Cowel, Ewenmar Creek, Marra Creek, Lower Macquarie River and Marthaguy Creek all have high or very high values due to the presence of endangered ecological communities and threatened fish; and
- Lower Macquarie River also rates very high due to its proximity to Ramsar wetlands.

Table 4-3. Consequence results for the Macquarie Bogan and Castlereagh unregulated water sources in the Macquarie-Castlereagh WRPA

Unregulated water source	Consequence Rating (HEVAE consequence score)
Backwater-Boggy Cowal	Medium
Bell River	Low
Bulbodney-Grahway Creek system	High
Burrendong Dam Storage Tributaries	Medium
Campbells River	Medium
Coolbaggie Creek system	High
Cooyal Wialdra Creek System	Low
Ewenmar Creek system	High
Fish River	High
Goolma Creek	Low
Lawson's Creek	Low
Little River	High
Lower Bogan River	High
Lower Macquarie River	Very High
Lower Talbragar River	Medium
Macquarie River above Burrendong	Medium
Marra Creek system	Very High
Marthaguy Creek	High
Maryvale-Geurie	Low
Molong Creek and tributaries	Low
Piambong Creek	Low
Pipeclay Creek	Low
Queen Charlottes Vale Creek/Evans Plains Creek	Medium
Summerhill Creek	Low

Unregulated water source	Consequence Rating (HEVAE consequence score)
Turon/Crudine	Medium
Upper Bogan catchment	Medium
Upper Cudgegong River above Windamere	Medium
Upper Talbragar/Goolaburra-Gundy River	Medium
Wambangalong Whylandra System	High
Winburndale Rivulet	Medium
Castlereagh River Binnaway-Gilgandra	Low
Castlereagh River above Binnaway	Very High
Castlereagh River below Coonamble	Low
Castlereagh River Gilgandra-Coonamble	Low
Nedgera Creek System	Low
Teridgerie Creek System	Medium
Tooraweenah Gulargambone Tributaries	Low
N/A - Consequence could not be calculated due to lack of data	
Reference:(Healey *et al.* 2018).	

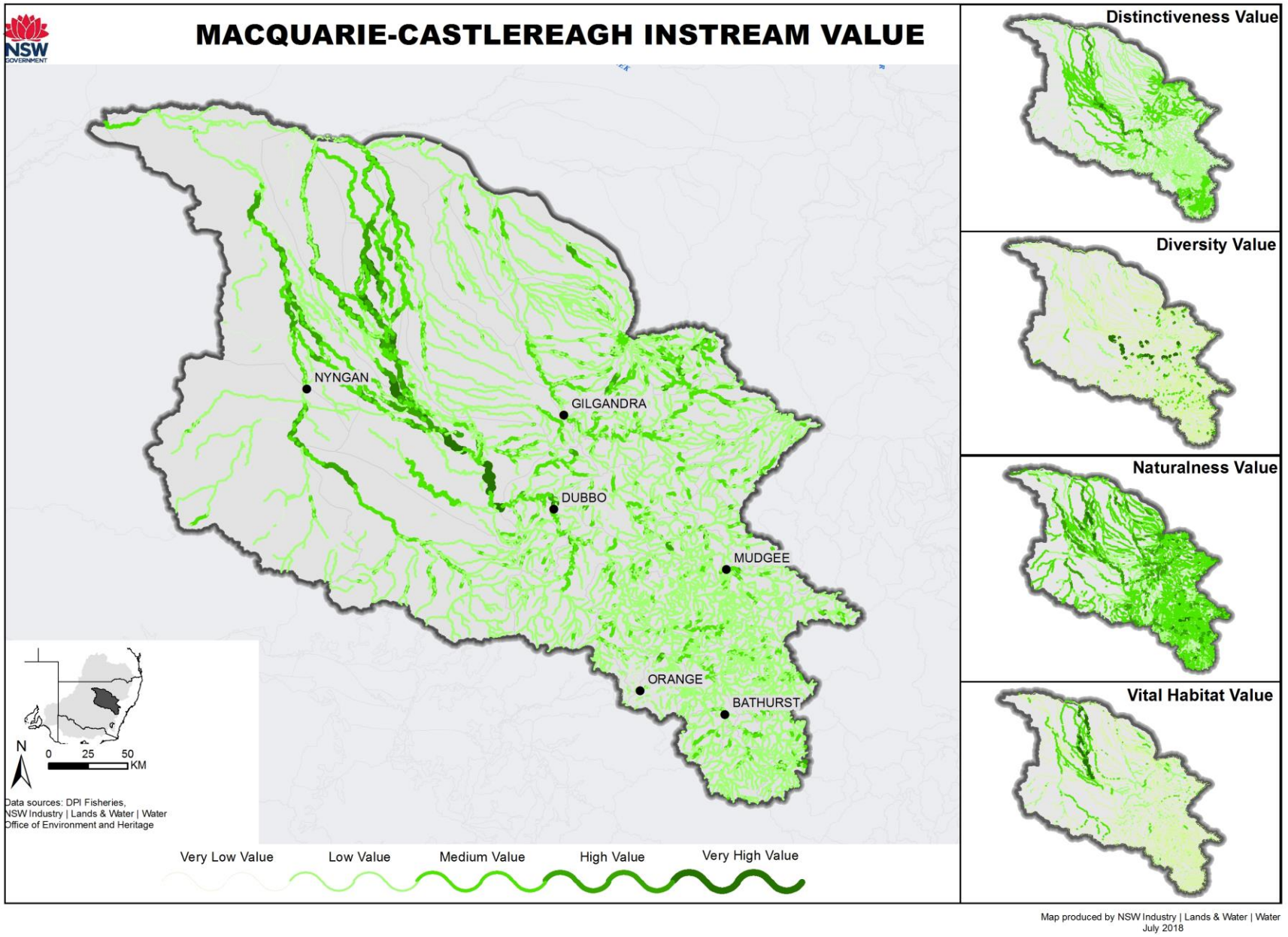


Figure 4-5. HEVAE scoring of in-stream values in the Macquarie-Castlereagh WRPA

4.3. Risks to water available for the environment and capacity to meet environmental water requirements [E(W)]

The regulation of river flows can impact on ecosystem functions and environmental assets through changes in the magnitude, frequency, duration and timing/seasonality of river flows, potentially leading to a loss or degradation of in-stream ecological values. In regulated systems, risks to the riverine environment can be due to insufficient water, particularly at the bottom end of a catchment, or too much water in circumstances where base flows or natural dry periods no longer occur. The channel and floodplain are functionally and ecologically inseparable with the hydrological connections between the main river channel and its floodplain controlled by the pattern of flow in the river. The regulation of flow, and extraction of water, may alter a river's hydrology to the extent that it cannot maintain its key ecosystem functions.

The extraction of unregulated flow can impact on ecosystem functions by reducing the magnitude of river flows and increasing the frequency and duration of zero flows. In some unregulated reaches, such as reaches downstream of regulated rivers or non-regulating dams, higher flows such as freshes can also be reduced.

The impact pathway is shown in Figure 4-6 and demonstrates that the threat of flow alteration is driven by licensed surface water extraction and river regulation. The likelihood is described as the extent of change to key flow components, while the consequence is assessed by considering the ecological assets and functions that would be impacted.

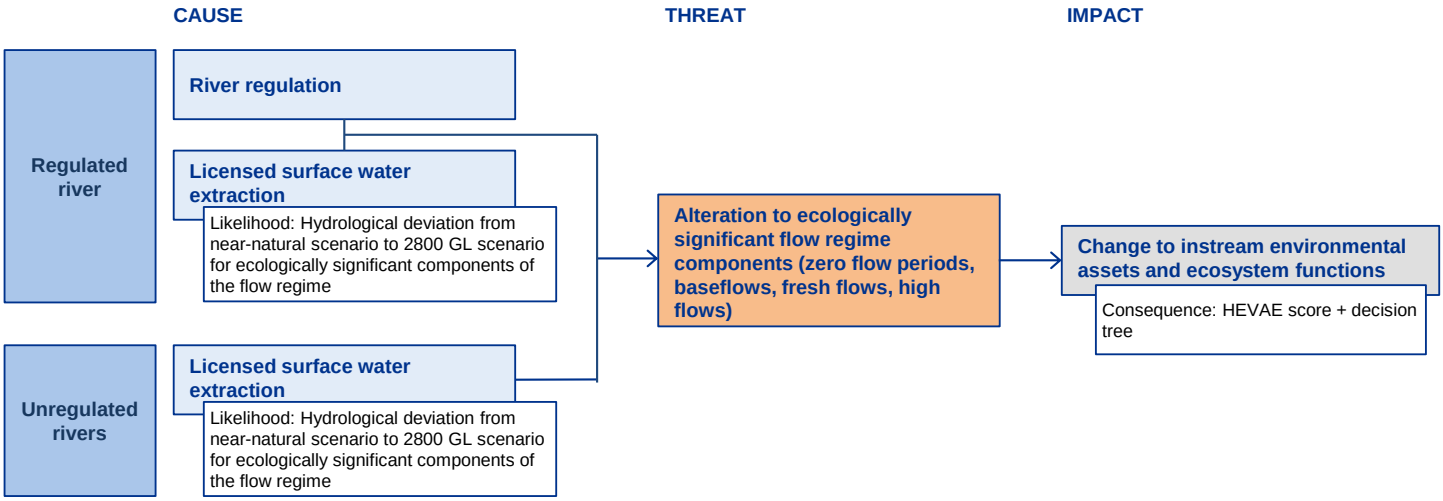


Figure 4-6. Impact pathway showing impact of river regulation and licensed extraction on water available for the environment

4.3.1. Determining the likelihood rating

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

This risk assessment process has identified key features of flow regimes which have impacts on key ecosystem functions and assets identified by the Murray–Darling Basin Authority (2010) and Alluvium (2010). These key flow components and their features are summarised below (Table 4-4).

Table 4-4. 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 (Z)	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.

Flow regime component	Key feature
Base flows (BF)	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 (F)	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 in-stream 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 (BKF and OB)	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 define and 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: (Chessman *et al.* 2006; Alluvium 2010; MDBA 2010; MDBA 2012a)	

Risks to ecosystem functions and environmental assets from not meeting environmental watering requirements are described by the extent of hydrological deviation from key flow regimes. All hydrological modelling was undertaken using IQQM software. IQQM is the principle modelling platform used in NSW and Queensland, and was also used by the MDBA (MDBA 2012a).

The hydrological alteration metrics used to assign a likelihood rating of impacting on the ecological assets and functions are the same as those used to prioritise flows for key ecological processes in the Basin Plan (MDBA 2012a).

Hydrological alteration metrics were chosen to reflect the key ecological features of flow regimes described in Table 4-4. These metrics indicate change to the following flow components:

- Zero flow periods (or cease to flow events) (Z)
- Base flows (BF)
- Freshes (F)
- High flows 1.5 year average recurrence interval (ARI) (BK1.5)
- High flows 2.5 year ARI (OB2.5)
- High flows 5.0 year ARI (OB5).

Differences in channel morphology along a river may mean that a high flow event could result in over bank flows on one reach but not others. The ARI events used in this risk assessment are therefore considered to be broadly indicative of a river section's likelihood. The specific ARI that might be needed, for instance, to inundate a particular wetland, will be addressed in the Long Term Water Plan (LTWP).

Under the Basin Plan, environmental watering requirements (EWRs) are the flow targets required to achieve ecological objectives for priority environmental assets (PEAs) and priority ecosystem functions (PEFs). EWRs are identified for PEAs and PEFs in the Macquarie-Castlereagh WRPA in the LTWP developed by OEH ((2018a) (Table 6)) and are based on seven flow components. Within each flow component, flow types have been assigned based on the timing, duration and frequency of flow required to support environmental assets and ecosystem functions.

This risk assessment was completed prior to EWRs being developed for the Macquarie-Castlereagh WRPA; therefore the ideal timing of EWRs was not an explicit consideration in the likelihood calculations discussed below. However, the likelihood assessment does identify the change in frequency, magnitude or duration of certain flow components, regardless of the seasonality. Therefore any changes to hydrology during the ideal LTWP timing periods have been identified.

The alignment between the EWRs identified in the LTWP and the flow components used in this risk assessment is provided in Table 4-5. Alignment of EWRs of the LTWP and flow components assessed in the Macquarie-Castlereagh WRPA risk assessment

Long Term Water Plan (OEH)[1]						**Macquarie-Castlereagh (NSW Department of In**	
Flow component 1	**EWR reference**	**Maximum inter-flow period**	**Ideal EWR**			**Flow component assessed (section 4.3)**	**How con**
			Timing	**Duration**	**Frequency**		
Cease-to-flow	CF	N/A	In line with natural	In line with natural, unless key refuges endangered.	No greater than natural	Zero flow (Z)	Metr likel com timi freq
Very-low flow	VF	No greater than natural	Any time	No less than natural	No less than natural	Base flow (BF)	Metr likel com low seas The equi (app
Base flow	BF1	As required during dry periods	Any time	No less than natural Maintain refuge habitat quantity and quality, and support connectivity	No less than natural	Base flow (BF)	Metr likel com low seas Like calc 80-9 perc desc sour
Base flow	BF2	2 years	September to March	In line with natural	5–10 in a 10 year period (1 every 1–2 years)	Fresh (F)	Metr likel com 20% seas capt flow

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh (NSW Department of In	
Flow component 1	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How con
			Timing	Duration	Frequency		
Small fresh	SF1	1 year	Ideally October to April, but can occur anytime	10 days minimum	Annual (1 per year)	Fresh/ARI 1.5 (F, BKF1.5)	Met likel duri 1.5 flow
Small fresh	SF2	2 years	September to April	14 days minimum	5-10 years in 10 (1 every 1-2 years)	Fresh/ARI 1.5 (F, BKF1.5)	Met likel com SF2
Small fresh	SF3	4 years	July to September for first flow and October to April for subsequent flow, (but either can occur any time)	14 days minimum	Initial flow: approximately 12-18 months following fish breeding event in Barwon Darling/ large fresh at Wilcannia. Follow up flow within 12 months of initial flow to allow further fish movement between the catchments	ARI 1.5 (BKF1.5)	Met likel com SF3
Large fresh	LF1	2 years	Ideally July to September but can occur anytime	5 days minimum	5-10 years in 10 (1 every 1-2 years)	ARI 1.5 (BKF1.5)	Met likel com LF1
Large Fresh	LF2	4 years	October to April	5 days minimum	3-5 years in 10 (1 every 2-3 years)	ARI 2.5 (BKF2.5)	Met likel com LF2
Over bank/ Wetland Small	OBWS1	18 Months	Anytime	In line with natural (no less than natural)	9-10 years in 10	Fresh/ARI 1.5 (F, BKF1.5)	Met likel duri 1.5 OBV
Over bank/ Wetland Small	OBWS2	4 years	October to April	10 days minimum	5 years in 10 (1 every 2 years)	ARI 1.5 (BKF 1.5)	Met likel com OBV
Over bank/ Wetland Small	OBWS3	5 years	Ideally Sept to Feb but can occur anytime	5 days minimum for fish dispersal In line with natural for riparian river red gum communities	2-3 years in 10 (1 every 3-5 years)	ARI 2.5 (OB2.5)	Met likel com OBV
Over bank/ Wetland Small	OBWS4 (Non-woody vegetation zone)	2 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	3-8 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration to fill the soil profile, depressions/ billabongs required.	8-10 years in 10	ARI 2.5 (OB2.5)	Met likel com OBV

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh (NSW Department of In	
Flow component 1	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How con
			Timing	Duration	Frequency		
Over bank/ Wetland Medium	OBWM (river red gum woodland zone)	4 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	3-6 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration to fill the soil profile, depressions/ billabongs required.	5 years in 10	ARI 5	Metr likel com OBV
Over bank/ Wetland Large	OBWL (Coolabah/ Black box zone)	5 years to 10 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	2-6 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration sufficient to fill the soil profile, depressions/ billabongs required.	2 to 3 years in 10	ARI 5	Metr likel com OBV

[1] Table 6,(OEH 2018a). Note that LTWP flow components do not provide definitions of percentiles or frequencies
[2] "Base flow" in the LTWP is not defined as a flow percentile or flow component, but rather a "base" flow required to provide minimum depth ar to support migratory fish.

below. This table demonstrates how regard was had to the EWRs for PEAs and PEFs in the preparation of the likelihood component of this risk assessment. As discussed in Section 4.2 above, there is also alignment between Schedules 8 and 9 of the Basin Plan and the assets and functions identified in the LTWP. Therefore the risks to the capacity to meet EWRs in the Macquarie-Castlereagh WRPA can be assessed and consideration given to strategies to manage these risks as required by Chapter 10 of the Basin Plan (see Section 8 of this report).

Table 4-5. Alignment of EWRs of the LTWP and flow components assessed in the Macquarie-Castlereagh WRPA risk assessment

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh WRPA risk assessment (NSW Department of Industry)	
Flow component[1]	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How this risk assessment considers the EWR
			Timing	Duration	Frequency		
Cease-to-flow	CF	N/A	In line with natural	In line with natural, unless key refuges endangered.	No greater than natural	Zero flow (Z)	Metrics used to calculate likelihood for the zero flow component identifies changes in timing, duration and ideal frequency
Very-low flow	VF	No greater than natural	Any time	No less than natural	No less than natural	Base flow (BF)	Metrics used to calculate likelihood of base flow components included identifying low flows during 'wet' and 'dry' seasons. The dry season calculation is equivalent to very low flows (approximately 90-95%ile)
Base flow	BF1	As required during dry periods	Any time	No less than natural Maintain refuge habitat quantity and quality, and support connectivity	No less than natural	Base flow (BF)	Metrics used to calculate likelihood of base flow components included identifying low flows during 'wet' and 'dry' seasons. Likelihoods were generally calculated on flows between the 80-95%ile, depending on which percentile most accurately described low flows in the water source.
Base flow	BF2	2 years	September to March	In line with natural	5–10 in a 10 year period (1 every 1–2 years)	Fresh (F)	Metrics used to calculate likelihood of fresh flow components included identifying 20%ile flows during 'wet' and 'dry' seasons and would capture alterations to the BF2 flows.
Small fresh	SF1	1 year	Ideally October to April, but can occur anytime	10 days minimum	Annual (1 per year)	Fresh/ARI 1.5 (F, BKF1.5)	Metrics used to calculate likelihood of fresh flow (20%ile during wet/dry periods) and ARI 1.5 would capture most of the SF1 flows.

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh WRPA risk assessment (NSW Department of Industry)	
Flow component[1]	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How this risk assessment considers the EWR
			Timing	Duration	Frequency		
Small fresh	SF2	2 years	September to April	14 days minimum	5-10 years in 10 (1 every 1-2 years)	Fresh/ARI 1.5 (F, BKF1.5)	Metrics used to calculate likelihood of ARI 1.5 flow component identifies changes to SF2.
Small fresh	SF3	4 years	July to September for first flow and October to April for subsequent flow, (but either can occur any time)	14 days minimum	Initial flow: approximately 12-18 months following fish breeding event in Barwon Darling/ large fresh at Wilcannia[1]. Follow up flow within 12 months of initial flow to allow further fish movement between the catchments	ARI 1.5 (BKF1.5)	Metrics used to calculate likelihood of ARI 1.5 flow component identifies changes to SF3.
Large fresh	LF1	2 years	Ideally July to September but can occur anytime	5 days minimum	5-10 years in 10 (1 every 1-2 years)	ARI 1.5 (BKF1.5)	Metrics used to calculate likelihood of ARI 1.5 flow component identifies changes to LF1.
Large Fresh	LF2	4 years	October to April	5 days minimum	3-5 years in 10 (1 every 2-3 years)	ARI 2.5 (BKF2.5)	Metrics used to calculate likelihood of ARI 2.5 flow component identifies changes to LF2.
Over bank/ Wetland Small	OBWS1	18 Months	Anytime	In line with natural (no less than natural)	9-10 years in 10	Fresh/ARI 1.5 (F, BKF1.5)	Metrics used to calculate likelihood of fresh flow (20%ile during wet/dry periods) and ARI 1.5 would capture most of the OBWS1 flows.

[1] Trigger is a demonstrated breeding event in the Barwon Darling with young of year. If there has been insufficient monitoring to confirm/deny this, the trigger is a large fresh at Wilcannia. Monitoring results noted in Stuart and Sharpe (2018) *Towards a Southern Connected Basin flow plan: Connecting rivers to recover native fish communities,* indicate that a flow of approximately 10,000 ML/day at Wilcannia coincides with breeding events for golden perch. The approximate 12-month delay following the breeding event is to allow recruits to reach sufficient maturity to move up into the Macquarie.

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh WRPA risk assessment (NSW Department of Industry)	
Flow component[1]	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How this risk assessment considers the EWR
			Timing	Duration	Frequency		
Over bank/ Wetland Small	OBWS2	4 years	October to April	10 days minimum	5 years in 10 (1 every 2 years)	ARI 1.5 (BKF 1.5)	Metrics used to calculate likelihood of ARI 1.5 flow component identifies changes to OBWS2.
Over bank/ Wetland Small	OBWS3	5 years	Ideally Sept to Feb but can occur anytime	5 days minimum for fish dispersal In line with natural for riparian river red gum communities	2-3 years in 10 (1 every 3-5 years)	ARI 2.5 (OB2.5)	Metrics used to calculate likelihood of ARI 2.5 flow component identifies changes to OBWS3.
Over bank/ Wetland Small	OBWS4 (Non-woody vegetation zone)	2 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	3-8 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration to fill the soil profile, depressions/ billabongs required.	8-10 years in 10	ARI 2.5 (OB2.5)	Metrics used to calculate likelihood of ARI 2.5 flow component identifies changes to OBWS4.
Over bank/ Wetland Medium	OBWM (river red gum woodland zone)	4 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	3-6 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration to fill the soil profile, depressions/ billabongs required.	5 years in 10	ARI 5	Metrics used to calculate likelihood of ARI 5 flow component identifies changes to OBWM.

Long Term Water Plan (OEH)[1]						Macquarie-Castlereagh WRPA risk assessment (NSW Department of Industry)	
Flow component[1]	EWR reference	Maximum inter-flow period	Ideal EWR			Flow component assessed (section 4.3)	How this risk assessment considers the EWR
			Timing	Duration	Frequency		
Over bank/ Wetland Large	OBWL (Coolabah/ Black box zone)	5 years to 10 years	August to March, with benefits also outside that period including by providing off-season bird foraging habitat	2-6 months for wetlands. Refers to the persistence of standing water, flow can be shorter. For streamside areas, only duration sufficient to fill the soil profile, depressions/ billabongs required.	2 to 3 years in 10	ARI 5	Metrics used to calculate likelihood of ARI 5 flow component identifies changes to OBWL.

[1] Table 6,(OEH 2018a). Note that LTWP flow components do not provide definitions of percentiles or frequencies

[2] "Base flow" in the LTWP is not defined as a flow percentile or flow component, but rather a "base" flow required to provide minimum depth and connectivity requirements to support migratory fish.

Regulated river water source

The MDBA modelled a 2800 gigalitre (GL) reduction target across the Basin (MDBA 2012a). Flow sequences were generated by the MDBA using NSW Department of Industry IQQM models. This modelling scenario modelled a 2800 GL/year reduction in consumptive water use across the Basin; this included 450 GL/yr recovery from the northern Basin. While an eventual Basin Plan recovery target was 2750 GL, the 2800 GL scenario is considered relevant as the change in the Condamine-Balonne valley had little impact on the environmental flow indicators downstream (MDBA 2012a).

The results published by the MDBA are the percentage change of the 2800 GL target scenario from a near-natural condition scenario; the latter is a modelled scenario approximating river flows without any dams, weirs or extraction (MDBA 2012b).

Likelihood category definitions are defined based on the extent of deviation from the near-natural condition (Table 4-6). Flow deviation can be positive (e.g. 125 %), which means more water is available for that particular flow component under the 2800 GL scenario than the near-natural condition; conversely a negative deviation (e.g. 75 %) means less water for that particular flow component.

Table 4-6. Likelihood metrics for risk of insufficient water available for the environment and risk to EWRs in the regulated Macquarie and Cudgegong Rivers

Likelihood metric	Metric category	Metric category definition
Flow Deviation (2800 GL target scenario compared to near-natural condition scenario (MDBA 2012b)	Low	< 20% departure from near-natural condition (+/-)
	Medium	20-50% departure from near-natural condition (+/-)
	High	> 50% departure from near-natural condition (+/-)
Reference: (Alluvium 2010); (VanLaarhoven and Van der Wielen 2009)		

Eight of the eleven MDBA hydrologic indicator sites were used to calculate likelihood results in the assessment of risk for the Macquarie Cudgegong regulated river (Table 4-7).

Table 4-7. Likelihood results for the Macquarie Cudgegong regulated rivers

Regulated river reach	Likelihood rating					
	Zero Flow Periods	Base-flow or Low Flows	Fresh Flows	High and Infrequent Flows		
				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Cudgegong River at Rocky Water Hole	H+	H+	H+	H-	H-	H-
Cudgegong River at Yamble Bridge	H+	H+	M-	M-	L-	L-
Macquarie River downstream Burrendong Dam	H-	H+	H+	H-	H-	H-
Macquarie River at Geurie	L^0	H+	H+	H-	H-	H-
Macquarie River at Dubbo	L^0	H+	H+	H-	H-	M-
Macquarie River at Narromine	H-	H+	H+	H-	H-	M-
Macquarie River at Gin Gin	H-	H+	H+	H-	H-	M-
Macquarie River at Warren Weir	H+	H+	H+	M-	L-	L-
Macquarie River downstream Marebone Weir	H+	H-	H+	L-	L-	L^0
Macquarie River at Oxley Station	H-	H-	H+	L-	L-	L-
Gunningbah Creek below regulator	H-	H-	H-	H-	H-	H-

Regulated river reach	Likelihood rating					
	Zero Flow Periods	Base-flow or Low Flows	Fresh Flows	High and Infrequent Flows		
				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Gunningbah Creek downstream Gunningbah Weir	H-	H+	H-	H-	H-	H-
Duck Creek at Offtake	H-	H+	H-	H-	H-	H-
Crooked Creek at Profile	H-	H+	H-	H-	H-	H-
Duck Creek upstream Bogan River junction	H-	H+	H-	H-	H-	H-
Bulgeraga Creek at Pillicawarrina	H+	H-	H+	L-	L-	L-
Key: L = low; M = medium; H = high; N/A = no hydrological data available + increase from near-natural condition; – decrease from near natural condition; ^{0} no change from near-natural condition Reference: (MDBA 2012b)						

Unregulated water sources

For the majority of unregulated water sources, single reach IQQM models were used to derive flow sequences. Extraction at full development of unregulated entitlement was assumed to simulate flow sequences to compare against the near-natural condition scenario (as defined above). Where appropriate, unregulated flow gauges were also used for single reach models in adjacent water sources if a suitable gauge was not available.

MDBA modelling was generally not used in the unregulated rivers as it is not representative of the hydrology at the water source scale. However, in some locations, the hydrologic alteration metrics for the regulated river could be used for higher flow metrics. An example is the unregulated effluent rivers associated with high flows in the regulated river or unregulated reaches directly downstream of regulated rivers. Therefore, MDBA modelling was used for four unregulated water sources (Figure 4-3).

Similar to regulated systems, likelihood category definitions are defined based on the extent of deviation from the near-natural condition (Table 4-8).

Table 4-8. Likelihood metrics for risk of insufficient water available for the environment and risk to EWRs in unregulated water sources in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition
Flow Deviation (full development of unregulated entitlement compared to near-natural condition scenario)	Low	< 20% departure from near-natural condition (+/-)
	Medium	20-50% departure from near-natural condition (+/-)
	High	> 50% departure from near-natural condition (+/-)
Reference: (Alluvium 2010); (VanLaarhoven and Van der Wielen 2009)		

The likelihood results for the unregulated Macquarie Bogan and Castlereagh water sources are shown in Table 4-9.

Table 4-9. Likelihood results for unregulated water sources in the Macquarie-Castlereagh WRPA

Unregulated water source	Likelihood rating					
	Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows		
				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Backwater-Boggy Cowal				H-	H-	M-
Bell River	H+	H-	L-	L^0	L^0	L^0
Bulbodney-Grahway Creek system	L+	H-	L-	L^0	L^0	L^0
Burrendong Dam Storage Tributaries	H+	H-	L-	L^0	L^0	L^0
Campbells River	H+	H-	L-	L^0	L^0	L^0
Coolbaggie Creek system	L^0	H-	L-	L^0	L^0	L^0
Cooyal Wialdra Creek System	H+	H-	H-	L-	L-	L-
Ewenmar Creek system				H-	H-	M-
Fish River	H-	M-	H-	H-	M-	M-
Goolma Creek	L^0	L^0	L^0	L^0	L^0	L^0
Lawson's Creek	H+	H-	L-	L^0	L^0	L^0
Little River	M+	H-	L-	L^0	L^0	L^0
Lower Bogan River	H-	H+	M-	M-	H-	M-
Lower Macquarie River	H-	M-	M-	H-	M-	M-
Lower Talbragar River	H+	H-	L-	L^0	L^0	L^0
Macquarie River above Burrendong	H+	H-	L-	L-	L-	L-
Marra Creek system	L+	H+	H+	H-	H-	M-
Marthaguy Creek	M+	H+	H+	M-	M-	L-
Maryvale-Geurie	L+	H-	L-	L^0	L^0	L^0
Molong Creek and tributaries	H+	H-	M-	L-	L-	L-
Piambong Creek	H+	H-	L-	L^0	L^0	L^0
Pipeclay Creek	H+	H-	L-	L-	L^0	L^0
Queen Charlottes Vale Creek/Evans Plains Creek	H+	H-	L-	L-	L-	L^0
Summerhill Creek	H+	H-	M-	L^0	L^0	L^0
Turon/Crudine	H+	M-	L-	L^0	L^0	L^0
Upper Bogan catchment	H+	H-	H-	M-	M-	M-
Upper Cudgegong River above Windamere	H+	H-	M-	M-	M-	M-
Upper Talbragar/Goolaburra-Gundy River	H+	M-	L-	L^0	L^0	L^0
Wambangalong Whylandra System	L+	L^0	L^0	L^0	L^0	L^0
Winburndale Rivulet	H+	H-	L-	L-	L^0	L^0
Castlereagh River Binnaway-Gilgandra	H+	H-	L-	L^0	L^0	L^0
Castlereagh River above Binnaway	L0	M-	L-	L^0	L^0	L^0

Unregulated water source	Likelihood rating					
	Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows		
				OB 1.5 ARI	OB 2.5 ARI	OB 5.0 ARI
Castlereagh River below Coonamble	H+	H-	L-	L-	L-	L-
Castlereagh River Gilgandra-Coonamble	H+	H-	L-	L-	L-	L-
Nedgera Creek System	L^0	L^0	L^0	L^0	L^0	L^0
Teridgerie Creek System	L+	L^0	L^0	L^0	L^0	L^0
Tooraweenah Gulargambone Tributaries	L+	L^0	L^0	L^0	L^0	L^0
Key: L = low; M = medium; H = high; N/A = no data available $^+$ increase from near-natural condition; $^-$ decrease from near-natural condition; ^{0} no change from near-natural condition A Cease to Pump (CtP) was included in the modelling scenario.						
Reference: (MDBA 2012b)						

4.3.2. Existing water management actions and mechanisms

The *Water Management Act 2000* requires that the sharing of water must protect the water source and its dependent ecosystems, and that water sharing plans establish specific rules that protect water for the environment. There are a range of existing management actions and mechanisms that are in place to protect environmental requirements in the Macquarie-Castlereagh WRPA. These mechanisms are provided for under the *Water Management Act 2000* and through specific rules within the regulated and unregulated water sharing plans.

The *Water Sharing Plan for the Macquarie Cudgegong Regulated River Water Source 2016* has the following actions and mechanisms to provide water for the environment:

- Reserve all water above the long term average annual extraction limit for planned environmental water.
- Flow triggers prior to announcement of supplementary water access by users. This protects important rises in the water level and natural flow variability, preserves a portion of natural tributary flows for river health and helps maintain wetland and floodplain inundation.
- An environmental water allowance of up to 160 GL/yr in Burrendong Dam to improve environmental outcomes in the Macquarie Marshes and the Macquarie river between Burrendong Dam and the Macquarie Marshes. This allowance is made up of both a translucency and active component.
- A translucent environmental water allowance of up to 10000 ML/yr is reserved in Windamere Dam which is released for the environmental benefit of the Cudgegong River once certain triggers are met
- To provide for specified replenishment flows that refill pools or waterholes in effluent systems downstream of a water source and provide water for stock and domestic purposes.
- The Minister can specify rules relating to the rates of change to releases from water storages to minimise environmental and geomorphological impacts.
- Adjust available water determinations to ensure compliance with the long term average annual extraction limit.
- The plan also provides for licensed water to be committed for adaptive environmental water purposes.

The *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* and the *Water Sharing Plan for the Castlereagh Unregulated and Alluvial Water Sources 2011* have the following actions and mechanisms to provide water for the environment:

- Reserve all water above the long term average annual extraction limit for planned environmental water.
- Cease to pump rules, commence to pump rules and flow rates/levels provide protection during dry times. Aquifer access licences that extract groundwater that is highly connected to the unregulated surface water may also have a cease to pump rule applied.
- Rules for granting and amending water supply works approvals are established for groundwater sources to provide protection for environmental assets. This provides protection for base flows and key assets such as groundwater-dependent ecosystems (GDEs). These rules stipulate buffer distances from which new bores can be placed from specific features such as GDEs, neighbouring bores and contaminated sites, as well as rules for existing bores.
- Restrictions on trade to protect areas of high ecological value.
- Restrictions on in-river and off-river pools when the volume of that water is less than the full capacity of the pool.

The 2800 GL scenario modelling (MDBA 2012a) included a water recovery volume in the Macquarie of 84 GL/yr (average long term use). This volume represents a reduction in diversions with 65 GL/y being the estimated need for in-valley environmental water requirements and 19 GL/y as assumed contribution towards the northern basin shared component.

4.3.3. Risk outcomes

The risk matrix used to determine the risk to environmental water for ecological functions and assets due to licensed surface water extraction and river regulation (in the regulated water source only) is provided in Table 4-10.

Table 4-10. Risk matrix to determine risk outcomes of insufficient water for the environment and capacity to meet EWRs

		Likelihood (of hydrological alternation)		
		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

Regulated river water source

Combining the risk consequence and likelihood ratings (Table 4-2 and Table 4-7) for the Macquarie Cudgegong regulated river results in the overall risk levels to ecological assets and functions as shown in Table 4-11. Overall, there were high and medium risks across all flow components (i.e. zero flow, base flows, fresh flows and each ARI).

The flow regime of the Macquarie and Cudgegong Rivers has been substantially altered by the construction of Burrendong and Windamere Dams, respectively. Downstream of Burrendong Dam there are also five weirs that regulate the diversion of water within the Lower Macquarie River. Dubbo, Narromine and Gin Gin weirs are all ponding structures that provide pumping pools for irrigation diversion. Warren Weir controls the diversion of flow into Gunningbah Creek from which further regulators supply Duck Creek, Crooked Creek and the Albert Priest Canal. Marebone Weir is located just upstream of the Macquarie Marshes. It supplies water to Marra Creek on the southern side of the river, and Bulgeraga Creek (via Marebone Break) on the northern side of the river.

Downstream of Burrendong Dam, the combination of very high values of consequence, along with significant flow alterations (likelihood), were a contributing factor in influencing the high and medium risk categories throughout the regulated river. In particular, the regulated Macquarie River between Dubbo and Warren and at Oxley Station, together with Crooked and Bulgeraga Creeks, had very high consequence coupled with medium-high likelihood metrics for each of the flow components. The impact of regulation has generally been a decrease in the frequency and magnitude of larger flow events in the Macquarie River downstream to Warren and also in Gunningbah, Duck and Crooked Creeks.

Immediately downstream of Windamere Dam the Cudgegong River had high consequence and high flow alteration resulting in high risk but this mediated somewhat in the downstream reach where medium and low risks were evident for the medium to high flows respectively as the influence of the dam on higher flows becomes less pronounced with larger tributary inputs.

Unregulated water sources

Combining the risk consequence and likelihood ratings (Table 4-8 and Table 4-9) for the Macquarie Bogan and Castlereagh unregulated water sources results in the overall risk levels to ecological assets and functions as shown in Table 4-12.

In the upland zone the Fish River has high values due to the presence of several species of threatened frogs and the Castlereagh River above Binnaway has very high value due to threatened fish.

In the midland zone, Coolbaggie Creek has high values due to the presence of endangered ecological communities and threatened fish.

For thee lowland zones, the Upper Bogan, the Lower Bogan River, Bulbodney-Grahway Creek, Backwater-Boggy Cowel, Ewenmar Creek, Marra Creek, Lower Macquarie River and Marthaguy Creek all have high or very high values due to the presence of endangered ecological communities and threatened fish; and Lower Macquarie River also rates very high due to its proximity to Ramsar wetlands

The majority of water sources in the mid to upper Macquarie, with the exception of the Fish River, had low risk outcomes for higher flows. However many sites were in the medium or high risk category for zero and base flows. In the lower Macquarie water sources, particularly those associated with effluent streams, high and medium risks were identified in the higher flow metrics as well as in the low flow metrics.

The Fish River has high risk for zero and fresh flows and smaller overbank flows with medium risk in other flow categories. The Lower Macquarie River, Mara Creek, Marthaguy Creek also had high to medium risks for most flows. Both Backwater Boggy Cowal and Ewenmar Creek could not be assessed for lower flows but were of medium-high risk for all higher flows.

Upper Talbragar River was at high risk during zero flow periods and medium risk during baseflow. Bulbodney Grahway, Coolbaggie Creeks and Little River had high risk during base flows but low risk for all other flows. Lower Talbragar River, Macquarie River above Burrendong, Molong Creek, Upper Cudgegong River, Bell River, Burrendong Dam tributaries, Campbells Creek, Winburndale Rivulet as well as the Castlereagh from Binnaway to Coonamble had medium-high levels of risk for zero and baseflows.

Goolma Creek, Wambangalong/Whylandra, Nedgera Creek Teridgerie Creek System and Tooraweenah Gulargambone Tributaries were the unregulated river water sources which did not register a medium or high risk for any flow category.

Table 4-11. Risk of insufficient water for the environment and capacity to meet EWRs in the regulated Macquarie and Cudgegong Rivers [E(W)]

Regulated river reach	Consequence	Likelihood						Overall risk rating - E(W)					
		Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Base-flow 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
Cudgegong River at Rocky Water Hole	H	H+	H+	H+	H-	H-	H-	H	H	H	H	H	H
Cudgegong River at Yamble Bridge	M	H+	H+	M-	M-	L-	L-	H	H	M	M	L	L
Macquarie River downstream Burrendong Dam	M	H-	H+	H+	H-	H-	H-	H	H	H	H	H	H
Macquarie River at Geurie	M	L^{0}	H+	H+	H-	H-	H-	L	H	H	H	H	H
Macquarie River at Dubbo	VH	L^{0}	H+	H+	H-	H-	M-	M	H	H	H	H	H
Macquarie River at Narromine	VH	H-	H+	H+	H-	H-	M-	H	H	H	H	H	H
Macquarie River at Gin Gin	VH	H-	H+	H+	H-	H-	M-	H	H	H	H	H	H
Macquarie River at Warren Weir	VH	H+	H+	H+	M-	L-	L-	H	H	H	H	M	M
Macquarie River downstream Marebone Weir	M	H+	H-	H+	L-	L-	L^{0}	H	H	H	L	L	L
Macquarie River at Oxley Station	VH	H-	H-	H+	L-	L-	L-	H	H	H	M	M	M
Gunningbah Creek below regulator	H	H-	H-	H-	H-	H-	H-	H	H	H	H	H	H
Gunningbah Creek downstream Gunningbah Weir	H	H-	H+	H-	H-	H-	H-	H	H	H	H	H	H
Duck Creek at Offtake	L	H-	H+	H-	H-	H-	H-	M	M	M	M	M	M

Regulated river reach	Consequence	Likelihood						Overall risk rating - E(W)					
		Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Base-flow 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
Crooked Creek at Profile	VH	H-	H+	H-	H-	H-	H-	H	H	H	H	H	H
Duck Creek upstream Bogan River junction	M	H-	H+	H-	H-	H-	H-	H	H	H	H	H	H
Bulgeraga Creek at Pillicawarrina	VH	H+	H-	H+	L-	L-	L-	H	H	H	M	M	M

Key: L = Low; M = Medium; H = High; N/A = no hydrological data available

$^{+}$ increase from near natural condition ; $^{-}$ decrease from near-natural condition; ^{0} no change from near-natural condition

Table 4-12. Risk of insufficient water for the environment and capacity to meet EWRs in the unregulated water sources of the Macquarie-Castlereagh WRPA [E(W)]

Unregulated water source	Consequence	Likelihood						Overall risk rating - E(W)					
		Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Base-flow 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
Backwater-Boggy Cowal	M				H-	H-	M-				H	H	M
Bell River	L	H+	H-	L-	L°	L°	L°	M	M	L	L	L	L
Bulbodney-Grahway Creek system	H	L+	H-	L-	L°	L°	L°	L	H	L	L	L	L
Burrendong Dam Storage Tributaries	M	H+	H-	L-	L°	L°	L°	H	H	L	L	L	L
Campbells River	M	H+	H-	L-	L°	L°	L°	H	H	L	L	L	L
Coolbaggie Creek system	H	L°	H-	L-	L°	L°	L°	L	H	L	L	L	L
Cooyal Wialdra Creek System	L	H+	H-	H-	L-	L-	L-	M	M	M	L	L	L
Ewenmar Creek system	H				H-	H-	M-				H	H	M
Fish River	H	H-	M-	H-	H-	M-	M-	H	M	H	H	M	M
Goolma Creek	L	L°	L°	L°	L°	L°	L°	L	L	L	L	L	L
Lawson's Creek	L	H+	H-	L-	L°	L°	L°	M	M	L	L	L	L
Little River	H	M+	H-	L-	L°	L°	L°	M	H	L	L	L	L
Lower Bogan River	H	H-	H+	M-	M-	H-	M-	H	H	M	M	H	M
Lower Macquarie River	VH	H-	M-	M-	H-	M-	M-	H	H	H	H	H	H
Lower Talbragar River	M	H+	H-	L-	L°	L°	L°	H	H	L	L	L	L
Macquarie River above Burrendong	M	H+	H-	L-	L-	L-	L-	H	H	L	L	L	L
Marra Creek system	M	L+	H+	H+	H-	H-	M-	L	H	H	H	H	M
Marthaguy Creek	H	M+	H+	H+	M-	M-	L-	M	H	H	M	M	L

Unregulated water source	Consequence	Likelihood						Overall risk rating - E(W)					
		Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Base-flow 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
Maryvale-Geurie	L	L+	H-	L-	L°	L°	L°	L	M	L	L	L	L
Molong Creek and tributaries	L	H+	H-	M-	L-	L-	L-	M	M	L	L	L	L
Piambong Creek	L	H+	H-	L-	L°	L°	L°	M	M	L	L	L	L
Pipeclay Creek	L	H+	H-	L-	L-	L°	L°	M	M	L	L	L	L
Queen Charlottes Vale Creek/Evans Plains Creek	M	H+	H-	L-	L-	L-	L°	H	H	L	L	L	L
Summerhill Creek	L	H+	H-	M-	L°	L°	L°	M	M	L	L	L	L
Turon/Crudine	M	H+	M-	L-	L°	L°	L°	H	M	L	L	L	L
Upper Bogan catchment	M	H+	H-	H-	M-	M-	M-	H	H	H	M	M	M
Upper Cudgegong River above Windamere	M	H+	H-	M-	M-	M-	M-	H	H	M	M	M	M
Upper Talbragar/Goolaburra-Gundy River	M	H+	M-	L-	L°	L°	L°	H	M	L	L	L	L
Wambangalong Whylandra System	H	L+	L°	L°	L°	L°	L°	L	L	L	L	L	L
Winburndale Rivulet	M	H+	H-	L-	L-	L°	L°	H	H	L	L	L	L
Castlereagh River Binnaway-Gilgandra	L	H+	H-	L-	L°	L°	L°	M	M	L	L	L	L
Castlereagh River above Binnaway	VH	L°	M-	L-	L°	L°	L°	M	H	M	M	M	M
Castlereagh River below Coonamble	L	H+	H-	L-	L-	L-	L-	M	M	L	L	L	L
Castlereagh River Gilgandra-Coonamble	L	H+	H-	L-	L-	L-	L-	M	M	L	L	L	L

Unregulated water source	Consequence	Likelihood						Overall risk rating - E(W)					
		Zero flow periods	Base-flow or low flows	Fresh flows	High and infrequent flows			Zero flow periods	Base-flow 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
Nedgera Creek System	L	L°	L°	L°	L°	L°	L°	L	L	L	L	L	L
Teridgerie Creek System	M	L+	L°	L°	L°	L°	L°	L	L	L	L	L	L
Tooraweenah Gulargambone Tributaries	L	L+	L°	L°	L°	L°	L°	L	L	L	L	L	L

Key: L = Low; M = Medium; H = High; ; N/A = no hydrological data available

$^{+}$ increase near-natural condition; $^{-}$ decrease near-natural condition; ^{0} no change from near-natural condition

N/A no risk outcome or modelling available due to lack of data

4.4. Risks to water available for the environment from extraction under basic landholder rights [E(BLR)]

All landholders in NSW have rights to access water for some basic purposes. There are three types of basic landholder rights (BLR) in NSW under the *Water Management Act 2000*:

- Native title rights: holders of native title with respect to water, as determined under the Commonwealth *Native Title Act 1993*, can take and use water for a range of personal, domestic and non-commercial purposes.

  There are currently no native title rights to water in NSW; however, these rights may be activated during the term of a WSP

- Domestic and stock rights: owners or occupiers of land which has river, estuary or lake frontage can take water without a licence for domestic (household) purposes or to water stock

- Harvestable rights (dams): harvestable right water allows landholders in most rural areas to collect a proportion of BLR runoff on their property and store it in one or more farm dams up to a certain size

  Note that any volume of water that exceeds the maximum harvestable right dam capacity must be licensed; any dam which exceeds the maximum harvestable right dam capacity is subject to a works approval. The requirements of harvestable rights have been inherently considered as the design of access rules is also based on river flows that result after harvestable rights extractions have occurred (NOW 2011a).

In both regulated and unregulated water sources, the principles of the WM Act require that water sharing must protect BLR. Water requirements for BLR are identified in water sharing plans and have been taken into consideration when designing rules for licensed water extractions (NOW 2011a). Access rules for water access licences (such as cease to pump rules) do not apply to BLR users and provides them with a higher level priority of water access. Impacts to the environment due to farm dams are discussed in Section 4.5.1.

In some areas, basic right use is a significant proportion of flow and therefore contributes to hydrological stress. Increased extraction of surface water under BLR in unregulated water sources may reduce the water available for the environment, as shown in the impact pathway in Figure 4-7. The likelihood is described by the ratio of low flow to the estimated BLR within each water source, while the consequence is assessed by considering the ecological assets and functions that would be impacted.

Figure 4-7. Impact pathway showing risk of growth in BLR reducing water available for the environment

This risk is not applicable in regulated systems where the system is managed in such a way to maintain supply of BLR water requirements. Sufficient reserves of water are set aside and held in storage to ensure supply of domestic and stock rights and native title rights.

4.4.1. Determining the likelihood rating

The likelihood of growth in BLR causing a reduction in water available for the environment is described by the ratio of the following two metrics:

- Daily 80th percentile flow (of full development of unregulated entitlement)
- Daily BLR extraction.

This ratio was calculated for each water source and is based on the rationale that where the 80th percentile flow is high and the daily BLR take is low, then the likelihood is low. Alternatively, where the 80th percentile flow is low when compared to the daily extraction of BLR, the likelihood is high. If the 80th percentile flow is zero (i.e. an intermittent stream), then a high likelihood is also assigned.

The 80th percentile flows were calculated from recorded flows in each water source and were those used for the macro-planning process. The 80th percentile was selected as it is generally considered to represent the low flow portion.

The BLR volume was estimated using the same method developed for the macro planning process. This method calculated the annual stock use based on potential grazing areas within a water source (including unimproved and improved irrigated grazing land) and stock water allowances. Rural domestic use was also estimated using data from the Australian Bureau of Statistics population and housing census data and assumed domestic water consumption for rural lots.

Likelihood category definitions are defined by the ratios identified in Table 4-13. The likelihood results for water sources in the unregulated Macquarie-Castlereagh system are shown in Table 4-14.

Table 4-13. Likelihood metrics for risk of growth in BLR in unregulated water sources

Likelihood metric	Metric category	Metric category definition
Ratio of daily 80th percentile flow to estimated daily BLR extraction	Low	Daily 80th percentile: daily BLR extraction >2 i.e. extraction is less than 50% of the 80th percentile flow
	Medium	Daily 80th percentile: daily BLR extraction between 1.01 - 2 i.e. extraction is 50% - 99% of the 80th percentile flow
	High	Daily 80th percentile: daily BLR extraction <1 i.e. extraction is equal to 100% or more of 80th percentile flow Intermittent streams (80th percentile flow is zero)

Table 4-14. Likelihood results for risk of growth in BLR for unregulated water sources in the Macquarie-Castlereagh WRPA

Unregulated water source	Likelihood rating
Backwater-Boggy Cowal	N/A
Bell River	Low
Bulbodney-Grahway Creek system	High
Burrendong Dam Storage Tributaries	High
Campbells River	Low
Coolbaggie Creek system	High
Cooyal Wialdra Creek System	High
Ewenmar Creek system	N/A
Fish River	Low
Goolma Creek	High
Lawson's Creek	High
Little River	High
Lower Bogan River	N/A
Lower Macquarie River	N/A
Lower Talbragar River	High

Unregulated water source	Likelihood rating
Macquarie River above Burrendong	Low
Marra Creek system	N/A
Marthaguy Creek	High
Maryvale-Geurie	High
Molong Creek and tributaries	Low
Piambong Creek	High
Pipeclay Creek	High
Queen Charlottes Vale Creek/Evans Plains Creek	Low
Summerhill Creek	Low
Turon/Crudine	Low
Upper Bogan catchment	High
Upper Cudgegong River above Windamere	Low
Upper Talbragar/Goolaburra-Gundy River	Low
Wambangalong Whylandra System	High
Winburndale Rivulet	Low
Castlereagh River Binnaway Gilgandra	High
Castlereagh River above Binnaway	Low
Castlereagh River Gilgandra-Coonamble	N/A
Tooraweenah Gulargambone Tributaries	High
Teridgerie Creek System	N/A
Nedgera Creek System	N/A
Castlereagh River below Coonamble	High
N/A = Risk could not be calculated because hydrological data was unavailable or unsuitable for this analysis	

4.4.2. Existing water management actions and mechanisms

Under the *Water Management Act 2000*, BLR are made up of domestic and stock rights, harvestable rights and native title rights. Water sharing plans recognise basic landholder rights in their respective water sources. Water may be extracted under these rights without the need for a water access licence, although in the case of accessing groundwater under a domestic and stock right, the bore must still be approved by the Department. The water sharing plan cannot limit or restrict these rights, but the Act itself provides for restrictions on BLR through the development of mandatory guidelines. Additionally, during periods of water shortage, domestic and stock users may be required, by Ministerial Order, to restrict usage to essential purposes.

The proliferation of new domestic and stock rights through the subdivision of land will be managed through a further regulation to the *Water Management Act 2000*. This regulation, made under section 52(2) of the Act, will limit the growth in basic landholder rights when a landholding is subdivided. Effectively this will mean that the reasonable use for the pre-subdivision landholding will be 'frozen' and the vendor will have to apportion this reasonable use limit between the proposed lots in the subdivision. Although still in development, it is intended that such limitations will be applied only to rivers and aquifers that could be subject to high hydrologic stress or high in-stream risk.

Additionally, the water supply system is managed to ensure sufficient water is set aside to supply basic landholder rights while maintaining compliance with the long term average annual extraction limit (LTAAEL). If

extractions are determined to be exceeding the LTAAEL, water use will be reduced until compliance with the LTAAEL occurs. This provides for the protection of planned environmental water above the extraction limit.

4.4.3. Risk outcomes

The risk matrix used to determine the risk of BLR extraction impacting the availability of water to the environment in the unregulated water sources in the Macquarie-Castlereagh WRPA is provided in Table 4-15.

Table 4-15. Risk matrix to determine risk outcomes of increased BLR extraction impacting on water available for the environment

		Likelihood (low flow against BLR extraction)		
		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

Combining the risk consequence and likelihood ratings (Table 4-2 and Table 4-14) for the Macquarie Bogan and Castlereagh unregulated water sources results in the overall risk levels to ecological assets and functions as shown in **Error! Reference source not found.**. Overall, eight water sources had a high risk, ten water sources had a medium risk, and eleven water sources had a low risk due to extraction by BLR. Eight water sources had insufficient data to calculate a likelihood score therefore a risk score could not be calculated.

Table 4-16. Risk of increased BLR extraction impacting on water available for the environment in the unregulated water sources of the Macquarie-Castlereagh WRPA [E(BLR)]

Risk factor/source	Consequence	Likelihood	Overall risk rating - E(BLR)
Backwater-Boggy Cowal	Medium	N/A	N/A
Bell River	Low	Low	Low
Bulbodney-Grahway Creek system	High	High	High
Burrendong Dam Storage Tributaries	Medium	High	High
Campbells River	Medium	Low	Low
Coolbaggie Creek system	High	High	High
Cooyal Wialdra Creek System	Low	High	Medium
Ewenmar Creek system	High	N/A	N/A
Fish River	High	Low	Low
Goolma Creek	Low	High	Medium
Lawson's Creek	Low	High	Medium
Little River	High	High	High
Lower Bogan River	High	N/A	N/A
Lower Macquarie River	Very High	N/A	N/A
Lower Talbragar River	Medium	High	High
Macquarie River above Burrendong	Medium	Low	Low
Marra Creek system	Very High	N/A	N/A

Risk factor/source	Consequence	Likelihood	Overall risk rating - E(BLR)
Marthaguy Creek	High	High	High
Maryvale-Geurie	Low	High	Medium
Molong Creek & Tributaries	Low	Low	Low
Piambong Creek	Low	High	Medium
Pipeclay Creek	Low	High	Medium
Queen Charlottes Vale Creek/Evans Plains Creek	Medium	Low	Low
Summerhill Creek	Low	Low	Low
Turon/Crudine	Medium	Low	Low
Upper Bogan catchment	Medium	High	High
Upper Cudgegong River above Windamere	Medium	Low	Low
Upper Talbragar/Goolaburra-Gundy River	Medium	Low	Low
Wambangalong Whylandra System	High	High	High
Winburndale Rivulet	Medium	Low	Low
Castlereagh River Binnaway-Gilgandra	Low	High	Medium
Castlereagh River above Binnaway	Very High	Low	Medium
Castlereagh River below Coonamble	Low	N/A	N/A
Castlereagh River Gilgandra-Coonamble	Low	High	Medium
Nedgera Creek System	Low	N/A	N/A
Teridgerie Creek System	Medium	N/A	N/A
Tooraweenah Gulargambone Tributaries	Low	High	Medium

Key: L = Low; M = Medium; H = High

* N/A Risk could not be calculated because hydrological data was unavailable or unsuitable for this analysis.

4.5. Risk to water available for the environment from interception activities [E(I-FD), E(I-PF)]

Interception activities can impact on environmental assets and ecosystem functions by altering the hydrology of a system.

The National Water Commission (NWC) defined interception as occurring when flows of surface water or groundwater are stopped, reduced or redirected (SKM *et al.* 2010). This definition excludes precipitation and focuses solely on changes to runoff and recharge. This is further expanded by NWC to imply that interception activities, for the purpose of water management, are human-induced activities that intercept significant volumes of water and therefore decrease the amount of water reaching surface water and groundwater bodies.

Chapter 10 Part 5 of the Basin Plan identifies the following interception activities which may have the potential to impact on the water resources of a WRPA:

- Interception by runoff dams
- Interception by commercial plantations
- Interception by mining activities, including coal seam gas mining
- Interception by floodplain harvesting.

The impact pathways shown in Figure 4-8 demonstrate that the threat of flow alteration driven by the interception activities identified in the Basin Plan can impact on water available for the environment. The key threat is the interception of water that would otherwise reach a water course, thereby reducing the water available for the environment.

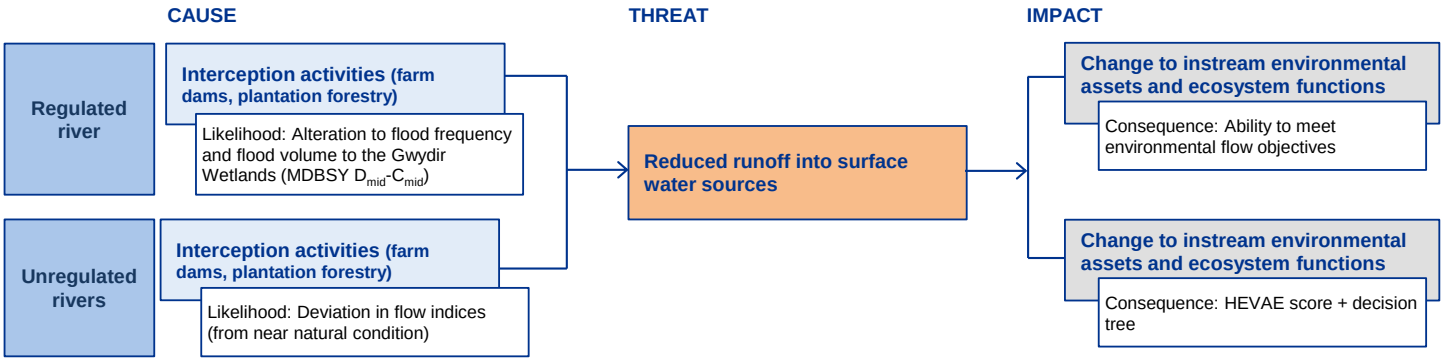


Figure 4-8. Impact pathway showing impact of interception activities on ecological functions and assets

For the purpose of risk due to interception in the risk assessment, NSW utilised results published in the CSIRO Murray–Darling Basin Sustainable Yields (MDBSY) project (CSIRO 2008a; CSIRO 2008b) and model outputs that contributed to the MDBSY project. Comparative results were also produced by NSW. Details on the methodology used for determining likelihood ratings and consequence scores for risk due to interception are detailed in the section below.

4.5.1. Farm dams (runoff dams) [E(I-FD)]

For the purpose of this risk assessment, runoff dams refer to private dams that intercept catchment runoff which would otherwise have contributed to stream flow. The impacts of runoff dams are considered to have implications primarily for surface flow; any potential impact on recharge to aquifers is considered to be minor. Interception by runoff dams is considered only in surface water risk assessments.

While the impact of an individual dam is generally relatively small, the cumulative impact of runoff dams on stream flows can be significant. The larger the total volume of runoff dams in a catchment, the greater the potential impact. The magnitude of demand is also important as higher rates of extraction result in reduced volumes of stored water, which in turn increases the potential for dams to intercept runoff. The seasonal pattern of demand has a direct impact on the likelihood of drawdown at different times of the year, with implications for environmental flows and security of supply. The impacts of runoff dams also are heavily dependent on the seasonal distribution of flows, the nature of antecedent conditions, consumption patterns, and the distribution of rainfall. Caution is needed when inferring impacts from dam size and average stream flows based on hillside dams.

Under the NSW *Water Management Act 2000*, harvestable rights are a type of basic landholder right and allow landholders to capture rainwater runoff on their property. The harvestable right is intended to satisfy essential farm needs such as stock and household water, but can be used for any purpose, including commercial irrigation. The maximum harvestable right dam capacity (MHRDC) is the total dam capacity allowed under the harvestable right and takes into account rainfall and variations in rainfall pattern.

For any dam with a capacity larger than the MHRDC, the volume of water that exceeds the MHRDC must be licensed, unless the water is taken under a domestic and stock right or native title right. A water supply water approval is also required for a dam which exceeds the MHRDC. Farm dams also require a licence only if they are located on a 3rd order (or greater) river, irrespective of the dam capacity or purpose, or if they are on a permanent (spring feed) 1st and 2nd order stream. The provisions relating to harvestable rights are unaffected by any of the rules identified in a water sharing plan. The volume of licensed farm dams has been considered in determining hydrologic stress and access (NOW 2011a).

4.5.1.1. Assigning a consequence rating

Regulated river water source

Geoscience Australia mapped farm dams in the MDB in 2006 (CSIRO 2008a). Satellite imagery analysis was used to detect which farm dams mapped using 2004/5 imagery also existed in 1994, which is an indicator growth trends over a ten year period.

The CSIRO MDBSY project (CSIRO 2008a; CSIRO 2008b) considered the impacts of climate change, increases in farm dams and plantation forests and changes in groundwater use on water resources across the MDB. In the MDBSY project, farm dams refer only to dams with their own water supply catchment and do not include those dams that store diverted (and licensed) water, as these are already included within existing river system models. A 2030 farm dam development scenario was developed by considering current distribution and storage volume, and policy controls and trends in farm dam expansion. The NSW maximum harvestable right volume was also considered.

In assigning a consequence level to farm dams and plantations, the approach undertaken by the NSW Office of Water (NOW 2010) for the *Assessment of risk to NSW Murray–Darling Basin shared water resources* was applied in this current risk assessment. The approach used in NOW (2010) adopted indicators that were based on information readily available in the MDBSY reports (CSIRO 2008a; CSIRO 2008b).

The MDBSY project engaged technical experts that examined assets and environmental water requirements and flow objectives required for the assets. Changes caused by the activity (including farm dams, plantation forestry and climate change) where classified according to whether they are considered critical or non-critical.

The criteria used were:

- Critical – ecosystem values associated with other flow objectives will not be maintained if this objective is not met; or
- Non-critical – ecosystem values associated with other flow objectives will be maintained, even if this flow objective is not met.

The MDBSY Project assessed two Ramsar sites in the Macquarie-Castlereagh River system: the Macquarie Marshes, and Wilgara Wetland. The Macquarie Marshes are the most northern river red gum forests in the MDB and support high value inland reed swamp and open floodplain wetland areas that are important for waterbird breeding (CSIRO 2008a). The MDBSY Project used four characteristics of flows exceeding 200 GL at Oxley gauge during the period June to November to describe beneficial events for waterbird breeding in the Macquarie Marshes. The Wilgara Wetland is on the Gum Cowal/Terrigal system in the eastern portion of the Macquarie Marshes. Sustained bird breeding events at Wilgara Wetland occur when the wetland is inundated in 5 of every 10 years, during the winter-spring period (Biosis Research 2006).

A summary of the environmental indicators reported for the Macquarie Marshes and Wilgara Wetland are presented in Table 4-17.

Table 4-17. Environmental flow indicators developed in the MDBSY Project for the Macquarie Marshes and Wilgara Wetland Wetlands (CSIRO 2008a)

Environmental flow indicator
Average period between flows exceeding 200 GL between June and November at Oxley gauge
Maximum period (years) between flows exceeding 200 GL between June and November at Oxley gauge
Average annual volume above 200 GL between June and November at Oxley gauge
Average event volume above 200 GL between June and November at Oxley gauge
Average period between flows exceeding 80 GL over four months between June and November at Marebone
Maximum period (years) flows exceeding 80 GL over four months between June and November at Marebone

Average annual volume above 200 GL between flows exceeding 80 GL over four months between June and November at Marebone
Average event volume 80 GL over four months between June and November at Marebone
Reference: (CSIRO 2008a)

A consequence score was determined by assessing the ability to meet the defined environmental flow objectives under the base case of historical climate and 2004/5 water sharing arrangements and development levels (Scenario A0) (see Table 4-20).

The consequence of meeting all objectives was then classified based on level of objectives being met for the Macquarie Marshes and Wilgara Wetland (SKM 2008). The consequence score for this asset is negligible (Table 4-18).

Table 4-18. Consequence results for environmental assets (Macquarie marshes and Wilgara Wetland) in the Macquarie Cudgegong regulated water source in the Macquarie-Castlereagh WRPA

Environmental asset	Consequence
Macquarie Marshes	Negligible
Wilgara Wetlands	Negligible
Reference: (CSIRO 2008a)	

Unregulated water sources

The MDBSY project did not consider environmental assets in the Macquarie Bogan and Castlereagh unregulated water sources.

Consequence scores for the unregulated water sources were determined using the HEVAE in-stream value (Section 4.2) at the reach intersecting the site where likelihood was determined (Table 4-19).

Table 4-19. Consequence results for environmental assets in the unregulated water sources in the Macquarie-Castlereagh WRPA

Gauging station	Consequence rating (HEVAE consequence score)
Belar Creek @ Warkton (Blackburns)	Low
Castlereagh River @ Mendooran	Medium
Wallumburrawang Creek @ Bearbung	Low
Butheroo Creek @ Neilrex	Low
Castlereagh River @ Hidden Valley	Medium
Bell River @ Newrea	Medium
Turon River @ Sofala	Medium
Bogan River @ Neurie Plains	Medium
Talbragar River @ Elong Elong	Medium
Little River @ Obley No.2	Low
Bell River @ Molong	Medium
Coolbaggie Creek @ Rawsonville	Low
Coolaburragundy River @ Coolah	Low
Green Valley Creek @ Hill End	Low

Spicers Creek @ Saxa Crossing	Low
Bogan River @ Peak Hill No.2	Low
Campbells River u/s Ben Chifley Dam	Low
Brisbane Valley Creek @ Stromlo	Low
Reference: (Healey *et al.* 2018).	

4.5.1.2. Determining the likelihood rating

Regulated river water source

For the purpose of determining the likelihood of farm dams intercepting runoff which would otherwise have contributed to stream flow, likelihood was calculated by the difference between two MDBSY scenarios (D_{mid} - C_{mid}) (Table 4-20). The farm dam component of this impact was estimated at 50 % of the total (NOW 2010).

Likelihood metrics were adopted from SKM (2008), which developed guidelines for assessing risks to shared water resources in the Murray–Darling Basin (Table 4-21), however it is important to note that the SKM report used a different definition of likelihood compared to how it has been defined in the rest of this risk assessment (Section 2.2).

The SKM report defined likelihood as the chance of a specified event occurring under different climate scenarios, with events being the specific flow indicators identified for a WRPA. Specified flow indicators for the Macquarie-Castlereagh WRPA, based on flow thresholds at the Oxley and Marebone gauges, are described in Table 4-17. Likelihoods are therefore the chance that a given flow indicator would be reported under a given climate scenario. For example, if there was a 1 % chance that maximum period in years between flows exceeding 200 GL between June and November at Oxley gauge would be recorded in a given climate scenario, the likelihood would be classed as “rare” (Table 4-21).

Table 4-20. MDBSY Project Scenarios

MDBSY scenario		Description
P	Modelling period standardised to 1/7/1895-30/6/2006 and all water regulation and usage removed	Estimate of natural flow regime
A	Historical climate and current development	When compared to A0 risk from current groundwater usage determined
A0	Historical climate and 2004/5 water sharing arrangements and development levels	Baseline for comparison with projected climate change and development scenarios
B	Same as A0 with future climate based on recent decade’s climate	
C_{dry}	2nd driest of 45 estimates of future climate, and 2004/5 levels of development	When compared to A0 climate change risk determined
C_{mid}	Median of 45 estimates of future climate, and 2004/5 levels of development	When compared to A0 climate change risk determined
C_{wet}	2nd wettest of 45 estimates of future climate, and 2004/5 levels of development	When compared to A0 climate change risk determined
D_{dry}	C_{dry} with projected 2030 levels of groundwater usage, and increases in farm dams and plantation forestry	When compared to C_{dry} development risk (farm dams and plantations) determined When compared to A0 cumulative risk (climate change + development) determined
D_{mid}	C_{mid} with projected 2030 levels of groundwater usage, and increases in farm dams and plantation forestry	When compared to C_{mid} development risk (farm dams and plantations) determined When compared to A0 cumulative risk (climate change + development) determined

MDBSY scenario		Description
D_{wet}	C_{wet} with projected 2030 levels of groundwater usage, and increases in farm dams and plantation forestry	When compared to C_{mid} development risk (farm dams and plantations) determined When compared to A0 cumulative risk (climate change + development) determined

Table 4-21. Likelihood metrics selected for modelled scenarios in the Macquarie Bogan and Castlereagh Regulated River Water Sources in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Probability (%)
Rare	May occur only in exceptional circumstances	<1
Unlikely	Could occur at some time	1-33
Possible	Might occur at some time	33-66
Likely	Would occur at some time	66-99
Almost Certain	Expected to occur in most circumstances	>99
Reference: (SKM 2008)		

As stated, the likelihood rating was based on the differences between the MDBSY D_{mid} – C_{mid} scenario. The likelihood rating for the Macquarie Marshes and Wilgara Wetland from interception by farm dams was assessed as possible (Table 4-22).

Table 4-22. Likelihood results for modelled scenarios in the Macquarie Cudgegong regulated river

Environmental asset	Likelihood
Macquarie Marshes	Possible
Wilgara Wetland	Possible
Reference: (NOW 2010, p.201)	

Unregulated water sources

The MDBSY Project did not assess unregulated rivers; therefore the SKM (2011) assessment of the hydrological impacts of farm dams in the MDB was used to describe likelihood. This study assessed the impact of existing farms dams at a detailed regional scale and fits into the hydrology theme of the Sustainable Rivers Audit 2 (SRA2) (Davies *et al.* 2012). The assessment undertook a sensitivity analysis on the results of the SRA hydrology metrics to identify those most sensitive to farm dams. Sixteen flow stress indices were calculated across 162 study catchments using catchments and flow gauges that met a set of criteria, including a record of at least 15 years of gauged streamflow data. In this work, the reference regime assumes no direct human influence on water management (that is, with no storages or diversions in place. The current regime represents actual licensed current demands as per NSW's hydrological model at the time of the project.

The median score of every index exceeded 0.9, indicating only a small departure from reference condition, and the overall small impact due to farm dams.

The three indices which showed moderate to high sensitivity to farm dams (SKM 2011) were:

- The low flow (LF) index had the greatest sensitivity to farm dams, consistent with other studies that note that farm dams tend to take a greater proportion of available flow during low flow periods

- The annual variation index (CV) (the ratio of coefficient of variation of flow in reference and current regime) was moderately affected by farm dams, possibly because flow variability was increased as low flows are made lower by farm dams
- The high flow (HF) index was moderately affected, possibly because farm dams can delay the onset of high flows at the start of winter in highly developed catchments.

These indices were selected as the metrics to describe the likelihood in unregulated water sources in the Macquarie-Castlereagh WRPA.

Likelihood category definitions are defined by the extent of deviation from the near-natural condition (Table 4-23). Likelihood results are provided in Table 4-24 for eighteen flow gauges used in the hydrological assessment that are within the Macquarie-Castlereagh WRPA. Maps showing results of indices and metrics used to assess the likelihood of farm dams intercepting surface flows in unregulated water sources in the Macquarie-Castlereagh WRPA are provided in Appendix E.

Table 4-23. Likelihood metrics for risk to water available for the environment in unregulated water sources due to interception

Likelihood metric	Metric category	Metric category definition
Departure of current regime from reference (near-natural) regime	Low	0.66-1.33
	Medium	0.33-0.66 or 1.33-1.66
	High	0-0.33 or 1.66-2.0
Reference: (NOW 2010)		

Table 4-24. Likelihood results for risk to water for the environment in unregulated water sources in the Macquarie-Castlereagh WRPA due to interception activities

Gauging station	Likelihood		
	CV	LF Q_{90}	HF Q_{10}
Belar Creek @ Warkton (Blackburns)	Low	Low	Low
Castlereagh River @ Mendooran	Low	Low	Low
Wallumburrawang Creek @ Bearbung	Low	Low	Low
Butheroo Creek @ Neilrex	Low	Low	Low
Castlereagh River @ Hidden Valley	Low	Medium	Low
Bell River @ Newrea	Low	Low	Low
Turon River @ Sofala	Low	Low	Low
Bogan River @ Neurie Plains	Low	Low	Low
Talbragar River @ Elong Elong	Low	Low	Low
Little River @ Obley No.2	Low	Low	Low
Bell River @ Molong	Low	Low	Low
Coolbaggie Creek @ Rawsonville	Low	Low	Low
Coolaburragundy River @ Coolah	Low	Low	Low
Green Valley Creek @ Hill End	Low	Low	Low
Spicers Creek @ Saxa Crossing	Low	Low	Low
Bogan River @ Peak Hill No.2	Low	Low	Low

Gauging station	Likelihood		
	CV	LF Q_{90}	HF Q_{10}
Campbells River u/s Ben Chifley Dam	Low	Low	Low
Brisbane Valley Creek @ Stromlo	Low	Low	Low

4.5.1.3. Existing water management actions and mechanisms

The current harvestable rights provisions for farm dams became official policy in 1999 prior to being included in the WMA in 2000 as a component of basic landholder rights (BLR). The harvestable rights provisions allows a Maximum harvestable right dam capacity on each property and is the total dam capacity allowed for your property and takes into account rainfall and variations in rainfall pattern. Also see Section 4.4.2.

4.5.1.4. Risk outcomes

Regulated river water source

The basin-wide growth in numbers of farm dams was estimated at about 0.5-0.6 % per year, with growth rates at the time higher in the north than the south (MDBA 2008). The volumetric growth rate was lower than the numerical growth rate as the newer dams are smaller on average than the dams constructed pre-1994. As the Harvestable Rights Policy commenced in 1999, it is likely the volumetric growth rate in the period 1994 to 1999 was higher than the period 2000 to 2004.

In 2008 the volume of in-stream farm dams in the Macquarie-Castlereagh WRPA was estimated at 242 GL (NOW 2010). The MDBSY Project estimated growth rate of 0.6 % for the entire Basin was applied to the 2008 Macquarie-Castlereagh WRPA estimated volume, yielding a predicted increase of 38 GL. This equates to a reduction of inflows of 0.9-1.5 % to streams as a result of farm dam interception, depending on the climatic scenario adopted (NOW 2010).

As mentioned in Section 4.5.1.2, SKM (2008) used different definitions of likelihood and consequence compared to the rest of this report, hence the SKM risk matrix has also been used for this section (Table 15-1 in SKM 2008). The SKM matrix has been modified by merging high and very high risks into a single 'high' category. This was done to maintain consistency with the risk mitigation strategies in the rest of this report. The adapted risk matrix is provided in Table 4-25.

Table 4-25. Matrix used to determine risk outcomes of insufficient water available for the environment from potential interception activities in Macquarie –Castlereagh WRPA, adapted from CSIRO (2008)

		Likelihood of insufficient water availability				
		Rare	Unlikely	Possible	Likely	Almost Certain
Consequence (%change in water use)	Negligible	Low	Low	Low	Medium	Medium
	Minor	Low	Low	Medium	Medium	High
	Moderate	Low	Medium	Medium	High	High
	Major	Medium	Medium	High	High	High
	Severe	Medium	High	High	High	High

Combining the risk consequence and likelihood rating (Table 4-18 and Table 4-22) results in a low overall risk level to ecological assets and functions at the Macquarie Marshes and Wilgara Wetlands (Table 4-26). The development of farm dams is unlikely to have additional impact on the hydrology of the Macquarie.

Table 4-26. Risks of insufficient water available for the environment in the Macquarie Marshes and Wilgara Wetland as a result of growth in interception by farm dams [E(I-FD)]

Environmental asset	Consequence	Likelihood	Risk level - E(I-FD)
Macquarie Marshes	Negligible	Possible	Low
Wilgara Wetland	Negligible	Possible	Low
Reference: (NOW 2010)			

Unregulated water sources

The risk matrix used to determine the risk rating of flow alteration from an increase in farm dams intercepting runoff and impacting the availability of water for the environment in the Macquarie, Bogan and Castlereagh unregulated water sources is provided in Table 4-27.

Table 4-27. Matrix used to determine risk outcomes of insufficient water available for the environment from potential interception activities in unregulated water sources in the Macquarie-Castlereagh WRPA

		Likelihood - current farm dam development		
		Low Departure from reference: 0.66-1.33	Medium Departure from reference: 0.33-0.66 or 1.33-1.66	High Departure from reference: 0-0.33 or 1.66-2.0
Consequence (HEVAE)	Very Low	Low	Low	Low
	Low	Low	Low	Medium
	Medium	Low	Medium	High
	High	Low	Medium	High
	Very High	Medium	High	High

Combining the risk consequence and likelihood ratings (Table 4-19 and Table 4-24) results in a low risk level to ecological assets and functions from interception due to farm dams for all but one site in the Macquarie-Castlereagh WRPA (Table 4-28). Castlereagh River at Hidden Valley has a medium risk at the LF Q_{90} level.

Table 4-28. Risks of insufficient water available for the environment in unregulated water sources in the Macquarie-Castlereagh WRPA as a result of growth in interception by farm dams [E(I-FD)]

Gauging station	Consequence *	Likelihood			Risk level - E(I-FD)		
		CV	LF Q_{90}	HF Q_{10}	CV	LF Q_{90}	HF Q_{10}
Belar Creek @ Warkton (Blackburns)	Low	Low	Low	Low	Low	Low	Low
Castlereagh River @ Mendooran	Medium	Low	Low	Low	Low	Low	Low
Wallumburrawang Creek @ Bearbung	Low	Low	Low	Low	Low	Low	Low
Butheroo Creek @ Neilrex	Low	Low	Low	Low	Low	Low	Low
Castlereagh River @ Hidden Valley	Medium	Low	Medium	Low	Low	Medium	Low
Bell River @ Newrea	Medium	Low	Low	Low	Low	Low	Low
Turon River @ Sofala	Medium	Low	Low	Low	Low	Low	Low
Bogan River @ Neurie Plains	Medium	Low	Low	Low	Low	Low	Low

Talbragar River @ Elong Elong	Medium	Low	Low	Low	Low	Low	Low
Little River @ Obley No.2	Low	Low	Low	Low	Low	Low	Low
Bell River @ Molong	Medium	Low	Low	Low	Low	Low	Low
Coolbaggie Creek @ Rawsonville	Low	Low	Low	Low	Low	Low	Low
Coolaburragundy River @ Coolah	Low	Low	Low	Low	Low	Low	Low
Green Valley Creek @ Hill End	Low	Low	Low	Low	Low	Low	Low
Spicers Creek @ Saxa Crossing	Low	Low	Low	Low	Low	Low	Low
Bogan River @ Peak Hill No.2	Low	Low	Low	Low	Low	Low	Low
Campbells River u/s Ben Chifley Dam	Low	Low	Low	Low	Low	Low	Low
Brisbane Valley Creek @ Stromlo	Low	Low	Low	Low	Low	Low	Low
CV = variation index annual; HF Q_{10} = high flow index; LF Q_{90} = low flow index * HEVAE in-stream value at the same location							

4.5.2. Commercial plantations

Plantation forestry is an increasingly important land use in Australia (ABS 2010). Although plantation forestry can contribute both commercial and environmental benefits, land use change to plantations can have an impact on catchment hydrology (SMEC 2010).

In the long-term, water yield from a catchment, including streamflow and groundwater recharge, is the difference between rainfall and evapotranspiration, assuming no net change in soil water storage in the catchment. Consequently, any change in evapotranspiration will translate directly to a change in catchment yield. For example, if a large number of trees are removed from a catchment, total evapotranspiration will be reduced and this may cause the water table to rise, leading to increased water yield. Conversely large plantations will increase evapotranspiration and therefore reduce water yield (SMEC 2010).

Afforestation is defined as the large-scale planting of trees for timber production, carbon offsetting, land conservation or other environmental purposes.

For this assessment only commercial plantations have been considered as there is no reliable regional or national data available on other types of tree plantings.

The planting of trees for timber production can be broadly classified as:

- Softwood forest plantations – stands of softwood trees for commercial production using various species of pines (including Radiata pine). Rotation lengths are typically 25-35 years; and
- Hardwood forestry plantations – stands of hardwood trees for commercial production typically on a short rotation (i.e. 10-15 years). The species used varies across the MDB.

As part of the MDBSY Project (CSIRO 2008a), a 2030 scenario for commercial forestry plantations for the MDB was developed using regional projections from the Bureau of Rural Sciences which takes into account trends, policies and industry feedbacks. The increase in commercial forestry plantations is distributed to areas adjacent to existing plantations (which are not natural forest land use) to project likely growth.

The Bureau of Rural Sciences projected negligible growth in commercial forestry plantations in the Macquarie region. Therefore no growth in plantation forestry was included in the modelling completed for the MDBSY Project in the Macquarie (CSIRO 2008a).

Where there is no projected growth in commercial plantations there is no pathway for additional future impact and therefore this risk has not been assessed.

4.5.2.1. Existing water management actions and mechanisms

The NSW regulatory approach including compliance to plantation forests is described in DWE (2008). Compliance with the *NSW Plantations and Reafforestation Act 1999* (PRA) is considered to be high as it provides a basis for legal harvesting. The PRA and regulations exclude the consideration of water impacts from the assessment process. However scope for amending the PRA will be considered as part of NSW response to its interception obligations under the NWI and COAG Water Reform agenda.

4.5.3. Mining

Mining activities in NSW must go through stringent assessment and approval processes. Any new mining project, or the expansion of an existing mining project, requires approval under the NSW *Environmental Planning and Assessment Act 1979*, and, depending on their location and the value of capital investment, may require approval from the Minister for Planning. Coal seam gas (CSG) exploration and commercialisation must be consistent with the CSG regulations and exclusion zones that apply in NSW.

Mining activities in the Macquarie-Castlereagh catchment currently comprise of less than one percent of the total catchment area (ABARES 2017). There are currently two coal mines operating in the Macquarie Castlereagh WRPA and seven mines for other metals and minerals (Australian Mining 2015).

All take for mining operations, including water required for operations and processing and intercepted water, must be accounted for by appropriate NSW water access licences acquired within the affected surface or groundwater source. This includes any direct or indirect take from surface waters. Risks associated with all licensed take of surface waters are addressed in Section 4.3.3, thus risk associated with surface water licenses for the purpose of mining will not be addressed individually.

No commercial coal seam gas extraction is currently occurring in the Macquarie-Castlereagh WRPA (DTIDRE 2016). As there is no pathway for this impact to occur at present, it has not been assessed in this risk assessment.

4.5.3.1. Existing water management actions and mechanisms

The NSW Aquifer Interference Policy (AI Policy) details the water licensing and impact assessment processes for aquifer interference activities under the *Water Management Act 2000* and other relevant legislation. The assessment criteria are called 'minimal impact considerations' and include impacts on surface water systems, connected alluvial aquifers, various groundwater impacts and water-dependent assets. Thresholds are set in the Policy so that the impacts of both an individual activity and the cumulative impacts of a number of activities within each water source can be considered.

4.5.4. Floodplain harvesting

Floodplain harvesting is identified in the Basin Plan as a potential interception activity. In NSW, the Floodplain Harvesting Policy and Healthy Floodplains Projects are converting this form of take into a licensable right. This form of take will be managed under the Floodplain licencing framework. As such, floodplain harvesting is not considered an ‘interception activity’ for NSW.

4.6. Risk to water available for the environment due to climate change [E(CC)]

There has been a sustained and statistically unambiguous increase in mean temperatures across the MDB. Increases in mean annual temperature tend to be slightly greater (more than 0.2°C per decade) in the northern parts of the Basin and lower (less than 0.1°C per decade) in the southeast. There is also some evidence that warming is greater at higher elevation than at lower elevation (Van Dijk *et al.* 2006).

The impacts of climate change by 2030 are uncertain; however, surface water availability across the entire Basin is more likely to decline than increase (Van Dijk *et al.* 2006)

Change in climate across the Basin is likely to result in:

- Greater annual variability in rainfall and the intensity of rainfall events
- Change in regional and seasonal rainfall patterns
- Changes to the flow regime
- Change in water security
- Altered water quality and the health of rivers, environmental assets and ecosystem functions over time
- Potential increases in evaporation.

The impact pathway is shown in Figure 4-9 and demonstrates how change in climate can alter patterns and volumes of surface runoff impacting water available for the environment in the Macquarie-Castlereagh WRPA.

The likelihood is described as the change in frequency of flow indicators at the Oxley gauge, while the consequence is assessed as the loss of annual water diversions for environmental entitlements.

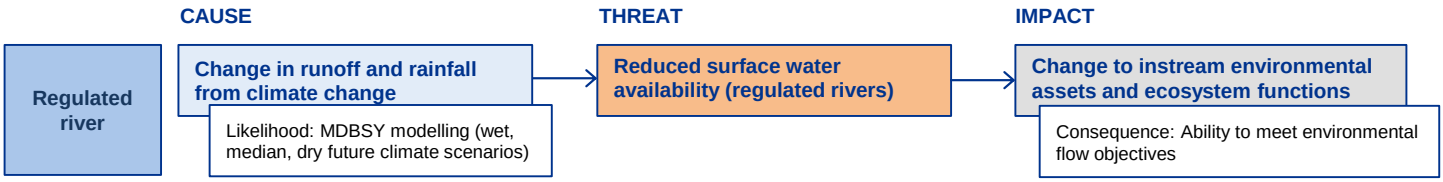


Figure 4-9. Impact pathway showing how change in climate can impact on the availability of water for the environment

4.6.1. Assigning a consequence rating

Regulated river water source

The MDBSY Project (CSIRO 2008a; CSIRO 2008b) considered the impacts of climate change on water resources across the Murray–Darling Basin. A range of likely climate conditions at the year 2030 was assessed by analysing three global warming scenarios in 15 global climate models (GCM) to provide a spectrum of 45 climate variants. The method also took into account overall changes in total runoff for dry, median and wet climate change scenarios (scenario type C), these were compared to scenario A0 (Table 4-20) (NOW 2010).

As noted in Section 4.5.1.1, the environmental assets assessed in the MDBSY Project were the Macquarie Marshes and the Wilgara Wetland. The consequence scores for this asset are provided below (Table 4-29). Consequence levels were defined by the magnitude of change and were set by experienced consultants at levels considered to be ‘reasonable’.

Table 4-29. Consequence results for environmental assets (Macquarie Marshes and Wilgara Wetland) not receiving flows from the Macquarie regulated river in the Macquarie-Castlereagh WRPA

Environmental asset	Consequence		
	Dry climate change scenario	Median climate change scenario	Wet climate change scenario
Macquarie Marshes	Severe	Severe	Severe
Wilgara Wetlands	Severe	Severe	Severe
Reference: (NOW 2010)			

Unregulated water sources

For the unregulated system, due to a lack of appropriate information and modelling climate change scenarios were unable to be compared against HEVAE values.

4.6.2. Determining the likelihood rating

Regulated river water source

As discussed earlier in Section 4.5.1.2, customised hydrological indicators were developed in the MDBSY Project for the Macquarie Marshes (CSIRO 2008a). Comparing MDBSY Project C scenarios to the 2004/05 (A0 scenario) determines likelihood of specific flow indicator events occurring under the three different climate projections (wet, dry, median) (Table 4-30). Also as discussed in Section 4.5.1.2, likelihood rankings were adapted from SKM (2008) guidelines for assessing risks to shared water resources in the Murray–Darling basin (Table 4-31) which define likelihood differently to how it has been defined in the majority of this risk assessment (Section 2.2).

Table 4-30. Data used to assess risk likelihood to the Macquarie Marshes and Wilgara Wetland from change in climate (CSIRO 2008)

Environmental flow indicator	A0	C_{dry} (% change from A0)	C_{mid} (% change from A0)	C_{wet} (% change from A0)
Average period between flows exceeding 200 GL between June and November at Oxley gauge	4.7 yrs	24	10	-25
Maximum period (years) between flows exceeding 200 GL between June and November at Oxley gauge	15 yrs	20	0	0
Average annual volume above 200 GL between June and November at Oxley gauge	75 GL	-38	-16	21
Average event volume above 200 GL between June and November at Oxley gauge	322 GL	-6	-5	5
Average period between flows exceeding 80 GL over four months between June and November at Marebone	2.0	135	55	-10
Maximum period (years) flows exceeding 80 GL over four months between June and November at Marebone	10.7	46	46	-1
Average annual volume above 200 GL between flows exceeding 80 GL over four months between June and November at Marebone	146	-43	-24	22
Average event volume 80 GL over four months between June and November at Marebone	355	22	10	10
Reference: (SKM 2008; NOW 2010)				
A0: historical climate, 2004/2005 level of development and water management arrangements C_{dry}: 2004/2005 levels of development; dry climate change projections for 2030 C_{mid}: 2004/2005 levels of development; median climate change projections for 2030 C_{wet}: 2004/2005 levels of development; wet climate change projections for 2030				

Table 4-31. Likelihood of insufficient water results for each climate scenario occurring in the Macquarie-Castlereagh WRPA

Environmental asset	Likelihood		
	Dry climate change scenario	Median climate change scenario	Wet climate change scenario
Macquarie Marshes	Likely	Possible	Unlikely
Wilgara Wetland	Likely	Possible	Unlikely

4.6.3. Existing water management actions and mechanisms

The WSPs for NSW MDB catchments were developed in consultation with community stakeholders, and are applicable for 10 year periods. The WSPs are designed to share the available water on both a daily and longer term basis for the full range of known (historical) climate variability. There is provision in the *Water Management Act 2000* (WMA) to suspend WSPs. In extreme climatic circumstances, prescriptive sharing rules cannot allow for real-time management of transmission losses, understanding of antecedent and forecast conditions and competing user requirements. This WMA provision has been invoked in NSW MDB valleys where actual climatic conditions have occurred outside the range of prior climate variability.

4.6.4. Risk outcomes

Regulated river water source

The impact of the three climate scenarios (i.e. dry, median, and wet) on rainfall varied according to season. Rainfall increased in summer and decreased in spring and winter, with little impact in autumn. Individually, these are considered small changes in rainfall, but when combined with potential evapotranspiration rates, the seasonal runoff changes are magnified, with higher summer runoff offset by lower runoff for the other seasons (NOW 2010). The resulting change in average annual rainfall and runoff is presented in Table 4-32.

Table 4-32. Impacts of climate change scenarios on mean annual runoff and rainfall

Scenario	Change to mean annual rainfall (%)	Change to mean annual runoff (%)
C_{dry}	-10	-28
C_{mid}	0	-9
C_{wet}	+12	+31

According to the MDBSY Project (CSIRO 2008a), wet scenario climate change is predicted to increase mean annual runoff by 31 %, but there is a predicted 28 % and 9 % reduction in inflows for the dry and median climate change scenarios respectively.

As mentioned in Section 4.5.1.2, the risk matrix used to determine the risk rating of flow alteration from change in climate impacting the availability of water for the environment in the Macquarie marshes and Wilgara Wetland is adapted from SKM (2008) with high and very high risks merged into a single ‘high’ category. This was done to maintain consistency with the risk mitigation strategies in the rest of this report. The adapted risk matrix is provided in Table 4-25.

The risk matrix used to determine the risk rating of flow alteration from change in climate impacting the availability of water for the environment in the Macquarie Marshes and Wilgara Wetland is provided in Table 4-33.

Table 4-33. Matrix used to determine risk of insufficient water available for the environment from potential change in climate adapted from (CSIRO 2008a)

		Likelihood of insufficient water availability				
		Rare	Unlikely	Possible	Likely	Almost Certain
Consequence (%change in water use)	Negligible	Low	Low	Low	Medium	Medium
	Minor	Low	Low	Medium	Medium	High
	Moderate	Low	Medium	Medium	High	High
	Major	Medium	Medium	High	High	High
	Severe	Medium	High	High	High	High

Combining the risk consequence and likelihood ratings (Table 4-29 and Table 4-31) results in the overall risk levels to the ecological assets and functions at the Macquarie Marshes and Wilgara Wetland as shown in Table 4-34. The risk assessment determined a high risk to the Macquarie Marshes and Wilgara Wetland from all climate change scenarios.

Table 4-34. Risks of insufficient water available for the environment in the Macquarie Marshes and Wilgara Wetland as a result of change in climate [E(CC)]

Environmental asset	Scenario	Consequence	Likelihood	Risk level - E(CC)
Macquarie Marshes	Wet climate change	Severe	Unlikely	High
	Median climate change	Severe	Possible	High
	Dry climate change	Severe	Likely	High
Wilgara Wetland	Wet climate change	Severe	Unlikely	High
	Median climate change	Severe	Possible	High
	Dry climate change	Severe	Likely	High

5. Risks to health of water-dependent ecosystems from poor water quality [E(WQ)]

5.1. Background

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

The Basin Plan requires that a WRP must include a water quality management plan (WQM Plan). A separate WQM Plan for the Macquarie-Castlereagh WRPA has been prepared to meet the requirements of the Basin Plan. The WQM Plan is supplemented by a number of other documents including:

- The Incident Response Guide
- Salinity Technical Report
- Surface Water Quality Technical Report.

Water quality problems occurring within the Macquarie catchment are mostly caused by a combination of alteration to natural flow regimes and land use change (DPI Water 2016). There are a number of causes and threats that will impact the health of water-dependent ecosystems. In the NSW MDB, the types of water quality degradation include:

- Water temperatures outside natural temperature range
- Elevated levels of nutrients and suspended sediments
- Dissolved oxygen and pH outside of natural ranges
- Elevated levels of in-stream salinity.

These impacts could all lead to the alteration of in-stream ecological functions and reductions in the condition of ecological assets. Risks arising from elevated levels of salinity or other types of water quality degradation to the condition and continued availability of water resources have been assessed below. The risk pathways for considering potential impacts of poor water quality on water-dependent ecosystems are provided in the following sections.

Pathogens, pesticides, heavy metals and other toxic contaminants are not monitored regularly. As such, risks arising from these types of water quality degradation are not assessed in this risk assessment due to lack of data. The WQM Plan identifies strategies to address risks of water quality degradation, including risks from toxicants and pesticides.

5.2. Existing water management actions and mechanisms

The WMA sets a principle requirement that water quality of all water sources should be protected and, wherever possible, enhanced. Key objectives within NSW Basin WSPs also relate to the maintenance of water quality.

There are a suite of rules within the WSPs that assist in protecting and maintaining water quality within the valley. Under the current water sharing plan there are restrictions on drawdowns on in-river and off-river pools when the volume of water is less than full capacity of the pool. Cease to pump rules and commence to pump rules also reduce the pressure on pools by extraction of water. During these low flow periods and as pools

contract, water quality can deteriorate, algal blooms occur, dissolved oxygen levels decline. Restricting the extraction pressure on these systems helps protect water quality.

There are also rules in the regulated system that benefit water quality. These rules include:

- Reserve all water above the long-term average annual extraction limit for planned environmental water. This helps maintain base flows which are important to slow the decline in water quality by preventing pools from stratifying and stagnating.
- Protect supplementary water events from extraction by users until flow triggers have been met. This protects important rises in the water level and natural flow variability, preserves a significant portion of natural tributary flows for river health and maintains wetland and floodplain inundation.
- Reserve water in Burrendong Dam to the limit of 160,000 ML/y to strategically use for environmental purposes (translucent and active accounts).
- Provide for translucent flows from Windamere Dam up to allocated allowance (to be determined) for environmental water purposes.
- To provide for specified replenishment flows that refill pools or waterholes in effluent systems downstream of a water source and provide water for stock and domestic purposes.
- The plans also provide for licensed water to be committed for adaptive environmental water purposes.

Further details can be found in the WQM Plan, Salinity Technical Report and the Surface Water Quality Technical Report.

5.3. Risks due to water temperature outside natural ranges

The Basin Plan identifies water temperature outside natural ranges as one type of water quality degradation in the MDB (Schedule 10). One cause of water temperature below natural ranges is the release of stored 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, as well as the removal of shading riparian vegetation and reduced flows.

Schedule 11 of the Basin Plan identifies target temperatures (monthly median) within the range of the 20th and 80th percentiles of natural monthly water temperature. Natural monthly temperature has not been specified for the Macquarie-Castlereagh WRPA.

This risk assessment focuses on cold water pollution (CWP) as identified by (Preece 2004) in the technical report *Cold water pollution below dams in NSW.* Windamere and Burrendong Dams are the only large storages located in the Macquarie-Castlereagh WRPA; the risk from CWP is relevant to the regulated river only.

Water temperature influences many biological and ecosystem processes. The release of cold water from Windamere and Burrendong Dams in the regulated Macquarie Cudgegong Rivers can impact on ecosystem function and condition of ecological assets by causing temperature depression in the downstream regulated river. Water temperature influences many biological and ecosystem processes. Warmer temperatures can increase growth rates and metabolism of in-stream plants, animals and algae. Temperature influences spawning, breeding and migration patterns of many aquatic animals.

The impact pathway is shown in Figure 5-1. The likelihood is described by the persistence of CWP downstream from dams.

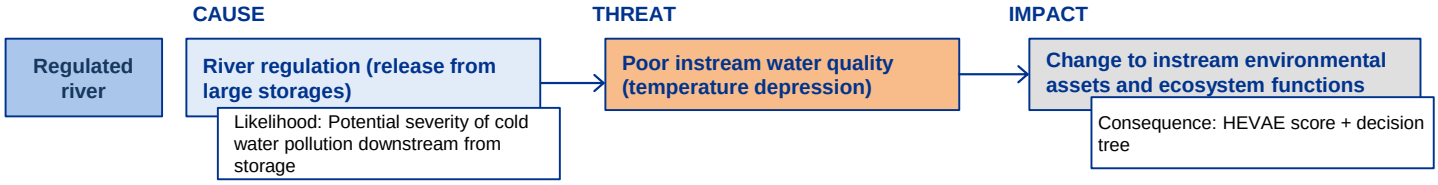


Figure 5-1. Impact pathway showing impact of cold water pollution on ecological functions and assets

The risk from unnaturally high water temperatures could not be calculated due to insufficient data, and is not discussed further in this report.

5.3.1. Assigning a consequence rating

Temperature has a wide range of influences on biological processes. The release of cold water can interrupt important biological cues such as fish spawning and other fauna, and can reduce the growth rate of fish, and increase mortality (Lugg and Copeland 2014). CWP also has the potential to impact on the recovery potential of fish (as a result of increased environmental water) in the Macquarie catchment (DPI Water 2016).

Thermal pollution from dams results in water temperatures below natural during the summer months and above natural during the winter months. NSW Fisheries (Lugg 1999) estimated that severe cold water pollution (defined as more than 5^{o}C peak depression) persists for 400 km downstream of Burrendong Dam. There are no estimates of thermal pollution from Windamere Dam as it is fitted with a variable offtake.

The same consequence scores as determined in Section 4.2.3 (regulated only) are used to assess risks due to water temperatures falling below natural ranges due to releases from major storages.

5.3.2. Determining the likelihood rating

The potential for CWP can be described by the two indicators, being the size of the structure (namely intake depth) and the scale of downstream temperature disturbance (being summer discharge) (Preece 2004). These two metrics provide a basis for categorising dams according to the potential severity of downstream CWP. These same categories have been used to define likelihood categories for CWP (Table 5-1).

Table 5-1. Likelihood metrics for risk to the health of water-dependent ecosystems from CWP

Likelihood metric	Metric category	Metric category definition
Potential severity of downstream CWP	Low	Minor CWP Shallower intake (<10 m) and smaller discharge (<1000 ML/d)
	Medium	Moderate CWP Deep intake (≥10 m) and smaller discharge (>5 and <1000 ML/d)
	High	Severe CWP Deep intake (≥10 m) and large discharge (≥1000 ML/d)
Reference: (Preece 2004)		

Windamere Dam includes a variable offtake to allow water to be released from different depths to suit water quality and temperature management objectives. Preece (2004) reports the offtake is generally at 7 m depth and an average discharge of 150 ML/d. Windamere Dam therefore has a low likelihood for causing CWP during normal operations. The author does however report that there is potential for severe CWP during bulk water transfers to Burrendong Dam. Bulk water transfers are operational releases undertaken infrequently during exceptionally dry times and are not governed by rules in the water sharing plan so are not considered in this risk assessment.

Burrendong Dam is a deep storage with an intake depth estimated at 37 m and a discharge rate of 4000 ML/d (Preece 2004). Burrendong Dam was not constructed with a variable off take but was retrofitted with a thermal curtain to enable shallower waters to be released. Unfortunately the curtain failed during a flood and is undergoing redesign and modification. At the time of writing the curtain has yet to be reinstalled therefore risks are based on the original dam specifications. Based on the above criteria, Burrendong Dam has a high likelihood for causing CWP.

5.3.3. Risk outcomes

The risk matrix used to determine the risk rating of CWP impacting the health of water-dependent ecosystems in the regulated system of the Macquarie-Castlereagh WRPA is provided in Table 5-2.

Table 5-2. Risk matrix to determine risk outcomes of water temperature below natural range impacting the health of water-dependent ecosystems

		Likelihood (of in-stream structure having the potential to cause CWP)		
		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

Combining the risk consequence and likelihood ratings (Table 4-2 and Table 5-2) for the Cudgegong River downstream of Windamere Dam results in a low risk, and the Macquarie River downstream of Burrendong Dam as a high risk, as shown in Table 5-3.

Table 5-3. Risks of water temperature below natural range impacting the health of water-dependent ecosystems [E(WQ-CWP)]

Regulated river reach	Consequence rating	Likelihood rating	Risk rating - E(WQ-CWP)
Cudgegong River downstream of Windamere Dam	High	Low	Low
Macquarie River downstream of Burrendong Dam (400 kms)	Very High	High	High

5.4. Risks due to turbidity, TP, TN, pH and DO

Elevated levels of suspended matter and nutrients and dissolved oxygen (DO) and pH outside natural ranges are also types of water quality degradation identified in Schedule 10 of the Basin Plan. There are a range of causes that contribute to water quality degradation of this type. Schedule 11 of the Basin Plan identifies target values for water quality indicators for application zones across the Basin.

Windamere and Burrendong Dams have a major disruptive effect on water quality immediately downstream of the dams. It causes reduced primary productivity and leads to an increase in nutrient concentrations (Westhorpe *et al.* 2015). Nutrient concentrations are influenced by land use, rainfall and discharge, as well as the combination of naturally occurring high concentrations of nitrogen and phosphorus in soils and erosion. Soil erosion can be exacerbated by clearing, degradation of stream banks and other land use issues. Turbidity and suspended sediment are also influenced by high flows, particularly in those reaches where bank and riparian condition is poor (DPI Water 2016).

Dissolved oxygen is influenced by organic carbon concentrations, nutrient concentrations and temperature, particularly during low and cease to flow periods.

The impact pathway is shown in Figure 5-2. The consequence is described using HEVAE scoring for 50 km river reaches based around river monitoring stations. Likelihood is described by the frequency that Basin Plan water quality targets are exceeded.

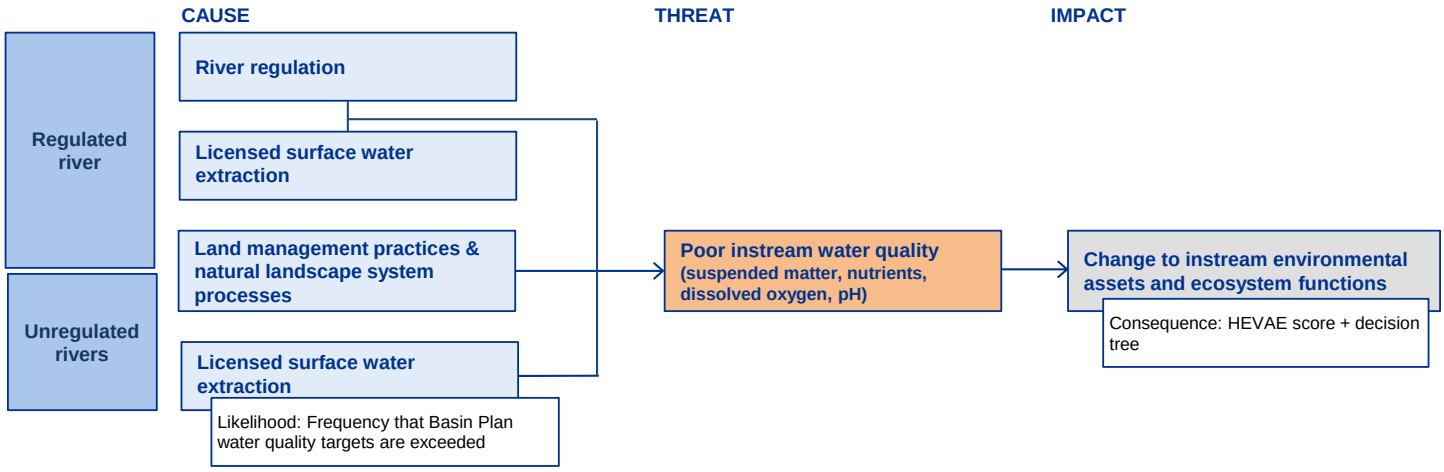


Figure 5-2. Impact pathway showing impact of water quality degradation (increased turbidity, TP, TN, pH and DO) on ecological functions and assets

5.4.1. Assigning a consequence rating

There are 15 NSW Department of Industry water quality monitoring sites in the Macquarie-Castlereagh WRPA across the unregulated and regulated systems. For each monitoring station, a reach was defined as 25 km upstream and downstream (Figure 5-3) as a conservative estimate of the spatial representativeness of water quality data and movement of in-stream biota within the river channel.

Risk consequence was determined using the HEVAE in-stream value scoring (Section 4.2.1). The consequence decision support tree (Section 4.2.2; Appendix B) was then used to define the final consequence score using the HEVAE in-stream values within each reach area. Consequence scores for regulated and unregulated reaches are shown in Table 5-4 and Table 5-5.

Regulated river water source

Table 5-4. Consequence results for reaches of the Macquarie Cudgegong regulated rivers in the Macquarie-Castlereagh WRPA

River reach	Consequence Rating
421019 Cudgegong River at Yamble Bridge	High
421077 Macquarie River at u/s Spillway Burrendong Dam	Low
42110101 Macquarie River at Molong Rail Bridge	Very High
421004 Macquarie River at Warren Weir	Very High

Unregulated water sources

Table 5-5. Consequence ratings in unregulated reaches in the Macquarie-Castlereagh WRPA

River reach	Consequence rating
42110171 Fish River at Hazelgrove	High
42110170 Turon River at Bathurst Point	Low

River reach	Consequence rating
421025 Macquarie River at Bruinbun	Medium
421038 Cudgegong River at Rylstone Bridge	Medium
421018 Bell River at Neurea	Medium
421176 Little River at Arthurville No. 2	High
421042 Talbragar River at Elong Elong	Low
421011 Marthaguy Creek at Carinda*	Very High
421012 Macquarie River at Carinda (Bells Bridge)	Very High
421023 Bogan River at Gongolgon	Medium
420004 Castlereagh River at Mendooran	Low
420020 Castlereagh River at Gungalman Bridge	Medium

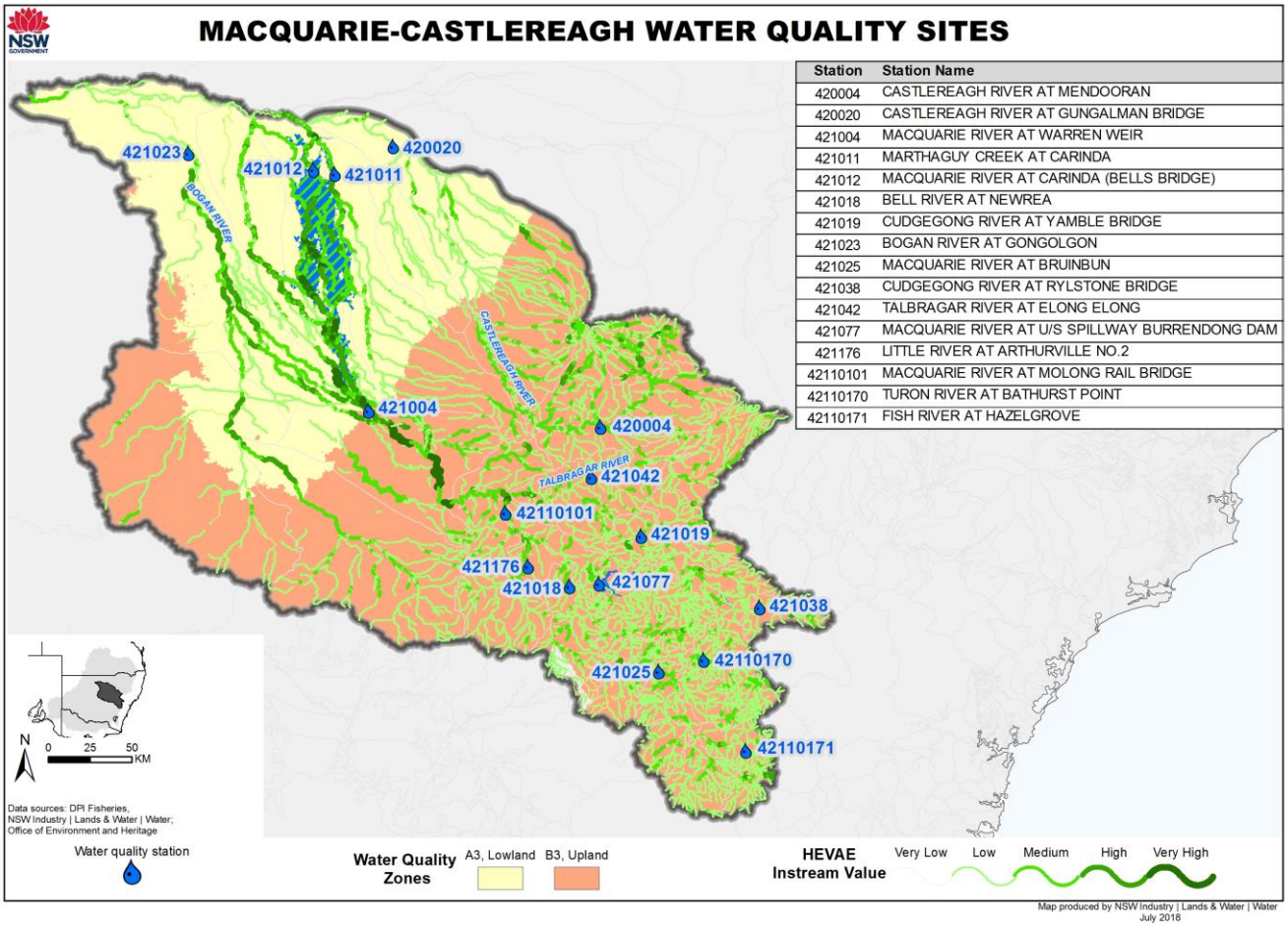


Figure 5-3. Water quality monitoring sites used to determine water quality target application zones for water-dependent ecosystems (Schedule 11 of the Basin Plan)

5.4.2. Determining the likelihood rating

Likelihood is described by the frequency that the water quality target, as nominated by the Basin Plan, was exceeded over a five year monitoring period. Data was based on monthly sampling for the period 2010/11 - 2014/15.

Schedule 11 water quality target values used for this risk assessment were for 'other water-dependent ecosystems' in the Upland and Lowland zones (B3 and A3 zones respectively) (Figure 5-3) (**Error! Reference source not found.**).

Table 5-6. Basin Plan (Schedule 11) water quality targets for 'other water-dependent ecosystems'

Ecosystem type	Target application zone	Turbidity (NTU) (annual median)	Total phosphorus (µg/L) (annual median)	Total nitrogen (µg/L) (annual median)	Dissolved oxygen (mg/L; or saturation (%)) (annual median within the range)	pH (annual median within the range)
Streams, rivers, lakes & wetlands	B3 (includes Macquarie-Castlereagh WRPA Upland zone)	20	35	600	90-110 %	7.0-8.0
	A3 (includes Macquarie-Castlereagh WRPA Lowland zone)	35	50	600	80-110 %	6.5-8.0

Likelihood category definitions are defined by the frequency that the water quality target is exceeded over the five year sampling period (Table 5-7). Likelihood scores for regulated and unregulated reaches are shown in Table 5-8 and Table 5-9.

Table 5-7. Likelihood metrics for risk of water quality impacting water-dependent ecosystems in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition
Number of years the annual medium water quality exceeds the Basin Plan target	Low	The annual site median exceeds the water quality target no more than once between 2010/11 - 2014/15
	Medium	The annual site median exceeds the water quality target at least two twice but not more than three times between 2010/11 - 2014/15
	High	The annual site median exceeds the water quality target at least four times between 2010/11 - 2014/15

Unless otherwise noted, a minimum of five samples per year were used when calculating the median.

Regulated river water source

Table 5-8. Likelihood results in regulated river reaches exceeding Basin Plan water quality targets

Regulated river reach	Turbidity	Total phosphorus	Total nitrogen	pH	DO
421019 Cudgegong River at Yamble Bridge	Low	High	Low	Low	High
421077 Macquarie River at u/s Spillway Burrendong Dam	Low	Medium	High	Low	Low
42110101 Macquarie River at Molong Rail Bridge	Low	Medium	Medium	Low	High
421004 Macquarie River at Warren Weir	High	High	Medium	Low	High

Unregulated water sources

Table 5-9. Likelihood results in unregulated river reaches exceeding Basin Plan water quality targets

Unregulated river reach	Turbidity	Total phosphorus	Total nitrogen	pH	DO
42110171 Fish River at Hazelgrove	Low	Low	Low	Low	Low
42110170 Turon River at Bathurst Point	Medium	Low	Low	Medium	Medium
421025 Macquarie River at Bruinbun	Low	Medium	Low	Medium	Low
421038 Cudgegong River at Rylstone Bridge	Low	Low	Medium	Low	Medium
421018 Bell River at Neurea	Low	Low	Low	Low	High
421176 Little River at Arthurville No. 2	Low	Low	Low	Medium	Medium
421042 Talbragar River at Elong Elong	High	High	High	Medium	High
421011 Marthaguy Creek at Carinda*	High	High	Medium	Low	Medium
421012 Macquarie River at Carinda (Bells Bridge)	Medium	High	High	Low	Low
421023 Bogan River at Gongolgon	Medium	High	High	Low	Low
420004 Castlereagh River at Mendooran	Medium	High	Medium	Medium	High

5.4.3. Risk outcomes

The risk matrix used to determine the risk to the health of water-dependent ecosystems due water quality targets being exceeded is provided in Table 5-10.

Table 5-10. Risk matrix to determine risk outcomes of exceeding water quality targets on water-dependent ecosystems

		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

Combining the risk consequence (Table 5-4 and Table 5-5) and likelihood ratings (Table 5-10) for the Macquarie-Castlereagh WRPA results in the overall risk levels to ecological assets and functions as shown in Table 5-11 and Table 5-12 for regulated and unregulated water sources respectively.

The highest risk to water-dependent ecosystems was generally found in the northern section of the catchment. Low concentrations of dissolved oxygen and elevated levels of nutrients appear to be the highest risks to water-dependent ecosystems in the Macquarie-Castlereagh WRPA.

Regulated river water source

Table 5-11. Risks of exceeding water quality targets impacting the health of water-dependent ecosystems in the regulated reaches of the Macquarie-Castlereagh WRPA [E(WQ)]

Regulated river reach	Consequence	Turbidity		Total phosphorus		Total nitrogen		pH		DO	
		Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating
421019 Cudgegong River at Yamble Bridge	High	Low	Low	High	High	Low	Low	Low	Low	High	High
421077 Macquarie River at u/s Spillway Burrendong Dam	Low	Low	Low	Medium	Low	High	Medium	Low	Low	Low	Low
42110101 Macquarie River at Molong Rail Bridge	Very High	Low	Medium	Medium	High	Medium	High	Low	Medium	High	High
421004 Macquarie River at Warren Weir	Very High	High	High	High	High	Medium	High	Low	Medium	High	High

Unregulated water sources

Table 5-12. Risks of exceeding water quality targets impacting the health of water-dependent ecosystems in the unregulated water sources of the Macquarie-Castlereagh WRPA [E(WQ)]

Unregulated river reach	Consequence	Turbidity		Total phosphorus		Total nitrogen		pH		DO	
		Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating	Likelihood	Overall risk rating
42110171 Fish River at Hazelgrove	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
42110170 Turon River at Bathurst Point	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Medium	Low
421025 Macquarie River at Bruinbun	Medium	Low	Low	Medium	Medium	Low	Low	Medium	Medium	Low	Low
421038 Cudgegong River at Rylstone Bridge	Medium	Low	Low	Low	Low	Medium	Medium	Low	Low	Medium	Medium
421018 Bell River at Neurea	Medium	Low	Low	Low	Low	Low	Low	Low	Low	High	High
421176 Little River at Arthurville No. 2	High	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium	Medium
421042 Talbragar River at Elong Elong	Low	High	Medium	High	Medium	High	Medium	Medium	Low	High	Medium
421011 Marthaguy Creek at Carinda*	Very High	High	High	High	High	Medium	High	Low	Medium	Medium	High
421012 Macquarie River at Carinda (Bells Bridge)	Very High	Medium	High	High	High	High	High	Low	Medium	Low	Medium
421023 Bogan River at Gongolgon	Medium	Medium	Medium	High	High	High	High	Low	Low	Low	Low
420004 Castlereagh River at Mendooran	Low	Medium	Low	High	Medium	Medium	Low	Medium	Low	High	Medium

5.5. Risks due to elevated levels of in-stream salinity [E(WQ-S)]

Elevated levels of in-stream salinity can be caused by the mobilisation of salt stores in the landscape and/or a geological predisposition to salinity development.

Salinity targets referred to in the Basin Plan are end-of-valley salinity targets described in Schedule B, Appendix 1 of the Commonwealth *Water Act (2007)*. These targets have been used to assess risks to water-dependent ecosystems from salinity.

The impact pathway is shown in Figure 5-4. The consequence is described using HEVAE scoring for 50 km river reaches based around the relevant river monitoring stations. Likelihood is described by the frequency that the Basin Plan end-of-valley target is exceeded.

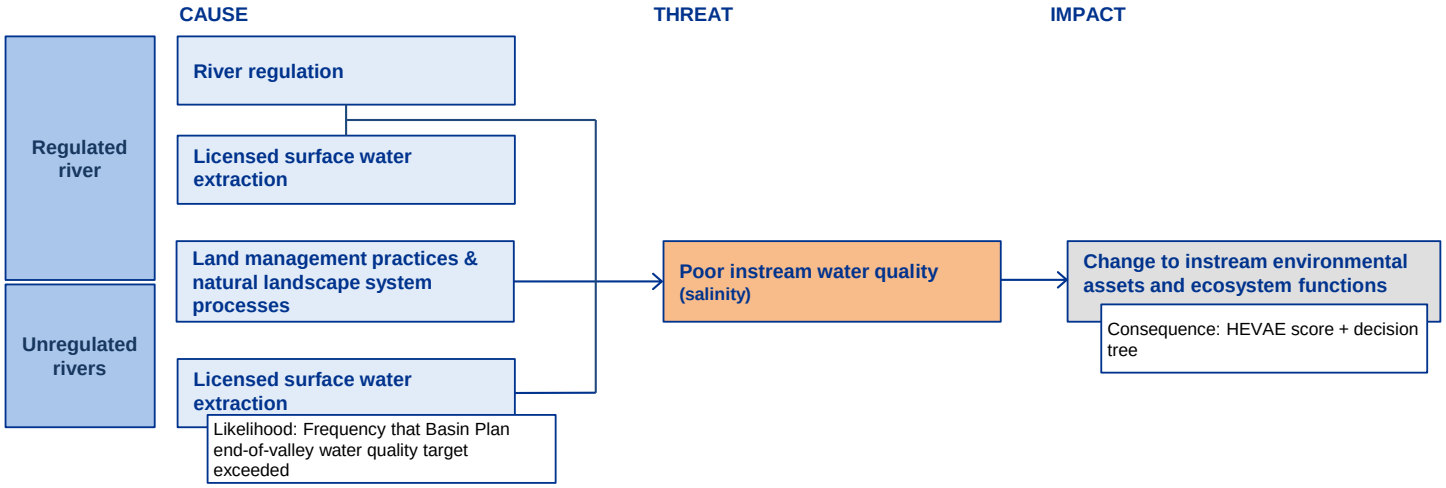


Figure 5-4. Impact pathway showing impact of elevated levels of in-stream salinity on ecological functions and assets in the Macquarie-Castlereagh WRPA

5.5.1. Assigning a consequence rating

The same consequence rating as applied in Section 5.4.1 was used. The end-of-valley target locations in the Macquarie-Castlereagh WRPA are the Bogan River at Gongolgon, Macquarie River at Carinda (Bells Bridge) and Castlereagh River at Gungalam Bridge (Schedule B, Appendix 1 of the Commonwealth *Water Act 2007*). These stations have consequence ratings of medium, very high and medium, respectively (Table 5-5).

5.5.2. Determining the likelihood rating

Likelihood is described by the frequency that the end-of-valley electrical conductivity target was exceeded during the five-year period 2010/11 to 2014/15. Data was based on monthly sampling for the period 2010/11 - 2014/15.

The end-of-catchment salinity targets for the Macquarie-Castlereagh WRPA, as nominated in the Basin Plan are:

- Bogan River at Gongolgon – 80th percentile should not exceed 456 µS/cm;
- Macquarie River at Carinda (Bells Bridge) – 80th percentile should not exceed 744 µS/cm; and
- Castlereagh River at Gungalam Bridge – 50th percentile should not exceed 368 µS/cm.

Likelihood category definitions are defined by the frequency that the end-of-valley target is exceeded over the five-year sampling period (Table 5-13).

Table 5-13. Likelihood metrics for risk to health of water-dependent ecosystems from poor water quality in the regulated river in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition
Number of years the annual 80th percentile salinity exceeds the end-of-valley target at each location	Low	The annual 80th percentile exceeds the end-of-valley target no more than once between 2010/11 - 2014/15
	Medium	The annual 80th percentile exceeds the end-of-valley target at least two twice but not more than three times between 2010/11 - 2014/15
	High	The annual 80th percentile exceeds the end-of-valley target at least four times between 2010/11 - 2014/15

The annual 80th percentile salinity level at the Bogan River at Gongolgon (421023) exceeded the salinity target 2 out of the five years between 2010/11 and 2014/15. Therefore this risk has a medium likelihood rating.

The annual 80th percentile salinity level at the Macquarie River at Carinda (421012) at Gongolgon exceeded the salinity target 2 out of the five years between 2010/11 and 2014/15. Therefore this risk has a high likelihood rating. Salinity data was not available for the Macquarie River at Carinda during the year 2012-13. For the purpose of calculating the likelihood score this year was treated as exceeding the target.

The annual 80th percentile salinity level at the Castlereagh River at Gungalman Bridge (420020) exceeded the salinity target 5 out of the five years between 2010/11 and 2014/15. Therefore this risk has a high likelihood rating.

5.5.3. Risk outcomes

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 Table 5-14.

Table 5-14. Risk matrix to determine risk outcomes of elevated levels of in-stream salinity on water-dependent ecosystems

		Likelihood (of salinity target 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

Combining the consequence (Table 5-5) and likelihood ratings (Section 5.5.2) results the Bogan River at Gongolgon having a medium risk of elevated salinity impacting the health of water-dependent ecosystems, the Macquarie River at Carinda a high risk and the Castlereagh River at Gungalman Bridge also a high risk (Table 5-15).

Table 5-15. Risks of elevated levels of in-stream salinity impacting the health of water-dependent ecosystems in the Macquarie-Castlereagh WRPA [E(WQ-S)]

Regulated river reach	Consequence rating	Likelihood rating	Risk rating - E(WQ-S)
421023 Bogan River at Gongolgon	Medium	Medium	Medium
421012 Macquarie River at Carinda	Very high	Medium	High
420020 Castlereagh River at Gungalman Bridge	Medium	High	High

6. Risk to other water uses due to unsuitable water quality [O(WQ)

6.1. Background

There are a number of risks that may reduce the quality of water used for a number of consumptive and other economic uses in the Macquarie-Castlereagh WRPA. Land use within the Macquarie and Castlereagh catchments is predominantly agricultural, and includes livestock grazing, dryland cropping and irrigated cropping.

6.2. Existing water management actions and mechanisms

As discussed in Chapter 5.2, under the WMA a key principle sets a requirement that water quality of all water sources should be protected and, wherever possible, enhanced. Key objectives within the WSPs also relate to the maintenance of water quality. For more information refer to Chapter 5, the WQM Plan, Salinity Technical Report and the Surface Water Quality Technical Report.

6.3. Risks to irrigation water from elevated in-stream salinity [O(WQ-S)]

Irrigation water with elevated levels of salinity can lead to potential crop damage. The Basin Plan sets water quality targets for irrigation water for salinity (Part 4 of Chapter 9). For the Northern Basin, the target is that the 95th percentile does not exceed 957 µS/cm across a 10 year period. These targets apply at sites where water is extracted by an irrigation infrastructure operator for the purpose of irrigation. In NSW, irrigation infrastructure operators are defined as a separate third party that holds a water access entitlement and delivers water to shareholders and can include NSW irrigation corporations, private irrigation districts and private water trusts. There is one qualifying organisation in the Macquarie-Castlereagh WRPA (the Narromine Irrigation Board of Management).

The sodium adsorption ratio (SAR) is another indicator of the suitability of water for irrigation. Irrigation water with a high SAR may lead to soil degradation. The Basin Plan also sets a target for the SAR for irrigation water. The target value is the value which, if exceeded, could cause soil degradation when that water is applied to land. This risk is not addressed in this assessment as adequate data is not yet available.

The impact pathway is shown in Figure 6-1 and demonstrates the threat to water used for irrigation driven by elevated levels of in-stream salinity in the Macquarie-Castlereagh WRPA. The consequence is described by the water salinity rating of irrigation water. Likelihood is described by the frequency that Basin Plan salinity targets for irrigation are exceeded.

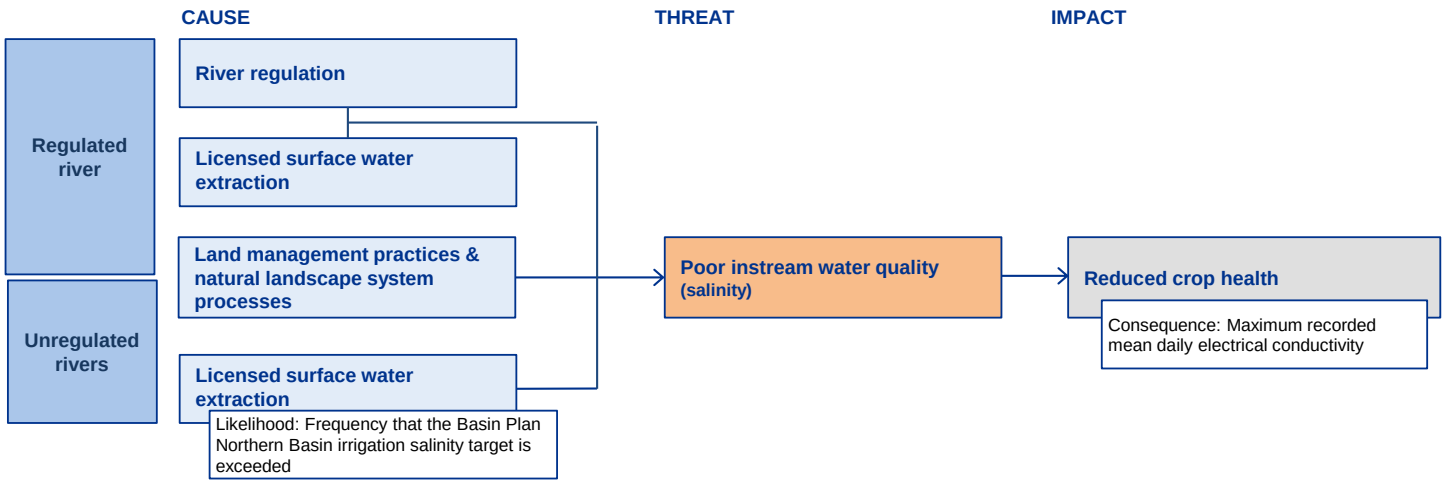


Figure 6-1. Impact pathway showing elevated salinity levels causing water to be unsuitable for irrigation

6.3.1. Assigning a consequence rating

Elevated levels of in-stream salinity can be driven by a number of causes. Consequence is described by the water salinity rating of irrigation water (ANZECC and ARMCANZ (2000), Chapter 9 Table 9.2.5).

A single irrigation event of highly saline water can cause crop damage. Therefore the consequence metric is the maximum mean daily electrical conductivity recorded between 2005/06-2014/15.

The closest salinity monitoring station to Narromine Irrigation Board of Management irrigation operation is 421127 – Macquarie River at Baroona (Figure 6-2). This sites was used to assess the risk due to elevated in-stream salinity.

Consequence categories are defined by different water salinity rating and the sensitivity of different crops to saline irrigation water (Table 6-1).

Table 6-1. Consequence metrics for risk to irrigation water due to elevated salinity level

Consequence metric	Metric category	Metric category definition
Maximum mean daily electrical conductivity recorded between 2005/06 – 2014/15	Low	Maximum mean daily EC over 10 years <1300 µS/cm Very low to low salinity rating
	Medium	Maximum mean daily EC over 10 years 1300 - 5200 µS/cm Medium to high salinity rating
	High	Maximum mean daily EC over 10 years >5200 µS/cm Very High to extreme salinity rating
Reference: ANZECC and ARMCANZ 2000, Chapter 9 Table 9.2.5		

The Baroona site had a Low consequence rating (Table 6-2).

Table 6-2. Consequence results for risk due to high salinity levels to irrigation water

River reach	Consequence
421127 Macquarie River at Baroona	Low

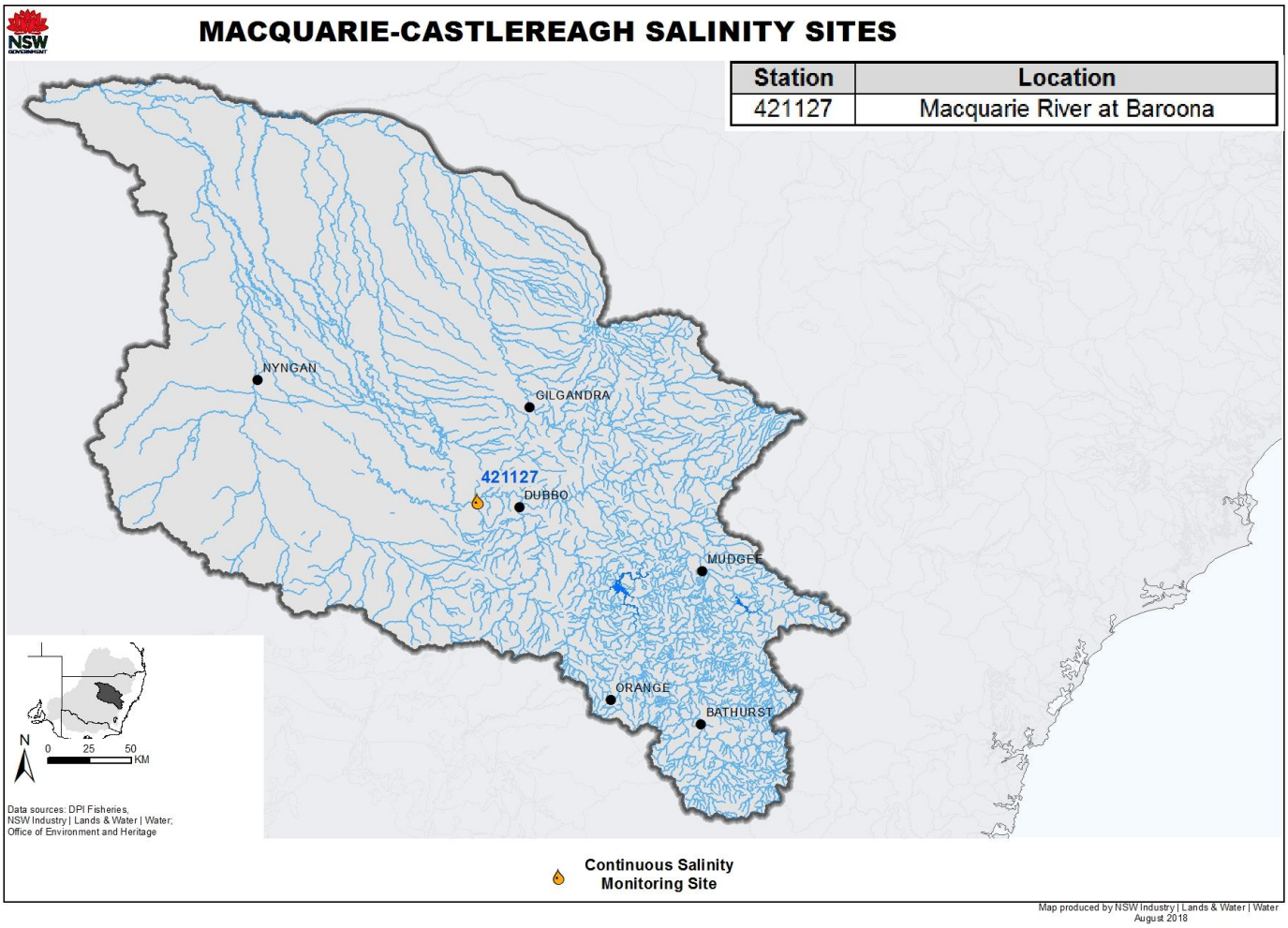


Figure 6-2. Monitoring stations used to determine the risk of elevated salinity to irrigation use

6.3.2. Determining the likelihood rating

A target value of 957 µS/cm is set for the Northern Basin in the Basin Plan. This target value should not be exceeded 95% of the time over a 10 year period (i.e. that 95th percentile must be less than 957 µS/cm).

The likelihood is described by the number of years that the annual 95th percentile of daily means of electrical conductivity exceeds the irrigation salinity target over the ten year period of 2004/05 to 2014/15.

Salinity was measured as real time data at the three monitoring stations identified above (Table 6-1). These sites are considered representative of areas of significant irrigation.

Likelihood categories are defined by different water salinity rating and the sensitivity of different crops to saline irrigation water (Table 6-3). Likelihood ratings for the three monitoring stations are provided in Table 6-4.

Table 6-3. Likelihood metrics for elevated salinity levels in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition[1]
Annual 95th percentile of daily mean electrical conductivity recorded between 2005/06 – 2014/15	Low	Annual 95th percentile of daily EC mean never exceeds the irrigation salinity target for the 10 year period
	Medium	Annual 95th percentile of daily EC mean exceeds the irrigation salinity target for at least 1 year but no more than 4 years over the 10 year period
	High	Annual 95th percentile of daily EC mean exceeds the irrigation salinity target for more than 4 years over the 10 year period

Table 6-4. Likelihood results for risk due to high salinity levels in irrigation water in the Macquarie-Castlereagh WRPA

River reach	Likelihood
421127 Macquarie River at Baroona	Low

6.3.3. Risk outcomes

The risk matrix used to determine the risk to irrigation water from elevated salinity used for irrigation purposes in the Macquarie-Castlereagh WRPA is provided in Table 6-5.

Table 6-5. Risk matrix to determine risk outcomes of elevated salinity levels on irrigation water

		Likelihood (of salinity water quality target being exceeded)		
		Low	Medium	High
Consequence (Maximum EC value)	Low	Low	Low	Medium
	Medium	Low	Medium	High
	Very High	Medium	High	High

Combining the risk consequence and likelihood ratings (Table 6-2 and Table 6-4) results in the overall risk as high (Table 6-6).

Table 6-6. Risks of elevated levels of in-stream salinity impacting on irrigation water in the Macquarie-Castlereagh WRPA [O(WQ-S)]

Regulated river reach	Consequence rating	Likelihood rating	Risk rating – O(WQ-S)
421127 Macquarie River at Baroona	Low	Low	Low

6.4. Risks to water used for recreational purposes [O(WQ-BGA)]

Most algae are safe 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 and form visible 'blooms' that can adversely affect water quality.

Blue-green algae can cause environmental problems, disrupt drinking water supplies, recreational activities and water-dependent industries, and pose a risk to livestock, wildlife and human health.

Blue-green algae was chosen as the indicator for risk to recreational water quality because of the potential for some species of blue-green algae to impact on health through direct contact. Some species can produce

potent neurotoxins and hepatotoxins, allergens or irritants to the skin and eyes as well as compounds that affect the taste of water and produce unpleasant odours. In severe cases the toxins can cause damage to the liver and nervous systems and there have been human deaths associated with non-routine exposure to algal toxins through dialysis.

The impact pathway is shown in Figure 6-3 and demonstrates the threat to water used for recreational purposes due to blue-green algae blooms. The consequence is described by the level of recreational use at the assessed location, while the likelihood is described by the frequency of red alert occurrence.

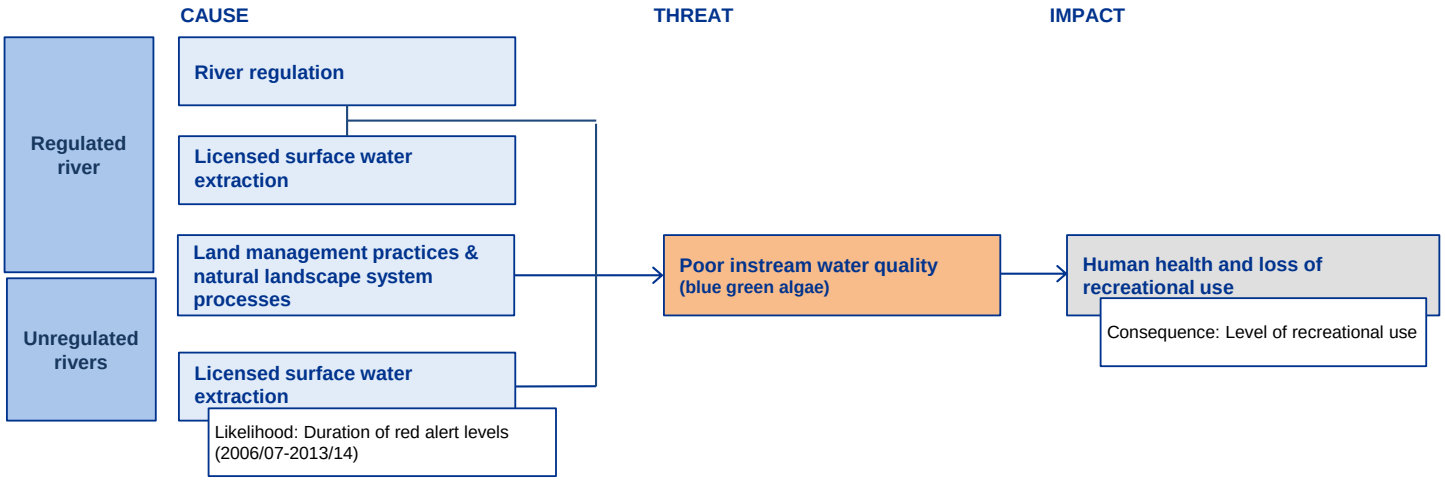


Figure 6-3. Impact pathway showing risk to recreation water quality and human health from blue-green algae

6.4.1. Existing water management actions and mechanisms

The risk of human exposure to blue-green algal blooms is managed in NSW through a coordinated regional approach with the Regional Algal Coordination Committees (RACC). State-wide and regional contingency plans and guidelines have been developed to provide methodologies on the management of algal blooms (NOW 2014). The objective of the guidelines is to provide a risk assessment framework to assist with effective management response to freshwater, estuarine and marine algal blooms. The guidelines aim to minimise the impact of algal blooms by providing adequate warning to the public ensuring their health and safety in recreational situations and for stock and domestic use.

Alert levels have been developed to determine the actions to be implemented in response to an algal bloom. These levels were adopted from the National Health and Medical Research Council algal bloom response guidelines (NHMRC 2008). A conceptual model of how these guidelines are applied for cyanobacterial blooms in waters used for stock, domestic, farm use and recreation is provided in Figure 6-4. The stock alert is also triggered within an amber alert if waters are used for stock watering and the stock alert levels are exceeded**.**

Water bodies with high levels of recreational use or those used as a source of potable supply have algal contingency plans for the issuing of warnings and treatment of town water supplies if sampling reveals potentially toxic levels of blue-green algae.

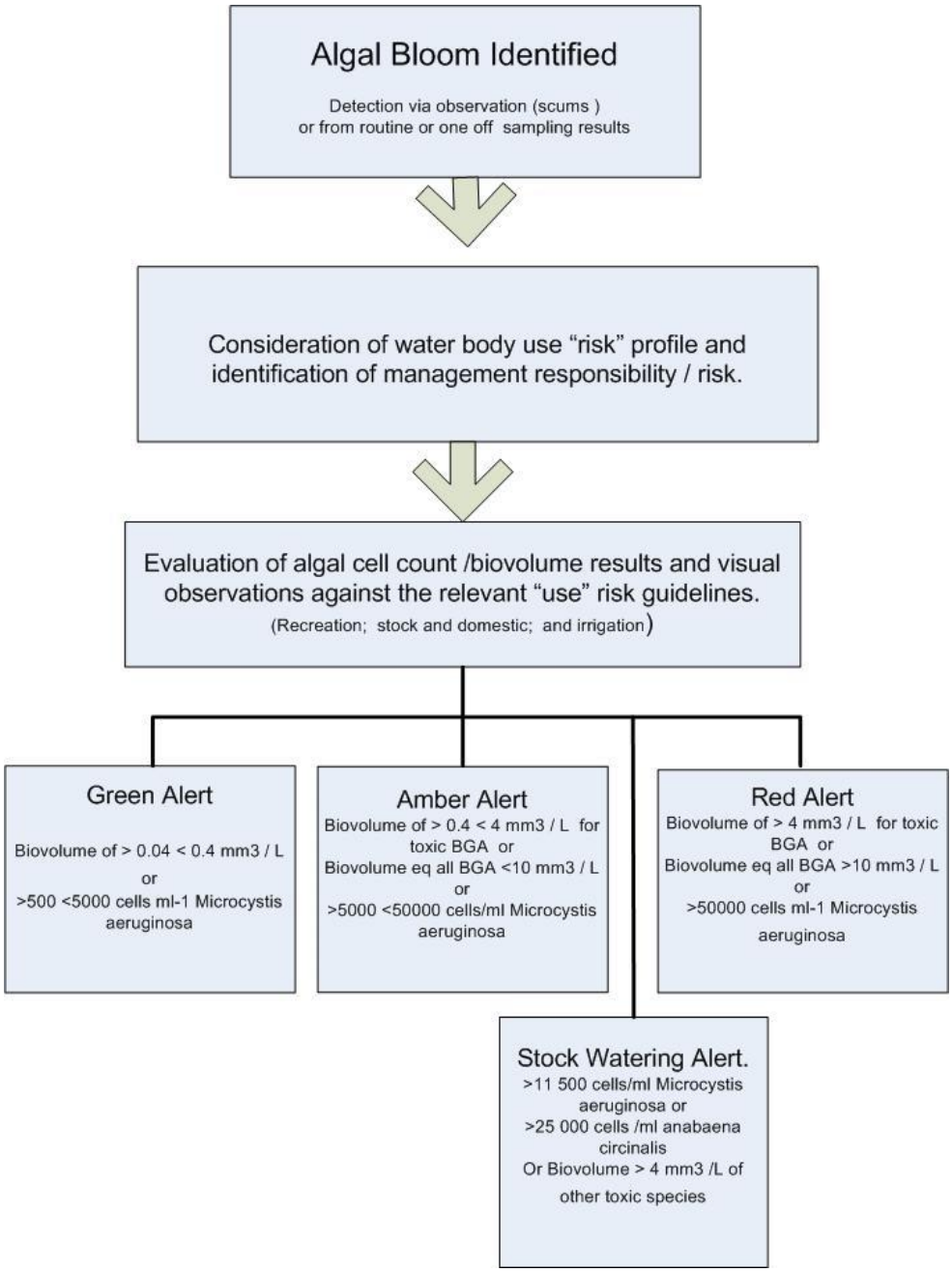


Figure 6-4. Conceptual outline of how algal alert levels are used in NSW

6.4.2. Assigning a consequence rating

Consequence is described by the degree of recreational use of the water source. Recreational usage of the four sites monitored for blue-green algae was determined during sampling to assign a use level.

Consequence categories are defined by usage levels (Table 6-7). Consequence ratings are provided in Table 6-8.

Table 6-7. Consequence metrics for risk to water used for recreational uses due to blue-green algae in the Macquarie-Castlereagh WRPA

Consequence metric	Metric category	Metric category definition
Degree of use for recreational purposes	Low	No, or very little, use of untreated water supplies Public advised to avoid contact with water body
	Medium	Some recreational usage (e.g. bush camping)
	High	Untreated water used for domestic use or town water supply High levels of recreational usage

Table 6-8. Consequence results for risk to recreational water users in the Macquarie-Castlereagh WRPA

River reach	Consequence
Oberon Reservoir	Low
Chifley Reservoir	Low
Windamere Reservoir	Low
Cudgegong River downstream of Windamere Dam	Low
Burrendong Reservoir	Low
Macquarie River d/s of Burrendong Dam	Low
Macquarie River at Geurie	Low
Macquarie River at Wellington	Low
Macquarie River at Dubbo	Low

6.4.3. Determining the likelihood rating

The likelihood is described by the annual frequency of red alerts during the period 2006/07 to 2013/14.

A red alert level is triggered when >50,000 cells/mL of *Microcystis aeruginosa* are present or the biovolume of all toxin producing blue-green algae exceeds 4 mm^3/L are detected. This alert level is also triggered if the total of all blue-green algae (toxic and non-toxic) exceeds 10 mm^3/L or scums are present for long periods. This alert level triggers contact to be made with relevant local authorities including health services and appropriate measures are taken to assess the risks and to inform users.

Likelihood categories are defined by length of time a red alert is in place (Table 6-9). Likelihood ratings are provided in Table 6-10.

Table 6-9. Likelihood metrics for risks from blue-green algae in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition[1]
Annual duration of red alerts	Low	< 2 weeks / year
	Medium	2 – 4 weeks / year
	High	> 4 weeks /year

Table 6-10. Likelihood results for risk due to blue-green algae

River reach	Likelihood
Oberon Reservoir	Low

Chifley Reservoir	High
Windamere Reservoir	High
Cudgegong River downstream of Windamere Dam	Low
Burrendong Reservoir	High
Macquarie River d/s of Burrendong Dam	Low
Macquarie River at Geurie	Low
Macquarie River at Wellington	Low
Macquarie River at Dubbo	Low

6.4.4. Risk outcomes

The risk matrix used to determine the risk to recreational water users from blue-green algae in the Macquarie-Castlereagh WRPA is provided in Table 6-11.

Table 6-11. Risk matrix to determine risk outcomes of blue-green algae to recreational water uses

		Likelihood (annual duration of red alerts)		
		Low	Medium	High
Consequence (degree of recreational use)	Low	Low	Low	Medium
	Medium	Low	Medium	High
	Very High	Medium	High	High

Combining the risk consequence and likelihood ratings (Table 6-8 and Table 6-10) results in the overall risk as medium for Chifley, Windamere and Burrendong Reservoirs and low for other locations (Table 6-12).

Table 6-12. Risks from blue-green algae to recreational water uses in the Macquarie-Castlereagh WRPA [O(WQ-BGA)]

Regulated river reach	Consequence rating	Likelihood rating	Risk rating
Oberon Reservoir	Low	Low	Low
Chifley Reservoir	Low	High	Medium
Windamere Reservoir	Low	High	Medium
Cudgegong River downstream of Windamere Dam	Low	Low	Low
Burrendong Reservoir	Low	High	Medium
Macquarie River d/s of Burrendong Dam	Low	Low	Low
Macquarie River at Geurie	Low	Low	Low
Macquarie River at Wellington	Low	Low	Low
Macquarie River at Dubbo	Low	Low	Low

6.5. 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).

Risks to raw water and their management strategies are identified in the Drinking Water Management Systems for the following water suppliers in the Macquarie-Castlereagh WRPA and will not be addressed further in this document:

- Bathurst Shire Council
- Cabonne Shire Council
- Coonamble Shire Council
- Fish River Water Supply
- Lithgow City Council
- Narromine Shire Council
- Orange City Council
- Warrumbungle Shire Council
- Bogan Shire Council
- Cobar Shire Council
- Dubbo Shire Council
- Gilgandra Shire Council
- Mid-Western Regional Council
- Oberon Council
- Warren Shire Council
- Wellington Shire Council

6.6. Other values

Other risks to the suitability of water for other public benefit values (Indigenous, socio-economic) have not been assessed in this analysis due to a lack of data. Future risk assessments will include an assessment of these risks as further data becomes available. Aboriginal cultural requirements will be addressed in a separate document..

7. Risks to water available for other uses

7.1. Background

In this section of the risk assessment, an attempt has been made to estimate the risk of interception activities on other users.

The National Water Commission (NWC) defined interception as occurring when flows of surface water or groundwater are stopped, reduced or redirected (SKM *et al.* 2010). This definition excludes precipitation and focuses solely on changes to runoff and recharge. This is further expanded by NWC to imply that interception activities, for the purpose of water management, are human-induced activities that intercept significant volumes of water and therefore decrease the amount of water reaching surface water and groundwater bodies.

Chapter 10 Part 5 of the Basin Plan identifies the following interception activities which may have the potential to impact on the water resources of a WRPA:

- Interception by runoff dams
- Interception by commercial plantations
- Interception by mining activities, including coal seam gas mining
- Interception by floodplain harvesting.

The impact pathways are shown in Figure 7-1 and demonstrate the threat of flow alteration driven by the interception activities identified in the Basin Plan can impact on water available for other users. The key threat is the interception of water that would otherwise reach a water course, thereby reducing the water available for other users.

For the purpose of risk due to interception, NSW utilised results published in the CSIRO Murray–Darling Basin Sustainable Yields (MDBSY) project (CSIRO 2008a; CSIRO 2008b) and model outputs that contributed to the MDBSY project. Comparative results were also produced by NSW. Details on the methodology used for determining likelihood ratings and consequence scores for risk due to interception are detailed in the section below.

7.2. Risks to other water users from interception activities [O(I-FD),O(I-PF)]

Just as interception activities can impact on environmental assets and ecosystem functions by altering the hydrology of a system, they can also impact on the water available for other uses. Interception activities identified in the Basin Plan are discussed below. The impact pathway is provided in Figure 7-1.

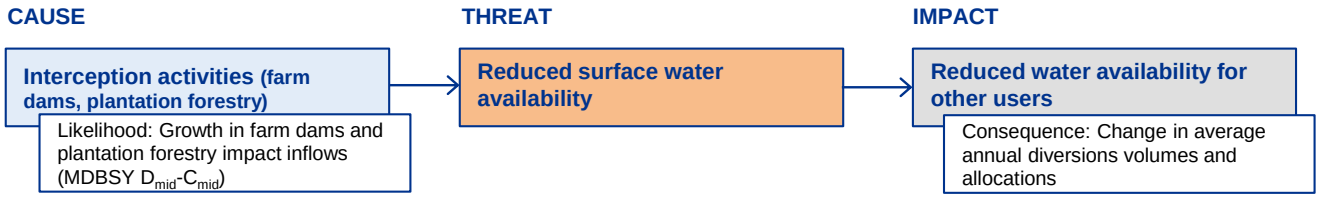


Figure 7-1. Impact pathway showing impact of interception activities on water available for other uses

7.2.1. Farm dams (runoff dams) [O(I-FD)]

The basin-wide growth in numbers of farm dams was estimated at about 0.5-0.6 % per year, with growth rates at the time higher in the north than the south (MDBA 2008). The volumetric growth rate was lower than the numerical growth rate as the newer dams are smaller on average than the dams constructed pre-1994. As the

Harvestable Rights Policy commenced in 1999, it is likely the volumetric growth rate in the period 1994 to 1999 was higher than the period 2000 to 2004.

In 2008 the volume of in-stream farm dams in the Macquarie valley was estimated at 242 GL. The MDBSY Project estimated growth rate of 0.6 % for the entire Basin was applied to the 2008 Macquarie valley estimated volume, yielding a predicted increase of 38 GL. This equates to a reduction of inflows of 0.9 to 1.5 % to streams as a result of farm dam interception, depending on the climatic scenario adopted (NOW 2010).

The impact pathways are shown in Figure 7-1 and demonstrate how the threat of flow alteration driven by the interception activities identified in the Basin Plan can impact on water available for other users. The key threat is the interception of water that would otherwise reach a water course, thereby reducing the water available for other users in the system.

Unregulated river water sources

As described in Section 4.5.1 the MDBSY Project did not assess unregulated rivers; therefore the SKM (2011) assessment of the hydrological impacts of farm dams in the MDB could be used to describe likelihood. This study assessed the impact of existing farms dams at a detailed regional scale and fits into the hydrology theme of the Sustainable Rivers Audit 2 (SRA2) (Davies *et al.* 2012).

As there is no extraction data available to calculate and assign a consequence rating for unregulated river water access licences, this risk cannot currently be assessed.

Regulated river water source

In assigning a consequence level to farm dams, the approach undertaken by the NOW (2010) was applied in this current risk assessment. This approach was provided to the MDBA Independent Audit Group which described the process used to assess risks to different water access entitlements and to the achievement of environmental objectives. The approach taken in NOW (2010) adopted indicators that were based on information readily available in the Murray–Darling Basin Sustainable Yields (MDBSY) reports (CSIRO 2008a; CSIRO 2008b).

To assess risks to other water users, three types of water access licences were considered based on information readily available in the MDBSY reports, these are:

- High security water access licences, local utilities, and stock and domestic licences
- General security water access licences
- Supplementary access licences.

The change in average annual diverted volumes was used to calculate consequences of interception by farm dams. For general security access licences, change in the number of years with 100 % allocation, and the percentage of years with 0 % allocation were also considered. Consequence levels were defined by the magnitude of change and were set by experienced consultants at levels considered to be ‘reasonable’ (Table 7-1) (NOW 2010).

Data used to assess consequence is presented in Table 7-2; results are provided in Table 7-3.

Table 7-1. Consequence thresholds for different types of water access licences in regulated rivers

Consequence levels	Percent change relative to base case				
	High security	General security			Supplementary access
	Average annual diversions	Average annual diversions	% years with 100% allocation	% years with 0% allocation	Average annual diversions
Negligible	x < 1	x < 1	x < 1	x < 1	x < 1
Minor	1 ≤ x < 10	1 ≤ x < 10	1 ≤ x < 10	1 ≤ x < 5	1 ≤ x < 10
Moderate	10 ≤ x < 20	10 ≤ x < 20	10 ≤ x < 20	5 ≤ x < 10	10 ≤ x < 20

Consequence levels	Percent change relative to base case				
	High security	General security			Supplementary access
	Average annual diversions	Average annual diversions	% years with 100% allocation	% years with 0% allocation	Average annual diversions
Major	20 ≤ x < 30	20 ≤ x	20 ≤ x	10 ≤ x	20 ≤ x
Severe	30 ≤ x	N/A*	N/A	N/A	N/A
Reference: (NOW 2010) N/A = This consequence level was not used for this indicators					

Table 7-2. Data used to assess consequences to different types of water access licences in the regulated river due to interception by farm dams

Water access licence type	Consequence		
	% change in average annual diversions	% change years with 100% allocation	% change in years with 0% allocation
High security	0	N/A	N/A
General security	-1	+0.9	-0.5
Supplementary access	-0.3	N/A	N/A
Reference: (NOW 2010) N/A = This metric was not used for this type of water access licence			

Table 7-3. Consequence results for different types of water access licences in the Macquarie Cudgegong regulated river due to interception by farm dams

Water access licence type	Consequence		
	% change in average annual diversions	% change years with 100% allocation	% change in years with 0% allocation
High security	Negligible	N/A	N/A
General security[1]	Negligible	Minor	Negligible
Supplementary access	Negligible	N/A	N/A
Reference: (NOW 2010) N/A = This metric was not used for this type of water access licence [1] An overall consequence level of minor will be applied to general security to calculate risk (i.e. the most conservative)			

7.2.1.1. Determining the likelihood rating

Regulated river water source

For the purpose of determining likelihood for farm dams, likelihood was calculated by differences between MDBSY scenarios D_{mid} - C_{mid} (see Table 4-20). The farm dam component of this impact was estimated at 50 % of the total (NOW 2010).

As previously mentioned, SKM have developed guidelines for assessing risks to shared water resources in the Murray–Darling Basin. Likelihood categories identified by SKM (2008) have been adopted for this risk assessment (Table 4-21). These thresholds describe the overall chance that the scenario will have on the assessed impact.

The likelihood rating is based on the differences between the MDBSY D_{mid} – C_{mid} scenario. The likelihood rating for the other users from interception by farm dams is provided below (Table 7-4).

Table 7-4. Likelihood results for different types of water access licences in the regulated Macquarie River. Likelihood metric estimates the likelihood of insufficient water access.

Water access entitlement holder	Likelihood
High Security	Negligible
General Security	Minor
Supplementary Water	Negligible
Reference: (NOW 2010)	

7.2.1.2. Existing water management actions and mechanisms

The current harvestable rights provisions allow for farm dams to capture some rainfall runoff under BLR, as previously discussed in section 4.5.1. If estimates of BLR increase over time, extraction by other users will be reduced to ensure compliance with the Long Term Average Annual Extraction Limit, also see section 4.4.2.

Under existing legislation the category of an access licence defines the level of priority when resources are being allocated in regulated rivers. The *Water Management Act 2000* and *Water Management (General) Regulation 2011* describe priority of licences in the following order (these may be varied by an individual water sharing plan):

1. Local water utility access licences, major utility access licences and domestic and stock access licences have priority over all other access licences
2. Regulated river (high security) access licences have priority over other regulated river access licence subcategories, and supplementary access licences
3. Regulated river (general security) access licences and other regulated river access licence subcategories
4. Supplementary water access licences have priority below all other access licences.

Understanding the priority of licence categories and subcategories enables licence holders to appropriately manage risk.

7.2.1.3. Risk outcomes

Regulated river water source

The risk matrix used to determine the risk rating of flow alteration from an increase in farm dams intercepting runoff and impacting the water available to different categories of water access licences in the Macquarie-Castlereagh WRPA is provided in Table 7-5.

Table 7-5. Matrix used to determine risk from potential interception activities to other water users

		Likelihood of insufficient water access				
		Rare	Unlikely	Possible	Likely	Almost Certain
Consequence (%change)	Negligible	Low	Low	Low	Medium	Medium
	Minor	Low	Low	Low	Medium	High
	Moderate	Low	Low	Medium	High	High
	Major	Low	Medium	Medium	High	High
	Severe	Medium	Medium	High	High	High

Combining the consequence and likelihood ratings (Table 7-3 and Table 7-4) results in the overall risk levels to water access licences and other users in the Macquarie Cudgegong regulated river as shown in Table 7-6.

Table 7-6. Risks of insufficient water available for different categories of water access licences in the Macquarie Cudgegong regulated river as a result of growth in interception by farm dams [O(I-FD)]

Water access licence type	Consequence	Likelihood	Risk level – O(I-FD)
High security	Negligible	Possible	Low
General security[1]	Minor	Possible	Low
Supplementary access	Negligible	Possible	Low
Reference: (CSIRO 2008a) N/A = This metric was not used for this type of water access licence [1] An overall consequence level of minor was applied to general security to calculate risk			

7.2.2. Commercial plantations [O(I-PF)]

As previously mentioned in section 4.5.2, afforestation is defined as the large-scale planting of trees for timber production, carbon offsetting, land conservation or other environmental purposes. The Bureau of Rural Sciences projected negligible growth in commercial forestry plantations in the Macquarie region at a catchment scale. As such, no growth in plantation forestry was included in the modelling completed for the MDBSY Project in the Macquarie (CSIRO 2008a)

Where there is no projected growth in commercial plantations there is no pathway for additional future impact and therefore this risk has not been assessed.

7.2.3. Mining (including CSG)

Mining activities in the Macquarie-Castlereagh catchment currently comprise of less than one percent of the total catchment area (ABARES 2017). There are currently two coal mines operating in the Macquarie Castlereagh WRPA and seven mines for other metals and minerals (Australian Mining 2015).

All take for mining operations, including water required for operations and processing and intercepted water, must be accounted for by appropriate NSW water access licences acquired within the affected surface or groundwater source. This includes any direct or indirect take from surface waters. Risks associated with all licensed take of surface waters are addressed in Section 4.3.3, thus risk associated with surface water licenses for the purpose of mining will not be addressed individually.

No commercial coal seam gas extraction is currently occurring in the Macquarie-Castlereagh WRPA (DTIDRE 2016). As there is no pathway for this impact to occur at present, it has not been assessed in this risk assessment.

7.2.4. Floodplain harvesting

Floodplain harvesting is identified in the Basin Plan as a potential interception activity. In NSW, the Floodplain Harvesting Policy and Healthy Floodplains Projects are converting this form of take into a licensable right. As such, floodplain harvesting is not considered an ‘interception activity’ in NSW.

Any impact from floodplain harvesting on water available for other users is not assessed in this risk assessment.

7.3. Risk to other water users due to climate change [O(CC)]

As discussed in section 4.6, there has been sustained and statistically unambiguous increase in mean temperatures across the MDB.

For the purpose of risk to other users due to climate change in the risk assessment, NSW utilised results published in the CSIRO Murray–Darling Basin Sustainable Yields (MDBSY) project (CSIRO 2007; CSIRO 2008) and model outputs that contributed to the MDBSY project. Comparative results were also produced by NSW. Details on the methodology used for determining likelihood ratings and consequence scores are detailed in the section below. The impact pathway is shown in Figure 7-2.

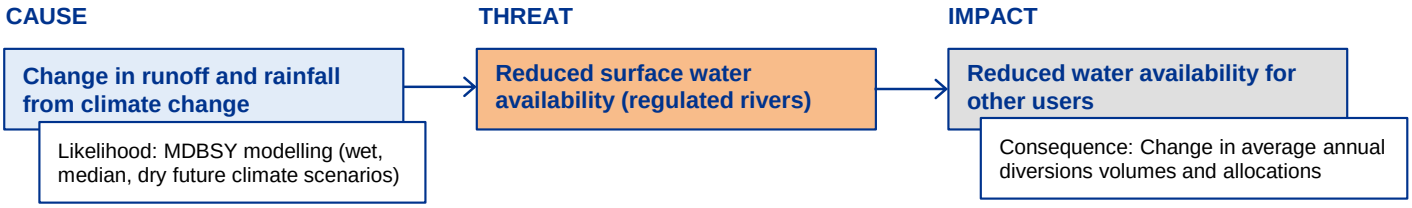


Figure 7-2. Impact pathway showing impact of change in climate on ability to meet other water user's water requirements.

7.3.1. Assigning a consequence rating

As discussed earlier in Section 7.2.1.1, in assigning a consequence level to farm dams, the approach undertaken by the NOW (2010) was applied in this current risk assessment. This approach adopted indicators based on information readily available in the Murray–Darling Basin Sustainable Yields (MDBSY) reports (CSIRO 2008a; CSIRO 2008b).

To assess risks to other water users, three types of water access licences were considered based on information readily available in the MDBSY reports, these are:

- High security water access licences, local utilities, and stock and domestic licences
- General security water access licences
- Supplementary access licences.

The MDBSY reports covered a range of possible 2030 climate scenarios (CSIRO 2008a). Dry, median and wet climate change scenarios were selected after implementing a daily scaling method to produce a comparable long-time series and ranking the overall change in total runoff. These scenarios were used in each catchment to assess the risks of the climate change by NOW (2010). The scenarios were compared against the base case to determine the percentage change to predict the level of the consequence.

Consequence levels selected for each type of water use category are located in the 2008 Risk Assessment (NOW 2010) and shown in Table 7-2

Data used to assess consequence is presented in Table 7-8; results are provided in Table 7-7.

Table 7-7. Consequence results for different types of water access licences in the Macquarie Cudgegong regulated river

Water access licence type	Consequence
Wet climate change scenario	
High Security	Negligible
General Security	Negligible
Supplementary Water	Negligible
Median climate change scenario	
High Security	Negligible
General Security	Minor
Supplementary Water	Minor
Dry climate change scenario	
High Security	Negligible
General Security	Major
Supplementary Water	Major

Water access licence type	Consequence
Reference: (NOW 2010)	

Table 7-8. Data used to assess consequences to different types of water access licences in the Macquarie Cudgegong regulated river due to climate change

Water access licence type	Consequence		
	% change in average annual diversions	% change years with 100% allocation	% change in years with 0% allocation
Wet climate change scenario			
High security	-2.0	N/A	N/A
General security	14.0	11.7	-1.8
Supplementary access	11.0	N/A	N/A
Median climate change scenario			
High security	+4.0	N/A	N/A
General security	-4.0	-1.8	-11.7
Supplementary access	-4.0	N/A	N/A
Dry climate change scenario			
High Security	+9.0	N/A	N/A
General Security	-18.0	-11.7	+5.4
Supplementary Water	-14.0	N/A	N/A
Reference: (NOW 2010) N/A = This metric was not used for this type of water access licence			

7.3.2. Determining the likelihood rating

Comparing MDBSY Project C scenarios to the 2004/05 (A0 scenario) determines likelihood of climate change impacting water available for other users under the three different climate projections (wet, median and dry) (Table 4-30). Likelihood rankings are provided in Table 7-9.

Table 7-9. Likelihood results for different types of water access licences in the Macquarie Cudgegong regulated river under different climate change scenarios. Likelihood metric estimates the likelihood of insufficient water access.

Water access licence type	Likelihood
Wet climate change scenario	
High Security	Unlikely
General Security	Unlikely
Supplementary Water	Unlikely
Median climate change scenario	
High Security	Possible
General Security	Possible
Supplementary Water	Possible
Dry climate change scenario	
High Security	Likely
General Security	Likely
Supplementary Water	Likely
Reference: (NOW 2010)	

7.3.3. Existing water management actions and mechanisms

Existing actions and mechanisms correspond to those identified in Section 4.6.3.

7.3.4. Risk outcomes

As discussed earlier, the wet climate change scenario is predicted to increase mean annual runoff by 31 %, but there is a predicted 28 % and 9 % reduction in inflows for the dry and median climate change scenarios respectively, see section 4.6.4.

The risk matrix used to determine the risk rating of flow alteration from change in climate impacting the availability of water for other uses in the Macquarie and Cudgegong regulated rivers is provided in Table 7-10.

Table 7-10. Matrix used to determine risk from potential change in climate

		Likelihood of 2030 projected hydrologic change from baseline (insufficient water access modelled C runs)				
		Rare	Unlikely	Possible	Likely	Almost Certain
Consequence (%change in water use)	Negligible	Low	Low	Low	Medium	Medium
	Minor	Low	Low	Low	Medium	High
	Moderate	Low	Low	Medium	High	High
	Major	Low	Medium	Medium	High	High
	Severe	Medium	Medium	High	High	High

Combining the risk consequence and likelihood ratings (Table 7-7 and Table 7-9) results in the overall risk levels to other users from climate change are shown in Table 7-11. The risk assessment determined a low risk for all users under the median scenario and high security users under the dry scenario. Under a dry climate

change scenario, general security and supplementary water users are at medium risk of a reduction in inflows together with all users under the wet scenario.

Table 7-11. Risks to different types of water access licences in the Macquarie Cudgegong regulated river under different climate change scenarios [O(CC)]

Water access licence type	Consequence	Likelihood	Risk level – O(CC)
Wet climate change scenario			
High Security	Negligible	Unlikely	Low
General Security	Negligible	Unlikely	Low
Supplementary Water	Negligible	Unlikely	Low
Median climate change scenario			
High Security	Negligible	Possible	Low
General Security	Minor	Possible	Low
Supplementary Water	Minor	Possible	Low
Dry climate change scenario			
High Security	Negligible	Likely	Medium
General Security	Major	Likely	High
Supplementary Water	Major	Likely	High
Reference: NOW 2010			

7.4. Risk to other water users due to growth in BLR [O(BLR)]

As described earlier in Section 4.4, all landholders in NSW have rights to access water for some basic purposes. The principles of the WM Act require that water sharing must protect BLR.

Access to BLR is not controlled by access rules that restrict licensed water users in unregulated water sources (for example, low flow access cease to pump rules); BLR is afforded a higher priority of access.

Any future growth in BLR therefore represents a potential future risk to other (licensed) water users at very low flows. Any increase in the volume taken by BLR access will necessitate a decrease in the volume share of access by licensed water users.

This risk is not applicable in regulated systems where the system is managed in such a way to maintain supply of BLR water requirements.

The impact pathway is shown in Figure 7-3 and demonstrates the risk to water availability for licensed water uses driven by growth in BLR in unregulated water sources. The consequence is described by the volume of licensed entitlement in the unregulated water source. Likelihood is described by the ratio of BLR to licensed entitlement. The greater the ratio of BLR to entitlement, the greater the likelihood that there will be less water available to other licensed water users; this consequence will be greater in areas of high entitlement.

Figure 7-3. Impact pathway showing risk to licensed water users due to growth in BLR access in unregulated water sources in the Macquarie-Castlereagh WRPA

7.4.1. Assigning a consequence rating

Consequence is described by the current volume of entitlement in each water source. It is assumed that the higher the level of entitlement within a water source, the greater the impact on licensed water users if cease to pump (CtP) levels are triggered more frequently due to increased BLR access.

Consequence categories are defined in Table 7-12. Consequence ratings are shown in Table 7-13.

It is assumed that all entitlement is fully active and utilised. That is, the volume extracted is the volume of entitlement for each water source.

Table 7-12. Consequence metrics for increased extraction by BLR in unregulated water sources in the Macquarie-Castlereagh WRPA

Consequence metric	Metric category	Metric category definition
Volume of entitlement	Low	Volume of entitlement < 5,000 ML
	Medium	Volume of entitlement 5,000 – 10,000 ML
	High	Volume of entitlement > 10,000 ML
Reference: NSW Water Register (NSW Department of Industry)		

Table 7-13. Consequence ratings for increased extraction by BLR in unregulated water sources in the Macquarie-Castlereagh WRPA

Water source	Consequence rating
Backwater - Boggy Cowal	Low
Bell River	Medium
Bulbodney - Grahway Creek	Medium
Burrendong Dam Storage tributaries	Low
Campbell's River	Low
Coolbaggie Creek system	Low
Cooyal Wialdra Creek	Low
Ewenmar Creek	High
Fish River	High
Goolma Creek	Low
Lawsons Creek	Low
Little River	Low
Lower Bogan River	High
Lower Talbragar	Low
Macquarie above Burrendong	High
Marra Creek	Low

Water source	Consequence rating
Marthaguy Creek	Low
Maryvale-Geurie	Low
Molong Creek and tributaries	Medium
Piambong Creek	Low
Pipeclay Creek	Low
Queen Charlottes Vale Creek/Evans Plains Creek	Low
Summerhill Creek	High
Turon/Crudine River	Low
Unregulated Lower Macquarie	High
Upper Bogan River Catchment	Low
Upper Cudgegong River above Windamere	Medium
Upper Talbragar River/Coolaburragundy River	Low
Wambangalang - Whylandra	Low
Winburndale Rivulet	Low
Castlereagh River Binnaway to Gilgandra	Low
Castlereagh River above Binnaway	Low
Castlereagh River below Coonamble*	Low
Castlereagh River Gilgandra to Coonamble	Low
Nedgera Creek*	Low
Teridgerie Creek*	Low
Tooraweenah to Coonamble Tributaries	Low

7.4.2. Determining the likelihood rating

Likelihood is described by the ratio of the volume of BLR to all licensed water entitlement in each water source (i.e. irrigation, town water supply, etc.). Entitlement is the current volume of licensed entitlement in each water source. It was assumed that all entitlement is fully active in the unregulated water sources.

Likelihood categories are defined in Table 7-14. Consequence ratings are shown in Table 7-15.

Table 7-14. Likelihood metrics for increased extraction by BLR in unregulated water sources in the Macquarie-Castlereagh WRPA

Likelihood metric	Metric category	Metric category definition[1]
Ratio of BLR volume to total licensed entitlement	Low	BLR/Entitlement ≤ 0.5
	Medium	BLR/Entitlement 0.5-1
	High	BLR/Entitlement ≥ 1
Reference: NSW Water Register (NSW Department of Industry)		

Table 7-15. Likelihood ratings for increased extraction by BLR in unregulated water sources in the Macquarie-Castlereagh WRPA

Water source	Likelihood rating
Backwater - Boggy Cowal	Low
Bell River	Low
Bulbodney - Grahway Creek	Low
Burrendong Dam Storage tributaries	Medium
Campbell's River	Low
Coolbaggie Creek system	Low
Cooyal Wialdra Creek	Low
Ewenmar Creek	Low
Fish River	Low
Goolma Creek	Low
Lawsons Creek	Low
Little River	Low
Lower Bogan River	Low
Lower Talbragar	Low
Macquarie above Burrendong	Low
Marra Creek	Low
Marthaguy Creek	Low
Maryvale-Geurie	Low
Molong Creek and tributaries	Low
Piambong Creek	Low
Pipeclay Creek	Low
Queen Charlottes Vale Creek/Evans Plains Creek	Low
Summerhill Creek	Low
Turon/Crudine River	Medium
Unregulated Lower Macquarie	Low
Upper Bogan River Catchment	Low
Upper Cudgegong River above Windamere	Low
Upper Talbragar River/Coolaburragundy River	Medium

Water source	Likelihood rating
Wambangalang - Whylandra	Low
Winburndale Rivulet	Low
Castlereagh River Binnaway to Gilgandra	Low
Castlereagh River above Binnaway	Low
Castlereagh River below Coonamble*	Low
Castlereagh River Gilgandra to Coonamble	Low
Nedgera Creek*	Low
Teridgerie Creek*	Low
Tooraweenah to Coonamble Tributaries	Low

7.4.3. Existing water management actions and mechanisms

Under the *Water Management Act 2000*, BLR are made up of domestic and stock rights, harvestable rights and native title rights. Water sharing plans recognise basic landholder rights in their respective water sources. Water may be extracted under these rights without the need for a water access licence, although in the case of accessing groundwater under a domestic and stock right, the bore must still be approved by the Department. The water sharing plan cannot limit or restrict these rights, but the Act itself provides for restrictions on BLR through the development of mandatory guidelines. Additionally, during periods of water shortage, domestic and stock users may be required, by Ministerial Order, to restrict usage to essential purposes.

The proliferation of new domestic and stock rights through the subdivision of land will be managed through a further regulation to the *Water Management Act 2000*. This regulation, made under section 52(2) of the Act, will limit the growth in basic landholder rights when a landholding is subdivided. Effectively this will mean that the reasonable use for the pre-subdivision landholding will be 'frozen' and the vendor will have to apportion this reasonable use limit between the proposed lots in the subdivision. Although still in development, it is intended that such limitations will be applied only to rivers and aquifers that could be subject to high hydrologic stress or high in-stream risk.

7.4.4. Risk outcomes

The risk matrix used to determine the risk to water availability for other uses due to growth in BLR extraction is provided in Table 7-16.

Note that the standard matrix has been altered so that when the likelihood is low (i.e. the ratio of BLR to entitlement <0.5), the risk outcome is always considered low regardless of the level of consequence. This change was made to avoid falsely assigning medium risk outcomes when BLR ratios are very low but entitlement is high. High BLR ratios (e.g. >0.5) usually reflect higher levels of urban/peri-urban development within a water source and therefore a higher likelihood of future BLR growth.

Table 7-16. Risk matrix to determine risk outcomes of increased BLR extraction to other water users in unregulated water sources

		Likelihood (ratio of BLR to entitlement)		
		Low	Medium	High
Consequence (licensed volume of entitlement)	Low	Low	Low	Medium
	Medium	Low	Medium	High
	High	Low	High	High

Combining the risk consequence and likelihood ratings (Table 7-13 and Table 7-15) results in the overall risk as low for all unregulated water sources in the Macquarie-Castlereagh WRPA (Table 7-17) except Ewenmar

Creek, Fish River, Lower Bogan River, Macquarie above Burrendong, Summerhill Creek, and Lower Macquarie water sources. The risk level in these water sources is medium; Table 7-18 shows data on BLR volumes and entitlement volumes for these four water sources.

Table 7-17. Risks of increased BLR extraction to other water users in unregulated water sources in the Macquarie-Castlereagh WRPA [O(BLR)]

Water source	Consequence rating	Likelihood rating	Risk level – O(BLR)
Backwater - Boggy Cowal	Low	Low	Low
Bell River	Medium	Low	Low
Bulbodney - Grahway Creek	Medium	Low	Low
Burrendong Dam Storage tributaries	Low	Medium	Low
Campbell's River	Low	Low	Low
Coolbaggie Creek system	Low	Low	Low
Cooyal Wialdra Creek	Low	Low	Low
Ewenmar Creek	High	Low	Medium
Fish River	High	Low	Medium
Goolma Creek	Low	Low	Low
Lawsons Creek	Low	Low	Low
Little River	Low	Low	Low
Lower Bogan River	High	Low	Medium
Lower Talbragar	Low	Low	Low
Macquarie above Burrendong	High	Low	Medium
Marra Creek	Low	Low	Low
Marthaguy Creek	Low	Low	Low
Maryvale-Geurie	Low	Low	Low
Molong Creek and tributaries	Medium	Low	Low
Piambong Creek	Low	Low	Low
Pipeclay Creek	Low	Low	Low
Queen Charlottes Vale Creek/Evans Plains Creek	Low	Low	Low
Summerhill Creek	High	Low	Medium
Turon/Crudine River	Low	Medium	Low
Unregulated Lower Macquarie	High	Low	Medium
Upper Bogan River Catchment	Low	Low	Low
Upper Cudgegong River above Windamere	Medium	Low	Low
Upper Talbragar River/Coolaburragundy River	Low	Medium	Low
Wambangalang - Whylandra	Low	Low	Low
Winburndale Rivulet	Low	Low	Low
Castlereagh River Binnaway to Gilgandra	Low	Low	Low
Castlereagh River above Binnaway	Low	Low	Low

Water source	Consequence rating	Likelihood rating	Risk level – O(BLR)
Castlereagh River below Coonamble*	Low	Low	Low
Castlereagh River Gilgandra to Coonamble	Low	Low	Low
Nedgera Creek*	Low	Low	Low
Teridgerie Creek*	Low	Low	Low
Tooraweenah to Coonamble Tributaries	Low	Low	Low

Table 7-18. BLR and entitlement volumes for medium and high risk water sources in the Macquarie-Castlereagh WRPA

Water source	BLR rights[1] (ML/yr)	Total entitlement[2] (ML/yr)	Number of WALs
Ewenmar Creek	42	65125	13
Fish River	296	18071	41
Lower Bogan River	270	42305	29
Macquarie above Burrendong	260	25586	98
Summerhill Creek	150	11765	72
Lower Macquarie	31	51888	22
References: *1 Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* 2 Department of Industry Water Register for the 2017–18 Water Year			

7.5. Other values

Other risks to the availability of water for other public benefit values (Indigenous, socio-economic) have not been assessed in this analysis due to a lack of data. Future risk assessments will include an assessment of these risks as further data becomes available. Aboriginal cultural requirements will be addressed in a separate document.

8. Risk treatment overview

Section 10.43(1) of the Basin Plan requires WRPs to describe water resource management strategies to address medium or high levels of risk or explain why the risk cannot be addressed by the WRP in a manner commensurate with the level of risk. As strategies are not required for risk results that are low, they have not been further considered in the risk treatment overview.

Medium and high risk results were reviewed to determine whether they are adequately addressed by existing strategies, or whether modifications or new strategies may be required. Risk treatment options were developed following a systematic approach outlined in Figure 8-1 and further explained in Table 8-1. Defining tolerable risk results (those high or medium results NSW considers are acceptable or adequately managed by existing water resource management strategies) were also part of this approach.

Explanations for risk results that the WRP cannot address in a manner commensurate with the level of risk are provided in the consolidated risk table (Table 1) at the start of this document.

As this risk assessment examines risks to water quality, it is relevant to note that s10.31 of the Basin Plan also requires the WQM Plan to include measures to address water quality risks. Where the WQM Plan identifies measures that are contained within the WRP or WSPs, these strategies are also shown in this chapter. Note this material is included to show linkages between the two documents and the WQM Plan should be referred to in the first instance.

The risk treatment options reflect the complex nature of risk based water resource management and allow for a range of strategies to be identified and applied irrespective of their legislative base or approach.

Option A is used when other risk options have been assessed and no further strategies are available, or by default when a risk is defined as tolerable.

Options B and C guide the development of strategies that aim to improve knowledge about the risk or the resource. They allow for instances where there has not been adequate information available to fully assess a risk or to develop or modify an existing mitigation strategy. Although associated strategies cannot directly mitigate risk, they aim to provide sufficient information to enable mitigation strategies to be reassessed or developed under options D to G. Options B and C may be linked to adaptive management strategies that are responsive to information improvements during the term of the WRP or related plan. Additional information on strategies related to these options can be found in the Macquarie-Castlereagh Monitoring, Evaluation and Reporting (MER) Plan.

Options D to G guide the modification of existing or development of new strategies that mitigate risk through activity control mechanisms. Strategies related to these options may need consideration of impact on other risk results or third parties. This element has been included to reflect Basin Plan and NSW principles for WRP development which recognise the competing economic, social, cultural, and environmental demands on water resources. Identifying where strategy trade-offs have been applied is particularly important where mitigation strategies may not result in the full mitigation of an identified risk. The pathway allows the likely effects of adjusted or new strategies on risk results to be considered as residual risks. It also enables the acceptance of a high or medium risk result as tolerable if predefined criteria are met, or following the application of a risk treatment option. The difference between these tolerable risks is discussed in Chapter 8.2 below.

For detailed information on the application of the options and strategies applied to individual risk results, see the consolidated risk table (Table 1 of the Executive Summary). Note risk results that are low or have been assigned a tolerable status based on predefined criteria are assumed to have adequate strategies in place and have not been further reviewed in this risk assessment.

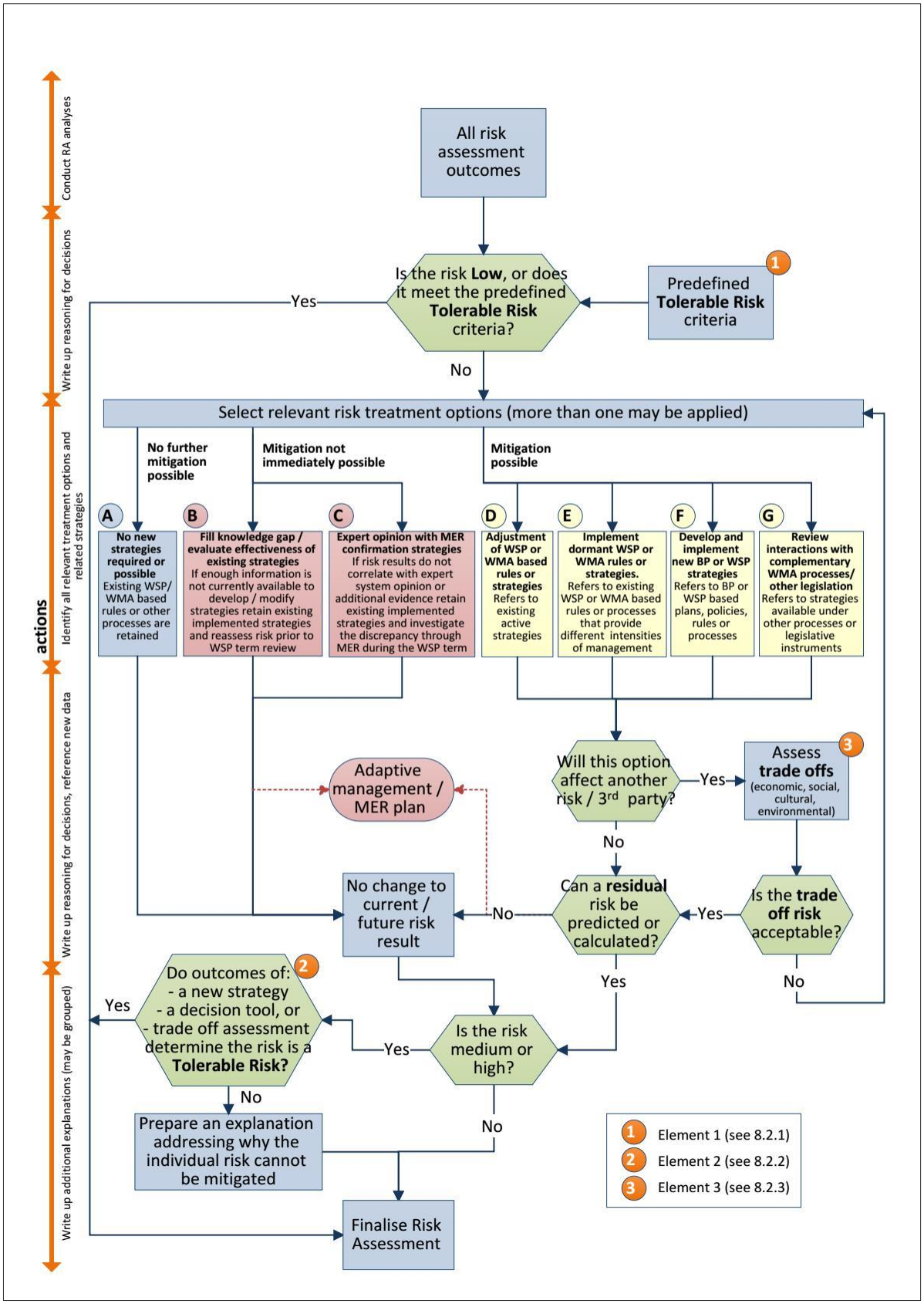


Figure 8-1. Risk treatment pathway

Table 8-1. Risk treatment options explained

Element	Description
A No new strategies required or possible	No further mitigation is possible and no new strategies are proposed. This may be relevant where the risk is adequately managed via existing strategies or where a risk cannot be fully mitigated and trade-offs limit other options. *Note:* existing strategies are retained and the risk result does not change.
B Fill knowledge gap / evaluate effectiveness of existing strategies	Mitigation is not immediately possible and knowledge improvement is proposed. Where there is not enough information available regarding the resource and/or the effectiveness of existing or alternative strategies this option can be used. The MER plan will address the knowledge gaps to enable the existing strategies to be reviewed in the future. *Note:* existing strategies are retained and the risk result does not change
C Expert opinion with MER confirmation strategies	Mitigation is not immediately possible and knowledge improvement via the MER plan is proposed. This option may be used where there is a discrepancy between risk assessment results and expert opinion or alternative evidence. Differences may be due to conservative estimations of consequence or likelihood in risk assessment calculations, knowledge from complementary WRP activities such as LTWP development (including identification of asset watering requirements), type of data available for risk calculation, or other factors that affect results such as data confidence. Note: existing strategies are retained and the risk result does not change. Alternative information sources may enable decisions around the tolerability of a risk result to be made.
D Adjustment of WSP or WM Act based rules or strategies	Mitigation is possible through adjustment of an existing active (i.e. implemented) water sharing strategy. These strategies are generally those currently implemented via WSPs, the WM Act or related policies. Note: existing strategies that are not modified by this risk treatment option are retained. Other risk results may change as a result of strategy modification. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
E Implement dormant WSP or WM Act strategies	Mitigation is possible through the implementation of an existing dormant (i.e. non-implemented but available for use via WSP or WM Act) water sharing strategy. These strategies often describe alternative levels of management intensity than the implemented active strategy. Examples include IDELs/TDELs or local area management in groundwater systems where they are not already in place. Note: unaffected existing strategies are retained, risk results may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
F (i) Develop and implement new water sharing strategies	Mitigation is possible through the development and implementation of new WSP or WM Act based sharing strategies such as rules, policies or other processes. Note: unaffected existing strategies are retained, risk results may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
F (ii) Develop / implement new strategies (WRP/WQSMP/IRG/LTWP/BP)	Mitigation is possible through the development and implementation of new strategies that are not covered by F(i) and are related to the introduction of the Basin Plan and appear in associated instruments. Note: unaffected existing strategies are retained, risk results may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
G (i) Review interaction with complementary WM Act processes	The WM Act covers a broad range of activities of which water sharing is one. This option focuses on reviewing linkages to WM Act based strategies that are complementary to water sharing such as floodplain harvesting and floodplain management. Note: unaffected existing strategies are retained, risk results may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.

Element	Description
G (ii) Review interaction with strategies available under other legislation	Other legislative instruments that contain strategies that may mitigate risk to water sources (e.g. the *Environmental Planning and Assessment Act 1979*, *Contaminated Land Management Act 1997*, *Dam Safety Act 2015*). Multi-agency strategies such as the NSW Cold Water Pollution Strategy and others covering land management should also be included. This strategy type aims to review interaction with and improve linkages to complementary non WM Act or Basin Plan processes and controls. Examples include: major storage infrastructure upgrades can mitigate risk to the environment from cold water pollution; improvement in land use management practices can reduce the risk to the environment by reducing suspended solid loads. Note: unaffected existing strategies are retained, risk results may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.

8.1. Existing water resource management strategies, actions and mechanisms

This risk assessment has assessed risks with existing WSP or WM Act based rules in place. It builds on the knowledge and experience of earlier risk based approaches to water planning and management in NSW (NOW 2011a). A range of strategies under the WM Act and associated WSPs address risk for the WRP area, these are consistent with strategies applied elsewhere in the NSW portion of the Basin and other areas of the State. These strategies have been identified for each risk as water management actions and mechanisms in previous sections of this report. They are also shown later in this chapter in the strategy summary table (Table 8-7) and the consolidated risk table. Further information on existing strategies and the way in which they address risk can also be found in the following documents (Table 8-2), and other material available from the NSW Department of Industry website. These references are provided for background information purposes and may be replaced with updated references as water resource plans are finalised and implemented.

Table 8-2. Further information regarding existing WM Act based strategies, actions and mechanisms

Document
Evaluation of NSW Water sharing plans for the major regulated rivers in the Murray–Darling Basin (DPI 2017) (in final draft)
Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012 Background Document, DPI Water 2012
Water Sharing Plan for the Castlereagh Unregulated and Alluvial Water Sources 2011 Background Document, DPI Water 2011
Macro water sharing plans – the approach for unregulated rivers. A report to assist community consultation, Office of Water 2011
Water sharing plans - Inland NSW unregulated and alluvial water sources – Overview NSW, Office of Water 2011

8.2. Tolerable risk results

A medium or high-risk result does not necessarily imply that existing water management strategies require change or are inadequate. In many circumstances these risks will already have an appropriate level of management in place under the WM Act that is commensurate with the risk result (i.e. via the relevant water sharing or other water management plans, water management policies etc.). In these situations NSW has made an informed decision to accept the risk result as an acceptable or tolerable risk in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* Where a risk result is considered tolerable, the Basin Plan does not require further strategies to be implemented. These results are not further considered in this document.

8.2.1. Predefined tolerable risk criteria

This section refers to element 1 on the risk treatment pathway. Risk results that meet the predefined tolerable risk criteria are automatically assigned risk treatment option A as no new strategies are required or possible.

There are a variety of reasons why medium or high-risk results may be tolerable including acceptance of the fundamental changes that river regulation has made to some NSW rivers and the balancing of environmental, social, cultural and economic demands on water resources. Table 8-3 lists the criteria that have been used to predefine risk results as tolerable. If a risk does not appear, no predefined criteria have been identified. The consolidated risk table identifies for each river reach the tolerable status and relevant rationale for each risk result. As noted earlier, strategies relating to risks to water quality are not discussed in this chapter; refer to the WQM Plan for this material.

Table 8-3. Tolerable risk result rationale

Risk	Component	Tolerable rationale
E(W) Risk to water available for the environment due to river regulation and licensed extraction (regulated rivers)	Zero flows	Risk inherent to regulated river reaches. Zero flow periods cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows. This impact is most pronounced in reaches closest to Windamere and Burrendong Dams. Zero flow periods will exhibit more natural patterns towards the downstream end of the water sources.
	Base flows	Risk inherent to regulated river reaches. Base flows cannot be scheduled due to dam operational constraints and requirements to deliver water orders and BLR (stock and domestic) replenishment flows. This impact is most pronounced in reaches closest to Windamere and Burrendong Dams. Base flow periods will exhibit more natural patterns towards the downstream end of the water sources.
	Fresh flows	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer and fewer events in winter. This impact is most pronounced in the reaches closest to Windamere and Burrendong Dams and is mitigated in a downstream direction as more tributary flows enter the regulated river.
	Medium to High flows ARI 1.5	Water ordering patterns have altered the duration and timing of freshes leading to unnaturally long events in summer and fewer events in winter. This impact is most pronounced in the reaches closest to Windamere and Burrendong Dams and is mitigated in a downstream direction as more tributary flows enter the regulated river.
	High flows ARI 2.5	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 2.5 ARI flows
	High flows ARI 5	River regulation, water ordering patterns, and third party inundation risks prevent an increase in the frequency of 5 ARI flows
	Some Medium Risks across various flow components	Some medium risks are driven by a low likelihood and a very high consequence. These risks are tolerable due to the low likelihood rating.

8.2.2. Risks assessed as tolerable following application of a risk treatment option

This section refers to element 2 on the risk treatment pathway. Although risk results may arrive at this element following the application of any risk treatment option, only those where a tolerable risk has been determined are discussed.

In this assessment risk treatment option C *Expert opinion with MER confirmation* has been applied to the following risks.

8.2.2.1. Risk to the environment and capacity to meet environmental water requirements from insufficient water (unregulated rivers)

The level of risk to the environment from water extraction in unregulated rivers has been difficult to assess. As there is little water extraction information collected, volumes and patterns of current use cannot be used to determine the likelihood of extraction impacts. The best available information is the entitlement information shown on water access licences and in WSPs. While this can be used to assess the risk to the environment for full extraction development, the information reflects potential risk rather than the current risk in those water sources where extraction has not reached full development levels.

In many circumstances these water sources may already have an appropriate level of management in place under the WM Act that is commensurate with the risk from current levels of water extraction. As the level of risk for many unregulated water sources is unclear, risk treatment option C has been applied and a strategy developed to improve the knowledge used to assess risk from extraction in unregulated sections of the WRP area (see strategy 18 in Table 8-6).

As the results of this strategy will not be available for some time, a decision tool was used to compare expert knowledge of individual water sources to the full development risk to assign a tolerable status to each result, and to make recommendations for ongoing monitoring. Further information on the decision tool can be found in Appendix F. Refer to the MER Plan for more information regarding the implementation of strategy 18.

The consolidated risk table indicates where tolerable risks have been identified for unregulated water sources. As no additional strategies have been applied to these results, they are not discussed further in this document. The table also addresses those risks this strategy has not determined to be tolerable.

8.2.3. Trade-off assessments

This section refers to element 3 on the risk treatment pathway. Risk results may arrive at this element of the pathway following the application of options D to G where a new or modified strategy affects another risk result or may result in a third-party impact.

8.3. New or modified water resource management strategies, actions and mechanisms

This section refers to strategies developed or modified as a result of applying options D to G on the risk treatment pathway. Although several options for new or modified strategies were developed for consideration, only those that are proceeding into the WRP have been included in this section. Appendix G contains further information on strategy development constraints, decision processes and draft strategies. The WRP describes the consultation undertaken to determine which strategies will be implemented.

A number of overarching principles guide the development of WRPs in NSW. These acknowledge the legislative framework and water resource management strategies in place in NSW prior to the introduction of the Basin Plan. These principles have been considered during the preparation of new actions and mechanisms and are summarised in Table 8-4.

Table 8-4 Principles guiding development of strategies in NSW

Instrument or source	Principles
Commonwealth Water Act 2007	There will be no net reduction in the protection of planned environmental water
	The Commonwealth is responsible for funding the gap between existing limits and the Sustainable Diversion Limits (SDL).
	WRPs will meet the requirements set out in the Basin Plan
Basin Plan	Nothing in the Basin Plan requires a change in the reliability of water allocations of a kind that would trigger Subdivision B of Division 4 of Part 2 of the Act (s. 6.14)
NSW Water Management Act 2000	WSPs are required to balance social, cultural, economic and environmental needs of the community and catchments (this is a fundamental objective of water management in NSW and is described in the objects of the Act).
Delivering WRP Plans for NSW Roadmap 2016-2019	WRPs are cost neutral for NSW licence holders
	Development of WRPs minimises change to NSW WSPs within their initial ten year terms

The strategies outlined in this section were developed with consideration to their implementation. As this is primarily through the rules and conditions within the WRP and the WSP, strategies have been limited to water management actions and mechanisms as these are within the scope of Basin Plan strategies and controls. As previously mentioned, strategies outside this scope that relate to the management of water quality risks are outlined in the WQM Plan. Table 8-5 provides information on the new strategies and explains how risk is addressed.

Table 8-5. New or modified water management actions and mechanisms

Mechanism	Description
N1 Sustainable Diversion Limits	This new mechanism is a Basin Plan requirement
N2 Strategic use of environmental water allowance (EWA) (and relevant held environmental water licences) as described in the Macquarie LTWP	Risk: Risk to the environment and risk to the capacity to meet environmental water requirements from insufficient water. Risk driver addressed: Reduced frequency and altered seasonality of freshes, reduced frequency of over bank flows in unregulated water sources downstream of the regulated river. Locations: Regulated rivers and downstream unregulated water sources Benefits: Improved pattern of freshes through improved environmental water management.
N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	The planned environmental water in the form of translucent flows from Windamere Dam is to be replace by an discretionary environmental water allowance to be controlled by the EFRG (or a local Cudgegong subcommittee)

8.4. Knowledge strategies

This section refers to strategies developed as a result of applying options B and C on the risk treatment pathway. Although knowledge improvement strategies cannot directly mitigate risk results, these strategies aim to provide information on which to base future calculations of risk and to inform planning decisions regarding strategy or mechanism application. A summary of these strategies is provided in Table 8-6, further information can be found in the MER Plan.

Table 8-6. Knowledge strategies

Strategy	Mechanism and description
18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 Projects resulting from application of risk treatment option C Expert opinion with MER confirmation strategies It is expected there will be ongoing monitoring to determine current extraction in the unregulated water sources of the WRP area resulting in a dataset that can be used to assess and monitor the likelihood component of relevant risks. *Note: N4 may also be used in conjunction with N5*
19 Improve knowledge of effectiveness of existing strategies	N5 Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies This risk assessment recommends review of current extraction management strategies in those unregulated water sources where medium or high risks have not been assessed as tolerable and no new strategies have been identified. Refer to the MER plan for further information. In this WRP area those water sources are: Bell River, Bulbodney Grahway Creek, Campbells River, Coolbaggie Creek, Fish River, Lower Bogan River, Lower Macquarie River, Lower Macquarie River, Macquarie River above Burrendong, Marra Creek, Marthaguy Creek, Queen Charlottes Vale Evans Plains, Turon Crudine River, Upper Bogan River, Upper Cudgegong River, Upper Talbragar River, Castlereagh River Binnaway to Gilgandra, Castlereagh River below Coonamble. *Note: where N5 applies, N4 also applies*

8.5. Summary of strategies to address risk

A summary of strategies is presented in Table 8-7 to complement the consolidated risk table. Hydrology components used in this risk assessment and the EWR references from Macquarie Long-term Water Plan Technical Report (OEH 2018b) are provided where relevant in the 'relevant risks column'. This meets the requirements of 10.41(2)(a) and 10.17(1). The listed strategies align with those used in the WRP, WSP, WQM Plan and LTWP objectives. Here, strategies are described with associated actions and mechanisms for each risk and the relevant WRP and water quality objectives. The applicable risk treatment option is included as well as links to relevant sections of the Basin Plan in order to streamline strategy assessment. For more information refer to the document map. Table 8-8 contains a list of abbreviations used in Table 8-7.

Note: The following table contains all relevant strategies and mechanisms including elements such as sections of the WM Act and trade rules that may not be accreditable. Refer to the WRP for the accreditation status of these strategies and mechanisms

Note: Red shaded boxes indicate elements of the table that cannot be completed until additional information becomes available.

Table 8-7. Summary of strategies to address risk

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
1 Limit consumptive water extractions in the WRP area to the predefined share of available water. This strategy reserves a share of water for the environment in order to protect: * native fish communities * flow dependent vegetation communities * low flow macroinvertebrate communities * carbon and nutrient flow pathways	E01 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E02 Available Water Determinations (AWD) adjust extractive use according to water availability. N1 Sustainable Diversion Limits	D A F	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* *Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011* Macquarie-Castlereagh water resource plan	**E(W)** Z, BF, F, BKF1.5, OB2.5, OB5 **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3,	**4.03(3)** **(a)(iii)** **(a)(iv)** **(c)** **(f)** **Ch. 10 Part 3, Part 8 Part 10**	**WSP** 1-14

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
* flow dependent frog communities * significant in-stream refuge pools, lagoons, and wetlands.	E28 Require all take to be licensed except for BLR or where a policy indicates otherwise. E03 Extraction limits for individual extractors and associated accounting provisions to manage extraction at the extraction point.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* *Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	LTWP LF1, LTWP LF2, LTWP OBWS1, LTWP OBWS2, LTWP OBWS3 LTWP OBWS4 LTWP OBWM, LTWP OBWL		
	E19 Compliance with individual extraction limits	D	Water Take Measurement and Metering Policy			
	E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth. E05 Prohibit trade between surface water and groundwater sources.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* *Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
2 Protect a portion of high flow events in the Macquarie-Castlereagh WRP area. This strategy reserves a share of high flows for the environment and aims to: * wet benches, banks, wetlands and floodplains, and recharge shallow groundwater lenses to facilitate vegetation growth and recruitment and provide fish and frog habitat, * facilitate the mobilisation of carbon and nutrients from river benches and floodplains, and facilitate deposition into lowland streams and floodplains, * Facilitate fish recruitment and movement, * allow flows to pass through to the Barwon-Darling Watercourse WRP (SW12) area. This strategy provides connectivity between WRP areas and facilitates fish movement and recruitment.	E06 & E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Water Sources 2016. (E06 Cudgegong rules, E07 Macquarie rules) E08 Planned Environmental Water (Translucent) releases from Windamere Dam (to be repealed) E09 Planned Environmental Water Sub Allowance 1 Translucent releases from Burrendong Dam	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*	**E(W)** F, BKF1.5, OB2.5, OB5 **E(WQ)** turbidity, TP, TN, dissolved oxygen **EWR ref.**, LTWP SF1, LTWP SF2 LTWP SF3, LTWP LF1, LTWP LF2, LTWP OBWS1, LTWP OBWS2, LTWP OBWS3 LTWP OBWS4 LTWP OBWM, LTWP OBWL	**4.03(3) (a)(i) (a)(ii) (a)(iv) (c) (d)** **Ch. 10 Part 6 Part 7**	**WSP** 1,2,3,5 **WQ** 3, 4
	E24 Protection of Environmental Water Allowance released from Burrendong Dam	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*			
3 Provide discretionary environmental watering events in the regulated river and downstream unregulated river sections of the WRP area.	E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*	**E(W)** Z, BF, F, BKF1.5, OB2.5, OB5 **E(WQ)** TP TN	**4.03(3) (a)(i) (a)(ii) (a)(iv) (c)**	**WSP** 1,2,3,5 **WQ** 4, 5, 6

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
This strategy offsets some effects of river regulation on the environment and aims to: * protect refuge pools during dry periods, * facilitate fish recruitment and movement, * wet benches, banks and wetlands to facilitate vegetation growth and recruitment, * mobilise carbon and nutrients from channels, river benches and wetlands in the Macquarie regulated water source, * reduce prolonged accumulation of organic material on floodplains,	E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group. N2 Strategic use of environmental water allowance (EWA) (and relevant held environmental water licences) as guided by the LTWP. N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	F	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* Macquarie Annual Environmental Water Plans Macquarie Long Term Water Plan	**EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3, LTWP LF1, LTWP LF2, LTWP OBWS1, LTWP OBWS2, LTWP OBWS3 LTWP OBWS4 LTWP OBWM, LTWP OBWL	**Ch. 10 Part 6 Part 7**	
4 Manage environmental water to meet flow targets specified in the Macquarie LTWP. This strategy aims to improve environmental water management in the WRP area.	E6 & E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Water Sources 2016. (E06 Cudgegong rules, E07 Macquarie rules)	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*	**E(W)** Z, BF, F, BKF1.5, OB2.5, OB5 **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3, LTWP LF1, LTWP LF2, LTWP OBWS1,	**4.03(3) (a)(i) (a)(iv) (c)** **Ch. 10 Part 6**	**WSP** 1,2,3,5
	E11 Coordinate release of environmental water allowance (EWA) and held environmental water with natural flow events.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* Macquarie Annual Environmental Water Plans			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
	N2 Strategic use of the environmental portion of supplementary flow events to manage environmental outcomes within the lower portions of the Macquarie-Castlereagh WRP as guided by the LTWP. N3 Environmental Water Allowance from Windamere Dam for Cudgegong system	F	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* Macquarie Long Term Water Plan	LTWP OBWS2, LTWP OBWS3 LTWP OBWS4 LTWP OBWM, LTWP OBWL		
5 Protect low flow habitats from accelerated rates of drying. This strategy offsets impacts of water extraction in rivers of the WRP area and aims to: * maintain surface water connectivity and habitat variability, * prevent accelerated rates of deterioration in water quality, * maintain surface/groundwater connectivity where there is groundwater-dependent riparian vegetation. *Note: BLR replenishment flows may provide incidental environmental benefit in line with this strategy.*	E15 Cease / commence to pump rules for streams.	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	**E(W)** Z, BF, F **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3	**4.03(3) (a)(i) (a)(ii) (a)(iv) (c) (d)** **Ch. 10 Part 4, Part 6**	**WSP** 1,2,3,5,6,7, 8,10,11,12, 13 **WQ** 3, 4
	E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group.	A	Macquarie Annual Environmental Water Plans			
	N2 Strategic use of environmental water allowance (EWA) (and relevant held environmental water licences) as guided by the LTWP.	F	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* Macquarie Long Term Water Plan			
	Note: Complimentary groundwater actions and mechanisms are identified in the Macquarie-Castlereagh Alluvium Water Resource Plan (GW11).		Macquarie-Castlereagh Alluvium Water Resource Plan (GW11)			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
6 Protect pools in streams, wetlands, lagoons and floodplains within the WRP area during dry periods. This strategy offsets impacts of water extraction from pools and aims to maintain natural rates of drying to protect water quality, and provide refugial habitat for fish, frogs and other water-dependent biota.	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools.	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	**E(W)** Z, BF, F **E(WQ)** all **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3,	**4.03(3) (a)(i) (a)(ii) (a)(iv) (c)** **Ch. 10 Part 4 Part 6 Part 7**	**WSP** 6,7,8,10,11, 12,13 **WQ** 3, 4, 5
	E35 while there is no visible flow at the location at which water is proposed to be taken, water must not be taken for any 24-hour period starting at 18:00 on an even-numbered calendar day under an access licence that nominates a water supply work (spearpoint) within the alluvial sand beds	A	*Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*			
	E17 Authorised in-river dam construction, operation, and passing flow requirements as specified on the dam approval. E32 Provide specified replenishment flows to refill pools or waterholes in effluent systems and provide water for stock and domestic purposes	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*			
7 Protect important lagoons and wetlands within the WRP area. This strategy aims to limit extraction induced declines in water quality and condition of: * wetlands listed under the Ramsar Convention and other significant wetlands and lagoons in the lower portion of the WRP area.	E15 Cease / commence to pump rules for streams. E16 Cease / commence to pump rules for in-stream and off-river pools. E17 Restrict construction of in-river dams on 3rd order or higher streams. E04 Trade limits or prohibitions between surface water plan areas, water sources, and management zones to manage entitlement growth.	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	**E(W)** Z, BF, F **E(WQ)** all **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1,	**4.03(3) (a)(i) (a)(ii) (a)(iv) (c)** **Ch 10 Part 4 Part 6 Part 7**	**WSP** 6,7,8,10,11, 12,13 **WQ** 3, 4

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
	E35 While there is no visible flow at the location at which water is proposed to be taken, water must not be taken for any 24-hour period starting at 18:00 on an even-numbered calendar day under an access licence that nominates a water supply work (spearpoint) within the alluvial sand beds	A	*Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	LTWP SF2 LTWP SF3, LTWP OBWS1		
8 Protect the connectivity between the regulated water source and downstream connected unregulated water sources of the WRP area. This strategy aims to optimise environmental water delivery to the Macquarie Marshes and the Barwon Darling in dry seasons by restricting extraction of low flows.	E15 Cease / commence to pump rules for streams	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	**E(W)** Z, BF, F **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3,	**4.03(3)** **(a)(i)** **(a)(iv)** **(c)** **(d)** **Ch. 10 Part 6**	**WSP** 10
	E24 Protection of Environmental Water Allowance released from Burrendong Dam through unregulated water sources in lower Macquarie system. E33 Protection of flows 500ML/d or less in the Lower Macquarie River Upstream Management Zone in the Lower Macquarie River Water Source	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012*			
9 Protect tributary flows within the WRP area as they move from the unregulated water source into the regulated river water source. This strategy protects connectivity within the WRP area and facilitates: * fish dispersal and carbon and nutrient transport, * facilitate thermal mixing in the Macquarie and Cudgegong Regulated River Water Sources.	E12 Cease / commence to pump rules for streams.	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012*	**E(W)** Z, BF **E(WQ-CWP)** **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3	**4.03(3)** **(a)(i)** **(a)(ii)** **(a)(iv)** **(c)** **Ch. 10 Part 6 Part 7**	**WSP** 1,2,3,5,8,10, 13 **WQ** 3, 4, 5
	E06 & E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Water Sources 2016. (E06 Cudgegong rules, E07 Macquarie rules)	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
10 Protect the regulated river sections of the WRP area from rapid increases and decreases in flow following releases from Windamere and Burrendong Dams. This strategy protects the integrity of river banks and assists in the management of suspended sediment loads.	E14 Rates of change to storage release protocol.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* WaterNSW Burrendong and Windamere Dams Water Supply Work Approvals	**E(WQ)** Turbidity	**4.03(3)** **(a)(ii)** **(a)(iv)** **(c)** **Ch. 10 Part 7**	**WSP** 4 **WQ** 2
11 Windamere and Burrendong Dams release strategies contribute towards the maintenance of water quality within the regulated sections of the WRP area. This strategy aims to mitigate the following water quality impacts of river regulation and flow regime alteration: * minimise the risk of cold or warm water thermal shock, * reduce the risk of CWP or poor WQ	E06 & E07 Supplementary access to natural flow events limited as per the WSP for the Macquarie and Cudgegong Regulated Water Sources 2016. (E06 Cudgegong rules, E07 Macquarie rules)	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016*	**E(WQ-S)** **E(WQ-CWP)** **E(WQ)**	**4.03(3)** **(a)(i)** **(a)(ii)** **(a)(iv)** **(c)** **(d)** **Ch. 10 Part 6 Part 7**	**WSP** 4 **WQ** 2, 5, 6
	E10 Strategic use of environmental water allowance Sub Allowance 2 Active as directed by Environmental Flows Reference Group.	A	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* Macquarie Annual Environmental Water Plans			
	N3 Strategic use of environmental water allowance (EWA) (and relevant held environmental water licences) as guided by the LTWP.	F	Macquarie Long Term Water Plan			
	E20 Manage water releases from the variable offtake at Windamere Dam to ensure releases are more closely match natural river ambient temperatures. E21 Repair and operate thermal curtain at Burrendong Dam to ensure water releases more closely match natural river ambient temperatures	A	NSW Cold Water Pollution Strategy WaterNSW Windamere Dam Water Supply Work Approval WaterNSW Burrendong Dam Water Supply Work Approval			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
12 Implement the WQM Plan for the WRP area.	*Refer to the WQM Plan for detailed listing. Note: actions and mechanisms are relevant to the WRP are listed in previous strategies.*	F	Water Quality Management Plan for the Macquarie-Castlereagh WRP area Basin Salinity Management Strategy	**E(WQ-S)** **E(WQ-CWP)** **E(WQ)** **O(WQ-BGA)**	**4.03(3)(a)(ii)** **Ch. 10 Part 7**	**WSP** 4,9,13 **WQ** 1, 2, 3, 4, 5, 6, 7, 8
13 Protect stream flow from reduced runoff attributable to farm dam interception. This strategy aims to reduce impacts on the health of rivers and on other consumptive water users.	E21 Require farm dams with a capacity above the maximum harvestable right dam capacity (MHRDC) to be licensed and comply with extraction limits as described in strategy 1.	A	*Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011* Harvestable Rights Policy (commenced 1999) NSW Government Gazette 40 dated 31 March 2006	**E(I-FD)** **O(I-FD)**	**4.03(3)(a)(iv)(c)(h)(i)** **Ch. 10 Part 5**	**N/A**
14 Protect stream flow from reduced runoff attributable to plantation forestry interception. This strategy aims to reduce impacts on the health of rivers and on other consumptive water users.	E22 Plantation forestry interception is considered low risk therefore no mechanisms have been implemented under the WM Act.	A	Plantation Forestry Policy Plantations and Reafforestation Act 1999 (PRA) Plantations and Reafforestation (Code) Regulation 2001 Macquarie Monitoring, Evaluation and Reporting Plan	**E(I-PF)** **O(I-PF)**	**4.03(3)(a)(iv)(c)(h)(i)** **Ch. 10 Part 5**	**N/A**
	E23 Ongoing risk monitoring to determine impact of future expansion of forest plantations at local and regional scales.	B				
15 Protect the environment and water users from changes in flow attributable to climate change. This strategy aims to reduce impacts on the health of rivers and on other consumptive water users. *Note: significant volumes of held*	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E2 Available Water Determinations (AWD) adjust extractive use according to water availability.	D	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* *Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the*	**E(CC)** **O(CC)**	**4.03(3)(a)(iv)(c)(g)(iii)(h)(ii)** **Ch. 10 Part 3**	**N/A**

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
environmental water may offset climate change impacts under the median scenario.	N1 Sustainable Diversion Limits.	F	*Castlereagh River Unregulated and Alluvial Water Sources 2011* Macquarie-Castlereagh water resource plan Note: No further climate change strategy has been identified beyond the SDL in this document.			
16 Protect the environment from changes in flow attributable to growth in BLR extractive use. This strategy aims to reduce impacts on the health of rivers.	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as PEW (defined and managed by the listed WSPs). E2 Available Water Determinations (AWD) adjust extractive use according to water availability.	D	*Water Sharing Plan for the Macquarie and Cudgegong Regulated River Water Sources 2016* *Water Sharing Plan for the Macquarie Bogan Unregulated Water Sources 2012* *Water Sharing plan for the Castlereagh River Unregulated and Alluvial Water Sources 2011*	**E(BLR)** **EWR ref.** LTWP CTF, LTWP VLF,	**4.03(3)** **(a)(iv)** **(c)** **h(ii)** **Ch 10 Part 3**	**N/A**
	N1 Sustainable Diversion Limits	F	Macquarie-Castlereagh water resource plan			
	E34 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA*	D	*Water Management Act 2000* s.52(2)			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
17 Protect the other water users from changes in flow attributable to growth in BLR extractive use. This strategy aims to reduce impacts on other consumptive water users. *Note: BLR are established and controlled through the WMA and are recognised in WSPs. Control mechanisms are only applied when required, related mechanism are not currently active in the Macquarie-Castlereagh WRPA*	E26 Minister may restrict BLR access through the establishment of mandatory guidelines *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA*	A	*Water Management Act 2000* s.336B	O(BLR)	4.03(3) (a)(iv) (c) (d) h(ii) Ch. 10 Part 3	N/A
	E27 Minister may temporarily restrict access where it is in the public interest to do so. *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA*	A	*Water Management Act 2000* s.324(1)			
	E30 Minister may direct landholder accessing BLR to not waste or improperly use water *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA.*	A	*Water Management Act 2000* s.325			
	E34 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. *Note: this mechanism is not currently applied in the Macquarie-Castlereagh WRPA*	D	*Water Management Act 2000* s.52(2)			

Strategies	Water management actions and mechanisms / supporting activities	RTO	Associated management plan or instrument	Relevant risks & EWR ref	Relevant BP clauses	Relevant objectives
18 Improve knowledge to assess risk in unregulated sections of the WRP area.	N4 Projects resulting from application of risk treatment option C Fill knowledge gap / evaluate effectiveness of existing strategies. *Note: It is expected there will be ongoing monitoring to determine current extraction in the unregulated water sources of the WRP area resulting in a dataset that can be used to assess and monitor the likelihood component of relevant risks.*	C	Macquarie Monitoring, Evaluation and Reporting Plan	**E(W)** unregulated Z, BF, F **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3,	**4.03(3) (c)**	**N/A**
19 Improve knowledge of effectiveness of existing strategies.	N5 Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies.	B	Macquarie Monitoring, Evaluation and Reporting Plan.	**E(W)** unregulated Z, BF, F **EWR ref.** LTWP CTF, LTWP VLF, LTWP BF1, LTWP BF2, LTWP SF1, LTWP SF2 LTWP SF3,	**4.03(3) (b) (c) (e) (g)**	**N/A**

Table 8-8. Abbreviations used in Table 8-7

Abbreviation	Explanation
RTO	Risk treatment option refer Figure 8-1
E	Existing action / mechanism / supporting activity
N	New or modified action / mechanism / supporting activity
E(W)	Risks to water available for the environment due to river regulation and licensed extraction (regulated and unregulated)
E(BLR)	Risks to water available for the environment from extraction by basic landholder rights (unregulated)
E(I-FD)	Risk to water available for the environment from interception activities (farm dams) (regulated and unregulated)
E(I-PF)	Risk to water available for the environment from interception activities (plantation forestry) (regulated)
E(CC)	Risk to water available for the environment due to climate change (regulated)
E(WQ-CWP)	Risk to the health of water-dependent ecosystems from poor water quality (cold water pollution)
E(WQ)	Risk to the health of water-dependent ecosystems from poor water quality (TP, TN, pH, Turbidity, DO)
E(WQ-S)	Risk to the health of water-dependent ecosystems from poor water quality (in-stream salinity)
O(WQ-BGA)	Risks to recreational water quality and human health from blue-green algae
O(I-FD)	Risk to water available for other uses from interception activities (farm dams) (regulated rivers)
O(I-PF)	Risk to water available for other uses from interception activities (plantation forestry) (regulated rivers)
O(CC)	Risk to water available for other uses from climate change (regulated rivers)
O(BLR)	Risk to water available for other uses from growth in BLR (unregulated rivers)
E(W)	Risks to water available for the environment due to river regulation and licensed extraction (regulated and unregulated)
E(BLR)	Risks to water available for the environment from extraction by basic landholder rights (unregulated)
Z	Zero flows
BF	Base flows
F	Fresh flows
BKF1.5	Bank full flows, average recurrence interval 1.5 years
OB2.5	Over bank flows, average recurrence interval 2.5 years
OB5	Over bank flows, average recurrence interval 5 years
LTWP CTF	Cease-to-flow, no greater than modelled natural maximum inter-flow period (note LTWP flow components do not provide definitions of percentiles or frequencies)
LTWP VLF	Very-low flow, no greater than modelled natural maximum inter-flow period (note LTWP flow components do not provide definitions of percentiles or frequencies)
LTWP BF1	Base Flow 2. Duration no less than natural, inter-flow period as required during dry periods
LTWP BF2	Base Flow 2. Duration in line with natural, 2-year maximum inter-flow period
LTWP SF1	Small Fresh 3. 10 days minimum, 1-year maximum inter-flow period.
LTWP SF2	Small Fresh 2. 14 days minimum, 2-year maximum inter-flow period.
LTWP SF3	Small Fresh 3. 14 days minimum, 4-year maximum inter-flow period.

Abbreviation	Explanation	
LTWP LF1	Large Fresh 1. 5 days minimum, 2-year maximum inter-flow period.	
LTWP LF2	Large Fresh 2. 5 days minimum, 4-year maximum inter-flow period.	
LTWP OBWS1	Overbank/Wetland Flow Small 1, in line with natural duration, 1- month maximum inter-flow period	
LTWP OBWS2	Overbank/Wetland Flow Small 2, 5 days minimum, 10 days minimum, 4-year maximum inter-flow period.	
LTWP OBWS3	Overbank/Wetland Flow Small 3, 5 days minimum, 5-year maximum inter-flow period.	
LTWP OBWS4	Overbank/Wetland Flow Small 4, 3-8 months standing water, flows can be shorter. 2-year maximum inter-flow period.	
LTWP OBWM	Overbank/Wetland Flow Medium, 4-year maximum inter-flow period. Discretionary water delivery seeks to avoid floodplain infrastructure and cultivated areas. Otherwise provided by tributary events or flood mitigation releases	
LTWP OBWL	Overbank/Wetland Flow Large, 5–10-year maximum inter-flow period. Overbank and wetland flows of this size rely on large tributary events or flood mitigation zone releases	
WSP 1	Regulated WSP	recorded distribution or extent of target ecological populations including native fish and native vegetation
WSP 2	Regulated WSP	population structure of target ecological populations including native fish and native vegetation communities
WSP 3	Regulated WSP	connectivity between water sources to support downstream processes including priority carbon and nutrient pathways and priority fish passages
WSP 4 (WQ)	Regulated WSP	water quality to support water-dependent ecosystems and ecosystem functions within this water source
WSP 5	Regulated WSP	support environmental watering to contribute to the maintenance or enhancement of ecological condition in streams, riparian zones, dependent wetlands and floodplains within the water source
WSP 6	Unregulated WSP (Macquarie Bogan)	the recorded distribution or extent of target ecological populations including native fish and native vegetation
WSP 7	Unregulated WSP (Macquarie Bogan)	the population structure of target ecological populations including native fish, native vegetation and low flow macroinvertebrate communities
WSP 8	Unregulated WSP (Macquarie Bogan)	protect, maintain and/or enhance the connectivity between these water sources and other water sources, including to support downstream processes including priority carbon and nutrient pathways and priority fish passages
WSP 9 (WQ)	Unregulated WSP (Macquarie Bogan)	protect, maintain and/or enhance water quality to support water-dependent ecosystems and ecosystem functions within the water source
WSP 10	Unregulated WSP (Macquarie Bogan)	protect connectivity with the upstream Macquarie and Cudgegong Regulated River Water Sources to support environmental watering events that contribute to the maintenance or enhancement of ecological condition within these water sources

Abbreviation	Explanation	
WSP 11	Unregulated WSP (Castlereagh)	the recorded distribution or extent of target ecological populations including native fish and native vegetation
WSP 12	Unregulated WSP (Castlereagh)	the population structure of target ecological populations including native fish native vegetation and low flow macroinvertebrate communities
WSP 13	Unregulated WSP (Castlereagh)	protect, maintain and/or enhance the connectivity between these water sources and other water sources, including to support downstream processes including priority carbon and nutrient pathways and priority fish passages
WSP 14 (WQ)	Unregulated WSP (Castlereagh)	protect, maintain and/or enhance water quality to support water-dependent ecosystems and ecosystem functions within the water source
WQ 1	Protect, maintain or enhance water quality to ensure it is fit for purpose	
WQ 2	Manage water source salinity concentrations and salt mobilisation within Macquarie-Castlereagh end-of-valley targets	
WQ 3	Maintain turbidity, total nitrogen and total phosphorus within target ranges to minimise eutrophication in the WRP Area	
WQ 4	Maintain dissolved oxygen and pH measurements within target ranges that support water-dependent ecosystems	
WQ 5	Maintain water temperature within the regulated Macquarie and Cudgegong Rivers within target ranges that support water-dependent ecosystems	
WQ 6	Manage the risk of harmful algal blooms in recreational use areas	
WQ 7	Reduce the mobilisation of toxicants and pesticides	
WQ 8	Reduce contamination from pathogens into water sources	
WQ 9	Protect, maintain or enhance connectivity between water sources to support downstream processes including priority carbon and nutrient pathways	

Definitions

Note: These definitions may change after alignment with other WRP document definitions is undertaken.

Access licence	Access licences allow the licence holder a share of the available water in the water source. An access licence is separate from the approvals to use the water or to construct and operate the works to extract the water e.g. pump, dam. Access licences do not have to be renewed.
Allocation	The volume of water assigned to water allocation accounts in a given season, defined according to rules in the relevant water plan.
Aquatic ecosystems	Ecosystems that are dependent on flows, or periodic or sustained inundation/waterlogging for their ecological integrity. Examples include wetlands, rivers, karst and other groundwater-dependent ecosystems, saltmarshes, estuaries and areas of marine water not exceeding 6 m deep at low tide.
Available water	In relation to a water management area or water source, is the water that is available in that area or water source in accordance with an available water determination that is in force in respect of that area or water source.
Available water determination (AWD)	A determination referred to in section 59 of the *Water Management Act 2000* that defines the proportion of the share component that will be available for extraction under each category of water access licence.
Bank full events	Reshapes the channel, creating habitats such as pools, bars and benches. Also called High Flows.
Base flows	Flows that are confined to the lower part of the channel and are also often called low flows. These flows are between pools and riffle areas between pools.
Basic landholder rights (BLR)	Domestic and stock rights, harvestable rights or native title rights.
Blue-green algae (cyanobacteria)	A type of microscopic, algae-like bacteria that inhabit freshwater, coastal and marine waters. Some species are known to produce toxins which are harmful to humans and livestock.
Cold water pollution	An artificial decrease in the temperature of water in a natural river.
Consequence	The loss of value for an impacted receptor
Dissolved oxygen	Concentration of oxygen dissolved in water.
Domestic consumption	In relation to land means consumption for normal household purposes in domestic premises on the land.
Ecological value	The perceived importance of an ecosystem which is underpinned by the biotic and/or abiotic components and processes that characterise that ecosystem.
Ecologically significant components of the flow regime	Comprise of cease to flow periods, base flows (low flows), freshes, bank full flows and over bank flows.
Ecosystem	A specific composition of animals and plants that interact with one another and their environment.
Ecosystem functions	The processes that occur between organisms and within and between populations and communities. They include interactions with the nonliving environment that result in existing ecosystems and bring about dynamism through changes in ecosystems over time.
Effluent	An effluent stream is one which leaves the main river and does not return.
Endangered ecological community	Ecological communities as listed in Schedule 1 of the *Threatened Species Conservation Act 1995* or Schedule 4 of the *Fisheries Management Act 1994*.
Eutrophication	The process where an accumulation of nutrients in water bodies leads to rapid growth of aquatic plants.

Farm dams	Private dams that are used to intercept catchment runoff that would otherwise contributed to streamflow or recharge of aquifers. For this risk assessment they are predominantly hillside dams. It does not include floodplain harvesting dams.
Floodplain harvesting dams	Are often entirely encircled by embankments and rely mainly on pumped diversions during episodic flushes or overland flow. Prevalent in southern Queensland and northern NSW.
Freshes	Larger flows that inundate the sides of the banks and any in-channel benches that may be present.
Groundwater-dependent ecosystems	Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
High Flows	Reshapes the channel, creating habitats such as pools, bars and benches. Also called bank full events.
Indices	Metrics are combined as indicators and indicators are combined as indices.
In-stream Value	Ecological condition value of river reaches based upon High Ecological Value Aquatic Ecosystems (HEVAE). In NSW HEVAE was calculated using the 4 criteria: distinctiveness, diversity, naturalness and vital habitat.
Interception	Occurs when flows or surface or groundwater are stopped, reduced or redirected.
Key Environmental Asset	Better studied key environmental assets identified across the Murray–Darling Basin with significant and representative high-flow requirements.
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.
Long term average annual extraction limit	The target for total extractions (under all water access licences plus an estimate of basic landholder rights within an EMU or water source) which is used to assess whether growth in extractions has occurred.
Low flows	Flows that are confined to the lower part of the channel and are also often called base flows. These flows are between pools and riffle areas between pools. Generally defined as the 80th percentile flow.
Macro water sharing plans	Water sharing plans that apply to a number of water sources across catchments or different types of aquifers. The macro planning process is designed to develop broader scale water sharing plans covering most of the remaining water sources in NSW.
Management zones	An area within a water source used for defining the location and applicability of water sharing rules, but secondary to the water source. A management zone is more likely to be designated where local dealing restrictions are in place or where ‘cease to pump’ (CtP) rules for works approvals apply.
Metric	A numerical comparison of an observed variable and its value expected under reference condition.
Nitrogen and phosphorous	Chemical nutrients essential for growth and added to many fertilisers.
Operational constraints	Existing infrastructure systems that may preclude the delivery of certain flows.
Over bank flows	Connect the river to floodplain and wetlands allowing the exchange of nutrients and sediment to these areas.
Pools	Lentic water bodies (standing water), including anything falling within the definition of a “lake” found in the Dictionary of the *Water Management Act 2000*, except for tidal pools and estuaries.
Reference condition	Is the benchmark against which the health of the ecosystem metric is assessed. Reference condition describes the patterns and processes that would be expected to prevail without substantial human intervention. A reference condition is not a target or an implied objective for management but is merely representing the river ecosystem in a definitive state of good health.

Regulated river	Gazetted under the NSW *Water Management Act 2000* and is a river where downstream flows are regulated by a major state-owned storage or dam to supply irrigation water.
Replenishment flows	Flows provided along effluent systems to supply water for household, town use and stock.
Salinity	The concentration of sodium chloride or other dissolved minerals in water, usually expressed in EC units or milligrams of total dissolved solids per litre. Conversion factor is 0.64 mg/l TDS = 1000 µS/cm = 1 dS/m.
SDL resource unit	Means the water sources, or particular parts of the water resources, of a water resource plan area that is either a surface water SDL resource unit or groundwater SDL resource unit.
Seasonality	The timing of flooding and low flow events.
Stock watering	The watering of stock animals being raised on the land but does not include water in connection with the raising of stock animals on an intensive commercial basis that are housed or kept in feedlots or buildings for all (or a substantial part) of the period during which the stock animals are being raised.
Stratification	The formation of separate water layers.
Supplementary water	Formerly known as off-allocation water, this is surplus flow resulting from storm events that cannot be captured in storages or weirs. When the water is not needed to meet current demands or commitments, then it is considered surplus to requirements and a period of Supplementary Access is announced. Supplementary Water Access Licence holders can only pump water against these licences during these announced periods. Other categories of licence holders may also pump water during these periods.
Trade zones	A trading zone represents a portion of a water source which may then be specified so that trading rules can be applied, if required.
Water access entitlement	A water product issued under the *Water Management Act 2000*.
Water sources	Under the *Water Management Act 2000*, is defined as the whole or any part of: (a) one or more rivers, lakes or estuaries, or (b) one or more places where water occurs on or below the surface of the ground (including overland flow water flowing over or lying there for the time being), and includes the coastal waters of the State. Water sources are used to define where water sharing rules apply

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Appendix A Data summary tables

Table A-1. Summary of data used for the Macquarie-Castlereagh water resource plan area risk assessment

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
	Basin Plan requirements	The MDBA provides a number of Position Statements (PS) that provide guidance material	not listed (generic background information logic to the RA)			1. Relevant Position Statements (PS) for the development of a Risk Assessment include but are not limited to: PS 1B, 4A, 5A, 6A, 7B, 9A, 9B, 12A	https://www.mdba.gov.au/publications/policies-guidelines/water-resource-plans-what-they-are-how-they-are-developed	Not Applicable (N/A)	N/A	Position statements are designed to assist in the development of water resource plans by the Basin states.
1	Hydrological modelling - regulated river	Flow Metrics (hydrological alteration): 2800 GL reduction scenario (MDBA 2012) against near-natural condition scenario	4.3.1 (Regulated river water source)	E(W)	Likelihood	1. MDBA 2012. *Hydrologic modelling to inform the proposed Basin Plan - methods and results*. Murray–Darling Basin Authority, Canberra, ACT. 2. Alluvium (2010) Key ecosystem functions and their environmental water requirements. Report by Alluvium for Murray–Darling Basin Authority, Canberra, ACT. 3. Regulated River Sites: NSW Department of Industry IQQM (Integrated Quantity Quality Model) used for both MDBA & NSW Department of Industry sites. 4. MDBA modelling report appendix - 2800 GL scenario - 847	**Regulated River Hydrologic Sites**: Cudgegong River at Rocky Water Hole Cudgegong River at Yamble Bridge Macquarie River downstream Burrendong Dam Macquarie River at Geurie Macquarie River at Dubbo Macquarie River at Narromine Macquarie River at Gin Gin Macquarie River at Warren Weir Macquarie River downstream Marebone Weir Macquarie River at Oxley Station Gunningbah Creek below regulator Gunningbah Creek downstream Gunningbah Weir Duck Creek at Offtake Crooked Creek at Profile Duck Creek upstream Bogan River junction Bulgeraga Creek at Pillicawarrina	July 1895 to June 2009	High	Peer reviewed MDBA (MDBA 2012) & Alluvium (2010) reports. The models provide a tool to apply new management of water resources across a longer period to see how the new arrangements would work under different water availability conditions. For the Basin Plan, the proposed new arrangements have been applied to the historical climate period of July 1895 to June 2009, which covers periods of drought as well as floods. A detailed description for the development of environmental watering requirements for key ecosystem functions and the basis for adopting the flow metrics can be found in 'Attachment C Technical Paper-3' (pp.90-134) in Alluvium (2010).
2	Hydrological modelling - unregulated water sources	Flow Metrics (hydrological alteration): 2800 GL reduction scenario (MDBA 2012) against near-natural condition scenario	4.3.1 (Unregulated water sources)	E(W)	Likelihood	1. Unregulated water sources: single reach NSW Department of Industry IQQM.	**Unregulated River hydrologic Sites:** Bell River, Bulbodney-Grahway Creek system, Burrendong Dam Storage Tributaries, Campbells River, Coolbaggie Creek system, Cooyal Wialdra Creek System, Fish River, Goolma Creek, Lawson's Creek, Little River, Lower Bogan River Lower Macquarie River, Lower Talbragar River, Macquarie River above Burrendong, Marra Creek system, Marthaguy Creek, Maryvale-Geurie, Molong Creek & Tributaries, Piambong Creek, Pipeclay Creek, Queen Charlottes Vale Creek/Evans Plains Creek, Summerhill Creek, Turon/Crudine, Upper Bogan catchment, Upper Cudgegong River above Windamere, Upper Talbragar/Goolaburra-Gundy River, Wambangalong Whylandra System, Winburndale Rivulet, Castlereagh River Binnaway-Gilgandra, Castlereagh River above Binnaway, Castlereagh River below Coonamble, Castlereagh River Gilgandra-Coonamble, Nedgera Creek System, Teridgerie Creek System, Tooraweenah Gulargambone Tributaries.	July 1895 to June 2009	Moderate	The assessment assumes all entitlement is active, whereas this is unlikely to be the case. The method assumes the worst case scenario and therefore likelihood may be overemphasised.

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
3	basic landholder rights - unregulated water sources	Based on dividing the 80th percentile flow (for all days) for each water source by the estimated BLR.	4.4.1	E(BLR)	Likelihood	1. Unregulated water sources: single reach NSW Department of Industry IQQM. 2. Basic landholder rights for NSW: Estimations of stock & domestic rights Dept of Water & Energy, September 2009. 3. NSW Office of Water (2011), Macro water sharing plans - the approach for unregulated rivers. A report to assist community consultation, 2nd edition. Published by the NSW Office of Water, August 2011, ISBN 978 0 7371 3917	**Unregulated River hydrologic Sites:** Backwater-Boggy Creek, Bell River, Bulbodney-Grahway Creek system, Burrendong Dam Storage Tributaries, Campbells River, Coolbaggie Creek system, Cooyal Wialdra Creek System, Ewenmar Creek system, Fish River, Goolma Creek, Lawson's Creek, Little River, Lower Bogan River Lower Macquarie River, Lower Talbragar River, Macquarie River above Burrendong, Marra Creek system, Marthaguy Creek, Maryvale-Geurie, Molong Creek & Tributaries, Piambong Creek, Pipeclay Creek, Queen Charlottes Vale Creek/Evans Plains Creek, Summerhill Creek, Turon/Crudine, Upper Bogan catchment, Upper Cudgegong River above Windamere, Upper Talbragar/Goolaburra-Gundy River, Wambangalong Whylandra System, Winburndale Rivulet, Castlereagh River Binnaway-Gilgandra, Castlereagh River above Binnaway, Castlereagh River below Coonamble, Castlereagh River Gilgandra-Coonamble, Nedgera Creek System, Teridgerie Creek System, Tooraweenah Gulargambone Tributaries.		Low/Moderate	Low confidence level: some water sources had insufficient or no data. Moderate confidence: BLR usage figures are estimates only: i.e., all entitlements are assumed to be active. Method needs further testing across valleys. A WRP must ensure that BLRs are maintained at baseline diversion levels (generally set at the 30 June 2009 diversion limit) (MDBA 2017. Water Compliance Review. ISBN (online): 978-1-925599-55-8)

<table>
<tr><th>#</th><th>Metric</th><th>Data description</th><th>Report reference</th><th colspan="2">Relevant risk #</th><th>Data source/s</th><th>Reference</th><th>Time period</th><th>Data confidence</th><th colspan="2">Reasoning</th></tr>
<tr><td>4</td><td>High ecological value aquatic ecosystems</td><td>HEVAE (high ecological value aquatic ecosystem) - Identifying environmental assets and ecosystems functions</td><td>4.2
4.2.3
4.3.3
4.5.1.1 (Unregulated water sources)

5.3.1 (Regulated river water source)
5.4.1
5.5.1
See also Appendix B: HEVAE alignment with Basin Plan Schedules 8 & 9
Appendix C: HEVAE consequence scoring & decision tree</td><td>E(W)
E(BLR)
E(I-FD) (Unregulated water sources)
E(WQ-CWP)
E(WQ)
E(WQ-S)</td><td>Consequence</td><td>1. HEVAE data based on the following sources:

Table 1: Data sources used in each of the criteria
<table><tr><th>Criteria</th><th>Data Sources</th></tr><tr><td>Base layer in all criteria</td><td>• River Styles® (DPI Water)
• Geofabric data layer (BOM)
• IBRA Subregions layer (OEH)</td></tr><tr><td>Diversity</td><td>• Fish diversity data (DPI Fisheries)
• AUSRIVAS macroinvertebrate data (OEH)</td></tr><tr><td>Distinctiveness</td><td>• Threatened species, populations and communities (recorded, known and predicted data) (OEH and DPI Fisheries)
• Rare River Styles® (DPI Water)</td></tr><tr><td>Vital Habitat</td><td>• Riparian Woody Extent raster dataset (DECC 2008)
• River Styles® recovery potential (DPI Water)</td></tr><tr><td>Naturalness</td><td>• Hydrologic stress and catchment disturbance (from River Condition Index) (DPI Water);
• Natural Parks estate (OEH)
• RAMSAR/DIWA/SEPP14 (Coastal) (OEH)
• Observed/Expected (O/E) macroinvertebrate data (OEH)</td></tr></table>Table A1 within Healey et al. (2017) also provides examples of primary evidence for each attribute within a HEVAE Criteria that is influenced / associated with hydrological flow.</td><td>1. Healey et al. 2017. Draft Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW. DPI Water. June 2017.
2. Aquatic Ecosystems Task Group. 2012. Aquatic Ecosystems Toolkit Module 3: Guidelines for identifying high ecological value aquatic ecosystems (HEVAE). Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.</td><td>Time periods vary for each source: Examples for the following criteria: 'Diversity' fish species abundance data covered a 10-yr period: 2002 - 2011. 'Naturalness' macroinvertebrate data from 1994 - 2013. For more information see Healey et al. 2017.</td><td>High</td><td>A. External Peer review by three independent organisations and also from NSW DPI-Fisheries.
B. The Threatened Species Table below provides an example list of threatened species of the Macquarie-Castlereagh Catchment. This information is used in helping determine consequence outcomes in the HEVAE process.</td><td>How Consequence Scores are derived:
Unregulated rivers, the scale of assessment was the Water Source. Each was analysed separately using the HEVAE layer, a licensing layer and the regulated river layer (where regulated river is excluded from water source);
Regulated river reaches are assessed separately, using the same process and decision tree, but based on individual reaches centred on Hydrologic Indicator sites.
Decision Tree:
The decision tree pushes the user through a series of questions about the ecological value of the Water Source, whether there is extraction in the Water Source, and whether the HEVAE result includes a high 'distinctiveness' metric (i.e. threatened species, populations, communities or rare river styles)</td></tr>
</table>

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
	Water Quality	Documented procedures are stored in the Corporate Data Quality System (Scientific and Technical Operating Procedures; STOP). All laboratory analysis undertaken at a NATA accredited laboratory. All data was audited and validated in accordance with documented procedures. Quality codes were assigned and the data archived in the Corporate Database (KiWQM).	5. Risks to health of water-dependent ecosystems from poor water quality	E(WQ) E(WQ-CWP) E(WQ-S)		1. Schedule 11 of Basin Plan lists water quality targets for water-dependent ecosystems and Ramsar wetlands.	Basin Plan 2012, Compilation No.2 (24 November 2016) registered 23 January 2017. *Water Act 2007*, Commonwealth.	2010/11 - 2014/15 (5-year period)	High	The Basin States are required to report against these targets to the MDBA every five years. For this reason, five years of water quality data was used in the Risk assessment, to be consisted with the MDBA reporting requirement. All data are generated according to documented procedures for collecting samples, providing quality control samples and the preservation and transport of samples as recommended in Australia Standard AS/NZS 5667.1:1998 Water Quality Sampling. All procedures are based on, and comply with, recognised departmental and external standards to ensure that the project delivers data of the highest possible standard. HEVAE in-stream values used to determine impact of water quality on in-stream biota only at the reach scale (25-km upstream and downstream) and are therefore an approximation for the whole water source.
5	Cold water pollution	Real-time gauge based monitoring	5.3.2	E(WQ-CWP)	Likelihood	1. WaterNSW water quality monitoring stations. 2. Preece, R 2004, Cold water pollution below dams in New South Wales, Department of Infrastructure, Planning and Natural Resources, Sydney. 3. Lugg 1999 *Eternal winter in our rivers: Addressing the Issue of Cold Water Pollution.* NSW Fisheries, Nowra, NSW.			High	Based on Real-time data and literature.
6	Water quality - pH, turbidity, total phosphorus & nitrogen, dissolved oxygen	Routine real-time site based sampling	5.4.2	E(WQ)	Likelihood	1. WaterNSW water quality monitoring stations	421019 Cudgegong River at Yamble Bridge 421077 Macquarie River at u/s Spillway Burrendong Dam 42110101 Macquarie River at Molong Rail Bridge 421004 Macquarie River at Warren42110171 Fish River at Hazelgrove 42110170 Turon River at Bathurst Point 421025 Macquarie River at Bruinbun 421038 Cudgegong River at Rylstone Bridge 421018 Bell River at Neurea 421176 Little River at Arthurville No. 2 421042 Talbragar River at Elong Elong 421011 Marthaguy Creek at Carinda* 421012 Macquarie River at Carinda (Bells Bridge) 421023 Bogan River at Gongolgon 420004 Castlereagh River at Mendooran Weir	2010/11 - 2014/15 (5-year period)	High	Based on Real-time data.
7	Levels of in-stream salinity	Real-time gauge based monitoring	5.5.2	E(WQ-S)	Likelihood	1. WaterNSW water quality monitoring stations	End of valley target site: 421023 Bogan River at Gongolgon 421012 Macquarie River at Carinda 420020 Castlereagh River at Gungalman Bridge	2010/11 - 2014/15 (5-year period)	High	Based on Real-time data.

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
	Water quality for other uses		6. Risk to other water uses due to unsuitable water quality	O(WQ) O(WQ-BGA) O(WQ-S)						
8	Recorded mean daily electrical conductivity 2005/06 – 2014/15	Continuous real-time gauge based monitoring	6.3.1	O(WQ-S)	Consequence	1. WaterNSW water quality monitoring stations	421127 Macquarie River at Baroona	2005/06 – 2014/15.	High	Based on Real-time data.
9	Annual 95th percentile of daily mean electrical conductivity recorded between 2004/05 to 2014/15	Frequency that the 95th percentile of mean daily electrical conductivity exceeds the irrigation salinity target for 10-yr (Northern Basin target = 957µS/cm)	6.3.2	O(WQ-S)	Likelihood	1. WaterNSW water quality monitoring stations	421127 Macquarie River at Baroona	2005/06 – 2014/15.	High	Based on Real-time data.
10	Degree of recreation usage	Level of recreational usage for four monitoring sites	6.4.2	O(WQ-BGA)	Consequence	1. WaterNSW water quality monitoring stations	Oberon Reservoir Chifley Reservoir Windamere Reservoir Cudgegong River downstream of Windamere Dam Burrendong Reservoir Macquarie River d/s of Burrendong Dam Macquarie River at Geurie Macquarie River at Wellington Macquarie River at Dubbo		Moderate	
11	Average annual duration of red alters for blue-green algae	Blue-green algae (BGA) samples used as an indicator because of the potential for some species of BGA to impact on health. Alert levels in place and are used to determine the actions that need to be undertaken in respect to an algal incident adopted from the National Health and Medical Research Council algal bloom response guidelines (NHRMC 2008).	6.4.3	O(WQ-BGA)	Likelihood	1. WaterNSW Algal Website: http://www.waternsw.com.au/water-quality/algae	Oberon Reservoir Chifley Reservoir Windamere Reservoir Cudgegong River downstream of Windamere Dam Burrendong Reservoir Macquarie River d/s of Burrendong Dam Macquarie River at Geurie Macquarie River at Wellington Macquarie River at Dubbo	Based on 2006 - 2014	High	Based on Real-time data. The water quality targets for water used for recreational purposes are that the values for cyanobacteria cell counts or bio-volume meet the guideline values set out in Chapter 6 of the Guidelines for Managing Risks in Recreational Water. National Health and Medical Research Council 2008, Guidelines for managing risks in recreational water. (National Health and Medical Research Council, Canberra).
12	Human consumption		6.5	O		1. The Public Health Act 201 2. Public Health Regulation 2012 r 3. Drinking Water Management System (DWMS)		N/A	N/A	Local councils have management strategies identified in the Drinking Water Management Systems.
13	Indigenous & Socio-economic	Placeholder.	6.6 & 7.5	O		Placeholder.		N/A	N/A	Cultural requirements addressed in a separate document. Socio-economic not assessed due to lack of data.

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
	Interception Activities	Risk due to interception activities - farm dams, commercial plantations, mining, floodplain harvesting	4.5 7.2	E(I-FD) E(I_PF) O(I-FD) O(I-PF)		1. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia. 2. Van Dijk AIJM, et al. (2008) Uncertainty in river modelling across the Murray–Darling Basin. A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project, CSIRO Australia. 93pp.			Moderate/High	CSIRO project undergone extensive peer review. Furthermore, NSW obtained the model output data from the MDBYS project (2008) and extracted 112 year time series on a daily time-step as well as the reliability data to improve the quality of analysis (NOW 2010).
14	Growth in farm dams (regulated)	Farm dam and plantation impacts on streamflow estimated using the SIMHYD rainfall-runoff model; this data was adapted to fit into river system models of state agencies (Van Dijk et al. 2008). A 2030 farm dam development scenario was developed by considering current distribution and policy controls and trends in farm dam expansion.	4.5.1.2 7.2.1.2	E(I-FD) O(I-FD)	Likelihood	1. NOW 2010, *Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008*, NSW Office of Water, Sydney. 2. Sustainable Rivers Audit 2 (SRA) in: MDBA 2011, Assessment of the hydrological impact of farm dams in the Murray–Darling Basin. Murray–Darling Basin Authority, Canberra. https://www.mdba.gov.au/sites/default/files/archived/annualreports/2011-12/chapter_02_6.html 3. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia.	Macquarie Marshes Wilgara Wetland High Security General Security Supplementary Water	Based on 2004/2005 satellite imagery (MDBYS Project) compared to 1994 to determine growth trends over 10-yr. Also based on period of prediction (from 2020 - 2030) and current period (from 2003 - 2008) (Van Dijk, 2008).	Moderate/High	Peer reviewed. 1. The estimated uncertainty associated with farm dam growth and plantation expansion is estimated in the order of 1 percent of total inflows across the MDB, increasing up to about 3 percent in sensitive regions, and more in certain catchments within regions. These are small numbers when compared to climate and other uncertainties (Van Dijk, 2008). 2. The uncertainty associated with the impact of farm dams is greater than that associated with forestry, particularly when considering the large uncertainty in farm dam expansion rate estimates. The estimate rate is about an order of magnitude smaller than rates in the recent past and therefore this must still be considered a significant uncertainty. If farm dam construction rates were to be closer to historical rates their impact would be very significant in several regions, and therefore this may still be considered a significant risk (Van Dijk, 2008). 1. Control measure: harvestable rights provisions which are one of the basic landholder rights under the WMA (NOW 2010). 2. Farm dams, forestry plantations and floodplain harvesting are all instances of non-metered take. Therefore, the hydrometric network and hydrological modelling are the way in which estimates are derived (MDBA 2017. The Murray–Darling Basin Water Compliance Review. Licensed from the MDBA under a Creative Commons Attribution 4.0 Licence).
15	Ability to meet environmental flow objectives		4.5.1.1	E(I-FD)	Consequence		Macquarie Marshes Wilgara Wetland;		Moderate/High	
16	Change in average annual diversions and allocations for licence holders		7.2.1.1	O(I-FD)	Consequence		High Security General Security Supplementary Water		Moderate/High	

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
17	Growth in farm dams (unregulated)	Deviation in flow indices from the reference (near natural) regime (SKM 2011)	4.5.1.2	E(I-FD)	Likelihood	1. Sustainable Rivers Audit 2 (SRA) in: MDBA 2011, Assessment of the hydrological impact of farm dams in the Murray–Darling Basin. 2. Murray–Darling Basin Authority, Canberra. https://www.mdba.gov.au/sites/default/files/archived/annualreports/2011-12/chapter_02_6.html 2. NOW 2010, Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008, NSW Office of Water, Sydney. 3. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia. 4. NOW 2010, Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008, NSW Office of Water, Sydney. 5. SKM (2011) Assessment of the hydrological impact of farm dams in the Murray–Darling Basin. Murray–Darling Basin Authority, Canberra, ACT	Belar Creek @ Warkton (Blackburns) Castlereagh River @ Mendooran Wallumburrawang Creek @ Bearbung Butheroo Creek @ Neilrex Castlereagh River @ Hidden Valley Bell River @ Newrea Turon River @ Sofala Bogan River @ Neurie Plains Talbragar River @ Elong Elong Little River @ Obley No.2 Bell River @ Molong Coolbaggie Creek @ Rawsonville Coolaburragundy River @ Coolah Green Valley Creek @ Hill End Spicers Creek @ Saxa Crossing Bogan River @ Peak Hill No.2 Campbells River u/s Ben Chifley Dam Brisbane Valley Creek @ Stromlo	Based on 2008/2010 SRA2 Audit. Also based on period of prediction (from 2020 - 2030) and current period (from 2003 - 2008) (Van Dijk, 2008).	Moderate/High	Peer reviewed. The estimated uncertainty associated with farm dam growth and plantation expansion is estimated in the order of 1 percent of total inflows across the MDB, increasing up to about 3 percent in sensitive regions, and more in certain catchments within regions. These are small numbers when compared to climate and other uncertainties. The uncertainty associated with the impact of farm dams is greater than that associated with forestry, particularly when considering the large uncertainty in farm dam expansion rate estimates. The estimate rate is about an order of magnitude smaller than rates in the recent past and therefore this must still be considered a significant uncertainty. If farm dam construction rates were to be closer to historical rates their impact would be very significant in several regions, and therefore this may still be considered a significant risk (Van Dijk, 2008). Farm dams, forestry plantations and floodplain harvesting are all instances of non-metered take. Therefore, the hydrometric network and hydrological modelling are the way in which estimates are derived (MDBA 2017. The Murray–Darling Basin Water Compliance Review. Licensed from the MDBA under a Creative Commons Attribution 4.0 Licence).
18	HEVAE (see 4 above)	See 4 above	4.5.1.1	E(I-FD)	Consequence	See 4 above	Belar Creek @ Warkton (Blackburns) Castlereagh River @ Mendooran Wallumburrawang Creek @ Bearbung Butheroo Creek @ Neilrex Castlereagh River @ Hidden Valley Bell River @ Newrea Turon River @ Sofala Bogan River @ Neurie Plains Talbragar River @ Elong Elong Little River @ Obley No.2 Bell River @ Molong Coolbaggie Creek @ Rawsonville Coolaburragundy River @ Coolah Green Valley Creek @ Hill End Spicers Creek @ Saxa Crossing Bogan River @ Peak Hill No.2 Campbells River u/s Ben Chifley Dam Brisbane Valley Creek @ Stromlo	See42 above	See 4 above	See 4 above.
19	Growth in plantation forestry (regulated)	Farm dam and plantation impacts on streamflow estimated using the SIMHYD rainfall-runoff model; this data was adapted to fit into river system models of state agencies (Van Dijk et al. 2008). A 2030 farm dam development scenario was developed by	4.5.2 7.2.2	E(I-PF) O(I-PF)	Likelihood	1. SMEC 2010, Afforestation risks to water resources in the Murray–Darling Basin, Murray–Darling Basin Authority, Canberra; 2. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia. 3. NOW 2010, Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008, NSW Office of Water, Sydney. 4. SKM (2011) Assessment of the hydrological impact of farm dams in the Murray–Darling Basin. Murray–Darling Basin Authority, Canberra, ACT	Macquarie Marshes Wilgara Wetland High Security General Security Supplementary Water	Based on 2004/2005 satellite imagery (MDBYS Project). Also based on period of prediction (from 2020 - 2030) and current period (from 2003 - 2008) (Van Dijk, 2008).	Moderate/High	Peer reviewed. The estimated uncertainty associated with farm dam growth and plantation expansion is estimated in the order of 1 percent of total inflows across the MDB, increasing up to about 3 percent in sensitive regions, and more in certain catchments within regions. These are small numbers when compared to climate and other uncertainties (Van Dijk, 2008). Plantations and Reafforestation Act controls the establishment and harvesting of plantations, although importantly it doesn't currently account for water use impacts. No methods have yet been developed to look at the probability of future bushfires and their hydraulic impact (NOW 2010).

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
20	Ability to meet environmental flow objectives	considering current distribution and policy controls and trends in farm dam expansion.	4.5.2	E(I-PF)	Consequence	1. NOW 2010, Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008, NSW Office of Water, Sydney. 2. Sustainable Rivers Audit 2 (SRA) in: MDBA 2011, Assessment of the hydrological impact of farm dams in the Murray–Darling Basin. Murray–Darling Basin Authority, Canberra. https://www.mdba.gov.au/sites/default/files/archived/annualreports/2011-12/chapter_02_6.html 3. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia.	Macquarie Marshes Wilgara Wetland			
21	Change in average annual diversions and allocations for licence holders		7.2.2	O(I-PF)	Consequence		High Security General Security Supplementary Water			
22	Mining	N/A	4.5.3 & 7.2.3					N/A	NA	
23	Floodplain harvesting	N/A	4.5.4 (environment) 7.2.4 (Other uses)			1. DPI-Water 2017. Draft Floodplain harvesting Monitoring Policy. March 2017. Department of Primary Industries - Water. https://www.water.nsw.gov.au/__data/assets/pdf_file/0016/700801/Draft-floodplain-harvesting-monitoring-policy.pdf		N/A	NA	To be managed under Floodplain licencing framework. Farm dams, forestry plantations and floodplain harvesting are all instances of non-metered take. Therefore, the hydrometric network and hydrological modelling are the way in which estimates are derived (MDBA 2017. The Murray–Darling Basin Water Compliance Review. Licensed from the MDBA under a Creative Commons Attribution 4.0 Licence).
24	Future climate scenarios	The MDBSY project assessed scenarios: i.e., historical climate change & current development; recent climate change & current development; future climate change and current & future development, respectively. All scenarios are defined at daily time series of climate variables based on different scaling of the historical 1895 - 2006 climate sequence (Van Dijk et al. 2008).	4.6.2 7.4.2	E(CC) O(CC)	Likelihood	1. NOW 2010, Assessment of risk to NSW Murray–Darling Basin shared water resources – 2008, NSW Office of Water, Sydney. 2. CSIRO 2008, Water availability in the Murray–Darling Basin; A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project. CSIRO, Australia. 3. Van Dijk, et al. (2008) Uncertainty in river modelling across the Murray–Darling Basin. A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project, CSIRO Australia. 93pp.	Macquarie Marshes Wilgara Wetland High Security General Security Supplementary Water	The average rainfall during the calibration period (Macquarie: 1985-1990) was compared to the long-term average rainfall, the number of years in the historical record (1895 to 2006) (Van Dijk 2008).	Low/Moderate	CSIRO project undergone extensive peer review. NSW obtained the model output data from the MDBYS project (2008) and extracted 112 year time series on a daily time-step as well as the reliability data to improve the quality of analysis (NOW 2010). Historical 112-year climate transformed to have the same statistics as the second-wettest, second-driest and median predictions of climate change by 15 different global climate models given three alternative emission scenarios (Cwet, Cdry and Cmid scenarios). However, there is still relatively high uncertainty associated with natural variability and also uncertainty associated with the range of climate models, with this combined uncertainty considered greater than the 'best estimate' climate change projection (Van Dijk, et al. 2008). 1. This section addresses NSW's obligations under the Basin Plan (2012): Chapter 10, Part 9: Section 10.41(1) - A water resource plan must be prepared having regard to current and future risks to the condition and continued availability of the water resource plan area. 2. Water Sharing Plans are the control mechanism which base water sharing decisions on the availability of flow and therefore they implicitly adjust for both climate variability and change. The legislation enables powers to temporarily suspend water sharing rules during extreme climatic conditions. WSPs are reviewed on a 10-yr cycle and the climatic record used as input to these planning decisions is based on all of the available data up to that point. 3. There is currently no explicit adjustment to the
25	Ability to meet environmental flow objectives		4.6.1	E(CC)	Consequence		Macquarie Marshes Wilgara Wetland			

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning
26	Change in average annual diversions and allocations for licence holders		7.41	O(CC)	Consequence		High Security General Security Supplementary Water			input data or selective sequencing from the data to use as input to the planning process to allow for potential future climate change. Water sharing plans cover all of the regulated systems in NSW, i.e. all but the Barwon-Darling in this risk assessment. In the Barwon-Darling, licence conditions on entitlements specify access rules based on the occurrence of flows above a specified level prior to allowing pumping to occur. These therefore implicitly allow for both climate variability & change (NOW 2010).
	Growth in basic landholder rights									
27	Growth in basic landholder rights	Based on dividing the 80th percentile flow (for all days) for each water source by the estimated BLR.	4.4.1 7.4 (other uses)	E(BLR)	Likelihood	1. WaterNSW gauging stations	Backwater-Boggy Cowal Bell River Bulbodney-Grahway Creek system Burrendong Dam Storage Tributaries Campbells River Coolbaggie Creek system Cooyal Wialdra Creek System Ewenmar Creek system Fish River Goolma Creek Lawson's Creek Little River Lower Bogan River Lower Macquarie River Lower Talbragar River Macquarie River above Burrendong Marra Creek system Marthaguy Creek Maryvale-Geurie Molong Creek & Tributaries Piambong Creek Pipeclay Creek Queen Charlottes Vale Creek/Evans Plains Creek Summerhill Creek Turon/Crudine Upper Bogan catchment Upper Cudgegong River above Windamere Upper Talbragar/Goolaburra-Gundy River Wambangalong Whylandra System Winburndale Rivulet Castlereagh River Binnaway Gilgandra Castlereagh River above Binnaway Castlereagh River Gilgandra-Coonamble Tooraweenah Gulargambone Tributaries Teridgerie Creek System Nedgera Creek System Castlereagh River below Coonamble		Low	BLR usage figures are estimates only: i.e., all entitlements are assumed to be active. Method needs further testing across valleys. This section also addresses Chapter 10, part 9: section 10.41 (1) outlined above. Also covers NSW obligations under section 10.41 (3) in identifying risk, and regard to risks identified in Section 4.02 (2). A WRP must ensure that BLRs are maintained at baseline diversion levels (generally set at the 30 June 2009 diversion limit) (MDBA 2017. Water Compliance Review. ISBN (online): 978-1-925599-55-8)
28	Growth in basic landholder rights	Ratio of BLR volume to total licensed entitlement	7.4.2	O(BLR)	Likelihood	1. WaterNSW gauging stations 2. NSW Water Register 3. Basic landholder rights for NSW: Estimations of stock & domestic rights Dept of Water & Energy, September 2009.	Backwater-Boggy Cowal Bell River Bulbodney-Grahway Creek system Burrendong Dam Storage Tributaries Campbells River Coolbaggie Creek system		High	

#	Metric	Data description	Report reference	Relevant risk #		Data source/s	Reference	Time period	Data confidence	Reasoning	
29	Volume of entitlement	Volume of entitlement (2015)	7.4.1	O(BLR)	Consequence	1. NSW Water Register	Cooyal Wialdra Creek System Ewenmar Creek system Fish River Goolma Creek Lawson's Creek Little River Lower Bogan River Lower Macquarie River Lower Talbragar River Macquarie River above Burrendong Marra Creek system Marthaguy Creek Maryvale-Geurie Molong Creek & Tributaries Piambong Creek Pipeclay Creek Queen Charlottes Vale Creek/Evans Plains Creek Summerhill Creek Turon/Crudine Upper Bogan catchment Upper Cudgegong River above Windamere Upper Talbragar/Goolaburra-Gundy River Wambangalong Whylandra System Winburndale Rivulet Castlereagh River Binnaway Gilgandra Castlereagh River above Binnaway Castlereagh River Gilgandra-Coonamble Tooraweenah Gulargambone Tributaries Teridgerie Creek System Nedgera Creek System Castlereagh River below Coonamble		High		

Table A-2. List of threatened species within Macquarie-Castlereagh catchment

Common name	Scientific name	Distinctiveness parameter	NSW status	Commonwealth listing	Flow sensitivity weighting	Status weights	Layers from OEH or DPIF
FISH							
eel-tailed catfish	*Tandanus tandanus*	EP	Endangered Population	not listed	4	3	Observed
olive perchlet	*Ambassis agassizii*	EP	Endangered Populations	not listed	4	3	Observed
purple spotted gudgeon	*Mogurnda adspersa*	Fish	Endangered Population	not listed	4	3	Observed
silver perch	*Bidyanus bidyanus*	Fish	Vulnerable	Critically endangered	4	4	Observed
trout cod	*Maccullochella macquariensis*	Fish	Endangered	Endangered	4	3	Observed
flathead galaxias	*Galaxias rostratus*	Fish	Critically endangered	Critically endangered	4	4	Predicted
Murray cod	*Maccullochella peelii*	Fish	not listed	Vulnerable	4	2	Observed
FROGS							
Booroolong frog	*Litoria booroolongensis*	Frog	Endangered	Endangered	4	3	Observed
yellow-spotted tree frog	*Litoria castanea*	Frog	Critically endangered	Endangered	4	4	Predicted
green and golden bell frog	*Litoria aurea*	Frog	Endangered	Vulnerable	3	3	Observed
southern bell frog	*Litoria raniformis*	Frog	Endangered	Vulnerable	4	3	Known
ENDANGERED ECOLOGICAL COMMUNITIES (EEC)							
Lowland Darling River aquatic endangered ecological community		EEC	Endangered Ecological Community	not listed	4	3	from DPI and EEC layer available on the EDB
Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions		EEC	Endangered Ecological Community	not listed	3	3	Known
Carbeen Open Forest Community in the Darling Riverine Plains and Brigalow Belt South Bioregions		EEC	Endangered Ecological Community	not listed	2	3	Known
Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregion		EEC	Endangered Ecological Community	Endangered	1	3	Known
BIRDS							
Australasian bittern	*Botaurus poiciloptilus*	Bird	Endangered	Endangered	2	3	Observed
Australian painted snipe	*Rostratula australis*	Bird	Endangered	Endangered	2	3	Known
black-necked stork	*Ephippiorhynchus asiaticus*	Bird	Endangered	not listed	2	3	Observed
blue-billed duck	*Oxyura australis*	Bird	Vulnerable	not listed	2	2	Observed
brolga	*Grus rubicunda*	Bird	Vulnerable	not listed	2	2	Observed
black-tailed godwit	*Limosa limosa*	Bird	Vulnerable	not listed	2	2	Known
cotton Pygmy-Goose	*Nettapus coromandelianus*	Bird	Endangered	not listed	2	3	Known
curlew Sandpiper	*Calidris ferruginea*	Bird	Endangered	Endangered	3	3	Known
freckled duck	*Stictonetta naevosa*	Bird	Vulnerable	not listed	2	2	Observed
magpie goose	*Anseranas semipalmata*	Bird	Vulnerable	not listed	2	2	Observed
MAMMALS							
greater broad-nosed bat	*Scoteanax rueppellii*	Mammal	Vulnerable	not listed	2	2	Known
OTHER AQUATIC							
river snail	*Notopala sublineata*	Other aquatic	Critically Endangered	not listed			Predicted
PLANTS							
A spear-grass	*Austrostipa wakoolica*	Plant	Endangered	Endangered	1	3	Known

Appendix B HEVAE alignment with Schedules 8 and 9 of the Basin Plan

Table B-1. Alignment of Schedule 8 key environmental asset criteria with HEVAE criteria

Key environmental asset criteria (Schedule 8)	HEVAE criteria/associated attributes
Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it is: (a) A declared Ramsar wetland; or (b) With environmental watering, capable of supporting a species listed in or under the JAMBA, CAMBA, ROKAMBA or the Bonn Convention.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports (see details below)
Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or (b) Represents the only example of a particular type of water-dependent ecosystem in the Murray–Darling Basin; or (c) Represents a rare example of a particular type of water-dependent ecosystem in the Murray–Darling Basin.	Naturalness: The ecological character of the aquatic ecosystem is not adversely affected by modern human activity. • Geomorphic recovery (conservation or rapid) potential of River Styles® • Hydrologic stress (demand versus low flow percentile) • Catchment Disturbance Index (infrastructure density, land use index & land cover change) • Macroinvertebrate (AUSRIVAS) O/E bands (i.e. deviation from reference) • River reaches in National Park Estate
Criterion 3: The water-dependent ecosystem provides vital habitat Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Provides vital habitat, including: (i) A refugia for native water-dependent biota during dry spells and drought; or (ii) Pathways for the dispersal, migration and movements of native water-dependent biota; or (iii) Important feeding, breeding and nursery sites for native water-dependent biota; or (b) Is essential for maintaining, and preventing declines of, native water-dependent biota.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i. unusually large numbers of a particular native or migratory species; and/or ii. maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress. • Vital wetlands (Ramsar and DIWA listed wetlands) • Dissolved Organic Carbon (DOC) input (surrogate measure = river reaches of 60% woody riparian vegetation cover & measure of unconfined or partially confined River Style) • Large Woody Debris (LWB) (surrogate measure = river reaches of 60% woody riparian vegetation cover & specific River Styles®)

Key environmental asset criteria (Schedule 8)	HEVAE criteria/associated attributes
Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Supports a listed threatened ecological community or listed threatened species; or Note: See the definitions of listed threatened ecological community and listed threatened species in section 1.07. (b) Supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law; or (c) Supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.	Distinctiveness: The aquatic ecosystem is rare/threatened or unusual; and/or The aquatic ecosystem supports rare/threatened/ endemic species/communities/genetically unique populations; and/or The aquatic ecosystem exhibits rare or unusual geomorphological features/processes and/or environmental conditions, and is likely to support unusual assemblages of species adapted to these conditions, and/or are important in demonstrating key features of the evolution of Australia's landscape, riverscape or biota. • State and/or Commonwealth listed threatened species, endangered populations and endangered ecological communities • Rare River Styles®
Criterion 5: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it supports, or with environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that: (a) Supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or (b) Supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.	Diversity: The aquatic ecosystem exhibits exceptional diversity of species (native/migratory), habitats, and/or geomorphological features/processes. • Macroinvertebrate Diversity (No. of AUSRIVAS Families) • Fish Diversity (Fish biodiversity hot spots assigned to specific River Styles® reach)
Reference: Healey M, Raine A, Lewis A, Hossain B, Hancock F & Sayers J (2018) *Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW*, NSW DPI Water, Sydney, NSW.	

Table B-2. Alignment of Schedule 9 key ecosystem function criteria with HEVAE criteria

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides vital habitat, including: (a) a refugia for native water-dependent biota during dry periods and drought; or (b) pathways for the dispersal, migration and movement of native water-dependent biota; or (c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or (d) a diversity of aquatic environments including pools, riffle and run environments; or (e) a vital habitat that is essential for preventing the	**HEVAE** The HEVAE method identifies a diverse range of in-stream and riparian riverine areas in very poor through to very high ecological value. Highest ecological value areas are assumed to provide a diverse range of aquatic habitats for native water-dependent flora and fauna. Vital habitat is a key criteria assessed in the HEVAE method. Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i. unusually large numbers of a particular native or migratory species; and/or ii. maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
decline of native water-dependent biota.	aquatic species that are dependent on the habitat, particularly at times of stress. • Vital wetlands (Ramsar and DIWA listed wetlands) • Dissolved Organic Carbon (DOC) input (surrogate measure = river reaches of 60% woody riparian vegetation cover & measure of unconfined or partially confined River Style) • Large Woody Debris (LWB) (surrogate measure = river reaches of 60% woody riparian vegetation cover & specific River Styles®) **Risk Assessment** The risk assessment process has identified key features of flow regimes which have impacts on key ecosystem functions identified by the MDBA (2010; 2012) and Alluvium (2010). Within the risk assessment method, impacts on ecosystem function are considered through assessment of altered stream flow in regulated and unregulated rivers. Flow regimes influence the hydrologic connectivity, longitudinal and lateral pathways for ecological dispersal, nutrient and organic and inorganic material delivery in river systems.
Criterion 2: The ecosystem function supports the transportation and dilution of nutrients, organic matter and sediment Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides for the transportation and dilution of nutrients, organic matter and sediment, including: (a) pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and to the ocean, and to and from the floodplain; or (b) the dilution of carbon and nutrients from the floodplain to the river systems.	
Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections: (a) for dispersal and re-colonisation of native water-dependent communities; or (b) for migration to fulfil requirements of life-history stages; or (c) for in-stream primary production.	
Criterion 4: The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including: (a) lateral connections for foraging, migration and re-colonisation of native water-dependent species and communities; or (b) lateral connections for off-stream primary production.	

References

Alluvium, (2010), *Key ecosystem functions and their environmental water requirements*. Report by Alluvium for Murray–Darling Basin Authority, Canberra, ACT.

MDBA, (2010), *Guide to the proposed Basin Plan: Technical Background, Murray–Darling Basin Authority, Volume 2, Part 1*, Canberra, ACT.

MDBA, (2012), *Hydrologic modelling to inform the proposed Basin Plan - methods and results*. Murray–Darling Basin Authority, Canberra, ACT.

Appendix C HEVAE consequence scoring

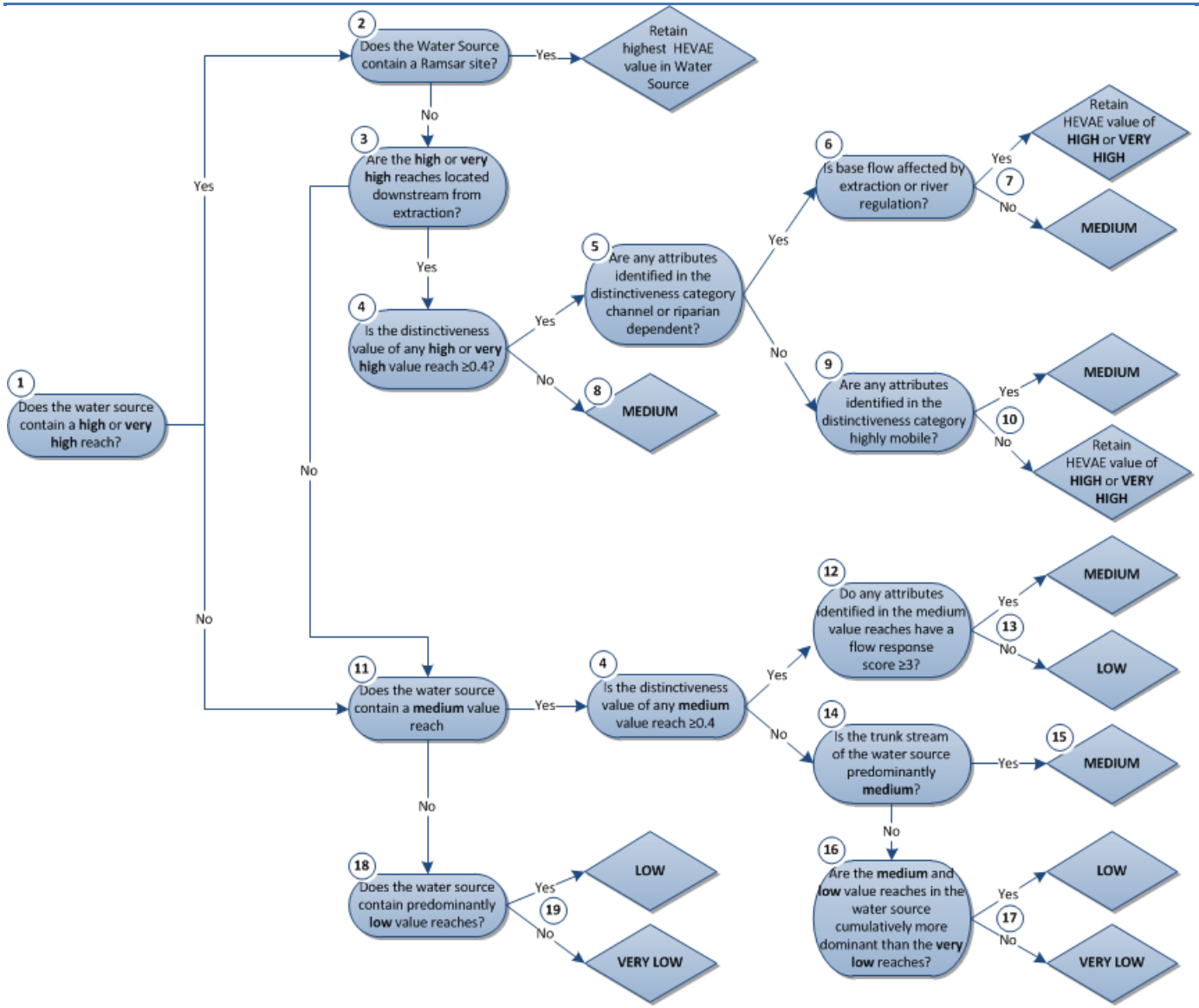

Figure C-1. Consequence decision tree used to convert HEVAE scores to a consequence rank

Table C-1. Rationale for each bifurcation in the decision tree used for converting HEVAE scores to 'consequence of extraction pressure on aquatic ecosystem condition' ranks

Decision tree 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 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.
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 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 criterion 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. • *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.
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.
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.

Decision tree annotation	Rationale
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 they 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 a risk category of 'medium'. • If a species/population/community has a flow response score <3 (i.e. it is less sensitive to extraction), it is assigned a risk category of '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 D Threatened fish species and distribution

Fish data from the MDB Sustainable Rivers Audit (Davies *et al.* 2012) and other sources were analysed by NSW Fisheries to assess the distribution of threatened species and to identify areas of relative high fish biodiversity within the Macquarie-Castlereagh WRPA. These data have been included in the HEVAE assessment and the results presented below. They are also further detailed in the Water Source Summaries provided in Volume 2.

The results show a significant spread of threatened fish species or endangered populations in the Macquarie-Castlereagh WRPA. Eel-tailed catfish were widespread in the Bogan, Macquarie and Castlereagh Rivers. Fish biodiversity was highest in the Macquarie River around Dubbo and in the upper Cudgegong River.

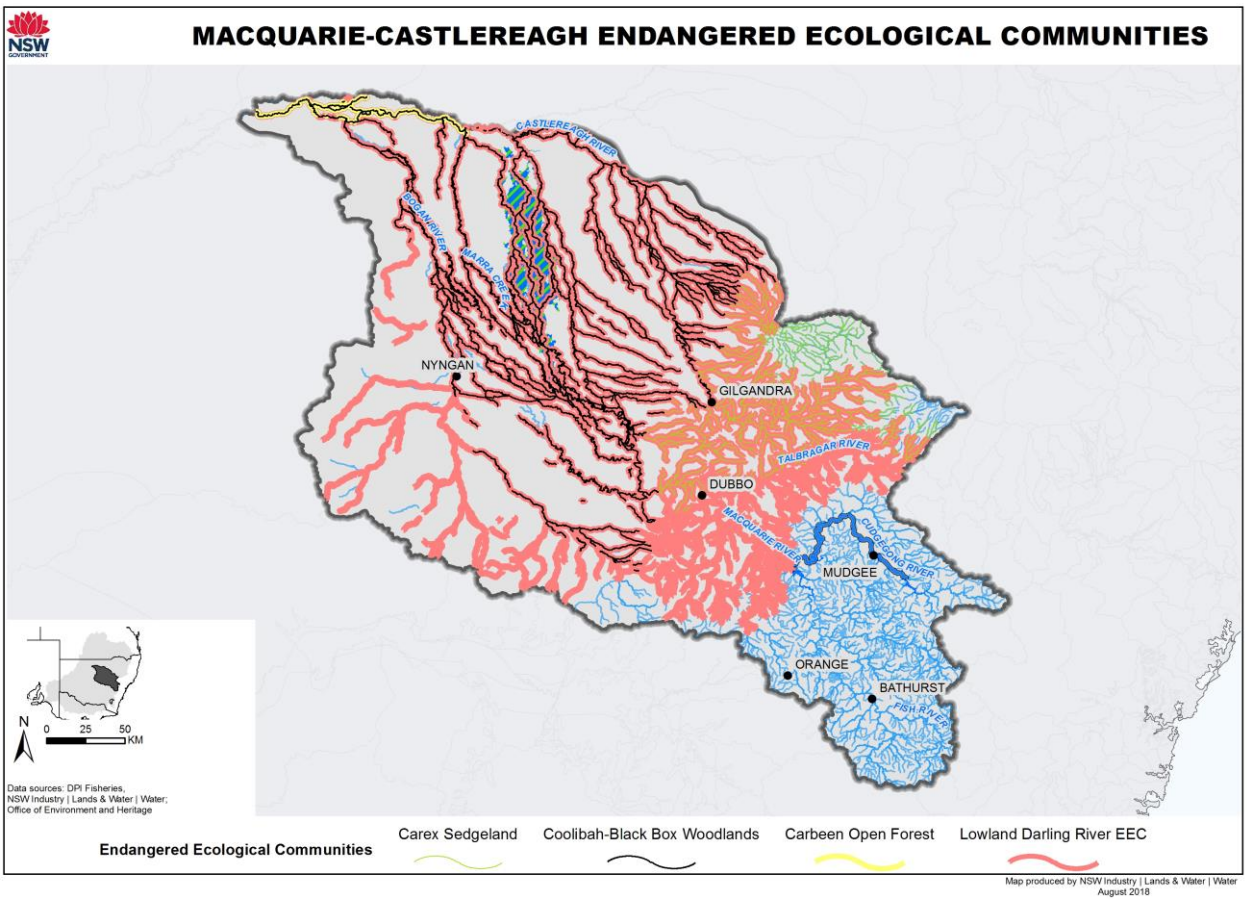

Figure D-1. Distribution of endangered ecological communities in the Macquarie-Castlereagh WRPA

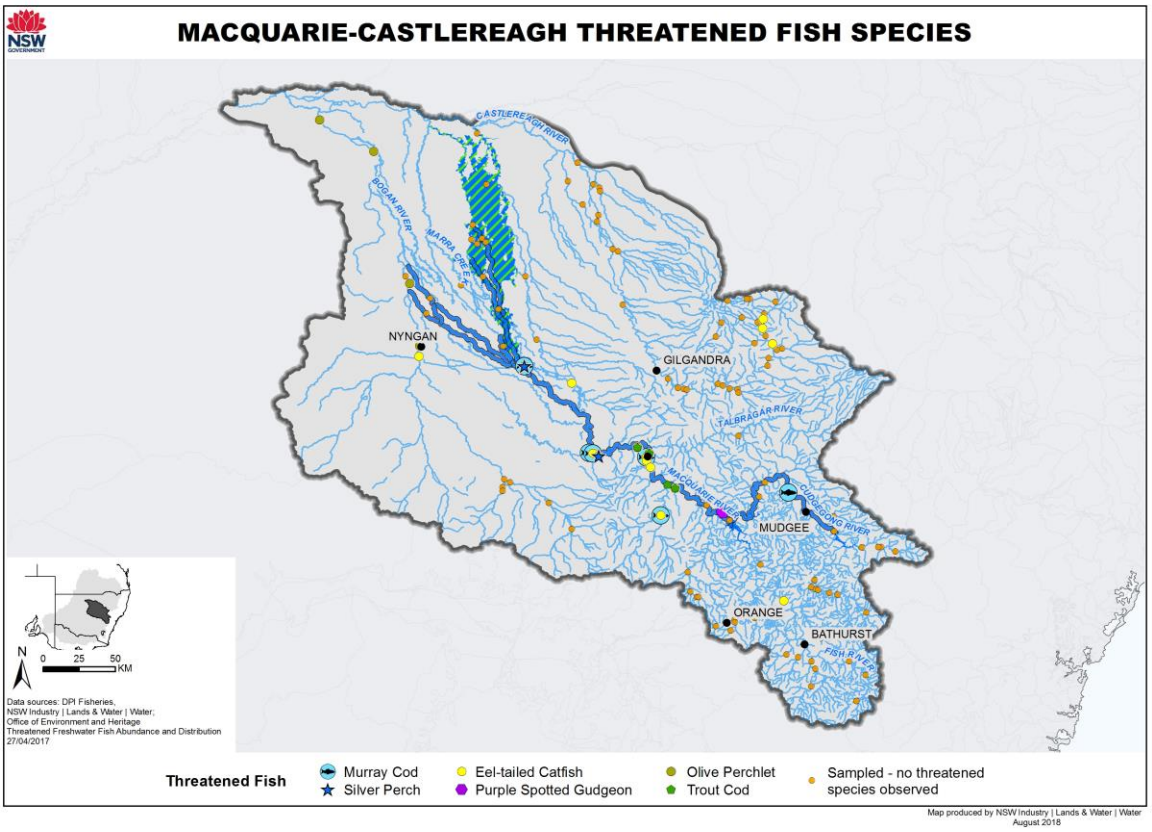

Figure D-2. Distribution of threatened fish species within the Macquarie-Castlereagh WRPA

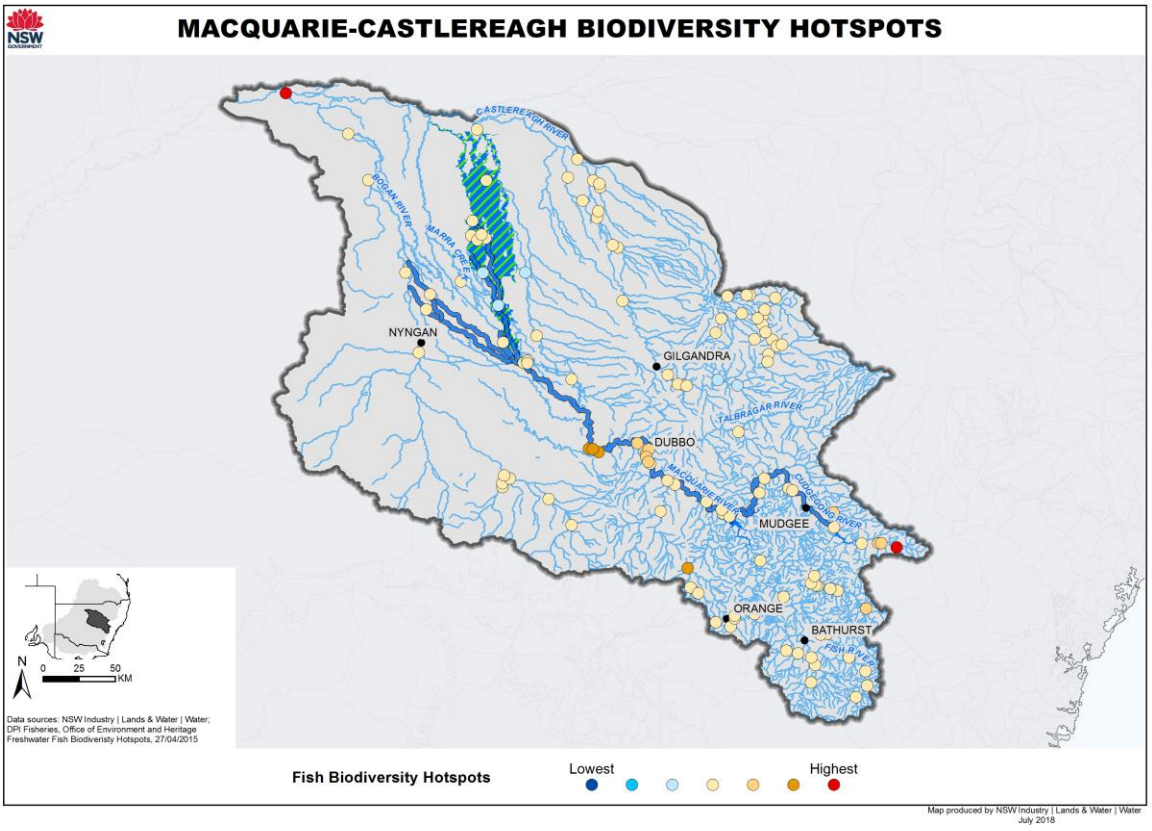

Figure D-3. Fish biodiversity hotspots in the Macquarie-Castlereagh WRPA

Appendix E Flow variation indices in unregulated water sources

Maps showing the flow variation indices and metrics used to assess the likelihood of farm dams impacting on surface flows in unregulated water sources in the Macquarie-Castlereagh WRPA are shown in the figures below.

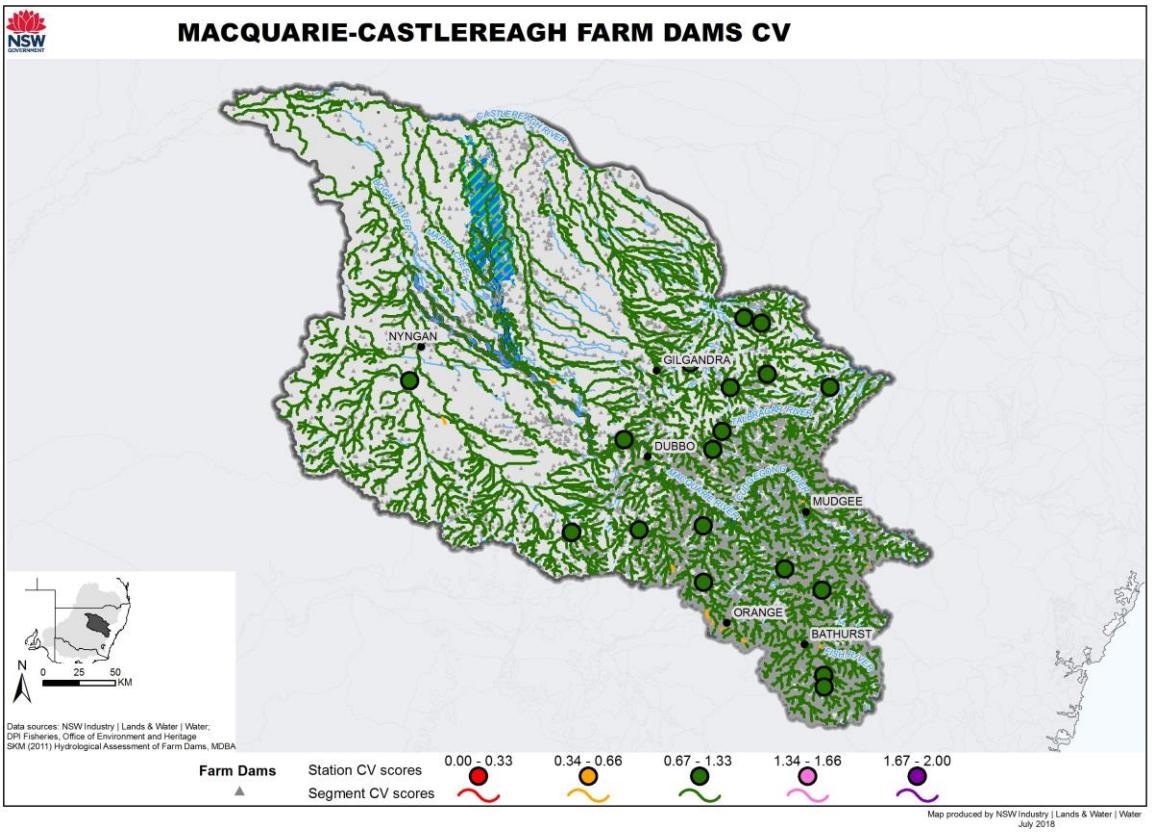

Figure E-1. Flow variation index (CV) results for farm dams in the Macquarie-Castlereagh WRPA (SKM 2011)

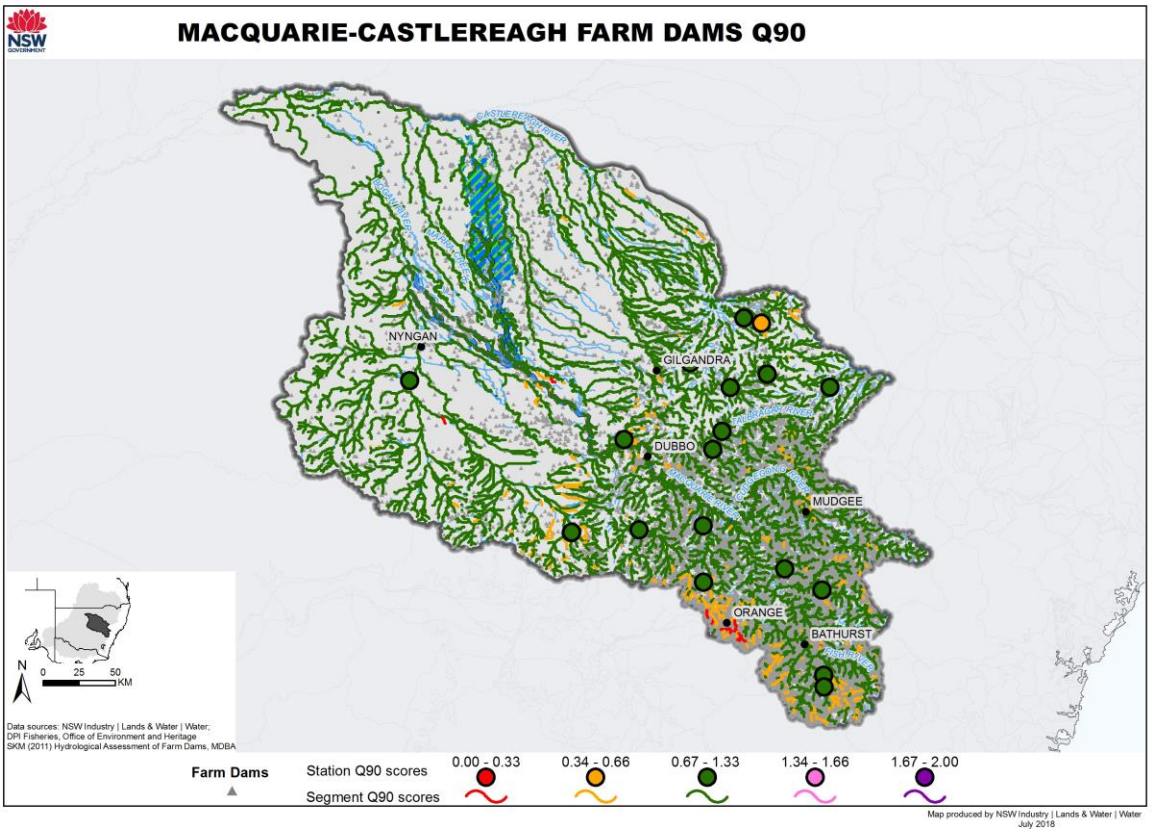

Figure E-2. Results for the Q90 low flow metric for farm dams in the Macquarie-Castlereagh WRPA (SKM 2011)

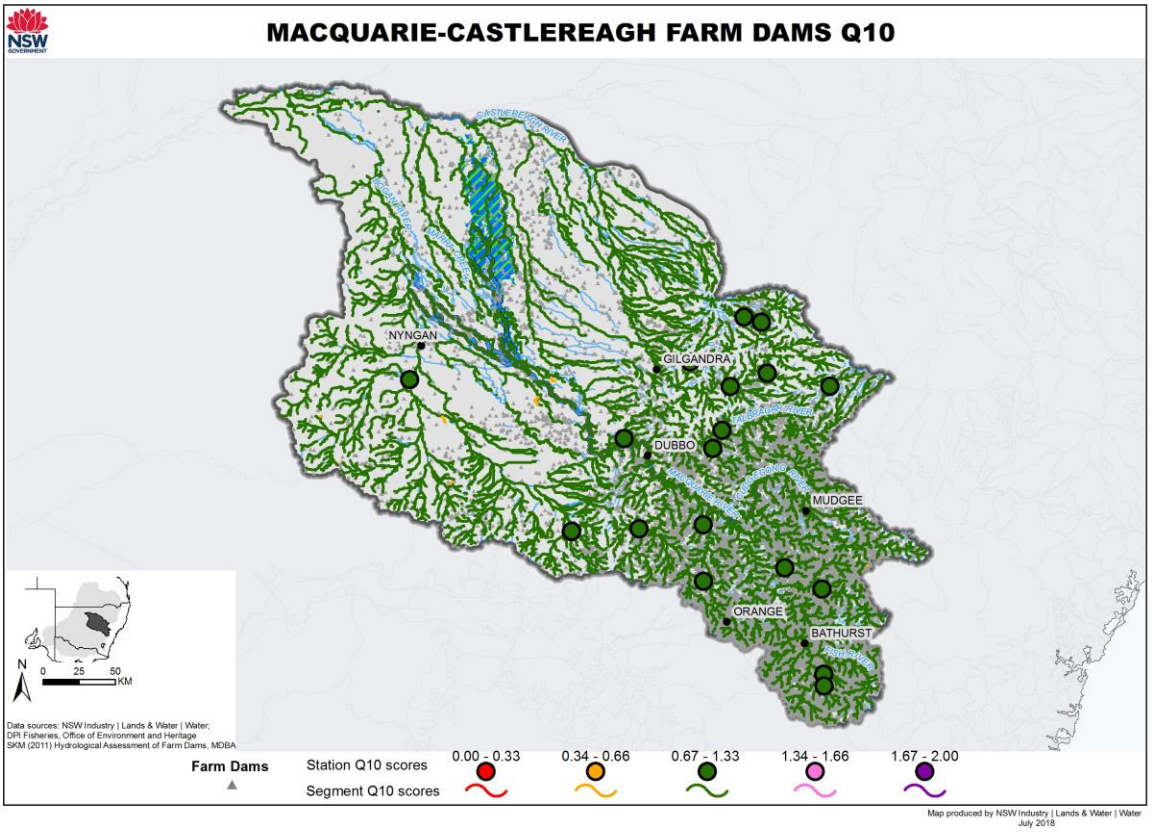

Figure E-3. Results for the Q10 high flow metric for farm dams in the Macquarie-Castlereagh WRPA (SKM 2011)

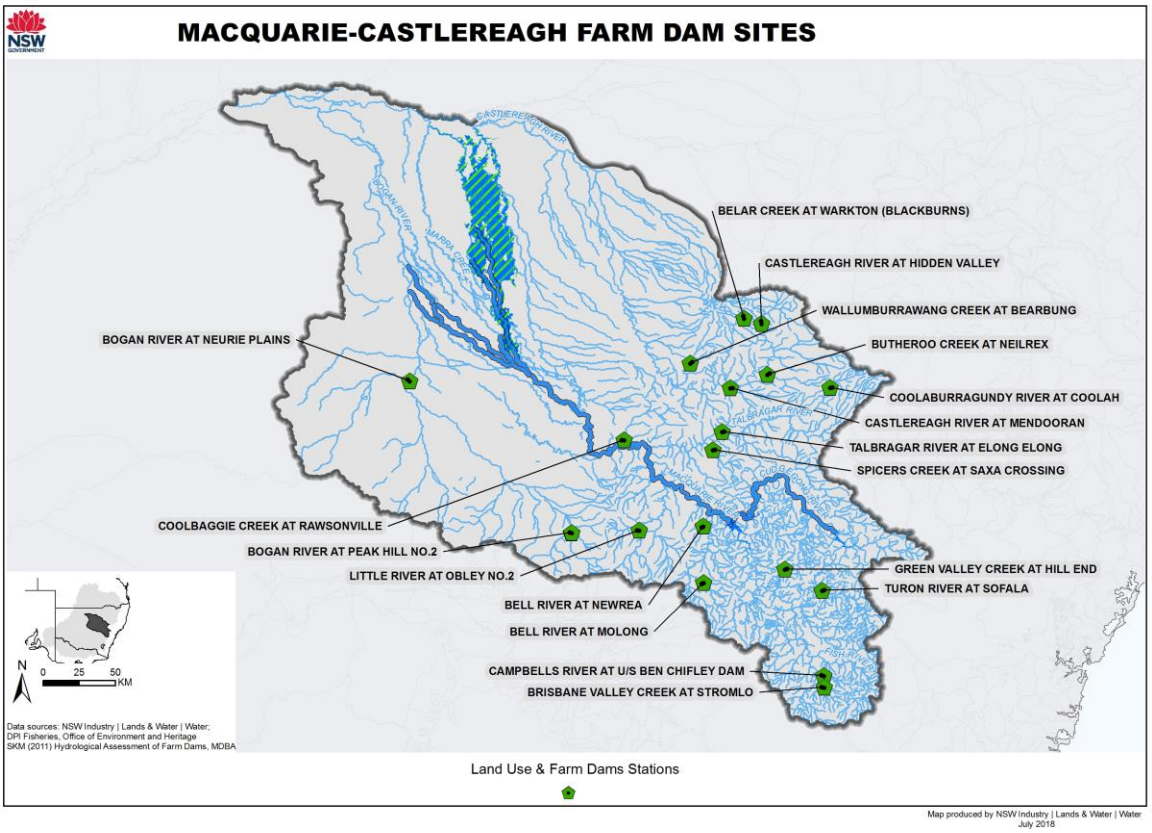

Figure E-4. Location of land use and farm dam stations in the Macquarie-Castlereagh WRPA (MDBA 2011)

Appendix F Unregulated rivers tolerable risk decision tool

This appendix relates to Figure 8-1. Risk treatment pathway (in particular element 2 and risk treatment option C), associated text in section 8.2.2.1, and strategy 18 in Table 8-6. Knowledge strategies.

The assessment of *Risk to water available for the environment due to licensed extraction in unregulated rivers* E(W) uses likelihood ratings based on potential risk rather than current risk. This is because best available likelihood information is entitlement data rather than actual use data. This may result in overestimations of risk in those unregulated water sources where extraction has not reached full development levels. In order to apply appropriate risk mitigation strategies to medium or high-risk results, a decision tool was used to compare expert knowledge of individual water sources to the full development likelihood results determined via single reach IQQM. This resulted in an assignment of tolerable status to each risk result and a recommendation for the intensity of ongoing access licence activation monitoring via remote sensing. Note that low risk results are not considered by the tool as the Basin Plan does not require strategies to be described for these risk results. Also note that neither likelihood data nor risk results change through the use of this decision tool.

Error! Reference source not found. shows the additional information used to determine the tolerable status of risk results and the decision tool's relationship to the risk treatment pathway through the likelihood metric. To use the decision tool, follow the decision tree in **Error! Reference source not found.**.

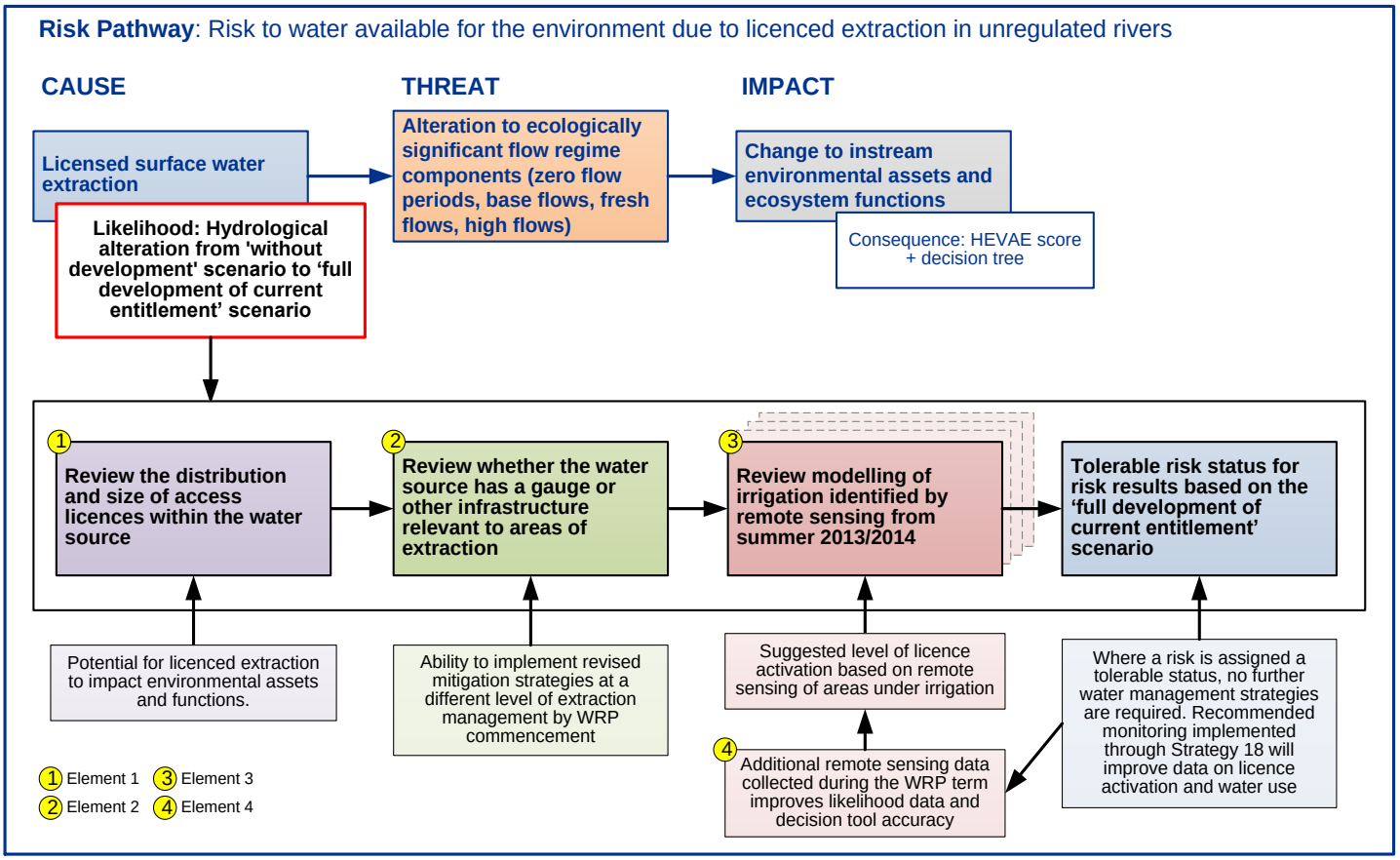

Figure F-1. Overview of decision tool

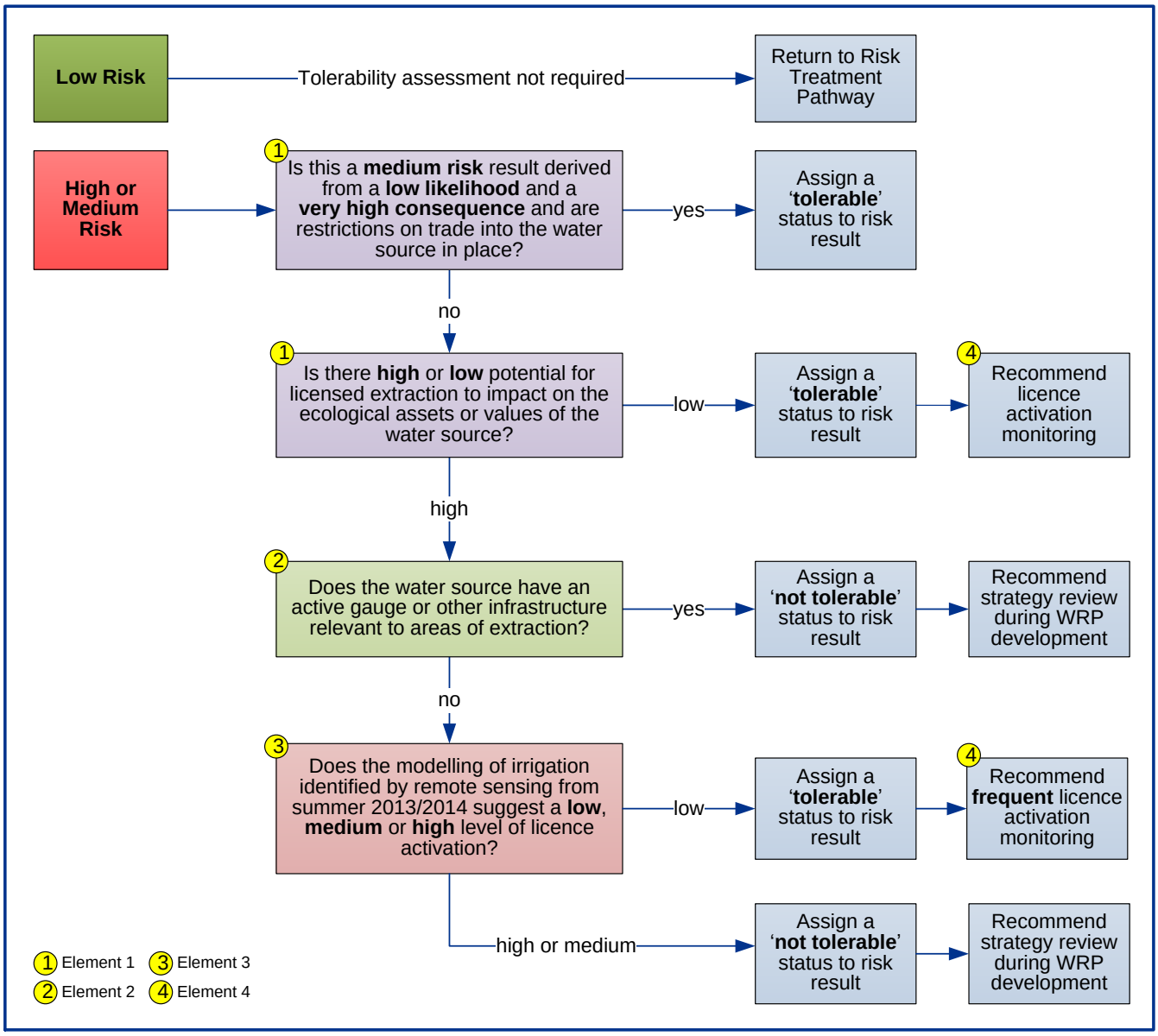

Figure F-2. Decision tree used as a guide to apply elements of the unregulated rivers tolerable risk decision tool

Review the distribution and size of access licences within the water source.

Element 1 of the decision tool reviews the potential for licensed extraction to impact on the ecological assets and values of a water source if all access licences were activated[2]. Where ecological value drivers of the consequence result occur upstream or on stream sections that are disconnected from access licence locations, there is little potential for extraction to impact environmental assets or functions. An exception to this statement may occur where an asset has high dispersal characteristics (e.g. fish such as Murray cod or silver perch).

Where there are significant access licences on the main stem of a stream in the water source, the single reach IQQMs will reflect the impact along the main stream and at the end of the water source. Where there are only

[2] An access licence must be linked to at least one pump (water supply work) for extraction to be possible.

a few small access licences on different tributaries, or just one tributary, the single reach IQQMs may not reflect the impacts on the ecological values in the water source (see **Error! Reference source not found.** for examples). This is most likely to be seen in headwater water sources where there is little floodplain extractive development. The complexity of a river system's structure (e.g. multiple tributaries) may need to be revised and updated in future versions of the single reach IQQMs prior to the next risk assessment.

Medium risk results driven by a very high consequence combined with a low likelihood were also considered in this step and automatically assigned a 'tolerable' status in the decision tree (**Error! Reference source not found.**) if rules were in place to prevent trade into the water source. Further information on the ecological value drivers for each water source can be found in Part 2 (Water Source Summaries) of this document.

There are two possible outcomes from this assessment of potential impact from access licences; high or low. Where the result is high, the risk result moves to the assessment of element 2. Where low is applied, the risk result is assigned a 'tolerable' status and further monitoring of access licence activation via remote sensing is recommended (element 4).

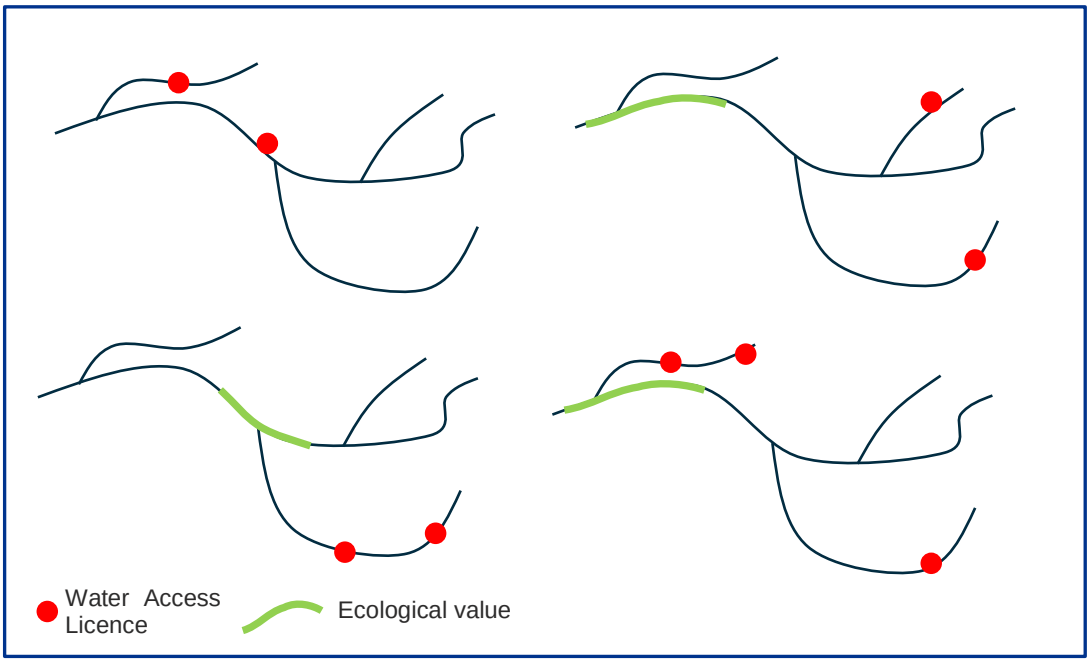

Figure F-3. Examples of the distribution of insignificant entitlement distribution

Review availability of infrastructure to implement revised mitigation strategies

Element 2 of the decision tool reviews whether it would be possible to implement a variation to the level of extraction management by WRP commencement. In unregulated rivers many high and medium risk results occur against base flow and zero flow characteristics. Commence and cease to pump (CtP) rules are often used to protect streams during these periods of low or no flow. To implement a CtP above visible flow, or to implement flow classes for management of fresh or higher flows, a river height monitoring gauge or other infrastructure is generally required.

A check for active flow gauges was made on the appropriate GIS layer and the results confirmed through consultation with WaterNSW Hydrometrics. There are two possible outcomes from this element; yes or no. Where the result is yes, the risk is assigned a 'not tolerable' status as alternative management strategies could be developed and implemented through the water resource plan or water sharing plan. Where no is applied, the risk result moves to the assessment of element 3. Note that any variations to the current river gauge network would have considerable resourcing implications for NSW which are unlikely to be resolved prior to water resource plan commencement. This is why recommendations for new gauge installations have not been considered by this decision tool.

Modelling of irrigation identified by remote sensing to suggest a level of access licence activation

Element 3 uses modelling of irrigation identified by remote sensing from summer 2013/2014 to suggest a level of access licence activation. It is important to note that unlike extractive water use in regulated rivers, unregulated river extraction is highly variable and often opportunistic. As the dataset used for this element is from a single season in a single year it does not provide enough information to generate a meaningful likelihood result for a current use scenario that can be used to assess risk in this report. It is anticipated that throughout the WRP term a more comprehensive indication of current use should be provided through the analysis of further remote sensing imagery (see Strategy 18 and the MER Plan for further information). This is indicated in **Error! Reference source not found.** by the broken line boxes underlying element 3.

Possible outcomes from this element are the suggested activation levels high, medium, and low. Where low is applied, the risk result is assigned a ‘tolerable’ status and further frequent monitoring of access licence activation via remote sensing is recommended (element 4). Where medium or high is applied the risk is assigned a ‘not tolerable’ status as the current use level is likely to be similar to the full entitlement scenario. This indicates the risk result should prompt the consideration of alternative risk mitigation strategies during WRP development.

Dry period for remote sensing where irrigation could be identified through remote sensing.

Appendix G Strategy development – constraints and decision trees

Material in this appendix has previously been presented in earlier drafts of this document. It describes considerations and decision processes supporting strategy development. A list of draft strategies that were considered for inclusion in the WRP has also been included.

The draft strategies outlined in this section have been developed with consideration to the means through which they can be implemented, which is primarily through the rules and conditions within the WRP. Risks that are associated with high flow events, however, may also be mitigated through discretionary environmental water, which is part of the operational scope of the LTWP rather than a WRP. In such instances, the mitigation strategy suggests that the risk would be most effectively managed by the LTWP. Mitigation strategies for water quality risks may be represented in one or more of the WRP, LTWP and WQM Plan. However, there may be unavoidable circumstances or constraints that prevent a strategy from being implemented, including:

- Operational constraints due to infrastructure or channel capacity, or
- Constraints due to a proposed strategy resulting in a risk to social and economic interests that is considered to outweigh the risk to the environment, or
- Environmental or other external constraints which limit a strategy from achieving its full ecological objective.

Operational constraints considered in developing and implementing new strategies

Operational constraints were identified through consultation with WaterNSW and other water management agencies that provided technical input around the operation of water regulation structures. Some examples of operational constraints may be the ability of a stream channel to convey a certain volume of water without incurring third party impacts (for example, through over bank flows), the inability of dam outlet works to be turned off, or conversely, to release a certain volume of water.

Operational constraints were considered against the anticipated resources that would be required to remedy them. Often the significance of these constraints means they are unable to be abated.

Social or economic constraints to implementing a strategy

The Basin Plan's objective is to achieve an optimal outcome for all water stakeholders in the Basin. Sections 5.02(1) (c) and 5.02(1) (d) of the Basin Plan state that:

The objectives of the Basin Plan as a whole are:

> *(c) To optimise social, economic and environmental outcomes arising from the use of Basin water resources in the Murray–Darling Basin; and*
>
> *(d) To improve water security for all uses of Basin water resources.*

NSW WSPs also have the objective of achieving optimal outcomes for social, economic and environmental objectives, but there are instances where it is not possible to achieve all of these outcomes in equal measure. Each mitigation strategy must therefore be considered in view of the potential impacts on water-dependent communities. If those impacts are considered to be significant, then the strategy may have to be constrained or modified.

Potential social or economic constraints were identified by:

- Estimating the community dependence on water extraction in each unregulated water source
- Directly consulting with stakeholders through forums such as Stakeholder Advisory Panels (SAPs).

Estimates of community dependence on water extraction were based on previous calculations undertaken as part of the Macro Water Sharing Plan process (NOW 2011a).

Community dependence was estimated by combining information about the volumes and economic value of water extraction (value of irrigated industries, town water supply, proportion of community employment in agriculture etc.) with information about community resilience to change, based on data obtained from the Australian Bureau of Statistics Index of Advantage and Disadvantage.

Community dependence for each unregulated water source was classified as either low, medium or high (**Error! Reference source not found.**). The regulated river network, however, was not assessed but deemed to always have high community dependence.

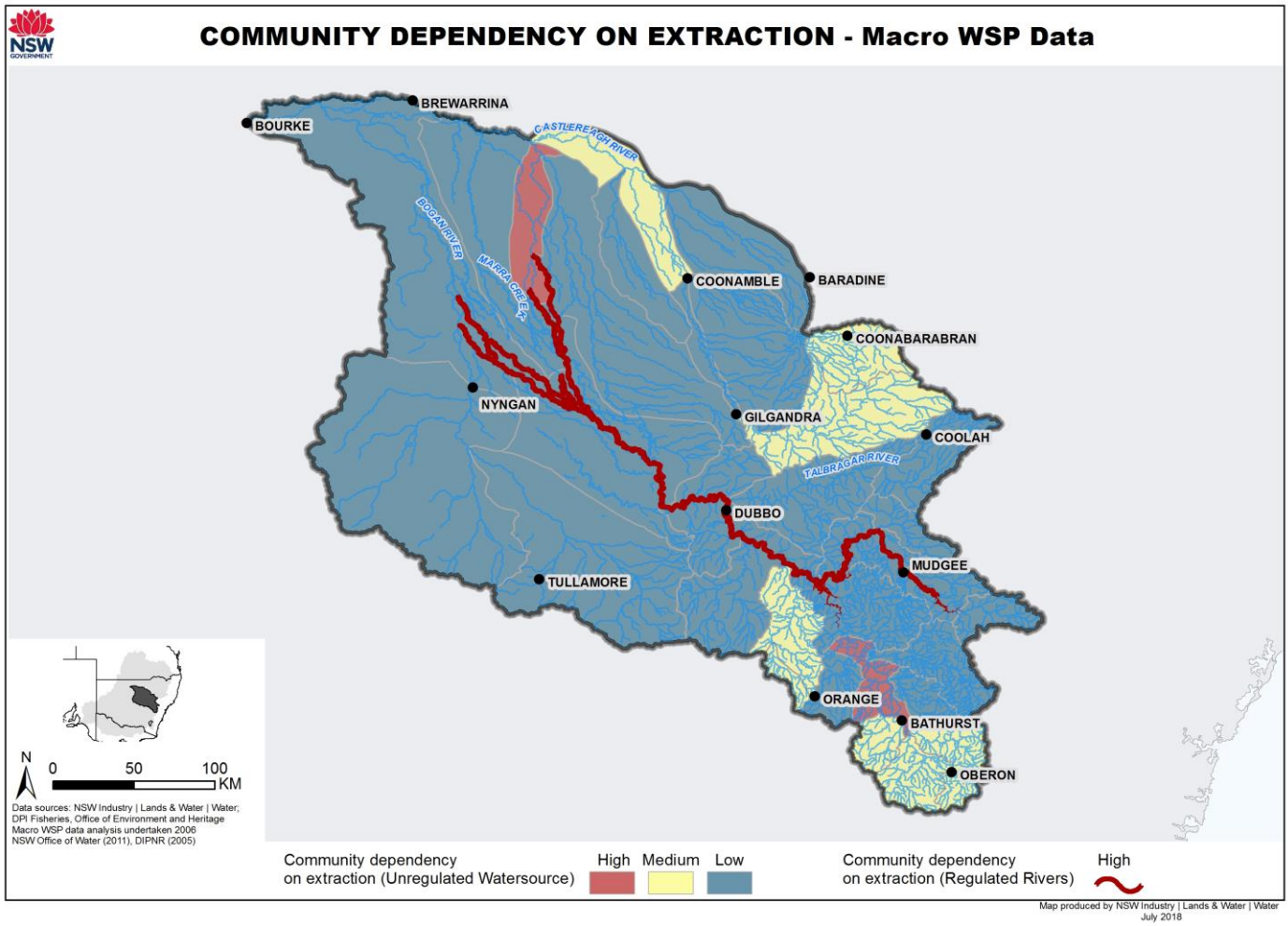

Figure G-1. Community dependency on extraction

In each unregulated water source, community dependence and risk to the environment were compared using an indicative matrix (Table G-1) to guide the prioritisation of mitigation strategies. Potential strategies were presented to stakeholders for consideration and further development undertaken if required. Preliminary strategies were formulated based on a general principle that if one risk is greater than the other, the proposed strategy should then be commensurate with this fact.

For example, there are two potential strategies that a WSP can employ to mitigate medium or high risks to low flows in an unregulated water source: restricting future water trade into the water source, or restricting water use by creating or amending access rules. If the risk to the environment from low flows is high and community dependence is low, then both of these strategies may be considered. If community dependence is high however, then trade restrictions may be the only viable strategy. Trade restrictions need not be applied to an entire water source but instead, may be targeted to the particular sub-catchments where key ecological assets have been identified.

Table G-1. Indicative matrix to guide the development of strategies relative to community dependence versus risk to the environment

		Community dependence on extraction		
		Low	Medium	High
Risk to the environment	Low	No strategy required	No strategy required	No strategy required
	Medium	Prioritise risk mitigation strategy	Reassess and modify strategy	Reassess and modify strategy
	High	Prioritise risk mitigation strategy	Prioritise risk mitigation strategy	Reassess and modify strategy

Environmental or other external constraints to implementing a strategy

Many of the draft strategies identified in this report aim to mitigate impacts resulting from changes in the flow regime due to river regulation and water extraction. Significant changes in the volume and timing of flows are identified in the likelihood metrics and strategies have been formulated to address high and medium risk as required in the Basin Plan.

Strategies can be formulated to address hydrological changes; however, their success in meeting the underlying ecological objectives may be reliant upon other externalities or environmental constraints, which may not be directly related to the hydrological regime. Examples of such externalities include; cold water pollution from in-stream storages, barriers to fish passage due to water regulation or road infrastructure, the entrainment of fish in irrigation infrastructure (such as channels or pumps), the condition of riparian vegetation or the degree of catchment disturbance. In these cases, complementary strategies to address the external constraints may also be required to achieve the maximum ecological benefit.

There are opportunities for government agencies, including NSW Local Land Services (LLS), to work closely with NSW Department of Industry in managing external constraints through complementary measures. Collaboration between natural resource management (NRM) groups to examine alignment of priorities has been a continued focus of NSW Government (NRC 2010). Alignment of NRM continues to be identified as a priority for LLS (LLS 2016) and for the management of environmental water and water quality in NSW (OEH 2014). Alignment of NRM priorities for river management will assist in strengthening the outcomes of mitigation measures identified through this risk assessment.

This section identifies the major environmental and external constraints to implementing strategies in the Macquarie-Castlereagh WRP.

Cold water pollution

Cold water pollution is the release of unseasonable cold water from deeper layers of thermally stratified storages. This occurs most often during the warmer months when irrigation water is in high demand. Temperature has a wide range of influences on biological processes, where the release of cold water can interrupt important biological cues such as spawning in fish and other fauna, creating a physiological barrier to habitat connectivity, reducing the growth rate of fish and also result in mortality (Lugg and Copeland 2014).

There are two irrigation dams located in the Macquarie-Castlereagh WRP area, Windamere Dam, on the Cudgegong River near Mudgee, and Burrendong Dam, on the Macquarie River near Wellington. Windamere Dam was completed in 1984 and being one of the more recent dams to be built in NSW, was designed and constructed with a variable level offtake mechanism. This offtake allows the water released to be taken from a level that optimises both temperature and water quality outcomes downstream of the dam. Thermal pollution downstream of Windamere Dam is not considered to be a constraint on the Cudgegong River.

Burrendong Dam was identified as a high priority for the control of thermal pollution (NOW 2011c) and was retrofitted with a thermal curtain in July 2014. This curtain allows for warmer surface waters to be funnelled

into the inlet structure for release downstream. The effectiveness of this solution is the subject of ongoing monitoring. Should the curtain operate as designed, it is envisaged thermal pollution in the Macquarie River downstream of Burrendong Dam would no longer be a constraint to meeting ecological objectives. Unfortunately, technical issues associated with the operation of the curtain has resulted in the curtain being temporarily removed pending design modification.

Barriers to fish passage

Migratory pathways across the majority of rivers in NSW have been disrupted through the construction of in-stream structures associated with river regulation such as dams and weirs as well as road crossings, culverts and other road infrastructure.

NSW DPI Fisheries (2015a) report that barriers to fish passage can impact native fish populations by:

- Interrupting spawning and seasonal migrations
- Restricting access to preferred habitat, food resources and breeding partners
- Reducing genetic flow between populations
- Increasing susceptibility to predation and disease through aggregation below barriers
- Stranding fish on floodplains or in drying waterbodies
- Fragmenting communities and preventing colonisation
- Advantage introduced species such as Carp (NSW DPI Fisheries 2015a)
- Disrupting downstream movement of adults and impeding larval drift (Jones & Stuart 2004; NSW DPI Fisheries 2006; Jones & Stuart 2008; Jones 2009).

In-stream structures and other mechanisms that alter natural flow regimes have been listed as a key threatening process under the *Fisheries Management Act 1994*. The NSW Office of Environment and Heritage has also listed in-stream barriers as a key threatening process under the *Threatened Species Conservation Act 1995*. The construction of fishways at major barriers and the management of in-stream structures to reduce their impact on biodiversity and habitats (for example, opening of flood gates at certain times of year) have been identified as high priority abatement actions.

DPI Fisheries have identified over 300 barriers to fish passage in the Macquarie-Castlereagh WRPA (NSW DPI Fisheries 2015b) including weirs, regulators and road crossings (**Error! Reference source not found.**). These fish barriers have a varying degree of impact on native fish, with some drowning out more frequently than others to provide suitable passage. The cumulative impact of such structures across the catchment impedes natural flow and connectivity, which is a fundamental ecological feature and likely to be a considerable constraint to the success of strategies. DPI Fisheries have identified 100 barriers which are considered to be high priority for mitigation action. These barriers are identified in the summaries presented in Volume 2 and are considered potential constraints to the success of hydrological risk mitigation strategies.

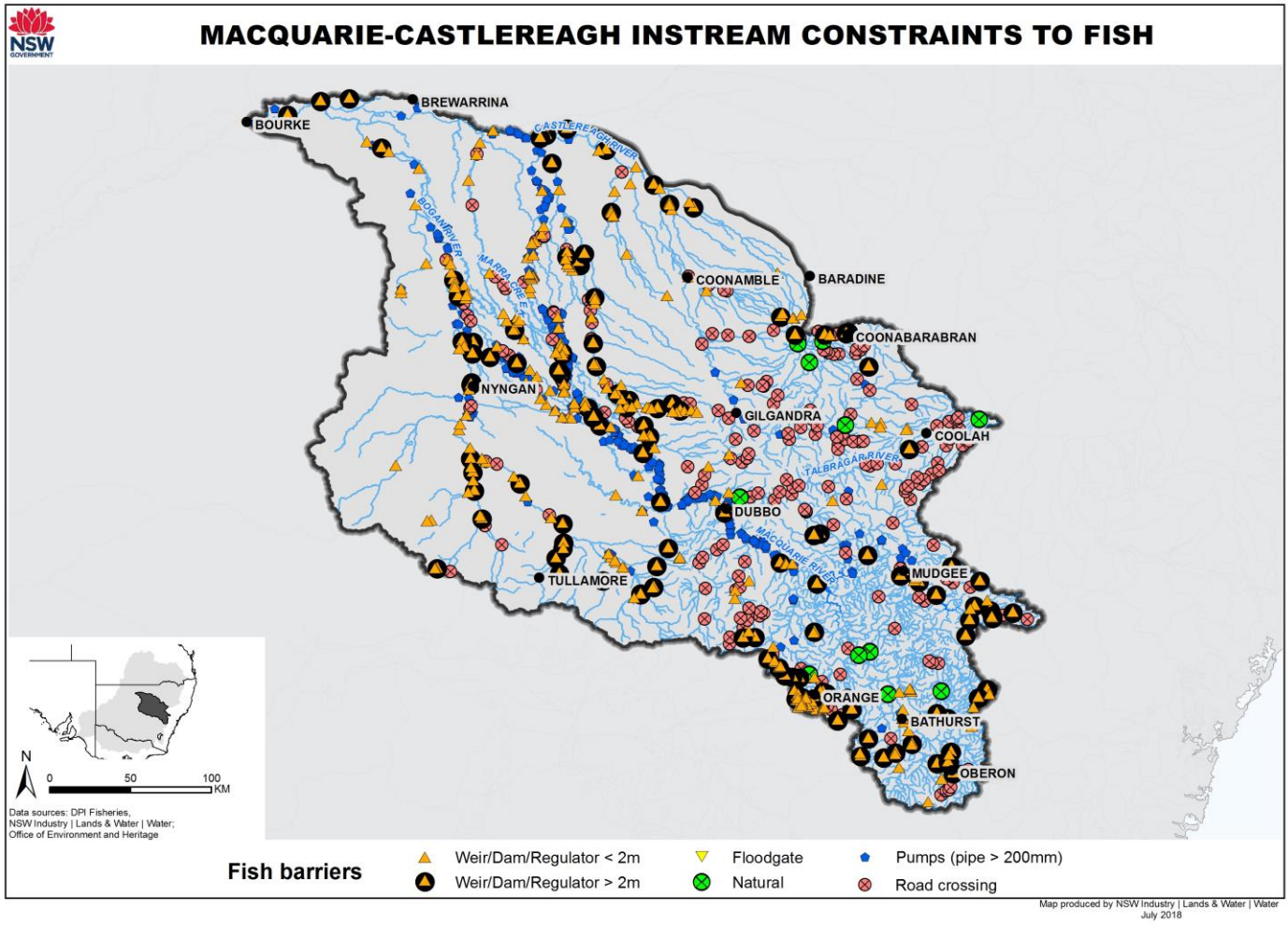

Figure G-2. In-stream constraints to fish in the Macquarie-Castlereagh WRPA (adapted from NSW Department of Primary Industries, 2015a)

Water diversion

NSW DPI Fisheries (2015a) cite that the diversion of water by pumps, pipelines, irrigation canals or regulators can have a significant impact on native fish by altering habitat and affecting flow dependent life history strategies such as spawning and recruitment (Baumgartner and Boys 2012). Diversion and stranding in off-channel irrigation systems is said to be particularly problematic for the larval stage of most native fish species, especially golden perch, silver perch and Murray cod, as the timing of irrigation diversion coincides with the peak egg and larval drift during the spring and summer seasons (Baumgartner *et al.* 2007).

The entrainment of fish in irrigation infrastructure is an issue which may influence the ability of flow management strategies to meet their ecological objectives. In Europe and the United States, a wide variety of pump screens are currently applied which could be readily adapted for use in the MDB. In New Zealand, the screen designs routinely applied are modifications of existing designs to meet the requirements of local conditions (Baumgartner and Boys 2012). For some years, DPI Fisheries have been advocating a screening program as the best way to reduce fish losses without compromising the needs of irrigators within the MDB.

In the Macquarie-Castlereagh WRPA, it is reported that there are over 1200 pump offtakes with a diameter greater than 200 mm (**Error! Reference source not found.**) (NSW DPI Fisheries 2015b). There is some suggestion that irrigation pump offtakes, with a diameter greater than 200 mm, influence the entrainment of freshwater fish (NSW DPI Fisheries 2015b). Based on the current information from the QLD Department of Agriculture and Fisheries and NSW DPI Fisheries, a 200 mm diameter size threshold was selected as a potential threat to native fish; however this threshold has not been substantiated and therefore should be considered as an interim threshold. The cumulative effect of these offtakes is expected to have a significant

impact on native fish populations in the lower Macquarie-Castlereagh WRPA during peak extraction times. In addition to this, NSW DPI Fisheries (2015a) report there are over 100 diversion channels that capture over bank flows in key fish habitats, significantly influencing an important flow component in the system with the potential to impact native fish populations.

Riparian vegetation condition and catchment disturbance

Riparian vegetation is a key attribute connecting rivers and terrestrial ecosystems. It is important for controlling river bank stability, mitigating runoff, providing sediment and nutrients from the adjacent land, providing habitat for a range of biota and influences in-stream processes (Lovett and Price 2007). Leaf litter derived from riparian vegetation is also a key contributor of allochthonous energy sources into rivers, driving primary production and stimulating the development of food chains (Robertson *et al.* 1999; Westhorpe *et al.* 2010). Native riparian vegetation cover greater than 60 % and a riparian buffer zone width of up to 30 m are considered to be within the ranges important for influencing good riparian condition (Jansen *et al.* 2005). A positive increase in the presence of large woody debris (LWD) within rivers was correlated with a positive increase in riparian tree cover, maximising when tree cover reaches 60 percent (Matheson & Thoms in prep). LWD derived from the riparian zone is associated with primary control on geomorphic stability and habitat heterogeneity in rivers (Brooks and Brierley 2002; Treadwell *et al.* 2007).

Changes to riparian vegetation can reduce the geomorphic condition of rivers (Brierley and Fryirs 2005). Reduction in geomorphic condition from good to moderate can be linked to reductions in macrophyte and macroinvertebrate assemblages (Chessman *et al.* 2006), while freshwater mussel abundance declines in river reaches where geomorphic condition also reduces (Jones and Byrne 2010). River Styles® recovery potential is synonymous with geomorphic condition. Recovery potential represents geomorphic stability and can indicate the capacity of a stream to return to good condition or to a realistic rehabilitated condition (Brierley and Fryirs 2005). Streams rated as having conservation or rapid recovery potential are likely to be the most stable and in a good condition, whereas streams with low recovery potential may never recover to a natural condition or may continue to decline quickly without intervention (Cook and Schneider 2006).

Long-lasting and complicated changes to stream ecosystems can occur through catchment disturbance impacts attributed to land use change (Maloney and Weller 2011). Catchment disturbance is recognised as an important factor that influences river condition (NLWRA 2002), where land use changes close to streams can have a more pronounced impact on reducing stream condition (Peterson *et al.* 2011).

Error! Reference source not found. and **Error! Reference source not found.** provide a general overview of riparian and geomorphic condition for the Macquarie-Castlereagh WRPA. For river recovery potential (**Error! Reference source not found.**), river reaches identified as being “strategic” can be in good, moderate or poor geomorphic condition. These reaches are often undergoing rapid change and should be a focus for action to control degradation. Where these constraints are considered to be particularly important for a specific water source and its mitigation strategies, further details are in the water source summaries (Volume 2).

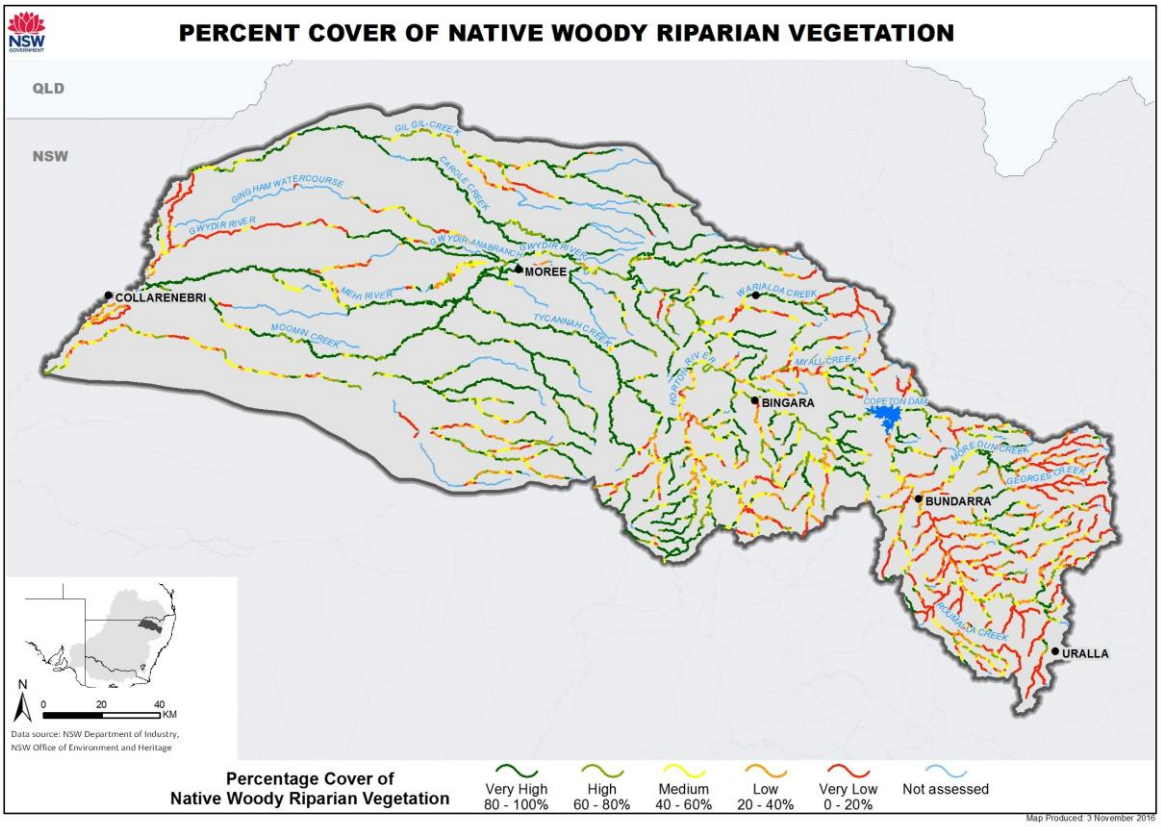

Figure G-3. Percent cover categories of native woody riparian vegetation in the Macquarie-Castlereagh WRPA

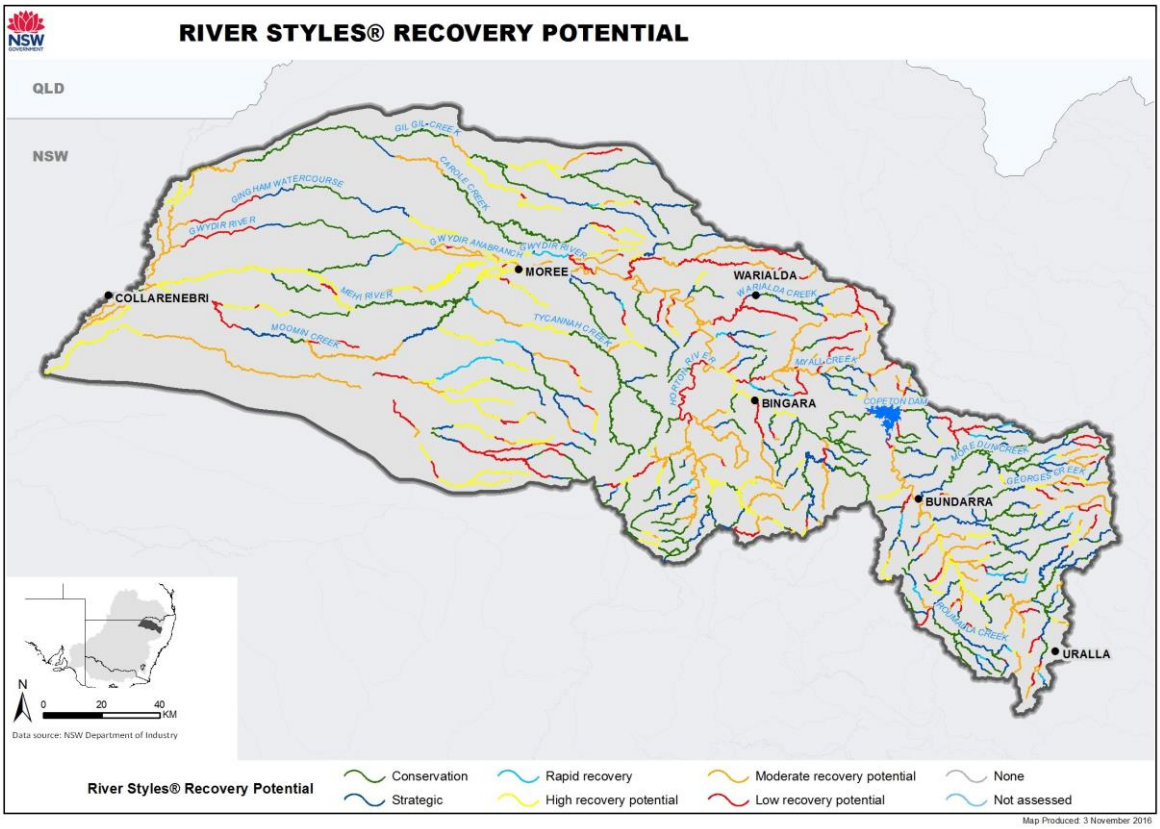

Figure G-4. Geomorphic recovery potential in streams in the Macquarie-Castlereagh WRPADetermining new or modified strategies for unregulated water sources

A decision tree logic (**Error! Reference source not found.**) was used to examine risks due to insufficient water available for the environment, and to prioritise mitigation strategies addressing these risks in unregulated water sources. Through this process, each risk is considered using the decision tree as a guide to offer a level of objectivity in the development of strategies whilst allowing for flexibility and adaptive management where necessary. Strategies are then discussed through consultation with NSW Department of Industry, Water Resource Plan Stakeholder Advisory Panels, the MDBA and other relevant stakeholders. The outcomes of these discussions can influence the development of the final strategies within the WRP in order to reduce the impact of medium and high risks of insufficient water for key ecosystem functions and assets.

The decision tree is focused on specific rules, such as a flow-based cease to pump (CtP). This is considered an immediate strategy with the potential to mitigate medium and high risks identified in a water source. Although the trade of entitlement is another potential rule to manage medium and high risks, it is not considered an immediate mitigation measure, as there is no certainty of it occurring. Should trade of entitlement occur within a medium or high-risk water source, it will likely have a longer term benefit by also assisting in mitigating the impact on in-stream values via reduced levels of extraction.

Each bifurcation in the decision tree was annotated, allowing for a rationale for each decision to be explained (Table G-2).

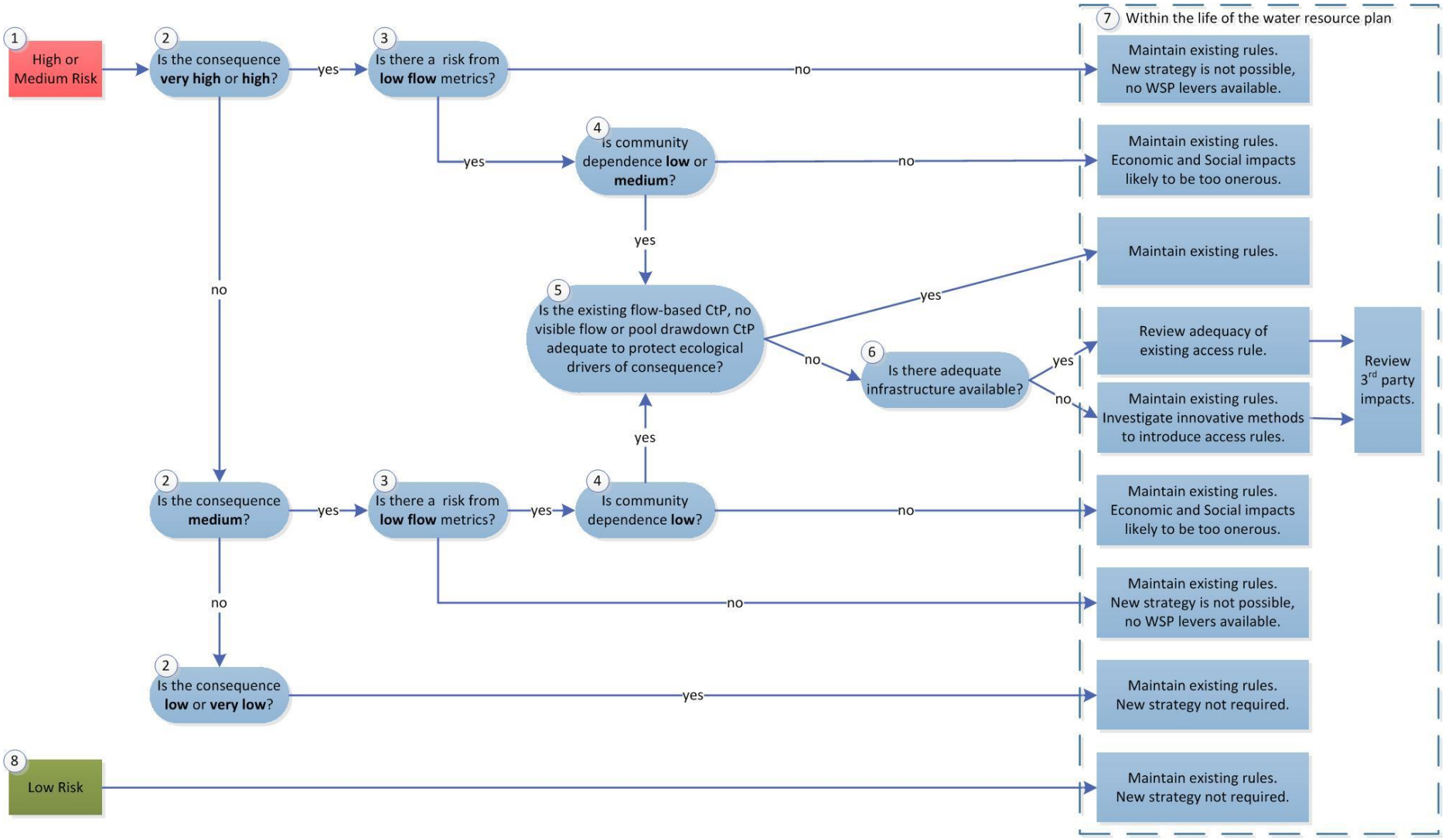

Figure G-5. Decision tree used as a guide for developing strategies in unregulated water sources

Table G-2. Rationale for each bifurcation in the decision tree used for determining strategies for unregulated water sources

Decision tree annotation	Rationale
1	• This step breaks up the strategies based on the Murray–Darling Basin Plan requirements that strategies are commensurate with the level of risk. • Where possible, draft strategies are being proposed to address water sources classified as medium or high risk. • Medium and high risks are considered the most important categories for ensuring adequate mitigation measures are determined. • Confidence in the data is high.
2	• This step is associated with medium and high-risk water sources. • High and very high consequence categories are considered the most important for ensuring adequate mitigation measures are determined. • Medium consequence categories are considered important but are not prioritised over high and very high consequence. • Low and very low consequence categories do not provide sufficient evidence to justify the changing of access rules. • Confidence in the data is high.
3	• Low and high flow risks to in-stream values are determined through the risk assessment process, where risks to six flow metrics were assessed. • Low flows are considered to be zero flows, base flows and freshes. High flows are considered to be the bank full to over bank flows, identified in the risk assessment as an average recurrence intervals (ARI) of 1.5, 2.5 and 5 years. • In unregulated systems, there are only opportunities to consider mitigation measures in low flows within a WSP. • Mitigation measures for high flows are outside the influence of a WSP/WRP, where low flow management is the key focus. • Confidence in the data is high.
4	• Community dependence is a factor that identifies the economic value of water extracted and the social benefit of extraction within a water source. • Where community dependence is high and the consequence is high or very high, competition for water between licensed extractors and the environment is greatest. Hence the need for more certainty in a CtP level using accurate, flow-based infrastructure. Low or medium community dependence allows high and very high consequence water sources to be further investigated for potential access rule options. • Medium consequence water sources are not prioritised for access rule reviews if the community dependence is considered to be high or medium. However, if community dependence is low, there is potential to further investigate access rule options. • Confidence in the data is LOW due to the data being collated in 2005-06 to support the macro WSP process. If the community dependence was updated with the latest data from the Australian Bureau of Statistics (ABS), confidence would be higher. • * Where there is no Community Dependency data, by-pass this step and the decision tree moves from step 4 to step 5. The attributes of high or very high value sites are influenced by extraction pressure.

Decision tree annotation	Rationale
5	• This step breaks up either medium and or high risk water sources to ensure steps progressing towards the strategies continue to be commensurate with the level of risk and available infrastructure. • Existing rules are determined to be adequate to help mitigate medium or high risk waters sources following: - An assessment of any monitoring of the rules during the life of the previous State-based WSP, - There is existing evidence that indicates connectivity and water quality are managed through the CtP measures, - There is inter-agency agreement that based on any of the above steps, existing WSP rules are adequate to reduce or limit the level of risk on the medium or high risk water sources. • Within the water source, consider the influence of any constraints that include: - The location of 200 mm pumps. This should also be considered in relation to the potential influence (entrainment) they may have on in-stream assets and function below and above where these pumps are located. - The location of priority in-stream barriers (weirs, road crossings, in-stream dams) that have the most influence on reducing or removing longitudinal flow connectivity during low flows need to be identified. - The condition of the riparian zone, including changes to riparian vegetation and the geomorphic recovery potential of river reaches.
6	• The presence or absence of infrastructure is a key factor that may influence how medium and/or high risk water sources may be managed during low flow periods. • If infrastructure is available, it must also be reliable and accurate before considering access rule-based mitigation strategies.
7	• All existing or new strategies to assist in mitigating the risk to medium and high risk water sources will operate for the life of a WSP (10 years) unless otherwise changed by the Minister. • If existing rules are considered to be adequate, it is unlikely cases of third party impacts will arise, as the access licence holders will be familiar with pre-existing rules and would have already made comment in earlier public exhibition phases of water sharing plan development.
8	• The Murray–Darling Basin Plan does not require mitigation strategies for water sources identified as low risk.

Determining new or modified strategies for regulated water sources

As identified in previous sections, the operational, social, economic and environmental constraints to mitigating risks often provide limited scope for addressing risks in regulated rivers. The ability to mitigate a risk in a regulated water source primarily depends upon the flow class in which the risk occurs, the rules available within the WSP or WRP, and any potential impact upon third parties. The rules available in a WSP for planned environmental water generally only apply to low and medium flows. Rules are specific and can be unique to each regulated river. They can take the form of rules to manage supplementary water, or in some WSP areas, translucency rules, which allow small volumes of water to be released from storages to introduce flow variability, often subject to seasonal and flow triggers. Large volumes of held environmental water are managed by NSW OEH through the LTWP component of the Basin Plan. The operation of held environmental water is not within the scope of either the WSP or the WRP.

Error! Reference source not found. shows the general decision-making process to address risks of insufficient water for the environment in regulated rivers. A rationale was not provided for this diagram as it is a consolidation of the concepts that are already detailed above.

Further draft strategies for future consideration

The following draft strategies were also considered during the development of the WRP (Table G-3).

Table G-3. Draft strategies

Draft strategy details	Relevant river reaches
Strategic delivery of irrigation orders to mimic natural flow events This draft strategy will investigate whether the risk associated with the reduced frequency of freshes during late spring and summer can be mitigated by delivering bulk water in patterns that mimic natural flow conditions. The ability to implement this strategy will vary between years and seasons and must be consistent with the need for efficient and timely water deliver. Discussions would need to be undertaken between OEH and the CSC at the start of the irrigation planning season, to examine whether delivery patterns can be varied without impacting on water security and efficiency.	All regulated river reaches downstream of Windamere Dam; Macquarie downstream of Burrendong Dam
Reduce the risk to baseflow and fresh frequencies by releasing water orders in a manner that more closely mimics natural flow events This strategy aims to improve the naturalness of flows in the Macquarie regulated river by attempting to mimic the rising and falling limbs of a natural flow event.	All regulated river reaches downstream of Windamere Dam; Macquarie downstream of Burrendong Dam

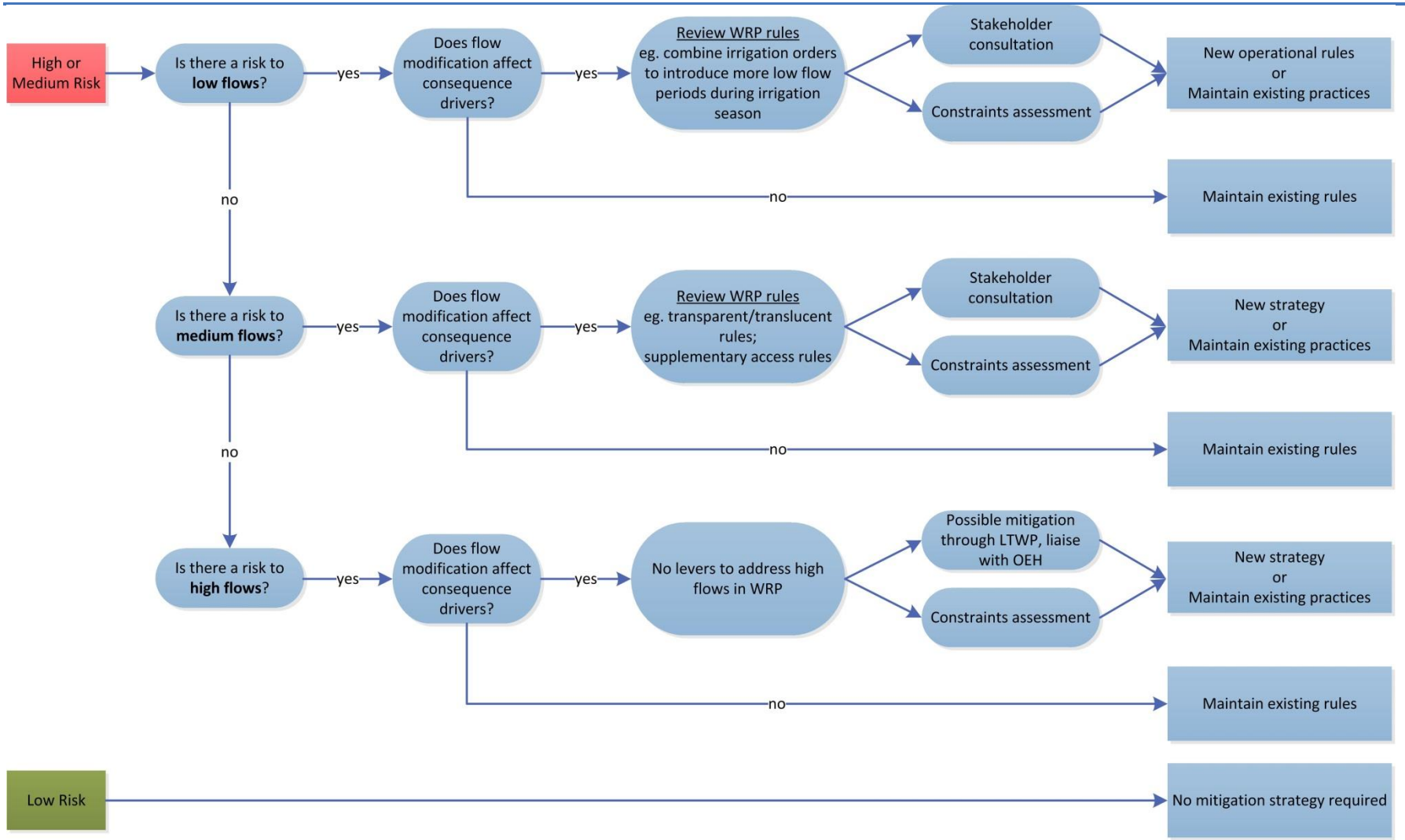

Figure G-6. Decision tree used as a guide for developing strategies in regulated water sources

Appendix H Risk assessment definitions

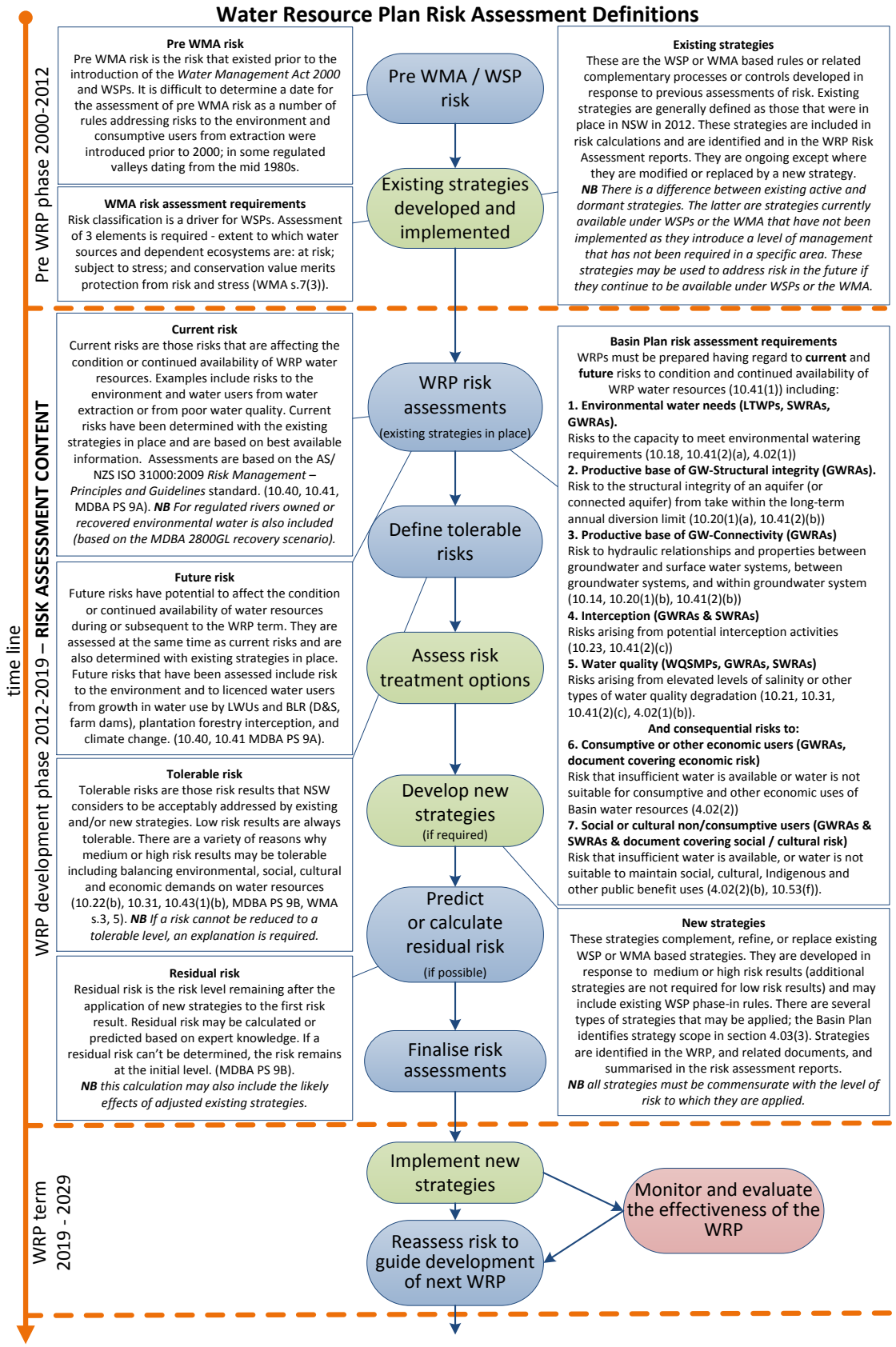

Figure H-1. Water resource plan risk assessment definitions